Using ICTs to Support Numeracy Learning Across Diverse Settings

Robyn Zevenbergen
Griffith University
rzevenbergen@griffith.edu.au

Steve Lerman
London Southbank Univerisity
lermans@lsbu.ac.uk

In this paper we draw on data from a larger study where we have been exploring the ways in which teachers in diverse settings use ICTs (or not) to enhance students' numeracy learning. Drawing on the data from a survey implemented in 6 schools that were representative of considerable diversity within the Australian education system, we report the ways in which various programs are used, the levels of ICT usage across grade levels and teachers' levels of skill and confidence with the use of ICTs. We find that there are differences between our schools in these areas that may be constitutive of aspects of a digital divide in mathematical learning.

With the increasing availability of computer resources to the wider community, there is a growing recognition of the potential divide between those who have access to particular forms of technology and those who do not. This is not to assume that access is the only issue in theorising a digital divide, as there are many compounding variables including the type of access: the type of technology being used; the synergy between home and school use; the quality of the learning environments in both home and school; access to internet or not; the type of access; and the regularity of that access. This is further compounded in the context of school mathematics where there is wide held acknowledgement of the power of technologies to support numeracy learning. The question that is fundamental to this paper is how are such technologies being used in schools and the implications for success in mathematical learning.

Drawing on a notion of human capital, it is proposed that for schools to be effective in the uptake of ICTs to support numeracy learning, teachers need to be supported in their learning and engagement with ICTs. By building up the skills, strengths, knowledge and dispositions of teachers to use ICTs in innovative ways that break away from dominant models of mathematics pedagogy, new learning environments and potential for learning can be created. Clements (1994) argued that "What we as early childhood educators are presently doing most often with computers is what research and NAEYC guidelines say we should be doing least often" (p. 33). Clements claimed that technologies were being used in ways that were antithetical to quality practice and tended to reinforce models of pedagogy that were, in other contexts, abhorrent to the profession.

Rather than use them in the ways that align with current dominant practices, *vis a vis* algorithmic models of learning, ICTs create new learning potentials that will not be realised unless teachers have the capacity to engage with pedagogical reforms related to their implementation, particularly when issues of equity and access are considered. However, little is known about the uptake of ICTs in mathematics classrooms and how they are used to support numeracy learning. This paper explores the dispositions of teachers to use ICTs in mathematics teaching and learning, and the ways in which ICTs have been used in these classrooms. A particular focus will be developed in the paper that explores the potential differences across schools in relation to digital differences and the implications for equity.

Using Technology to Support Mathematics Learning

In this section, we discuss two key issues related to the use of technologies in mathematics. In the first section, we discuss various forms of technology and how they can be used to support mathematical learning. In the second section, we discuss the implications of the differential uptake and use of technologies in schools and beyond with particular reference to the digital divide.

Within the mathematics education research literature, there are many ways in which technologies have been documented so as to show their potential in enhancing learning. This has been from the early childhood years through to senior secondary years. For example, in the early years, the work of Yelland (2002) has been powerful in showing how young preschool students can use LOGO to develop and enhance many spatial and other mathematical concepts. This has been documented in other countries as well, particularly through the work of Clements (1990) In the senior years of schooling, the work of Goos et al. (2003) has impacted significantly on understandings of the power of hand held tools to enhance understandings of functions and graphing. However, the technologies need not always be high-end types. For example, the work of Groves (1995) with calculators showed the possibilities of number learning through the open-ended use of very available resources.

The computer environment has also been found to create new learning potential. In their study of secondary students working in pairs at a computer, Hoyles, Sutherland and Healy (1995) reported that the computer environment "provokes any cognitive conflict necessary for the individual conceptual development" (p.175). They found that when working in pairs and with tasks that were challenging, students engage in complex dialogue that enabled them to move forward in their development of conceptual understandings. Similarly, Clements (2002) claimed that there was a large increase in interactions when early childhood children were working in pairs at a computer than when playing with puzzles on the floor. He noted the amount and quality of interactions and found them to be substantially enhanced when students worked at computers — in pairs.

While there is an increasing use of technology in schools, Ertmer (2005) found that "using technology for numerous low-level tasks (word processing, Internet research) [was more common and that] higher level uses are still very much in the minority" (p.399). She concluded that there is "uninspired technology use is especially prevalent in urban schools" (p. 397).

