JRTE | Vol. 44, No. 2, pp. 101–120 | ©2011 ISTE | iste.org/jrte

You use! I use! We use! Questioning the Orthodoxy of One-to-One Computing in Primary Schools

Kevin Larkin

University of Southern Queensland

Abstract

The current orthodoxy regarding computer use in schools appears to be that one-to-one (1:1) computing, wherein each child owns or has sole access to a computing device, is the most efficacious way to achieve a range of desirable educational outcomes, including individualised learning, collaborative environments, or constructivist pedagogies. This article challenges this notion, suggesting instead that 1:2 computing is an appropriate means of achieving such aims in primary school. It further suggests that 1:2 computing is preferable to 1:1 computing to achieve a balance between productivity, student engagement, social activity, and individualised learning. This article draws on data collected during the 2009 school year from four Year 7 classrooms (11- to 13-year-old students) with varied patterns of access to netbook computers. The researcher collected detailed information from two pieces of software installed in each computer and analysed the data through an Activity Theory conceptual and methodological lens. Recommendations from this research will assist school leaders in making informed decisions regarding 1:1 and 1:2 computing. (Keywords: Computing, primary education, qualitative research, Activity Theory, 1:1 computing)

This article argues that it should not be presumed that one-to-one (1:1) computing is the only appropriate means of providing substantial computing access to primary school students. It suggests that one-to-two (1:2) computing is particularly beneficial in regard to student learning, classroom collaboration, and pedagogic approach, and that 1:2 computing offers considerable economic benefits in terms of school expenditure on ICT resources. This article draws on data collected and analysed as part of a year-long research project in 2009 investigating netbook usage by four Year 7 classrooms (11- to 13-year-old students) in an Australian primary school. It addresses one of the specific research questions from the broader project: In what ways did varying the ratio of netbook availability from 1:1 to 1:2 or varying the pattern of availability from 5 days per week for 6 weeks versus 3 days per week for 10 weeks affect student usage in terms of quantum (as a ratio of available time) and modes of use?

The term *1:1 computing* is defined here as the availability of a mobile, wireless-enabled device for each student (Liang et al., 2005), whereas 1:2 computing indicates the availability of a mobile, wireless-enabled device for every two students. These definitions of 1:1 or 1:2 computing refer only to the level of access and say nothing about actual usage in relation to educational practices (Bebell & O'Dwyer, 2010).

This project used Acer Aspire One Netbooks as the mobile, wireless-enabled devices. As the software on the netbooks was similar to that on the classroom/laboratory computers already in use, it was not considered necessary for the students and teachers to receive specific training. The teachers in this study have had access to individual work computers for at least 5 years. This particular group of students has had access to a computer lab (30 computers) and four classroom computers since they commenced school. Findings from the overall research project, related to this article suggest that (a) the netbooks provided in a 1:2 pattern were used up to 30% more than those provided in a 1:1 pattern; and (b) the use of netbooks affected student learning, classroom collaboration, and teaching style, and these changes were more profound in the two classrooms with 1:2 access.

Brief Background from the Literature

Findings from research conducted in 1:1 laptop computing environments suggest that 1:1 computing leads to changes in pedagogy, such as more student-centred approaches (Donovan, Hartley, & Strudler, 2007; Swan, van t'Hooft, Kratcoski, & Unger, 2005; Zucker & Hug, 2008), flexible and constructivist teaching styles (Mouza, 2008; Rockman, 2003; Zucker, 2004), and delivery of learning episodes that are more project oriented and inquiry based (Swan, van t'Hooft, Kratcoski, & Schenker, 2007). In regard to student learning, research has documented increased media literacy (Hill & Reeves, 2002; Rockman, 2003), improved writing (Gulek & Demirtas, 2005; Mouza, 2008; Ricci, 1999; Russell, Bebell, & Higgins, 2004) and, in some cases, increased scores on standardized tests (Gulek & Demirtas, 2005; Stevenson, 1998; Suhr, Hernandez, Grimes, & Warschauer, 2010).

However, perspectives contrary to those noted above are also evident in the literature. Lei and Zhao (2008) report concerns over the effectiveness of the high cost of 1:1 computing programs and note increasing resistance by some parents, school administrators, and educational bureaucracies to their implementation. Selwyn, Potter, and Cranmer (2009) report on ICT use by students in British schools and note, "Whilst our data depict a generation of young people for whom ICTs are part of their everyday lives, closer inspection shows many primary pupils' actual engagement with ICT to be often perfunctory and unspectacular—especially within the school setting" (p. 928). Notwithstanding the findings of Lei and Zhao and Selwyn et al., the broad spectrum of research indicates that 1:1 computing has positive outcomes for students across a range of domains.

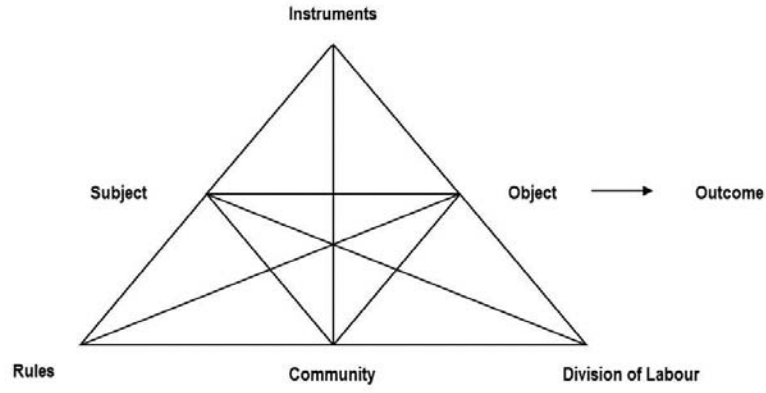

Figure 1. Activity Systems (Engeström, 1999, p. 31).

In addition to the educational advantages of 1:1 and 1:2 computing, it is incumbent on educational institutions to ensure that allocated funds are expended wisely. Budgetary realities often mean that schools struggle with the dilemma of providing cost-effective computing without compromising educationally appropriate access to such technology. What is apparent is that research studies completed to date have yet to test specifically the links between hypothesised outcomes for 1:1 initiatives (Penuel, Tatar, & Roschelle, 2004) and the impact of different implementation strategies to achieve these outcomes (Zucker, 2004). This article reports on a study that used mobile computing with four distinct variations in implementation and suggests that the positive outcomes of 1:1 computing noted above can be achieved at less than a 1:1 ratio.

