One-to-one laptop programs: Is transformation occurring in mathematics teaching?

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There is a body of research around the uptake of digital technologies in secondary schools, and a growing body of research specifically designed to investigate the use of one-to-one laptop programs. However this research focused on the initial uptake of the digital technology or initial implementation of a one-to-one (1:1) laptop policy. Given the expenditure of time and money associated with 1:1 laptop initiatives, investigation needs to be carried out to determine if the commitment has been worthwhile. This new study contributes to this body of research as it focused upon middle schools in which the 1:1 laptop program has existed for over seven years; it sought to examine the evolution of teacher practice in mathematics education. Anonymous online surveys as well as semi-structured interviews with teachers were used to collect descriptive data. The data revealed that issues associated with the initial implementation of 1:1 laptop programs continued to be problematic, and little authentic integration of the technology had taken place in the pedagogical practices of the mathematics teachers.

Introduction

Educational reforms in Australia in recent times have continually advocated the integration of information and communications technology (ICT) into schools. The Australian Government promoted a "digital education revolution" in 2007 and launched a process by which access to digital technology for every secondary school student would be enabled by funding purchases of personal computers or laptops by schools. The aspiration was to better-situate high school graduates to be academically competitive in a global sense (Australian Government, 2013). The Melbourne Declaration on the Educational Goals for Young Australians reflected the "digital revolution" notion by emphasising the need for school students to be proficient users of technology, along with the knowledge and confidence to utilise technology in all aspects of their lives (MCEETYA, 2008). Despite all good intentions, an inconsistent distribution and uptake of ICT into schools has occurred. The decision to participate in ICT integration, to what degree, aligned with what time frame, and with what specific hardware may have been made by governments, systems, schools, principals, parents, teachers or the wider community. The number of stakeholders involved in these programs may indeed be an underlying factor in the success of these programs.

Integration of ICT into schools involves incorporating these technologies into administrative tasks, assessments, communicative processes, and pedagogy to enhance teaching and learning (Jude, Kajura & Birevu, 2014). The integration of technology into pedagogical practice may be categorised in three ways (Hughes, 2005) namely replacement, amplification, or transformation. Replacement refers to the use of technology as a modern take on a traditional practice, such as displaying a *PowerPoint* slide instead of manually writing on the board. Amplification refers to utilising the technology to enhance an unchanged task, for example, creating a spreadsheet to calculate averages. In order for technology to be truly integrated, transformation needs to occur. This involves using the technology in its capacity to innovatively enhance student learning. Definitions and beliefs on what comprises "integration" of laptops into student learning differ, though most tend to indicate that it does involve using the laptops in student learning. Discrepancies in the understanding of, and consensus about, the characteristics of integration may result in teachers having unrealistic perceptions of their practice.

Education systems, public sectors, parents and students themselves are demanding accountability from schools for student learning and progression, and for the development of skills to support and enhance the future life of students. Student academic achievement is becoming more transparent and public, which in many cases has increased the competition between schools. As a result of these influencing factors, schools need to be utilising all available resources to demonstrably enhance student learning, engagement, and achievement at an individual student level. Many schools have adopted one-to-one (1:1) laptop programs as a strategy to integrate ICT in a highly visible fashion (Inan & Lowther, 2010). In his research synthesis Penuel (2006) identified three characteristics common to global 1:1 laptop initiatives: (1) student access to laptops that are loaded with contemporary productivity software (e.g. word processing and spreadsheet tools), (2) wireless access to the Internet, and (3) use of the laptops for academic tasks such as assignments, tests, and presentations. The number of schools electing to participate in 1:1 laptop initiatives has expanded significantly over the last decade. This is due to a number of factors: less expensive and more reliable hardware, improved Internet connectivity, and promotion by governments and education authorities. Some secondary school administrations decided to implement a 1:1 laptop policy throughout Year levels 9 to 12, supplementing the Australian Government's funding with school-generated funds. A number of elite, independent schools placed the onus for the provision of these laptops squarely on the shoulders of the parents, in many cases across year levels beyond those supported by Federal funding.

The integration of ICT into schools offers opportunities for teachers to employ innovative instructional platforms and applications. The use of ICT has been reported to increase academic achievement (Cheema & Zhang, 2013), increase engagement (Crooke, Harrison, Farrington-Flint, Tomas & Underwood, 2010) and enhance cognitive processes (Lim & Khine, 2006) of students. Students can develop and refine skills and knowledge that can be linked to future professions, ways of working, and personal use (Crooke et al., 2010). Whilst integration of ICT into schools does provide many positive opportunities for student learning (Yuen, Law & Wong, 2003), there are issues about the changes required for this integration process to be "transformative". Transformative in this context indicates generative change to teaching practice based upon a belief that the change is beneficial. Factors impacting on this change include developing and modifying teachers' knowledge and pedagogical practices, providing or accessing time to source and master the ICT, and resourcing hardware and software. To be able to integrate ICT into schools successfully, changes may need to be made to pedagogy, knowledge, beliefs and culture (Ertmer & Ottenbreit-Leftwich, 2010).