Given the richness of the potential of computer technologies to enhance learning, both social and cognitive, the concern raised by Clements (1994) about the approaches used by teachers needs to be considered. Despite considerable public money being invested in computer technologies in education, systems are asking why there is not the uptake by teachers in terms of quantity of use as well as quality.

Technology and a Digital Divide

In this section, we consider the impact of digital technologies in both homes and schools and the potential for creating divisions between those who have access and those who do not. The digital divide can exist at many levels. For example, there is divide between urban and rural access where, in a study of Canadian access to computers, it was reported that 53% of rural households have access to the Internet, compared to 68% of urban households (Harding, 2002). Similarly, the access that was available in country areas can often be restricted in terms of broadband access thus limiting the functionality of the internet. In terms of access according to age, Downes, Arthur and Beecher (2001) cite figures from 1998 where “48% of Australian homes where the oldest child is in the age range 0-4 years have computers. This proportion increases to 54% for homes where the oldest child is in the age range 5-9 years, and 71% where the oldest child is in the age range 10-14 years” (p. 141). However having access to a computer does not mean ‘access’ in terms of potential for learning. As Angus, Synder and Sutherland-Smith (2003) argue from their study of home computer use, there are quite different ways of using such technologies which may or may not align with the practices of schools, thus creating differential opportunities for children of those families. Angus et al.’s study focused on the access of economically disadvantaged families and found that their access and use of the internet was not aligned with the practices of school, thus even though they had access, it was still disadvantaging them in terms of creating greater digital capital.

In studying the use of computers in schools, Downes, Arthur and Beecher (2001) claim that there is an increasing uptake of computers as students progress through school, that is there are fewer computers in the lower years with more in the upper years of primary. They also contend there are few, if any, in many birth to three settings. One could contend that this increasing uptake in classes as students progress through school may be misplaced in terms of addressing a digital divide. Students whose home environments are digitally impoverished may be better served by experiencing greater access to technologies in their early years of schooling where there is potential to add digital capital earlier in their years and thus bridge the divide early in their schooling instead of when the gap is much wider.

The Study: Using ICTs to Support Numeracy Learning

Over a period of three years we have been working with a range of schools, with a focus on the middle years of schooling. The schools were selected so that they represented the diversity of Australian communities including social status, geographical location, and sector status. Classrooms were also included that were both straight-age or multi-age. Schools from Queensland and Victoria were included. As the project evolved, some schools dropped out and others commenced. In this paper we are presenting the data from the initial schools that commenced the project. At the commencement of the project, schools were surveyed, with most teachers responding, on their computer usage, with a particular emphasis on how technologies were being used to support and enhance numeracy learning.

A survey was developed and piloted with a small group of teachers separate from the study. This was to ascertain the clarity of the questions and to seek feedback as to whether or not other information should be sought. The final survey was distributed to all teachers in the participating schools. The responses to some of the questions will be the focus of subsequent sections of this paper. They have been selected as they indicate the extend to which computers are being used in the project schools; how they are being used to support numeracy learning; and teachers’ backgrounds in relation to ICT use and implementation. These data are collated around the schools so that a sense of the differential use across the schools be observed. In terms of this project, this provided us with information that subsequently enabled us to make sense of classroom observations and other analysis we undertook. It also allowed us to consider the outcomes of the overall project.

Summary of the Overall Project

As a project that sought to identify the ways in which ICTs were being used in the classroom, and where the focus was on the teaching practices being adopted, we used a range of tools to explore the phenomenon. Of particular interest to us was classroom practice. As such, video data were collected as the teachers undertook lessons. Over a period of 2 years, with a total of 10 schools ultimately participating in the study, we had a data bank of less than 40 lessons. In some schools, no video data were collected, whereas in two schools, the majority of lessons were video-taped. At the conclusion of the study, we sought to identify the reasons for this paucity of data, despite considerable attempts throughout the project to collect such data. While the threat posed by data collection through video was identified by some teachers as a reason, they did not see it as problematic. What was identified as the most significant factor was that they rarely used ICTs in their mathematics teaching. Indeed, as a number of teachers indicated, had it not been for this project where they were compelled to use ICTs, they would not have otherwise used them.

The Schools

In this paper we draw on the data from 6 schools who were the original participants in the study. Pseudonyms have been used for the schools and all participants in line with ethics protocols.

