

## How different is it really? – rural and urban primary students' use of ICT in mathematics

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**Abstract** Information and Communication Technology (ICT) offers the potential for changing mathematics education for both teachers and students. However, how ICT is used, and by whom, is critical to realizing this potential. This paper reports on an investigation of the use of ICT in the learning and teaching of mathematics in rural and urban primary schools in Victoria, Australia. Thirty-six teachers and almost 700 students were surveyed regarding their use of ICT for mathematics at home and at school, with a small number of selected teachers and students taking part in interviews. This paper focuses on students' perceptions of ICT use. A comparison of rural and urban students' responses shows little difference across most aspects of ICT use, and where there was a difference, the frequency of rural use almost always exceeded that in urban schools.

**Keywords** ICT · Mathematics · Rural students · Urban students · Primary school

Substantial funding is currently being allocated by Australian and some other Western governments to integrate Information and Communication Technology (ICT) into mainstream schooling. In the United Kingdom, for example, the equivalent of billions of Australian dollars has been invested in educational technologies for primary schools, with the introduction of the interactive whiteboard (IWB) seen as both a way to integrate technology into teaching and as a support for whole-class interactive teaching (Higgins 2010, p. 87). In Australia, government initiatives such as the \$2.2 billion Digital Education Revolution (DEEWR 2010a)

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and the roll-out in Victoria of a student-centred electronic learning environment, the Ultranet (DEECD 2009), have not only raised the profile of technology enhanced teaching, but are now resulting in multi-million dollar projects aimed at transforming the delivery of teacher education in Australian universities (DEEWR 2010b).

At the same time, there is considerable evidence that large gaps exist between the performance of students in remote, rural and metropolitan schools, particularly in areas such as mathematics and science (see, for example, Pannizon and Pegg 2007a; b). According to DEEWR (2010b) the projects to be funded through the *Information Communication Technology Innovation Fund* (ICTIF) will greatly benefit remote and rural areas due to resources and professional learning being accessible from anywhere in Australia, will support the introduction of the National Curriculum, and will lead to improved student learning outcomes by providing teachers and school leaders with resources and professional support in the use of ICT that can be translated into better teaching practices and more effective engagement of students.

This paper reports on a base-line study investigating teachers' and students' use of ICT in the learning and teaching of mathematics carried out in rural and urban primary schools in Victoria, Australia in 2009, shortly before the introduction of the Ultranet. In order to provide some insight into the structure of the student and teacher surveys, we begin this paper with a brief overview of some of the uses of technology in the learning and teaching of (mainly primary school) mathematics during the past 30 years, as well as some of the research relating to the effects of ICT use, before discussing findings from the student survey and interviews. Results from the teacher survey and interviews will be reported in a separate paper (Loong et al. [In preparation](#)).

## Background

We should have passed the stage of standing back in awe and amazement at what modern technology can do, and should be asking serious questions about the role of computers in school, the kind of classroom tasks which involve a computer, the nature of pupils' learning and the part that a computer might play in this. (Hunter, cited in Straker 1987, p. 180)

In the present climate, it is sometimes easy to forget that the use of technology in mathematics learning and teaching—at least in the form of computers and calculators—has a history of well over 30 years.

As early as the 1960s, Seymour Papert was talking about children using computers for learning and to enhance creativity, with the first turtle robot used with the *Logo* programming language being built at the MIT AI Lab in 1970. While infrastructure problems still loomed large, Papert's plenary lecture at the Fourth International Congress on Mathematical Education (ICME 4) held at the University of California, Berkeley in 1980, as well as his book *Mindstorms: Children, computers, and powerful ideas* (Papert 1980), caused considerable interest and excitement (see Villarreal and Borba 2010). Although the notion of learners coming to know the fundamental structures of mathematics through programming has been overtaken for many reasons, *Microworlds*, the successor of *Logo*, is still in wide use today.

The 1980s also saw the production in the UK of many highly creative programs aimed at conceptual development. Not least of these were the programs produced as part of the joint Shell Centre for Mathematical Education, University of Nottingham, and College of St Mark & St John, Plymouth project *Investigations on Teaching with Microcomputers as an Aid* (ITMA). One of the best known of these programs, *Eureka*, shows what happens to the water level in a bath when the taps are turned on and off, a man gets in and out, and the plug is put in and pulled out. These operations are shown both pictorially and as a graph of water level against time (see, for example, Phillips 1982). The ideas underpinning this program have been used in many contexts, including the technology-free *Tell me a Story* activity in the *Reality in Mathematics Education* (RIME) activity bank (Ministry of Education, Victoria 1989). A version of *Eureka* is freely available online at <http://www.mathsonline.co.uk/nonmembers/gamesroom/sims/archi/archi4.html>, the Games Room of the UK *Maths Online* site, where recent comments suggest it is continuing to cause great excitement.