In 2014, seven years after the initial implementation of the Digital Education Revolution, the anticipated digital education "evolution" has not resulted. Issues that were identified during implementation and the integration of digital devices in secondary schools are still evident, apparently having failed to be addressed. Despite the ICT resources available, the technology is not being used in an integrated manner to support and enhance student learning, particularly in mathematics. Adding to this is the substantial financial investment that has been made into technology use (hardware, software, Internet connections, power connections, security, and technical support) in classrooms by parents and school communities (Holcomb, 2009). In order for these laptops to be utilised in a truly integrated manner, teachers' pedagogical practices need to change; digital pedagogies need to be developed and made accessible. Whilst they are highly visible and their use can appear to be integrated, a field of open laptops may disguise how they are being utilised by students in classes.

Initial 1:1 laptop program issues

There is much research examining the initial implementation of 1:1 laptop programs in schools. These studies have been conducted in varying global locations due to wide-ranging adoption in countries such as the USA, Singapore, China, Taiwan, Canada, New Zealand, and the United Kingdom. The objectives of these programs are varied and include: preparing students for work forces of the future; increasing student achievement, ICT skills, and higher-order thinking; and improving the quality of teaching (Inan & Lowther, 2010). The rationale for the implementation of these programs is the increased global competition of the nations' economies (Penuel, 2006).

Research into the implementation of 1:1 laptop programs has reported significant positive influences on both student learning and teaching practices. Keengwe, Schnellert and Mills' (2011) study revealed a positive impact on student learning and engagement through the improvement of student motivation and autonomy. However the nature of this integration of laptops involved students watching videos, word processing, Internet searching, creating presentations, and managing their time and photos. Penuel (2006) synthesised findings from studies and reported improvements in student learning outcomes: proficiency with using technology, literacy and writing skills, motivation, collaboration, engagement, and participation. Students were more empowered in their learning and engaged in higher-order thinking when scaffolded in effectively managed classrooms (Lim & Khine, 2006). Student-centred learning increased with the implementation of 1:1 laptop programs; teachers who were generally more likely to integrate ICT into their practice held constructivist philosophies as opposed to teachers with more traditional teaching pedagogical beliefs (Sang, Valcke, Van Braak & Tondeur, 2009). Other indicators of successful laptop programs were: teacher readiness, targeted professional development, teacher attitudes and beliefs, and subject matter expertise. Mumtaz (2000) identified that in changing pedagogical practices to integrate ICT, teacher beliefs were the most important indicator of success. These beliefs were predominantly in regards to the content that should be taught and how it should be taught. Furthermore, teacher beliefs about what comprises "good teaching" mediate the integration of ICT into the classroom.

Despite the positive impact of 1:1 laptop programs, several negative aspects have also been identified. Teachers reported a need to employ different or adapted classroom behaviour management practices during integrated ICT learning episodes (Hew & Brush, 2006). Studies indicated that some teachers resorted to withdrawing laptop use from students when they were being inappropriately utilised, while others exploited laptop interaction as a form of reward. Critics of 1:1 laptop programs cite underuse, and minimal effects on the learning environment (Penuel, 2006). Teachers have expressed opinions that they can effectively "cover the curriculum" with direct instruction, and still meet accountability measures whilst taking less time to prepare lessons.

Barriers to effective ICT uptake and use during the initial implementation of the 1:1 laptop programs have been generally agreed upon. Even when a school is well resourced, barriers may be a result of teacher beliefs and attitudes, knowledge, and skill sets; past experiences; reluctance to change; affordances of time; and subject culture (Ertmer & Ottenbreit-Leftwich, 2010; Hennessy, Ruthven & Brindley, 2005; Hew & Brush, 2006; Lim & Khine, 2006; Pratt, Lai, Trewern, Concannon & Sutton, 2010). These are referred to as "first-order" and "second-order" barriers. First-order barriers are identified as obstacles over which the teacher does not generally have control, for example, insufficient resources and dedicated time required to plan ICT lessons. Second-order barriers are intrinsic obstacles in the teacher, for example, teacher beliefs about the value of ICT and their willingness to change. These barriers are often the more difficult to address as they can be deeply ingrained and teachers may not be aware they have them (Ertmer, 2005; Lim & Khine, 2006).