Conceptual Framework

Classrooms can be conceived of as sites where learning occurs as a social and cultural endeavour. Activity Theory, a specific sociocultural theory, is used as a framework to analyse, synthesise, and evaluate the classroom environments in this research. Activity Theory is considered particularly useful in understanding the range of complex factors related to computer use and how this use affects student learning. Engeström's (1999) conceptualisation of Activity Systems (Figure 1) is used in this research. Engeström suggests that sociocultural sites can be examined using six key elements. In the system, the subject uses tools to attain a specific object in a community context with specific rules and roles of responsibility. Contradictions and tensions between these various elements are resolved to attain a specific outcome.

Three particular features of any Activity System approach render it appropriate for this research:

1. Each classroom is taken as a unit of analysis, providing context and meaning to a range of events.

2. The classroom components can be understood as historical entities.
3. Inner contradictions within the classrooms are analysed as sources of disruption, innovation, change, and development (Young, 2005).

Activity Theory is thus useful in understanding the range of complex historical and sociocultural factors related to computer use in the four classrooms in this research and how this usage affected student learning. For instance, a common task for the students in this research was the production of a report. The use of the computer transforms the completed report (through the availability of digital images and text manipulation), but at the same time the historical structure of the report genre limits the potential of the computer (for instance, the report must be text based, with no multimedia). Activity Theory has been used widely as a conceptual and methodological tool in educational research contexts from the early years through to tertiary education (see Georgeson, 2006; Latheef & Romeo, 2010; Lloyd & Cronin, 2002; Romeo & Walker, 2002; Sweeney, 2010; Zevenbergen & Lerman, 2007).

By way of a brief example, both Latheef and Romeo (2010) and Sweeney (2010) used Activity Theory to examine the impact of interactive whiteboards (IWBs) on classroom environments. Latheef and Romeo investigated the impact of IWBs on interactivity in primary school classrooms. They suggest that interactivity is shaped by pedagogical, instructional, and technical aspects and use Activity Theory as a means of examining classrooms holistically. Sweeney (2010) utilized Activity Theory to investigate the development of teachers' technical and pedagogical skills and knowledge using IWBs in primary classrooms.

Methodology

It is suggested above that classroom environments are complex, historic entities with inherent contradictions and tensions that, if resolved, result in the growth and development of these environments. Given this, an approach to enquiry was required that captured both the subjective qualities that comprise individual consciousness, interest, and motivations as well as the contributions of the physical and social world (Creswell, Shope, Clark, & Green, 2006; Maxwell, 2004). Consequently, this research used a mixed-methods research approach (Burke & Onwuegbuzie, 2004) to direct the investigation of netbook usage by the teachers and students in this study.

Because this research sought to determine whether varying the ratio and access pattern to the netbooks affected their use, I provided four levels of netbook access to four Year 7 classes. To determine the impact of different patterns of netbook usage, I distributed the netbooks as described in Table 1.

I used a range of data collection methods or tools to collect data for this article:

Table 1. Pattern of Netbook Allocation

	Class A 1:1 five days/week)	Class B (1:2 three days/week)	Class C (1:2 five days/week)	Class D (1:1 three days/week)
Number of Netbooks	32	16	16	32
Days per Week	5	3	5	3
Number of Weeks	6	10	6	10
School Terms	Term 1	Term 2	Term 2	Term 3
Teacher Pseudonym	Vernon	Wendy	Neville	Jasmine

- Classroom observations (prior to, during, and after netbook use)
- Semistructured interviews, student forums, and surveys (Freebody, 2003)
- Data-logging software installed on the netbooks

Classroom Observations

Approximately 80 classroom observations lasting 15–30 minutes each occurred prior to and during periods of netbook use.To gain an accurate picture of netbook use, I conducted these observation periods at random times during the school day and did not tell the teachers when these observations would occur. To aid in the data collection of computer usage information, the research used a modified version of the Survey of Computer Use (SCU) Instrument (Dawson, Cavanaugh, & Ritzhaupt, 2008/2009). This instrument is specifically designed to conduct classroom observations in relation to computer usage. I collected further classroom observation data via observation records in the researcher diary and kept records that detail any direct interactions with students and teachers during these observation periods. Over the course of the project, I took six one-week periods of leave to spend substantial amounts of time observing the classroom use of the netbooks.

The purpose of the classroom observations were two-fold. First, observing the classrooms prior to and during the netbook usage periods generated a range of data about the impact of the netbooks on computer usage in these classrooms and meant that comparisons could be made regarding, for instance, student-to-student communication via ICTs in the classrooms pre- and postintervention. Second, I triangulated observations with quantitative data collected directly from the netbooks.

Semistructured Interviews and Surveys

The interviews consisted of a mixture of predetermined questions regarding specific aspects of the project, such as the impact of netbooks on specific curriculum areas or the effects of netbook use on access to information, as well as questions that arose from the nature of the discussion. The semistructured nature of the interviews thus allowed for deeper probing of participant responses as the need arose and allowed the participants the opportunity to contribute additional reflections, comments, or opinions and to ask me questions about the project if they so desired. The initial, interim, and final

interviews also contained a set of specific questions related to the classroom environment and curriculum use of the netbooks, which required a Likert-scale answer. I interviewed each of the teachers four times (16 interviews in total): prior to the class using the netbooks, during the use, at the immediate conclusion of the use, and after a period of time (4–6 weeks). I conducted the student interviews as paired interviews (36 interviews in total). I interviewed each pair three times: prior to their class using the netbooks, during their use, and at the conclusion of their use. I chose the six students in each class randomly and interviewed in pairs to minimize potential issues of power imbalance. I assigned each student in each of the four classes a number from 1 through 32. I used a Web-based random generator (http://www.random.org/integers) to generate six numbers, which I matched to the students to determine the six students to be interviewed. One student left the school during the usage period and was replaced by a randomly selected student from that class. The six students from each class also participated in a discussion forum conducted approximately 6 weeks after the completion of their netbook usage period. I gathered post-usage information about the classroom environment and patterns of post netbook computer usage. I recorded the interviews (with the consent of the participants) and took interview notes. The interviews were transcribed as soon as possible after the interviews, and the participants reviewed the transcripts to ensure their accuracy.