Table One: Brief descriptions of the 6 Schools

School	Description
Banksia	Metro school, Low SES, outskirts of a major city, had been recognised nationally for it excellence in web-based learning
Snow Gum	Small, rural school located in a farming district; low to mid SES
Melaleuca Hills	Inner city, Low SES
Huon Pine	Remote, mining town, large proportion indigenous students
Bottlebrush Plains	Mid SES; high technology use, multi-age, urban
Ash Gums	Mid–high SES; independent; high technology use

The schools were identified to represent the diversity of schools (government, independent); social demographics; geographic location, and cultural diversity that is across the Australian school sector. We also sought to include schools that were high technology-use schools. In the case of Banksia, this was a school in a low SES setting but had a strong focus on technology. It was intended that such sampling would enable us to explore any potential interactions of these variables so that we may be able to identify potential characteristics of classrooms where teachers had been using technology to enhance student learning.

Using Technology in Schools: Data Analysis

In the following section, we draw on data from three questions in the survey and then discuss these in light of other data collected from the project.

Technology Usage to Support Numeracy learning

In Table Two, the results are school means and then the sample mean for the question

"What levels do you think students in your schools use ICTs for supporting and enhancing numeracy learning?" The rating schedule was 1= never; 2 = sometimes; 3= often, 4= very often.

Table Two: Grade usage of ICTs to support numeracy learning

School	Prep	1	2	3	4	5	6	7
Banksia	2	2.5	2.5	2.3	3	3.5	2.5	2.5
Snow Gum	1.9	1.9	1.9	1.9	2	2	2	2
Melaleuca Hills	2.2	2.2	2.5	2.3	2.7	2.7	2.3	2.3
Huon Pine	2.2	2.4	2.4	2.4	2.4	2.4	2.6	2.6
Bottlebrush Plains	2	2.3	2.2	2.3	2.3	2.5	2.5	2.5
Ash Gums	2.5	2.5	2.5	2.5	2.5	3.0	3.5	4.0
Sample mean	*1.9*	*2.2*	*2.2*	*2.3*	*2.5*	*2.5*	*2.5*	*2.6*

What can be observed from Table One is that there is an increasing use of ICTs to support numeracy learning as the students progress through the school years. This reinforces the claims made by Downes et al. (2001) cited earlier in the paper. However, what is interesting to note is the reported increase in ICT use in the middle years at Banksia where there is more reported use in these years than the upper years. This is the only school that violated the trend of increasing use as the students progressed through their schooling.

In terms of equity, what is alarming is the degree of usage of ICTs in the independent school in the upper years of schooling. Banksia and Bottlebrush Plains were included in the study because of their work with ICTS, however, they did not report the same used of ICTs in these years of schooling as did Ash Gums (the independent school). This suggests to us, that the Independent school may be creating opportunities for their learners which may be very different from that of the state schools, at least in the upper years of primary school. However, as we noted at the commencement of the paper, quantity of access may not necessarily equate with quality. While there are still differences in the reported amount of ICT use between Ash Gums and Bottlebrush, our observations suggest that both of these classrooms provided high quality learning opportunities in terms of the resources available to the students as well as the learning outcomes, albeit, these were very different in structure and organization. Ash Gums had opted for a withdrawal room where students undertook computer work in a very well supported technology laboratory whereas Bottlebrush Plains had opted for an integrated model with considerable access to computers.

As our study did not focus on the middle years of primary school (i.e. below grade 5), we are unable to comment on the learning environment of the middle years at Banksia. In the upper years, the students had access to both computing laboratory and in-class computers which were located at the rear of the room in a withdrawal room. We can only contend that such an approach may have been taken with the middle years. As such, we are unable to expand on the learning environment in the middle years and hence unable to clarify the learning of the middle years students despite the counter trend noted in the data.

Programs used to Support Numeracy Learning

This question asked teachers to rate how often they used particular programs to support numeracy learning. The same rating scale was used as for Table Two: 1 = never; 2 = sometimes; 3 = often; 4 = very often

Table Three: Types of programs used to support numeracy learning

School	Excel	CD games	Web based	Logo	Word	Email	Drawing tool
Banksia	1.5	2	2.7	1	2.7	2.5	2
Snow Gum	1.7	2.6	2.3	1.8	3.1	2.9	2.7
Melaleuca Hills	1.8	2.8	2.5	1.3	2.5	2.9	2.7
Huon Pine	2	2.4	2.8	2	3.2	2.4	2
Bottlebrush Plains	2.3	2.8	2.8	1.8	3	2.2	2.8
Ash Gums	2.3	2.7	2.7	2.0	2.7	2	2.7
Sample mean	*1.9*	*2.6*	*2.8*	*1.6*	*3*	*2.4*	*2.5*