Assumptions have been made that 1:1 laptop programs will equate to an increase in student achievement (Hew & Brush, 2006). Lowther, Inan, Ross and Strahl (2012) conducted a study investigating the 1:1 laptop program Michigan's Freedom to Learn (FTL). This program aimed to improve student learning and prepare students for the 21st century, specifically by focussing on communication, creativity, collaboration, and critical thinking skills. The results from this study revealed that student achievement did not increase; however, students' 21st century skills and teacher confidence in integrating ICT improved. In other words, focussed ICT use led to better ICT use, rather than the hoped for improvement in academic achievement. Teachers who exhibited readiness and technical ability were more likely to integrate the laptop into their lesson preparation and execution. Students used the laptops mainly to create spreadsheets, access databases, and conduct information retrieval via Internet searches. In mathematics, laptop functionality was constrained to practising or testing mathematical skills and knowledge. Generally the process of integration of ICT into classrooms has been problematic (Lim & Khine, 2006). Studies initially reported the integration of ICT as occurring; however, as the research progresses and findings are critiqued, it becomes apparent that this is not the case (Ertmer & Ottenbreit-Leftwich, 2010).

Integration of 1:1 laptop programs in mathematics classrooms

Mumtaz (2000) undertook a review of literature and concluded that successful ICT integration, including an acceptance of digital pedagogies and a willingness to experiment, can be specific to a subject area of the curriculum. Wilkins (2008) conducted a study to investigate elementary teachers' attitudes towards mathematics, their depth and breadth of content knowledge, their beliefs about what mathematics is and how it should be taught, and their use of "inquiry instruction". Inquiry instruction is a pedagogical approach purported to support the integration of ICT into the classroom (Ertmer, 2005; Ertmer & Ottenbreit-Leftwich, 2010; Pratt et al., 2010). The results of the study detailed that content knowledge, beliefs, and attitudes were closely related to the instructional practices of the teachers. Teacher beliefs had the strongest effect on instruction practices; those who believed in the value of inquiry-based learning were more likely to utilise it in their mathematics instruction. Beliefs of teachers in relation to mathematics instruction were found to be based on personal experiences, observation of others teaching, teacher knowledge, and past successes or failures in mathematics learning. Teachers who had experienced personal success in mathematics learning often replicated the methods by which they were taught.

Mouza (2008) examined the implementation of a laptop program into a school in selected classes. Comparisons between the "laptop provided class" and the "non-laptop provided class" revealed that when teachers were well prepared in utilising the laptops, the students were more engaged. Teachers in all subject areas were more likely to instruct students to use the laptops for routine skills practice. Specifically relating to mathematics, teachers tended to use the laptop for chance and data applications, such as spreadsheets to enter and analyse data, and the production of graphs. Handal, Campbell, Cavanagh, Petocz and Kelly (2013) examined 280 secondary mathematics teachers' pedagogical practices and content knowledge whilst engaging in the integration of technology. Key findings from this research revealed high teacher capabilities in the use of productivity applications such as *PowerPoint* and *Excel*, and lower capabilities in digital assessments. The mathematics teachers' perceptions were that if the ICT would enhance student learning then it would be utilised. Rosen and Beck-Hill (2012) investigated mathematics achievement in constructivist 1:1 laptop program classes. Mathematics achievement results improved significantly for students engaged in the program. In addition, student absentee rates and behaviour management issues declined, and teacher differentiation of student learning increased.

The positive impacts of ICT integration on student learning are acknowledged and advocated in education. However, mathematics teachers have been reported as integrating laptops the least in comparison to other subject areas (Silvernail & Lane, 2004). When ICT is utilised, it is more frequently for online practice and drills of mathematical skills and procedures (Cavanagh & Mitchelmore, 2011), and teachers' decisions to utilise geometry software in their classroom practice was based on their perception of its usefulness (Stols & Kriek, 2011). Hsu, Wu and Hwang (2007) conducted a study of more than 600 mathematics and science teachers in Taiwan to investigate the integration of ICT into these subject areas. The findings were that a key predictor of the quality of ICT use in mathematics was the teacher's perception of how the ICT would enhance student learning outcomes. It was also noted that whilst many teachers were apparently utilising ICT, few were actually integrating ICT into their lessons as a learning technology. This highlights the point that there still seems to be lack of consensus in what "integration" actually means. Integration practices are often enacted in a trial and error process or experimentation (Stols & Kriek, 2011), with classroom experiences of success or failure impacting teacher integration practices more than specific professional development (Tondeur, Kershaw, Vanderlinde & van Braak, 2013).

Issues over time in 1:1 laptop programs

Although ICT is being used increasingly in classrooms (Tondeur, Cooper & Newhouse, 2010), the amount of research conducted has not matched the spread of this use (Penuel, 2006). Considerably fewer studies have been conducted to identify outcomes of 1:1 laptop programs over time. From the literature that is available, it appears that there are many findings from the initial implementation phase that remain unresolved.