Toward the end of the first 6-week period of access, it was apparent that I collecting qualitative data only from six students (and their teacher) and that it would be beneficial to collect further qualitative data from all of the students. This data would serve both as a means of verifying what the randomly selected interviewees were reporting and as a tool to ensure significant "student voice." Consequently, I created a survey for all students in the study to complete. The survey questions largely replicated the questions that I had used throughout the student interviews. I triangulated the data collected from these surveys with interview data, observations, and the qualitative data collected throughout the project to construct a picture of the four classrooms. The responses to the survey regarding the use of the netbooks supported and reinforced the perspectives that the interviewed students had offered.

Data-Logging Software

Although I gathered anecdotal information on computer usage, in terms of both duration and purposes of use, via observations, interviews, and student forums, I also collected actual usage data directly from the netbooks. Computer data collected electronically from each netbook was vital in accurately determining how usage varied according to the different modes of access. Automated data collection is a more reliable method of collecting usage data than relying on self-reports of usage. I used two tools to collect usage data. The primary data tool was a logon script on each netbook that

automatically recorded start-up, logon, logoff, and shutdown events. The second technical data tool was Spy KeyLogger, a piece of software that collected information on every keystroke to provide information regarding software usage and Internet activity. As part of the ethical clearance for this research, I informed all participants in writing that keystroke data would be collected. Spy KeyLogger also functioned as a proactive research tool in that it provided entry points into the experiences of the students and allowed triangulation of the data collected from the logon script, classroom observations, interviews, and surveys.

Data Analysis

Rather than leaving any analysis until the conclusion of the data collection phase of the project, I commenced initial data analysis soon after the start of the project. This early analysis shaped subsequent data collection procedures. Initial analysis involved transcribing interview data and the processing of classroom observations and other artefacts (Garthwait & Weller, 2005). The data collected were coded into emerging categories of interest, initially based on the six Activity Theory nodes (Subject, Object, Tool, Community, Rules, and Division of Labour). This early analysis primarily related to the data collected from Class A. At later stages throughout the research, as other teachers and classes became involved and other themes arose, I revisited these initial transcripts and, if necessary, recoded this early data into the emerging themes using NVivo. NVivo has been used as a data analysis tool in a range of ICT related educational projects (see Dunleavy, Dexter, & Heinecke, 2007; Thompson, 2005).

This article uses the terms credibility and transferability as guiding concepts in determining the integrity of this research. Credibility and transferability are reflected in the authentic representation to the reader of the research of the how the data were collected and the type of analysis that was conducted. Transferability is not concerned with the question of whether the findings are valid for all other contexts, but rather with the question of whether the research findings and analysis are helpful in understanding the reader's context (Bogdan & Biklen, 2007). Credibility is viewed as the fit between what is recorded and presented as data and what actually occurred in the setting under study. Transferability and credibility were enhanced via the employment of a number of strategies recommended by Creswell (1998). These strategies included triangulation of the data, an appropriate length of time spent observing and interviewing, the clarification and declaration of personal bias, and entering the research site as a participant rather than an observer. Member checking (Eisenhart & De Haan, 2005) was also a research strategy whereby, after completing data analysis, I returned to the students and teachers in the research and asked them "Is this right?" Where necessary, I reconsidered conclusions to accommodate the follow-up information that the participants provided.

Table 2. Average Daily Netbook Usage per Access Period

Access Period	Term 1 (Class A)	Term 2 (Class B & C)	Term 3 (Class D)
Average Daily Use	31 hours	41 hours	28 hours

Findings and Discussion

The situation in many schools is that, due to financial constraints, laptop computers, where available, are shared between two or more classrooms, resulting in either a full-time 1:2 access ratio or a 1:1 access ratio for 2 or 3 days per week. This research replicated these contexts by varying netbook availability (1:1 or 1:2) and by varying the pattern of availability (5 days per week or 3 days per week). For ease of discussion, this article will refer to Class A's access (1:1 for 5 days per week) as FA-FT (full access full time), Class B's access (1:2 for 3 days per week) as PA-PT (part access part time), Class C's access (1:2 for 5 days per week) as PA-FT (part access full time), and Class D's access (1:1 for 3 days per week) as FA-PT (full access part time).

Over the course of the school year, there were three distinct periods of usage for the class set of 32 netbooks. In Term 1, Class A (FA-FT) had access to all of the netbooks for 5 days per week. In Term 2, Classes B (PA-PT) and C (PA-FT) shared the netbooks, using 16 netbooks each. In Term 3, Class D (FA-PT) used all of the netbooks for 3 days per week. As noted earlier, each class had access to the netbooks for a total of 30 school days. Figure 2 represents the netbook usage in terms of time.

The information presented in Table 2 illustrates that the two classrooms (B and C) that shared the set of 32 netbooks used them on average for 10 hours more per day than Class A (FA-FT) and 13 hours more per day than Class D (FA-PT) This suggests that, from a quantum of usage perspective, students used the devices for up to 30% longer in the classrooms that shared the devices than in either of the classrooms that had access to the whole set. Based on this information, it is suggested that schools get increased return on their investment in the provision of computers in a ratio of 1:2.

Although overall use of the netbooks was relatively low (average daily use of 58 minutes), classroom usage varied markedly on a day-by-day basis. For example, although Class A (FA-FT) used the netbooks for an average 54 minutes per day, on some days netbook usage was more than 3 hours, yet on other occasions they were either not used or used for only 15 minutes per day. Figure 2 presents data regarding usage and patterns of access, which is expressed in terms of maximum, minimum, and mean usage for each class. In considering the data in Figure 2, it is useful to recall the conditions of use. Each teacher had a total of 30 days of netbook usage. Class A (FA-FT) and C (PA-FT) had 32 and 16 netbooks respectively and had 6 weeks of access, 5 days per week. Class D (FA-PT) and B (PA-PT) had 32 and 16 netbooks respectively and had access 3 days per week over 10 weeks. The teachers could choose which 3 days per week they used the devices (e.g., Monday, Tuesday, Thursday in Week 1; Tuesday, Thursday, Friday in Week 2, etc.).