Meanwhile, in the United States, Tom O'Brien at Sunburst was producing problem-solving orientated software aimed at producing "dynamic" rather than "static" knowledge—that is a "structure of ideas built by action rather than by copying" (O'Brien 1983, p. 111). For example, *Teasers by Tobbs* took the four operations beyond drill and practice by challenging children to use logical reasoning to complete puzzles based on these operations. Another example, *The Factory*, a version of which is still available, challenged children to design and produce their own products or duplicate existing products—square objects with a variety of holes and shapes made by using "machines" that punched holes, produced stripes and rotated the shapes. O'Brien saw the major role of educational software as enabling educators to promote children's mathematical thinking by allowing teachers to do what they had always wanted to do but could not do without the technology, warning that "buzzers and bells and wondrous graphics are often welcome in educational software. But the technician's magic can camouflage educational emptiness" (1983, p. 111).

From 1985 to 2005, the UK Association of Teachers of Mathematics published a separate journal *Micromath*, covering a wide range of topics including accounts of classroom lessons, reviews of books and software, puzzles and problems, news, and letters. As well as addressing pedagogical issues, articles addressed the use of a wide range of ICT including calculators, computers, spreadsheets, interactive whiteboards, dynamic geometry, and the internet. The journal is now incorporated in *Mathematics Teaching*, however a large collection of articles from 1985 to 2004, which are still seen as relevant, can be accessed at <http://www.atm.org.uk/journal/micromath.html>.

While we have referred here to a number of innovative uses of technology, it is unfortunate that the quotes from both Straker and O'Brien above, with the words "computer" and "educational software" replaced by "ICT", still seem as relevant today as they were approximately 25 years ago!

An important component of ICT in mathematics learning and teaching is the calculator. The first four-function hand-held calculators were readily available by early 1970s, closely followed by scientific calculators. The advent of graphic calculators (Casio FX-7000G in 1985) and symbolic computation

calculators (HP-28C in 1987) offered the potential of hand-held devices to overcome some of the infrastructure issues raised by the use of computers in schools. At the same time, the introduction of calculators at every level challenged the traditional curriculum, particularly where high-stakes assessment was involved.

A major development in the use of technology has been the opportunities it offers for connectivity, allowing teachers and students to “communicate in oral or written form through the Internet, through electronic learning environments, and through classroom connectivity facilities that allow for gathering students’ results from handheld devices and projecting them on an interactive whiteboard” (Trouche and Drijvers 2010, p. 677). Connectivity has enabled students to: access pedagogical resources and online artefacts; carry out internet searches for information; communicate with their teachers and peers through email and, more recently, through the use of social software such as *Facebook*; and access mathematics sites such as *NRich*,<sup>1</sup> where students and teachers can engage in a multitude of mathematics enrichment activities within a worldwide community. In Australia, projects such as *Maths by Email*,<sup>2</sup> include accounts of cutting-edge applications of mathematics to everyday problems—for example, designing a “wobble-free” rowing rig—together with problems and activities for students, the use of which is usually mediated by teachers.

Summarising the wide variety of technology available for use by students, Kissane (2010) lists hand-held devices (such as calculators, but also devices with connectivity, for example iPhones and iPads), computer software (such as spreadsheets, dynamic geometry, and statistics, rather than just computer tutor software), and the internet (which provides access to students to the worldwide web, online mathematics learning sites, digital learning objects, and social networking).

While the use of hand-held technology—for example calculators—initially overcame some of the infrastructure problems associated with computer use, research is now addressing the ways in which mathematics applications for mobile phones (*midlets*) can be used for students’ knowledge building in a web environment (see, for example, Daher 2010).

Findings from empirical studies on the outcomes of the integration of ICT have been mixed. For example, Goos and Cretchley (2004), in their review of Australian research into the use of computers, multi-media and the internet in mathematics education, warn that the use of ICT as a computer tutor is often inconsistent with current views of learning and marginalise the teacher’s role. Higgins (2010) reports that while the introduction of interactive whiteboards in a pilot program led to “significant changes in teachers’ practices ... and in aspects of classroom interaction, and ... perceptions of those involved were overwhelmingly positive, ... the impact in terms of students’ attainment on national tests was very small and short-lived” (p. 86). In a similar vein, Selwyn et al. (2009), reporting on a survey of primary school children in the UK, found that while students felt that the use of ICT had led to learning gains in terms of self-directed research both in

<sup>1</sup> See <http://nrich.maths.org/public/>

<sup>2</sup> See <http://www.csiro.au/helix/mathsbymail/newsletter/newsletter.html>

and out of school, they were less likely to indicate that they were learning mathematics better through the use of ICT. Moreover, they note that

In light of recent rhetoric over the changing nature of young people's Internet use, it was notable that creative and collaborative uses of so-called "Web 2.0" applications were not prevalent either inside *or* outside school, with passive consumption rather than active production the dominant mode of engagement. (pp. 928–929)

## The study

The study was conducted in six urban and seven rural schools in Victoria during 2009. A total of 36 teachers took part in an on-line survey, while a total of 676 students from Year 3 (9-year-olds) to Year 6 (12-year-olds) participated in a written student survey administered in their classes. Interviews were also conducted with a total of 5 teachers and 18 students.