Kopcha's (2012) study of integration of ICT, over a period of two years in 18 schools, revealed that over time teachers' integration practices, collaboration with colleagues, and beliefs about the value of ICT improved with engagement in targeted professional development. However, criticisms were noted regarding the amount of money spent in order to procure and maintain the technology, and the ICT not being utilised to its full potential, with much of the use being non-instructional tasks, such as administration and communication. The initial implementation issue of time to explore and practise with the technology remained, even with the targeted professional development. Howard, Chan and Caputi (2014) examined secondary subject teachers' integration of technology over three years. Findings revealed that teacher readiness was linked to time and subject areas, and beliefs were linked to subject areas. Mathematics teachers' mean scores for integration of technology, teacher readiness, and teacher beliefs pertaining to the usefulness of technology to support learning, and confidence were the lowest in comparison to science and English teachers across all year levels. Mathematics teachers' beliefs over the three years did not change.

Research specifically investigating whether the laptop is the most appropriate hardware for student learning in mathematics requires more investigation. Generally there appears to be initial enthusiasm for the adoption of laptops that is soon tempered by teachers adhering to conservative pedagogical approaches to integrating the laptops into student learning (Stols & Kriek, 2011). This conservative or traditional pedagogy resulted in the laptops being utilised as add-ons rather than integrated, or indeed not being used at all (Holcomb, 2009).

Research objectives and questions

The rationale for adopting digital pedagogical approaches in the integration of ICT into student learning appears clear, and it has been shown that teachers' ICT use and general abilities have increased (Ertmer & Ottenbreit-Leftwich, 2010). However, even in schools with high levels of support and resourcing, the integration of ICT is as add-ons in lessons to support traditional pedagogies (Mouza, 2008). This small-scale project sought to investigate the uptake of this specific technology in the teaching of mathematics.
The objectives of this research were to:

- Investigate the nature of the utilisation of Apple Macintosh laptops in mathematics classrooms across the middle years (i.e., Years 6 to 9), and
- Develop and trial an audit tool to ascertain the use of laptops in 1:1 laptop program schools in mathematics classes in the middle years.

To this end the research questions were:

1. What is the nature and frequency of laptop use in mathematics classes in Years 6 to 9?
2. In what ways has the 1:1 laptop program enhanced teaching and learning in mathematics classes in Years 6 to 9?

A focus of this project was on each teacher's beliefs about teaching and learning, and examining whether there was a connection between teaching experience, attitudes to the 1:1 laptop program, and the nature and frequency of the teachers' use of the laptops in their daily teaching of mathematics.

Methods

Research method

The research was undertaken using a qualitative approach within the parameters of a case study conducted at each school site. Two Western Australian independent schools were selected using prior knowledge of one of the researchers about the extent and duration of their 1:1 laptop programs. Both schools had had a 1:1 laptop program in place for more than seven years, and were financially very able to provide high quality technical support. In each case, the parents were responsible for the purchase of the laptops.

The purposefully selected participants were the current teachers of mathematics in year levels 6 to 9; they were approached through email to undertake an anonymous online questionnaire and also to indicate their willingness to volunteer for the semi-structured interviews. In total, 16 teachers (11 female and five male) completed the questionnaire and six teachers (three from each school site) volunteered to be interviewed. The data was collected over a one-month period in 2014. The participants' school sites operated on a ten-day cyclic timetable (teaching cycle). Six one-hour mathematics classes are timetabled within each teaching cycle. One participant had been teaching between five and 10 years, nine participants for 10 to 20 years, and six participants for more than 20 years. As there had been some sensitivity in regards to the successful integration of the laptops in both schools, the researchers decided to frame the interview and survey questions from a student-use perspective rather than directly inquiring about the teacher use.

Data instruments

Qualtrics was used as the online questionnaire tool. The questionnaire sought to collect data in regards to: (1) the participants' self-reported reflections on student use of the laptops in their classes, and (2) the participants' self-reported reflections on the affordances made by the laptops in terms of ease in performing their professional tasks. The questionnaire commenced with four demographic questions, followed by a general question about the integration of laptop use in their teaching practice. The major section of the questionnaire consisted of 41 statements to which the participants could indicate a frequency rating of frequently, often, sometimes, seldom, or never. "Frequently" was defined as five or more times per teaching cycle; "Often" as about four times per cycle; and "Sometimes" as once or twice per cycle.