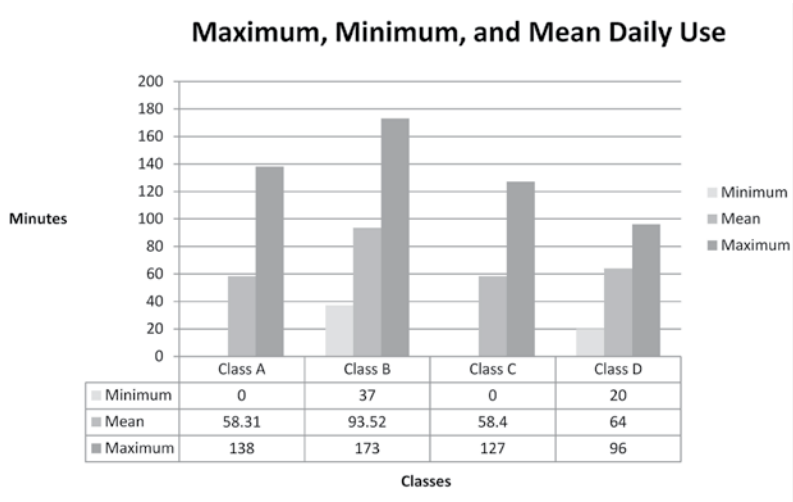

Figure 2. Maximum, Minimum, and Mean Daily Usage per Class

Although a large range of usage was evident across all four classes, the classes with access 3 days per week (Class B [PA-PT] and Class D [FA-PT]), were most consistent in their usage. Figure 2 illustrates that there were no days that students did not use the netbooks in these classrooms. This is in stark contrast with Class A (FA-FT) and Class C (PA-FT), which both recorded a number of days where the netbooks were available but not used. It is apparent that the teachers in Classes B (PA-PT) and D (FA-PT) were able to avoid external interruptions to classroom teaching time, as they could plan which 3 days each week they would use the netbooks. For instance, the teachers could check the school calendar, establish when external class events were to be held, and then elect not to use the netbooks on those days. This was not an option in this research for the two classes with access 5 days a week.

Data presented thus far indicate that the average use of the netbooks was approximately 60 minutes per day for three classes and just over 90 minutes per day for a fourth class. Over the course of the 30 days, usage fluctuated. On some days, the students did not use the netbooks, and on other days, they used them significantly. The findings presented in Figure 2 indicate that the four classrooms used the netbooks for different amounts of times and that the manner in which they utilised this time also varied. These data, of course, need to be tempered with considerations of homogeneity between the teachers, classes, and prevalence of interruptions due to testing, etc. The teachers in this study were all experienced Year 7 teachers with relatively similar ICT skills. The students were allocated to classrooms, as per the usual school procedures, to achieve, where possible, an even spread across gender, academic ability, and behavioural concerns. Major disruptive periods (e.g., National Standardised Tests) were not conducted during netbook access.

Taking into account the provisos noted, the data indicate that, from a pure "time usage" formula, the supply of computers in a 1:2 pattern, particularly when this access was provided for 3 days per week, resulted in the maximum usage. Although usage data is relevant in economic terms, it is not the decisive factor in recommending the use of computers in a 1:2 pattern. The educational benefits of 1:2 computing are also considerable and are discussed in the following section.

Availability Affects Usage Patterns: An Activity Theory Perspective

In analysing the data, three patterns of netbook usage became evident. For consistency, this article refers to these three patterns as 1:1, 1:2, and 1:1-1/2. Reference to 1:1 indicates that each student in the class used a netbook individually; 1:2 indicates that two students worked in a pair using one netbook; and 1:1-1/2 indicates situations where half the class were using the netbooks on an individual basis while the other half of the class was completing a non-netbook activity. By way of example, a non-netbook activity could include a directed teaching episode or a mathematics task that involved completing a worksheet. In relation to netbook usage, data collected from the devices using Spy KeyLogger indicates that the primary softwares used were Microsoft Office Applications (mainly Word and PowerPoint, with some use of Publisher), Internet Explorer, and some Windows Media Player.

Prior to examining in depth the usage of netbooks in the 1:2 classrooms, it is necessary to briefly explore usage in the 1:1 classrooms, as this provides a context and a point of contrast to the 1:2 usage. Activity Theory and, in particular, Activity Systems will be used for this exploration. Activity Systems can be used to identify the tensions and contradictions that are evident in classrooms and to analyse how the resolution of these tensions leads to growth. Figure 3 presents the Activity System operating in the two classrooms with 1:1 access. Points of tension and contradiction are indicated by the arrows. By way of example, the arrow drawn between Tools and Subject in Figure 3 indicates that the historical use of computers as primarily a tool for productivity (typing of prewritten stories) limited the opportunities for innovation (use of computers for collaboration).

Netbook Usage in the 1:1 Classrooms

The classrooms with access to 32 netbooks used the devices by and large as "digital textbooks," whereby the students all use the computers at the same time, for the same task, and often from the same, or a narrow range of, webpage(s). The teachers decided which activities required the netbooks, and usage would occur only for a specified time to directly support these activities. In both 1:1 classrooms (FA-FT and FA-PT), students used the devices to either produce assignments (narratives, reports) or complete targeted research (on prespecified websites), which would be used to write the narrative or report. The students were proficient in performing these project-based tasks using the

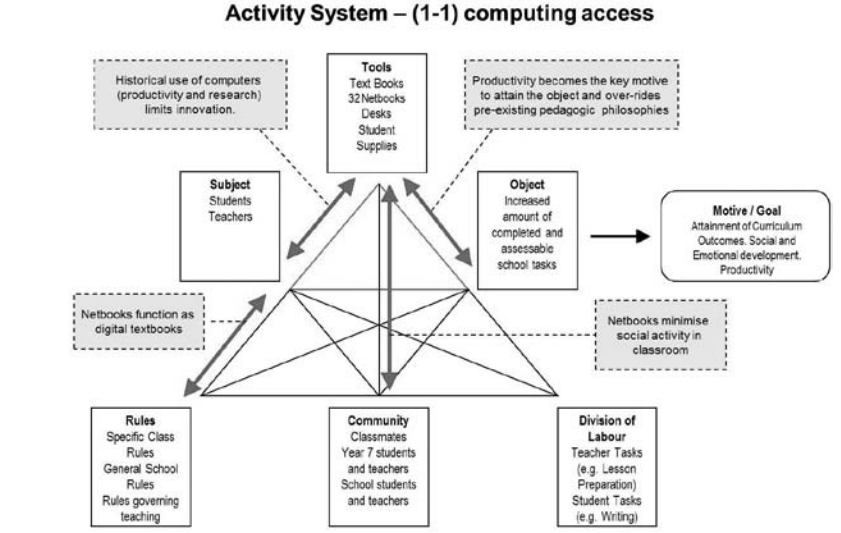

Figure 3. Activity System illustrating tensions evident in 1:1 classroom.

devices. The decision to use the devices in this manner is shaped by the historical factors mentioned previously—that is, that computers have historically been used as productivity tools for typing or research—and also by the pattern of access to the computers in these two classrooms.