The urban schools were part of a regional network of 23 schools that had technology use as its focus for the year. Despite the fact that the authors attended a meeting of the principals in the network to explain the study, and one of the authors provided a workshop on ICT as part of the professional development program, only six schools participated. The rural schools were recruited, with some difficulty, through contacts with staff from regional offices. Again, 43 schools from 6 networks from one region were invited to participate, but only seven chose to participate. Based on our experiences in the recruitment process, there was no evidence to suggest that the schools that chose to participate were in any way adopting different pedagogy with respect to technology use than the schools that did not participate. Nor was there any evidence that the focus on technology in the urban network translated to increased use of technology. However it is impossible to discount this possibility. Unfortunately it is also not possible to link the student data directly to the teacher data, as the surveys were anonymous and not all teachers responded. These are clearly limitations of this study.

The student survey was constructed to explore the wide range of ICT use identified above, including some of the more basic technologies such as television. It consisted of ten sections exploring: students' attitude to mathematics; the use of electronic whiteboards by students and teachers at school; and students' use at school and at home of audio-visual equipment, calculators, the Internet, and computers. In each section relating to the use of ICT, it was specified that the questions related to use of ICT for *mathematics* learning and teaching *during the previous week*. Ten of the 80 questions required an open-ended response. Several versions and formats for the survey were trialled before it was used in the project classrooms. A section from the student survey is shown in Fig. 1.

All students in Years 3 to 6, whose parents had given consent, completed the written survey. In total, 188 rural students and 488 urban students in Years 3 to 6 responded to the student survey (see Table 1).

**5. Interactive Whiteboard use for MATHS at SCHOOL LAST WEEK**

How often was it used? N   O   M

○   ○   ○   ■

Who used it? **T = Teacher, S = Students, B = Both** T   S   B

○   ○   ○   ■

Did the **teacher** use it to:

Yes   No

- Show things ○   ○   ■
- Write on it ○   ○   ■
- Do something else (please explain below) ○   ○   ■

Did **students** use it to:

Yes   No

- Watch only ○   ○   ■
- Show things ○   ○   ■
- Write on it ○   ○   ■
- Do something else (please explain below) ○   ○   ■

**Fig. 1** A sample section of the ICT use in primary mathematics student survey

Questions were read to classes to avoid problems with reading levels. Answers were written on the survey booklet, which included mark-sense response boxes, with answers to the open-response items coded later and entered in the booklets. Students with different patterns of engagement with ICT, as reported in the surveys, were interviewed and asked to elaborate on their survey responses.

A teacher survey was conducted on-line. This survey consisted of eight main sections: background information; school and classroom ICT infrastructure; purposes, frequency, and the different mathematics dimensions for which ICT were used; perceptions of ICT; and ICT support. Teachers who were interviewed were asked to elaborate on their perceptions of the impact of ICT use on their students, their use of ICT for particular purposes in mathematics, and the ways in which they used ICT in mathematics.

Apart from a few instances where teacher data is reported to complement student data, this paper reports on the findings from the student surveys and interviews only.

**Results**

Data from the student surveys were analysed using Item Response Theory (IRT) for the section on students’ perceptions of mathematics and ICT. For the remaining tick-

**Table 1** Year level of student participants

Year level	Rural ( <i>n</i> =188)	Urban ( <i>n</i> =488)
Year 3	44 (23.4%)	113 (23.2%)
Year 4	48 (25.5%)	130 (26.6%)
Year 5	36 (19.1%)	139 (28.5%)
Year 6	60 (31.9%)	106 (21.7%)

the-box data, SPSS was used to provide descriptive statistics comparing frequencies of use and displays of the data, and to carry out  $\chi^2$  significance tests where appropriate. For these tests, the significance level was set at  $\alpha=0.05$ . Open-ended responses and interviews were transcribed and the responses placed into categories with common, dominant themes. The results of these analyses are reported below.