The statements were categorised as: productivity activities, education-specific activities, communication activities, and creation activities thereby describing their use and output. The categories and statements were similar to those used by Handal et al. (2013) in their study, and were adapted to reflect the capabilities of the Apple Mac environment within a context of a 1:1 laptop program. The final nine statements were prefaced with, "The 1:1 laptop program has made it easier for me to …" to which the participants could indicate their agreement based on a 5-point Likert scale ranging from strongly agree to strongly disagree. The researchers, based upon their knowledge of the two school sites and staff, composed the additional statements.

The semi-structured interview consisted of six primary questions that were framed by the researchers to elicit more detail in regards to the participants' experiences with the laptop program. Each interview lasted for approximately 30 minutes and was audio-recorded. One researcher conducted all of the interviews to ensure a consistent approach, and the transcripts were completed by both researchers and cross-checked for accuracy.

Data analysis

The questionnaire data were analysed in single fields (e.g., productivity activities) and selected cross-tabulations (e.g., Do you think you have integrated laptop use into your mathematics teaching practice in Years 6–9 productivity activities) in order to answer the research questions. Furthermore, the frequency options of frequently, often and sometimes were merged into one data set (henceforth referred to as FOS) and the options of seldom and never were merged into the other data set (henceforth referred to as SN). The first data set indicated a positive response, while the second indicated a negative response. The audio recordings of the interviews were transcribed verbatim, and analysed for themes independently by each researcher and then together to reach consensus.

Findings

Online questionnaire

Preliminary question 5 (Do you consider that you have integrated laptop use into your mathematics teaching practice in Years 6–9?) was responded to with 50% of participants indicating "definitely" and 50% indicating "partially". In regards to the productivity activities (statements 1 to 7) for which students use their laptops, the SN options ranged from 62.5% to 93.75% and were noticeably higher than the positive responses. Table 1 shows the cross-tabulation of these two fields, with the SN options highlighted for each productivity activity.

Table 1: Cross-tabulation 1 (n = 16)
FOS = Frequently, Often and Sometimes; SN = Seldom and Never

Productivity activities		Do you consider that you have integrated laptop use into your mathematics teaching practice in Years 6-9?		
		Definitely	Partially	Total
1. Word processing	FOS	25%	12.5%	37.5%
	SN	25%	37.5%	62.5%
2. Construct graphs and charts	FOS	18.75%	0.06%	18.81%
	SN	31.25%	43.75%	75%
3. Construct spreadsheets	FOS	0.06%	0%	0.06%
	SN	43.75%	50%	93.75%
4. Create presentations	FOS	18.75%	0%	18.75%
	SN	31.25%	50%	81.25%
5. Create concept maps	FOS	12.5%	0.0625%	12.63%
	SN	37.5%	43.75%	81.25%
6. Draw diagrams	FOS	12.5%	0.06%	12.56%
	SN	37.5%	43.75%	81.25%
7. Desktop publications	FOS	18.75%	0%	18.75%
	SN	31.25%	50%	81.25%

In regards to section 7 (education-specific activities) of the questionnaire, several response sets were strongly positive (FOS 75% or greater), others were strongly negative (SN 75% or greater), while a few were distributed approximately equally between. Strongly positive responses were generated for: *Students in my class use their laptops to… access their textbook, do their homework, engage in content that has been specifically adapted for them, access videos/movies, access assessment results, catch up on missed work,* and *access feedback from the teacher on assessment items.* Table 2 summarises the results using frequencies.

Table 2: Responses for activities 8, 10, 11, 19, 27, 28 and 29 (n = 16)

Education-specific activities	Frequently	Often	Sometimes
8. Access their textbook	12	0	1
10. Do their homework	9	3	3
11. Engage in content that has been specifically adapted for them	5	3	6
19. Access videos/movies	5	5	3
27. Access assessment results	3	2	9
28. Catch up on missed work	1	2	11
29. Access feedback from the teacher on assessment items	1	1	10

Strongly negative responses were recorded for: *Students in my class use their laptops to… use graphics calculator emulators, engage with subject-specific apps, access podcasts/vodcasts, access YouTube, complete assessment tasks*, and *submit assessment tasks*. Table 3 shows the frequencies for these activities.

Table 3: Responses for activities 14, 18, 21, 22, 25 and 26 (n = 16)

Education-specific activities	Seldom	Never
14. Use graphics calculator emulators	7	7
18. Engage with subject-specific apps	4	8
21. Access podcasts/vodcasts	4	8
22. Access *YouTube*	8	4
25. Complete assessment tasks	6	9
26. Submit assessment tasks	4	11

The remaining statements were approximately evenly spread between the FOS and SN responses. These statements were: *Students in my class use their laptops to complete worksheets, investigate simulations, perform calculations, engage in interactive websites, gain information from websites, engage with subject-specific software, access animations, practise assessment tasks, practise NAPLAN items*, and *reflect on their learning.*

The questionnaire data from Section 8 (Communication activities) resulted in quite polarised scores, as indicated in Table 4.