The unlimited access to 32 netbooks was a significant determinant of the pattern of use. The unlimited availability of the tool shaped the behaviour of the subject(s). In summarising the attitude of the teachers to 1:1 computing, their thought processes seemed to suggest the following pattern: "I have access to enough computers so that each student can use one simultaneously. Therefore, regardless as to whether an activity might be better conducted in pairs or in groups, it will be completed individually by the students." The trajectory of netbook usage in Class D (FA-PT) is a clear example of the substantial influence of the tool on the relationship between the subject and the object.

Despite having access to 32 netbooks, Jasmine (Class D teacher [FA-PT]) initially used the netbooks to support her normal pedagogic practice, which is largely based on group activities. The students used the netbooks at different times during the day and for specific group rotational tasks. This pattern of usage lasted for just under 4 weeks. For the last 6 weeks of her usage, she reverted to the pattern of usage noted in Class A (FA-FT), in which each student used a netbook individually, at the same time and for the same task, for an hour or so a day. I discussed this change in usage with Jasmine (Teacher, Class D, September 2009) during an interview, and her reply was very illustrative of the influence tool availability can have on pedagogy:

> I have the 32, the kids want to use them, and they get a lot done with them—open them up and let's go.

This point was restated in the final interview with Jasmine:

> As I said before, if I am given 32 netbooks to use in the future, I would use them, but value-wise and effects-in-the-classroom-wise, I think 16 is the best. (Jasmine, Teacher, Class D, October 2009)

Neville and Wendy, who each received 16 netbooks, also noticed this pervasive influence of access to the 32 netbooks. Neville discussed the likely impact of 32 netbooks in his classroom in his interview:

> I think having access to 32 computers may lead to a deterioration of my teaching, as I might spend 5 minutes speaking to the kids in the morning and then getting them to research a project…. It would be very tempting to use the 32, as it frees up my time, and also the kids are very keen to use them and are productive and on task when they do so. (Neville, Teacher, Class C, October 2009)

This comment highlights an interesting contradiction, as it could be argued that on-task, productive, and motivated students are highly desirable. What Neville is indicating is that this productivity comes at the potential cost of other desirable educational outcomes, such as classroom discussion, collaborative group projects, and, at some level, direct teaching. Although all of these are possible in 1:1 environments, pressure was felt from the students, and from an ease-of-use perspective, to use the devices in the pursuit of individual tasks.

Likewise, in relation to 1:1 access, Wendy noted:

> The students would not have worked together in pairs. I would have felt that I had to use the 32 computers because I would not have wanted to waste them. (Wendy, Teacher, Class B, October 2009)

It appears that the availability of the netbooks meant that these teachers would plan activities where all students could use the netbooks and other activities where no one used the netbooks. Student autonomy in deciding whether or not to use the netbooks was largely nonexistent. As a consequence of the pattern of use, social interaction between students during periods of netbook usage was very limited.

Netbook Usage in the 1:2 Classrooms

In contrast to the 1:1 classrooms, the presence of the netbooks in the 1:2 classrooms was a major contributory cause of the contradictions that developed in the activity system in these classrooms. The contradictions that were directly related to the 1:2 availability of the netbooks are represented in Figure 4.

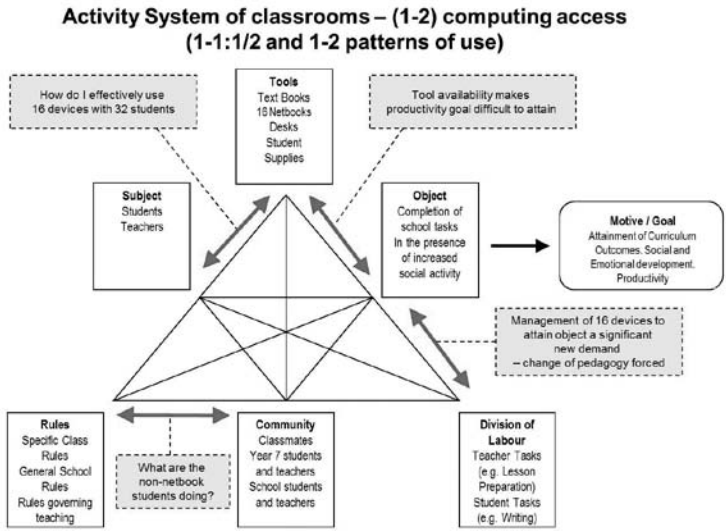

Figure 4. Activity System illustrating tensions evident in 1:1 classroom.

Prior to discussing the specific contradictions apparent in the 1:2 classrooms (e.g., effective patterns of use for 16 netbooks, modified pedagogic approach), it is necessary to indicate that the 1:2 classrooms also contained many of the contradictions which were evident in the 1:1 classrooms (e.g. productivity vs. social activity). It is also true that the teachers of Class A (FA-FT) and D (FA-PT) were able to more easily reconcile many of the contradictions, as 1:1 access did not require a fundamental change in their pedagogy (see Bateman & Oakley, 2009), and Vernon and Jasmine were therefore better able to assimilate the netbooks into pre-existing classroom practices. In Classes B (PA-PT) and C (PA-FT), the limited availability of the tool necessitated a fundamental change to classroom organisation and to the pedagogic practices of these teachers. Both Wendy and Neville were cognisant of this disruption to their teaching:

> A critical factor of the 16 computers was that it "forced" me to at least plan two different activities for the students to complete, and in the ideal situation "forced" me to teach the 16 students whilst the other 16 students worked on the computers. I am doubtful this would have happened if we had 32 computers. (Neville, Teacher, Class C, June 2009)

Neville identified in this statement that teaching 16 students while the other 16 completed a scaffolded task on the computers was his "ideal" pattern of usage. The limited availability of 16 netbooks meant that Neville (and Wendy) were not as easily able to integrate the technology into the existing classroom pattern as Vernon and Jasmine were. In these classrooms, a clear disruption had been caused that required a modification of pedagogic practice.