Table Three suggests to us that commonly available resources may be a mainstay for teachers in that they are familiar with these and use them in their classrooms. We are unable to comment on the use of some of these tools (email, web-based, CD Games or Word) as we did not observe them. As part of the project, we did support the schools on the use of LOGO, drawing tools, excel and games. We were able to spend considerable time at Bottlebrush Plains and observe the teachers using LOGO; similarly with Snow Gum using drawing tools. What this table suggests to us is that there is little realisation of the power of tools such as spreadsheets or LOGO in middle school classrooms. Given the research that has been conducted with these tools in terms of their capacity to bring about rich mathematical understandings, what struck us was their minimal uptake in all schools in this study, regardless of the demographics of the schools.

Confidence Levels

Part of the capacity to use ICTs has been linked to confidence in using the tool and the disposition then to apply this to the approaches being used in the classroom. Teachers were asked to asses their own confidence levels as they currently feel them and then where they would like to be, similarly for their students. Our intention with this question was to ascertain whether there were some areas which may be more important for teachers than others. The numbers alone are their current confidence levels while the numbers in brackets are their preferred levels)

Table Four: Confidence levels with ICTs

School	T/ICT	S/ICT	T/ICT for numeracy	S/CIY for numeracy	T/ICT for literacy	S/.ICT for literacy
Banksia	3.3 (4)	2.7 (3.7)	2.3 (3.3)	2.3 (3.3)	3.3 (4)	3 (3.7)
Snow Gum	3 (3.6)	2.6 (3.5)	2.6 (3.6)	2.1 (3.5)	2.8 (3.6)	2.5 (3.5)
Melaleuca Hills	3 (3.8)	3 (3.2)	2.8 (3.2)	2.8 (3.5)	2.8 (3.5)	3 (3.3)
Huon Pine	3.4 (4)	2.6 (3.7)	3.2 (4)	2.9 (3.8)	3 (4)	2.9 (3.8)
Bottlebrush Plains	3.2 (3.8)	3.1 (3.9)	2.9 (3.8)	2.9 (3.8)	3.3 (3.8)	3.1 (3.9)
Ash Gums	3.7 (4)	3.7 (3.3)	3.3 (3.7)	3 (3.3)	3.5 (3.5)	3.2 (3.3)
Sample mean	*3.2 (3.8)*	*2.9 (3.6)*	*2.9 (3.8)*	*2.6 (3.6)*	*3.1 (3.8)*	*2.8 (3.6)*

With this question teachers used a scale of 1 = very low; 2 = low; 3 = reasonable; 4 = high.

The results from this question posed a conundrum for us in that the literature often portrays younger generations as being the techno-savvy generation, and their older peers as more likely to be technophobes. The responses here show a counter position being taken by the teachers. In every case, teachers rank their confidence with technology as being higher than their students — whether for general ICT usage or specifically targeted at numeracy or literacy. Similarly, there are no differences between schools. These ratings are in stark contrast to the data we collected in the subsequent interactions with the participating teachers. In the case of Bottlebrush Plains, for example, the teachers would allow the students to manipulate the technology

It appears from these data that teachers were more confident in using ICTs in supporting literary than in supporting numeracy with teachers and students at the Independent School being more confident in all areas than their peers in the government schools. When this is compared with the data in Table

Skill Levels

In this question, we sought to identify how teachers rated their skill levels, again using current and preferred levels. With this question we were seeking to see how teachers rated their skill levels and where they would like to see improvement, or whether they felt that they had sufficient skill in that particular area.

Table Five: Teachers' skill levels on various programs

School	Internet	Excel	Logo	Word	Drawing	Games Edl
Banksia	3.3 (3.3)	2.7 (3.3)	2 (3.3)	3.7 (3.7)	3 (3.3)	3.3 (3.3)
Snow Gum	2.9 (3.5)	1.6 (3.2)	1.4 (3.2)	3.3 (3.7)	2.2 (3.4)	2.8 (3.5)
Melaleuca Hills	2.8 (3.5)	1.8 (3.3)	3 (3.5)	2.8 (3.5)	2.8 (3.5)	2.8 (3.5)
Huon Pine	3.4 (4)	2.6 (4)	2 (4)	3.8 (4)	2.6 (4)	3 (4)
Bottlebrush Plains	3.5 (3.9)	2.8 (3.9)	2.2 (3.8)	3.4 (3.9)	3.3 (3.9)	3.3 (3.9)
Ash Gums	2.7 (3.7)	2.3 (3.3)	1.5 (3)	3.7 (4)	2.7 (3)	2.3 (2.7)
Sample mean	*3.2 (3.7)*	*2.3 (3.6)*	*1.7 (3.5)*	*3.4 (3.8)*	*2.7 (3.6)*	*3 (3.5)*