Table 4: Responses for activities 31 to 38 (n = 16)

Communication activities	Frequently, Often and Sometimes	Seldom and Never
31. Access emails	14	2
32. Participate in blogs	0	16
33. Post wikis	0	16
34. Participate in online discussion	0	16
35. Engage with webquests	0	16
36. Access interactive whiteboard notes/workings	1	15
37. Access school intranet	14	2
38. Participate in online collaborative learning	3	13

The final category, Section 9 Creation activities, recorded one response in *Frequently* for all three statements (*Students in my class use their laptops to … create videos/movies, create animations, and create podcasts/vodcasts*), with all other responses resided in *seldom* and *never*.

The final section of the questionnaire, Section 11, had the statement stem of *The 1:1 laptop program has made it easier for me to …* in relation to nine activities that were considered by the researchers to be expected practice amongst teachers of middle years mathematics. Table 5 summarises the data as frequencies over the whole range of options.

Table 5: Responses for Section 11 (n = 16)
SA = strongly agree, A = agree, N = neither, D = disagree, SA = strongly disagree

The 1:1 laptop program has made it easier for me to ….	SA	A	N	D	SD
1. present lessons	5	6	5	0	0
2. cater for the specific needs of students	4	8	3	1	0
3. link mathematics to other curriculum areas	2	3	9	2	0
4. present mathematical concepts in different forms	3	8	5	0	0
5. provide feedback to students on assessment tasks	10	3	2	1	0
6. disseminate handouts and worksheets	7	8	1	0	0
7. scaffold collaborative learning	2	3	8	2	1
8. encourage students to be organised	5	4	5	1	1
9. support and monitor students in their use of e-portfolios	1	0	11	2	2

The combined positive responses (strongly agree plus agree) indicate that the tasks that have been facilitated by having the 1:1 laptop program are: the presentation of lessons, catering for the specific needs of students, presenting mathematical concepts in different forms, providing feedback to students on assessment tasks, and disseminating handouts and worksheets. Of note are the three activities that scored highly in the neither agree nor disagree category: link mathematics to other curriculum areas, scaffold collaborative learning, and support and monitor students in their use of e-portfolios.

Interviews

A number of themes emerged from the analysis of the interview transcripts. These have been categorised as: positive aspects of laptop use, unresolved issues with laptop use, and defense of the traditional paradigm of middle years mathematics teaching and learning. Table 6 summarises the positive aspects of laptop use and provides some quotes from the interviews.

There was greater consensus amongst the interviewees in terms of the unresolved issues of laptop use. The two key issues were time and professional development. All interviewees commented on the lack of time for them to peruse websites in order to source appropriate mathematical resources and to practise using applications:

Table 6: Positive aspects of laptop use as indicated in the interviews

Aspect	Quotations
1. Access to textbook	We have our kids using the textbook on their laptop, so that's one thing that they have quick access to which also has links to videos and examples ... it allows them to take them wherever they go. [Participant 1A-1] Every day the textbook is accessed and I often project things onto the screen. [Participant 1A-2]
2. Homework	The homework aspect is the thing I use it most for. [Participant 1B-2] I use it for the Study Ladder program …. We have that for homework. [Participant 1B-1]
3. Communication	… what's new is the communication about assessment (feedback) through the online marks book. [Participant 1A-1] They use email … they email questions about homework. We have instant messaging as well on our Connect site. [Participant 1B-1]
4. Videos/movies	I use motivational videos to help connect the maths to real life applications. [Participant 1A-1] I use videos quite often of teachers who have done some worked examples that the students can go back to and watch over and over if they haven't understood a concept. [Participant 1A-1] It's the movies that we use the majority of the technology for. [Participant 1A-3] I have really tailored my teaching for everything to do with using this video recording device [AverVision 3P300] and the laptop. [Participant 1A-3]

> I need time to have a go and to search and to practise. I need time to go away and use it and get comfortable before I use it with the class [Participant 1A-2].

> There's got to be time to prepare ... And then ongoing time to continue to refine, research more ... There's got to be time associated for it to work properly [Participant 1A-1].

Further to the comments made on "time" were those associated with the expenditure of time in relation to the perceived benefits in student learning, and the actual wasting of time resulting from accessing the textbook on the laptop rather than opening a physical textbook. The issue of "time" also segued into reflections on the necessity for a curation of websites:

> I'm so busy doing everything else that I don't have the time to research what's out there. But if someone put it on my desk and said you have to go to it then I would go. [Participant 1A-2].