New Pedagogical Approach Required

How the teachers in Class B (PA-PT) and Class C (PA-FT) responded to the presence of 16 netbooks, and their pedagogic decisions in response to the device allocation, had significant effects on teacher control, teacher support, student involvement, and student affiliation. Both Wendy and Neville used the 16 netbooks in either a 1:2 or 1:1-1/2 pattern. For productivity-type tasks—for example, typing an assignment or writing a letter to the principal—the 1:1-1/2 model was deployed, with the teacher working with one half of the class whilst the other half worked individually on the netbooks. In the initial stages of a new unit of work, the students would work with a partner on the netbooks in a 1:2 model of usage. In both the 1:2 classrooms, much of the brainstorming prior to the beginning of the research and during the research phase of the project required netbook usage, so this was completed in pairs. Both students and teachers considered the modified and flexible 1:1-1/2 model of use very successful. Student comments included:

> I like working with partners on the netbooks. I just feel comfortable using them this way. (Paige, Student, Class C, June 2009)

> We know each other a little better. We made a lot of friendships with the netbooks because we were with people we did not know. Term 2 with the computers helped change how we are with our teacher and with each other. (Kirstene, Student, Class B, May 2009)

Likewise, the teachers noted:

> I think the partner motivated them…. Some kids could lose their motivation without the pairs. (Wendy, Teacher, Class B, June 2009)

> I have found with the netbooks that the kids are, within the pair especially, sharing ideas and learning together and talking a bit more and discussing what they are researching. (Neville, Teacher, Class C, April 2009)

The sharing of ideas and collaborative learning identified in these comments from the classes with 1:2 access was conspicuously absent in the 1:1 computing scenarios, where student comments indicated a preoccupation with individual productivity tasks. The collaboration evident in the 1:2 classrooms was not evident in the 1:1 classrooms, where students completed all components involving the netbooks individually. The limited availability of the netbooks was a catalyst in shifting the learning focus from the teacher to students working in smaller groups with the teacher, and to scaffolded learning activities utilising the netbooks. In contrast, the 1:1 access in Classrooms A (FA-FT) and D (PA-FT) promoted a focus on individual, teacher-directed activity with the netbooks. In summary, all of the classrooms felt the impact of the computers, and the tensions that were

generated in these systems were largely a result of the patterns of access and availability of the netbooks.

Conclusion and Recommendations

A clear conclusion from this project was that the pattern of access not only significantly affected the quantum of netbook usage, but also influenced the manner in which this usage was distributed, which in turn contributed to a range of learning and teaching patterns in these classrooms.

Tool Allocation: A Significant Determinant of Object and Motive

Although the impact of a new tool became influential in the attainment of specific goals in all four classrooms; this impact was felt most noticeably in the classrooms that had access to only 16 computers. This "limited" availability at best facilitated and at worst "forced" a 1:1-1/2 model of use, whereby students alternated between two types of activities while using the netbooks. Although this required a greater commitment from the teacher to prepare scaffolded activities for the students to complete on the netbooks (e.g., answering research questions for a later report) as well as a willingness to teach the same non-netbook activities twice, this pattern of usage was seen as a positive experience for both students and teachers. Of course, the teachers in the 1:1 model could have used the devices in a similar manner. However, the situation seemed to be that, once the 32 were available, the teachers and students preferred to use them individually in productivity-related activities rather than in group or paired situations. It could be that if the netbooks were available all year round, this may become less of an issue. Clearly, pedagogic decisions were being made, but just as clearly, these were influenced in this research by the availability of the devices.

These 1:2 and 1:1-1/2 models of usage had a range of potential advantages and disadvantages for the teachers. The advantages for the teachers were an increase in student engagement and the opportunity to teach a smaller and more responsive group of students while half of the class was productively engaged in a largely self-managed netbook activity. The disadvantages were an increased workload for teachers and a reduced opportunity to conference with students individually or in small groups, as they were more likely to be busy in direct teaching activities with one half of the students. Overall, there are greater benefits in terms of interaction among students, and between the students and their teacher, in a 1:2 pattern of access than when the students use the netbooks individually in the 1:1 pattern.

Differing Forms of Activity in the Classroom

According to Pietsch (2005), classroom activity takes three forms:

1. **Educational:** This aspect is largely initiated by the teacher.
2. **School-going:** Students complete teacher-set activities.

3. **Social:** These are the social relationships that students and teachers establish in curricular and noncurricular discourses.

During the periods of their use, the netbooks substantively affected the social activity in three of the classrooms and affected the fourth classroom in a less significant way. Although the level of non-netbook social activity varied according to the task (e.g., individual reading activities, completion of tests, or group discussions) the level of social activity remained consistently and conspicuously low during all periods of netbook usage in Class A (FA-FT). When the students were using the netbooks, perhaps as a consequence of using the netbooks only in a 1:1 model, they preferred to work individually and were almost singularly focussed on completing set tasks. This in itself may be considered a positive outcome; however, the completion of set tasks on the netbooks resulted in a diminshed level of of paired or group work during the netbook usage period. There was no evidence of the students using the netbooks collaboratively prior to completing the tasks individually. The students preferred, and required, less instruction from the teacher, whose role was largely to support individuals in the completion of the task. One-to-one computer access worked against the establishment of high levels of social activity in the classrooms and therefore diminished the opportunities for student collaboration and the shared development of ideas and concepts important for student learning. Although individual task completion is a key student task, the netbooks facilitated this process so effectively that students completed less collaborative work.

In contrast, levels of student activity increased markedly in both classrooms with 16 netbooks. The access to only 16 netbooks required a restructuring of student work patterns and resulted in an increase in the amount of paired work. The teachers generally used the 1:2 model for initial brainstorming, research, and joint presentations and switched to the 1:1-1/2 usage for the completion of written tasks. The motive of the activity (paired research or productivity) was critical in determining whether or not a 1:2 or a 1:1-1/2 model was used. Regardless of the pattern of access, the focus of the teachers and students in the 1:1 classrooms in this project was largely on individual task completion; however, in the 1:2 classrooms, the process of achieving an individual completion of the task was more collaborative in that parts of the overall task (brainstorming and research) were completed in pairs using the netbook as a tool in this process.

Students noted that they enjoyed paired work on both a social and academic level and that prior to using the netbooks, they had not worked very often in pairs. Although these options regarding patterns of use were available to the four teachers, only the two teachers who had 16 netbooks deviated from a strict 1:1 regime of use. Although the pedagogic approach is a key consideration, patterns of access seemed to be a substantial indicator as to how the devices would be used. A key finding from this research was that, although

three of the four teachers thought that the best model of use from both a pedagogic and economic perspective was the 16 netbooks, all of the teachers, given the choice, would opt for the use of 32 netbooks. It appears from the reaction of these teachers that limiting teachers to 16 netbooks directed their pedagogy to a more balanced approach between educational, school-going, and social activity.