These data alerted us to a number of issues — Ash Gums does not see it as important to have skills in educational games technologies. On top of this, the staff are often in the lower ranks in terms of their skill levels against their peers in government schools. This outcome is surprising given the data in Table 3 where Ash Gums uses many of these tools in schools and yet the teachers report not being skilled in their use. Unlike the other schools, Ash Gums has a very contemporary computing laboratory with a designated computing teacher who is keenly interested and highly skilled in the use of technology. Students are taken to this laboratory for their computing lessons and then follow up in class. The classroom teacher accompanies the class to the laboratory to see what they are doing with the expectation that the learnings in the computer session will be followed up in class. As such, unlike their peers in the government schools where there were attempts to model this high tech classroom, the resources (teacher and computer) were much more restricted in all state schools by comparison. When these data are considered in the contexts of the schools, it is not so surprising.

As can be seen from this table, the skill levels of the teachers are much lower in the areas directly associated with numeracy — spreadsheets and LOGO, along with drawing tools. As such, the depth of professional learning related to tools to support numeracy learning appears to be limited.

Summary and Conclusion

What these data have enabled us to theorise is the poor outcomes we experienced in this project in terms of the uptake of ICTs to support numeracy learning. By including high-tech (and low-tech) schools in both state and independent sectors, and in high and low SES schools, we had anticipated being able to identify the ways in which teachers used these tools to support numeracy learning. However, the data indicated that there is little uptake in schools. The data here suggest that confidence and skill levels with these tools may be part of the issue. As part of our project we undertook minimal professional development, but participation in the project motivated some teachers to used ICTs. In other cases, the professional development and participation in the project was still insufficient to change practice. As one of our participants noted in interview, "I would like to do more of this work but I need to know how it works but how do I do that? How do I learn?" While such a comment is reminiscent of a particular model of teaching, noted by Clements in the earlier parts of this paper in that she felt she needed to know more about the ICTs (in this case spreadsheets) if she were to use them as a teaching tool, it does suggest that teachers feel they need more support to be able to use ICTs in their classrooms. The data on the uptake across year levels, coupled with the teachers' knowledge suggest that, in terms of equity, more work may be needed for teachers if they are to begin to add digital capital to those students, particularly those students who are entering our schools behind their more digitally-advantaged peers.

References

Angus, L. B., Snyder, I., & Sutherland-Smith, W. (2003). Families, cultural resources and the digital divide: ICTs and educational (dis)advantage. *Australian Journal of Education, 47*(1), 18-39.

Clements, D. A. (2002). Computers in early childhood mathematics. *Contemporary Issues in Early Childhood, 3*(2), 160-181.

Downes, T., Arthur, L., & Beecher, B. (2001). Effective learning environments for young children using digital resources: An Australian perspective. *Information Technology in Childhood Education Annual*.

Ertmer, P. A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *ETR&D, 53*(4), 25–39.

Goos, M., Galbraith, P., Renshaw, P., & Geiger, V. (2003). Perspectives on technology mediated learning in secondary school mathematics classrooms. *Journal of Mathematical Behavior, 22*(1), 73-89.

Groves, S. (1995). The impact of calculator use on young children's development of number concepts. In R. P. Hunting, G. E. Fitzsimons, P. C. Clarkson & A. J. Bishop (Eds.), *Regional collaboration in mathematics education* (pp. 301- 310). Melbourne: Monash University.

Harding, E. (2002). *Reaching rural Canada; Living the broadband dream. Ovum Repor*.

Hoyles, C., Sutherland, R., & Healy, L. (1995). Children talking in computer environments: New insights into the role of discussion in mathematics learning. In K. Durkin & B. Shire (Eds.), *Language in mathematical education: Research and practice* (pp. 162-176). Buckingham, UK: Open University Press.

Yelland, N. (2002). Creating Microworlds for exploring mathematical understandings in the early years of school. *Journal of Educational Computing Research, 27*(1), 77-92.

Acknowledgements: This project was funded through the Australian Research Council's Discovery Grant Scheme.