> Well there's so much out there in terms of stuff on the Internet … so if you said we could do this, this and this; then I would say "Yeah!" – A sounds great; B we don't need; C is good … that sort of thing. [Participant 1B-1].

The interviewees all revealed that they had had cursory professional development in regards to the operation of the laptop and the Apple Macintosh environment. However, none of them had participated in any structured professional development about the use of the technology to enhance teaching and learning. All of the interviewees stated that they learned how to do things with the laptop through informal collaboration with colleagues and their own trial-and-error approach.

The third theme that was identified from the interview transcripts (defense of the traditional paradigm of middle years mathematics teaching and learning) was gleaned from the statements in Table 7.

Table 7: Identifying third theme, defense of the traditional paradigm

Statement 1: (in response to the provision of electronic feedback to students)	No, it's written on their work … I'm a bit old school that way. I just find that it's too removed from the actual work and they need to see what my feedback is in relation to the actual question or what they've written… so reading it on the screen wouldn't make sense [Participant 1B-1]. I still put most of my feedback from assessments on the paper [Participant 1B-3].
Statement 2: (in response to the ways in which the laptop policy enhances student learning in mathematics)	The answers to the textbook are all done on pen and paper. I always make them do that. I think everyone here does that [Participant 1A-2]. The students mostly work out of a maths book with pencil and paper. It's still really important and we use it a lot [Participant 1B-3]. I want to be sure that it's improving the outcomes for the students and not impacting on the amount of time it takes to get through content [Participant 1A-1]. It's the setting out and it's not used in assessments and we are very driven by what's in the final product or WACE assessments or NAPLAN assessments, and they are not going to be using word processing in their final assessments [Participant 1A-3]. At the end of the day what we are trying to do is prepare them for examinations which are all still pencil and paper we are very much still encouraging proper setting out using pencil and paper [Participant 1A-1].
Statement 3: (in response to describing how they would typically use the laptop in their classes)	Drills and things like that… they are more likely to sit for longer and do them…. if we've finished with an activity they might have 5-10 minutes on them (the laptops) [Participant 1B-1]. Doing research, collecting data, then representing data, … things for homework [Participant 1A-1]. They have the notes in front of them so at the same time they are filling in the examples. They (the notes) are on paper; we do not do worked solutions on the laptop [Participant 1A-3]. I don't always need the (laptop) resources or need to rely on the resources as I am confident enough to stand in front of a class and teach what I need to and do it well [Participant 1B-2]. The students mostly work out of a maths book with pencil and paper. It's still really important and we use it a lot [Participant 1B-3]. They've done something concrete (in regards to Pythagoras' Theorem), then they've done something with the rule, abstract, and then they've done something visual with the video, then it's been really helpful [Participant 1A-2].
Statement 4: (in response to recommendations to other schools considering a 1-1 laptop policy)	The hands-on activities that I do in class with the students I think far outweigh anything I have seen on a screen or activities on the laptop, this is with all students and all abilities [Participant 1B-2].

Discussion

All of the participants demonstrated that they were operating in the replacement or amplification stages of integration (Hughes, 2005). First and second order integration barriers were identified, and the reluctance to experiment with ICT in the classroom was prevalent across both school sites. This reluctance stemmed from the teachers' perceived need for high levels of accountability to the students, the mathematics department, the school, and the parents. This was combined with a certainty that traditional methods of teaching mathematics work in teaching a concept; frequently with more success than using ICT. Underlying these perceptions was a drive to give the students the best education in mathematics that they could; however this translated itself into success in exams and external assessments, such as NAPLAN.

In regards to the first research question, "What is the nature and frequency of laptop use in mathematics classes in Years 6 to 9?", the following conclusions can be drawn based upon the questionnaire and interview data. The frequency of laptop use, for both the teachers and the students, was high, with the majority of teachers indicating use in every mathematics lesson. This phenomenon may be as a direct result of the leadership team at each of the school sites requiring staff to utilise the learning management systems (such as Student Connect) that have been established on the intranets. It appears that these requirements incorporate: submission of student grades, provision of assessment feedback, uploading of lesson and unit overviews, and as a repository for homework. Communication with students and parents is also conducted using the schools' email and instant messaging facilities. Therefore in regards to "frequency of use", the teachers are all required to fulfil a base quota of application.

The interview and questionnaire data further revealed three specific student uses of the laptops in the classes that are outside of these obligatory applications and have a high frequency of use. These are: (1) accessing the textbook, (2) viewing staff-made videos of instruction, and (3) viewing videos of real life applications of mathematics. Of these, the access to the textbook raised some interesting perspectives from teacher participants: "Now that the textbooks are on the laptops there is no choice, it has to be done" [Participant 1A-1]. Despite the high frequency of textbook access, participants disclosed unresolved issues with this application of the laptops:

> There are some students that have visual problems that need all their work blown up larger, different coloured paper that sort of thing so the laptop is just not appropriate for them at all … students struggle to manoeuvre around the electronic textbook more than they would if they had to turn the page in a book [Participant 1A-1].