Contributions for School-Based Practice

Based on the findings of this research study, it is recommended for this particular educational context that netbooks be made available in the ratio of 1:2. The 1:2 provision of netbooks was sufficient to provide a "critical mass" of computers that resulted in significant use by teachers and students (Norris, Sullivan, Poirot, & Soloway, 2003). Furthermore, the 1:2 pattern of usage had substantial pedagogical advantages over the 1:1 model and appeared to afford the best balance between individual student productivity, student collaboration, direct teacher instruction, and flexibility to respond to other curricular and extracurricular events. It was also the pattern of access that resulted in the greatest use of the devices, in terms of quantum of usage, with the netbooks used 30% more in the 1:2 model than in 1:1 model. As indicated earlier in this article, the increased usage is per device rather than per student. Although extensive data was collected in relation to actual time of use (via the Logon/Logoff script and Key SpyLogger), it was not feasible from a technical point of view to accurately track individual student usage in a paired context. To do so would require the students to either log on and log off each time either of them used the device or to keep a paper-based log of the respective contributions of each student. I suggest that these options are inconvenient and also contrary to the spirit of collaboration in a paired situation. What was clearly evident from classroom observation, from survey data as well as student and teacher interviews, is that during the collaboration-rich activities (e.g., brainstorming, initial research, planning of writing activities), the students in the 1:2 classrooms worked in pairs to complete this task. In these situations, student use per device was increased as the whole class were working on 16 computers. Once the students were required to produce individual work (based on their shared research), per-student usage in the 1:2 classrooms mirrored that in the 1:1 classrooms (Larkin & Finger, 2011).

In addition, without compromising the educational advantages of the netbooks to the students and teachers, there are significant economic benefits to schools in the decision to deploy netbooks in the 1:2 model. In the case of the research school, the difference in purchasing one netbook for each student, as opposed to one between two, was approximately $300,000. Recommending the 1:2 model makes a deliberate attempt to inform and shape a particular pedagogical approach to netbook usage. Based on the experiences gleaned from this project, supplying teachers with 32 netbooks

encouraged one pattern of usage (i.e., each student worked individually on the tasks that the teachers set). The teachers were strongly influenced by the 1:1 availability and seemed compelled to use all of the computers at the same time. Although this pattern of usage had advantages in terms of productivity and allowed teachers to spend time conferencing with students, it had a negative impact on the level of social activity in the classroom, made it more difficult to promote individual and self-directed learning, and was less viable from an economic point of view with the netbooks unused for large periods of the school week.

In contrast, the classrooms that used the 16 netbooks were characterised by increased levels of student involvement, teacher support, and social activity. The students valued highly both the opportunity to work with a peer with the netbooks and the opportunity to work individually on the devices as the activity demanded. In addition, and of significant value to the students, were the increased opportunities to interact with their teacher at a lower student teacher ratio, which the 1:1-1/2 model encouraged. Further research into the effects of 1:2 access in a range of schools is necessary as a potential alternative to the current 1:1 orthodoxy.

Author Notes

Kevin Larkin is a lecturer in information and communication technology (ICT) mathematics education and technology education at the University of Southern Queensland. He teaches Foundations of Numeracy, ICT and Pedagogy, and Technology and Pedagogy, and his research interests include m-learning, e-learning, ICT in education, Activity Theory, and 1:1 computing. He has been published in the areas of m-learning, Activity Theory, Web 2.0 (under review), and digital citizenship. Please address correspondence regarding this article to Kevin Larkin, Faculty of Education, Springfield Campus, University of Southern Queensland, PO Box 4196, Springfield Central, Queensland, Australia, 4300. E-mail: Kevin.Larkin@usq.edu.au

References

Bateman, D., & Oakley, C. (2009). *Research report: The Classmate PC 1:1 e-learning project in Australia.* Burwood, Australia: Deakin University. Retrieved from http://managementofchange.wikispaces.com/file/view/Classmate+PC+Australia+Pilot_+Deakin+Univ+Research+Report+Final+%282%29.pdf

Bebell, D., & O'Dwyer, L. M. (2010). Educational outcomes and research from 1:1 computer settings. *The Journal of Technology, Learning, and Assessment, 9*(1), 6–14. Retrieved from http://www.jtla.org

Bogdan, R. C., & Biklen, S. K. (2007). *Qualitative research for education. An introduction to theories and methods* (5th ed.). Boston: Pearson Education.

Burke, J. R., & Onwuegbuzie, A. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher, 33*(7), 14–26.

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions.* London: Sage Publications.

Creswell, J. W., Shope, R., Clark, V. L. P., & Green, D. O. (2006). How interpretive qualitative research extends mixed methods research. *Research in the Schools, 13*(1), 1–11.

Donovan, L., Hartley, K., & Strudler, N. (2007). Teacher concerns during initial implementation of a one-to-one laptop initiative at the middle school level. *Journal of Research on Technology in Education, 39*(3), 263–287.

Dawson, K., Cavanaugh, C., & Ritzhaupt, A. (2008/2009). Florida's EETT leveraging laptops initiative and its impact on teaching practices. *Journal of Research on Technology in Education, 41*(2), 143–159.

Dunleavy, M., Dexter, S., & Heinecke, W. F. (2007). What added value does a 1:1 student to laptop ratio bring to technology-supported teaching and learning? *Journal of Computer Assisted Learning, 23*(5), 440–452. doi: 10.1111/j.1365-2729.2007.00227.x

Eisenhart, M., & De Haan, R. L. (2005). Doctoral preparation of scientifically based education researchers. *Educational Researcher, 34*(4), 3–13.

Engeström, Y. (1999). Activity theory and individual social transformation. In Y. Engeström, R. Miettinen, & R.-L. Punamaki. (Eds.), *Perspectives on activity theory* (pp.19–38). Cambridge: Cambridge University Press.

Freebody, P. (2003). *Qualitative research in education interaction and practice.* London: Sage Publications.

Garthwait, A., & Weller, H. (2005). A year in the life: Two seventh grade teachers implement one-to-one computing. *Journal of Research on Technology in Education, 37*(4), 361–378.

Georgeson, J. (2006). *Using Sociocultural and Activity Theory in research in preschool settings.* Paper presented at the Summer School: Sociocultural and Activity Theory research; studying individuals in institutional settings, 18 July 2006, University of Bath. Received in private correspondence on 3 April, 2008.

Gulek, J., & Demirtas, H. (2005). Learning with technology:The impact of laptop use on student achievement. *The Journal of Technology, Learning, and Assessment, 3*(2), 4–32. Retrieved from http://escholarship.bc.edu/jtla/vol3/2/

Hill, J., & Reeves, T. (2002). *The impact of portable technologies on teaching and learning: Year three report.* Retrieved from http://lpsl.coe.uga.edu/Projects/AAlaptop/pdf/EvalPropoal.pdf

Larkin, K., & Finger, G. (2011). Informing one-to-one computing in primary schools: Student use of netbooks. *Australasian Journal of Educational Technology, 27*(3), 514–530.

Latheef, I., & Romeo, G. (2010). *Using Cultural Historical Activity Theory to investigate interactive whiteboards.* Paper presented at the ACEC 2010: Digital Diversity Conference, 6–9 April, 2010. Melbourne, Australia. Retrieved from http://acec2010.info/proposal/838/using-cultural-historical-activity-theory-framework-investigate-interactive-whiteboards

Lei, J., & Zhao, Y. (2008). One-to-one computing: What does it bring to schools? *Journal of Educational Computing Research, 39*(2), 97–122.

Liang, J.-K., Liu, T.-C., Wang, H.-Y., Chang, B., Deng, Y.-C., Yang, J.-C., et al. (2005). A few design perspectives on one-on-one digital classroom environment. *Journal of Computer Assisted Learning, 21*, 181–189.

Lloyd, M., & Cronin, R. (2002). *A community of teachers: Using Activity Theory to investigate the implementation of ICTE in a remote Indigenous school.* Paper presented at the AARE, 1–5 December, 2002, Brisbane, Queensland. Retrieved from http://eprints.qut.edu.au/3572/

Maxwell, J. A. (2004). Causal explanation, qualitative research, and scientific inquiry in education. *Educational Researcher, 33*(2), 3–12.

Mouza, C. (2008). Learning with laptops: Implementation and outcomes in an urban, underprivileged schools. *Journal of Research on Technology in Education, 40*(4), 447–473.

Norris, C., Sullivan, T., Poirot, J., & Soloway, E. (2003). No access, no use, no impact: Snapshot surveys of educational technology in K–12. *Journal of Research on Technology in Education, 36*(1), 15–27.

Penuel, W. R., Tatar, D. G., & Roschelle, J. (2004). The role of research on contexts of teaching practice in informing the design of handheld learning technologies. *Journal of Educational Computing Research, 30*(4), 353–370.

Pietsch, J. R. (2005). *Collaborative learning in mathematics.* (Unpublished doctoral dissertation). Sydney, Australia: University of Sydney.

Ricci, C. (1999). Program evaluation: *The New York City Board of Education Community School District Six laptop project.* Paper presentation conducted as part of the Tools and Transformations: The Community School District Six Laptop Project and Its Impact on Teachers and Students symposium at American Educational Research Association (AERA), Montréal, Canada, 19–23 April. Retrieved from http://www.notesys.com/Copies/aeralptp.pdf

Rockman, S. (2003). Learning from laptops. *Threshold, 1*(1), 24–28. Retrieved from http://www.rockman.com/publications/articles/LearningFromLaptops.pdf

Romeo, G., & Walker, I. (2002). Activity theory to investigate the implementation of ICTE. *Education and Information Technologies, 7*(4), 323–332.

Russell, M., Bebell, D., & Higgins, J. (2004). Laptop learning: A comparison of teaching and learning in upper elementary classrooms equipped with shared carts of laptops and permanent 1:1 laptops. *Journal of Educational Computing Research, 30*(4), 313–330.

Selwyn, N., Potter, J., & Cranmer, S. (2009). Primary pupils' use of information and communication technologies at school and home. *British Journal of Educational Technology, 40*(5), 919–932. Retrieved from http://www.wiley.com/bw/journal.asp

Stevenson, K. (1998). *Evaluation report, year 2: Schoolbook laptop project.* Beaufort, SC: Beaufort County School District. Retrieved from http://www.beaufort.k12.sc.us/district/ltopeval.html

Suhr, K. A., Hernandez, D. A., Grimes, D., & Warschauer, M. (2010). Laptops and fourth-grade literacy: Assisting the jump over the fourth-grade slump. *Journal of Technology, Learning and Assessment, 9*(5), 4–45.

Swan, K., van t'Hooft, M., Kratcoski, A., & Schenker, J. (2007). Ubiquitous computing and changing pedagogical possibilities: Representations, conceptualizations and uses of knowledge. *Journal of Educational Computing Research, 36*(4), 481–515.

Swan, K., van t'Hooft, M., Kratcoski, A., & Unger, D. (2005). Uses and effects of mobile computing devices in K–8 classrooms. *Journal of Research on Technology in Education, 38*(1), 99–112.

Sweeney, T. (2010). *Quality teaching and interactive whiteboards: Using Activity Theory to improve practice.* Paper presented at the ACEC 2010: Digital Diversity Conference, 6–9 April, 2010. Melbourne, Australia. Retrieved from http://acec2010.info/proposal/262/investigating-effective-use-iwbs-support-teaching-and-learning-across-curriculum

Thompson, J. (2005). *Cooperative learning in computer-supported classes.* (Doctoral dissertation.) Retrieved from Australasian Digital Theses Program. NBD 245188

Young, K. (2005). *Young, competent Internet users: A theory-based profile.* (Unpublished doctoral dissertation) Sydney, Australia: Sydney University of Technology.

Zevenbergen, R., & Lerman, S. (2007). Pedagogy and interactive whiteboards: Using an activity theory approach to understand tensions in practice. *Mathematics: Essential Research, Essential Practice, 2*, 853–862.

Zucker, A. (2004). Developing a research agenda for ubiquitous computing in schools. *Journal of Educational Computing Research, 30*(4), 371–386.

Zucker, A., & Hug, S. (2008). Teaching and learning physics in a 1:1 laptop school. *Journal of Science Education Technology, 17*, 586–594. Retrieved from http://www.springerlink.com.libraryproxy.griffith.edu.au/content/f8547370074470j5/fulltext.pdf