The instructional video clips made by the teacher participants at one of the school sites used AverVision 3P300. It is a digital device that records the teacher's hand writing with pen on paper, with an audio recording of the teacher's explanation. The resulting video is uploaded onto the school's intranet for student and parent access. The rationale for this process is so that students can view particular clips whenever they need to review or revise procedures that have been recorded. Interestingly, two potential problems have arisen from the use of these clips. Firstly, some of the teachers are using these instructional clips instead of real-time instruction, and secondly, it reinforces traditional practices rather than promotes innovative practices. In regards to the viewing of videos depicting real-life examples of mathematical applications, these were primarily used to introduce new topics; however, a potential problem is their over-use.

Participants reported the aspects of the laptop program that facilitated their teaching of mathematics (as presented in Table 5), scoring these highly: the presentation of lessons, catering for the specific needs of students, presenting mathematical concepts in different forms, providing feedback to students on assessment tasks, and disseminating handouts and worksheets. The interview data fleshed out the reasons for the high levels of agreement. The presentation of lessons was facilitated by the use of data projectors and multiple screens. Catering for the specific needs of students was explained through interviewees' comments that "less able" students could revisit the instructional videos as many times as necessary to grasp the concept, and "more able" students or those who had completed set tasks more quickly than others could move forward in the textbook or search the Internet for applications of the concept. The presentation of mathematical concepts in different forms actualised, across the board, as reference to the accessing of both types of video clips. Providing feedback to students on assessment tasks was a school assessment requirement, provided through the school's intranet. The uploading of student learning materials onto the intranet and the students printing off their own hard copies referred to the disseminating handouts and worksheets. It initially appears that there are high levels of integration but when examined, it becomes apparent that the stage of integration it resides in amplification and replacement (Hughes, 2005). Emerging transformative activities are occurring but these appear to be excessively repetitive, for example the use of the videos. Furthermore, the integration activities utilised most by the participants are those that have been classified as productivity and communication, and as Participant 1A-1 commented:

> In summary, the nature of laptop use … my feeling is it is used to do the same job as a whiteboard or a textbook.

The answer to the second research question, "In what ways has the 1:1 laptop program enhanced teaching and learning in mathematics classes in Years 6 to 9?", rests upon the understanding of the word "enhanced". The interviewees acknowledged the positive effects of access to the videos; however, as the following quotes illustrate, the laptop program in these schools has not had a great impact upon the teaching and learning of mathematics.

> The laptop is a great supplementary tool. I think the students would still learn the concepts without them but I think it helps the students through practice or a different angle. I think they are good but not irreplaceable. [Participant 1B-3]:

> Well I definitely think we integrate them into the classroom, whether we integrate them into their learning, I think we do to a limited amount … I'm not sure that what we do is necessarily enhancing their learning of mathematics any more than if we just did traditional you know sort of board work. [Participant 1A-1]:

Implications

This small-scale study, focusing on the extended use of a 1:1 laptop program, has revealed some key issues that have not been resolved from the initial implementation seven years ago. These are time, professional development, and traditional mathematics teaching practices. When the dollar figure is calculated for the purchase of the laptops, the on-going network maintenance and development, and access to software and sites such as *Mathletics*, the following questions must be asked: Are such programs value-adding students' mathematics learning? Has any real generative change occurred in the teaching practice of the teachers? What mechanisms can be put into place to assist with the curation and retrieval of digital resources that can enhance learning rather than sit as an add-on to traditional practice?

Although this study was small-scale, it did reveal some considerations for schools currently implementing such programs or planning to do so: (1) teachers need to be convinced that the time and energy that is required is warranted in terms of improved student outcomes; (2) merely supplying equipment coupled with expectations of use does not support change; and (3) identify and assimilate aspirational practice and digital pedagogies.

In conclusion, three final quotes from the interviewees that in part sums up their frustration with the program and genuine desire to do the best for their students:

> I think schools often think that it looks good to have a laptop program but they aren't really using the laptops particularly well. [Participant 1A-2]
>
> Putting a child in front of a screen doesn't necessarily mean they are going to learn. [Participant 1B-2]
>
> Personally, I think it would be great NOT to have them (laptops) because then you don't have to learn all the new stuff. [Participant 1B-1]

The successful integration of ICTs into classrooms involves more than consistently making it available for student use. Continual research is needed in this area as the mobility and functionality of digital technologies and devices continually change which then influences pedagogy.

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