Students' perceptions of mathematics and ICT

Students were asked to respond to nine statements relating to their perceptions of mathematics and ICT. The response format was a four-category Likert scale, ranging from Strongly Disagree to Strongly Agree. A Rasch Partial Credit Model analysis (Masters 1982) was performed, with the results providing the basis for Fig. 2.

The Rasch scale has been transformed into a simple integer scale, using a linear transformation, to facilitate reading the figure. Higher values on this Endorsement Scale indicate a more positive response. As this is an interval scale, equal distances in the ordinal raw scores do not appear as equal length intervals on this scale. Rather the ordinal data has been transformed onto an interval (logit) scale. Each statement lies beside a "bar" that visually represents the entire interval scale, with the boundary between categories indicated by a vertical line in the bar. The bar shows the four categories of response: the first, left-most, section represents the Strongly Disagree category, while the right-most section represents Strongly Agree. The length of the four sections of each bar indicates the distance on the interval scale between each "step". The range of each section indicates the strength of endorsement required to

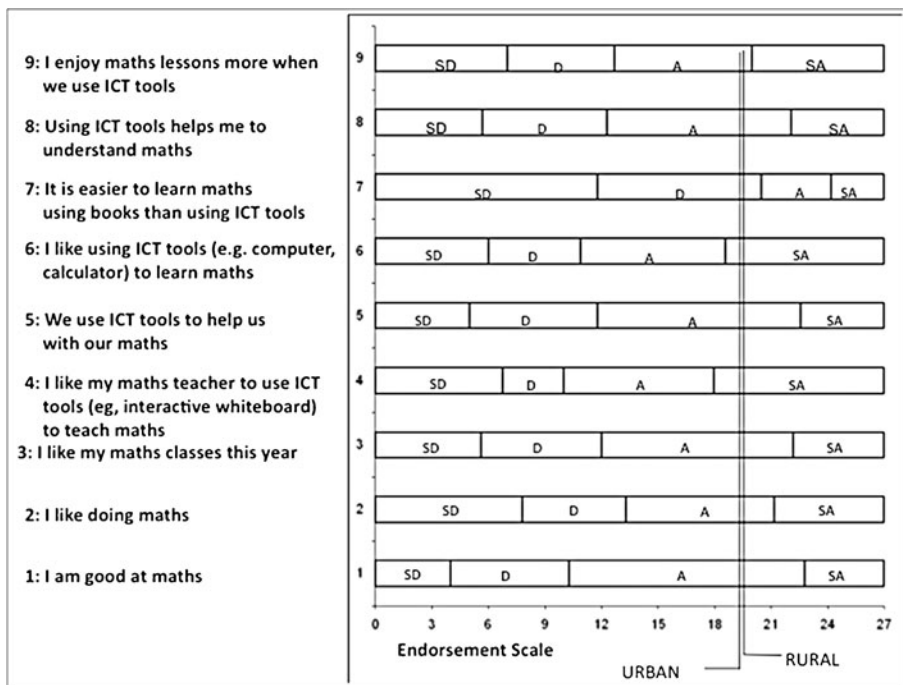


Fig. 2 Students' perceptions of mathematics and ICT

respond in that category. For example, Question 7 asks if “It is easier to learn maths using books than using ICT” and responses in the Strongly Agree category require a very high level of endorsement (scores in the range of 24 to 27).

When using such an ordinal map, knowing a student’s total raw score is sufficient to know the likelihood of a response to any survey statement. This can be accomplished by drawing a vertical line at the student’s raw score position on the scale at the foot of the ordinal map through all the statement bars. The two vertical lines in Fig. 2, labelled Rural and Urban respectively, indicate the mean score for each group of students, rural ( $n=188$ ) and urban ( $n=488$ ). The responses for the two groups are very similar, as can be seen from the fact that the vertical mean response lines for each group are separated by less than a third of a unit, with rural and urban students most likely to respond in the same category for all nine statements. (For a more detailed description of this form of reporting, see Doig and Groves 2006.)

It is clear from Fig. 2 that students are very positive about both the use of ICT in mathematics and mathematics *per se*, with the two most strongly endorsed statements being Question 1 “I am good at maths” and Question 4 “I like my teacher to use ICT tools to teach maths”. In Question 7, students also strongly disagree that “It is easier to learn mathematics using books than using ICT tools”. However, not all students shared these positive attitudes to the use of ICT, with Question 4 also having one of the highest levels of strong disagreement, together with Question 2 “I like doing maths” and Question 9 “I enjoy maths lessons more when we use ICT tools”. This was reflected in the interviews where there were very mixed responses as illustrated below.

I: Here you said you disagree that you like ICT tools for learning maths. Are there any reasons?

RG1<sup>3</sup>: My little brother is good with computers and I am not. My Dad is a maths teacher, so he teaches me a lot of maths. I enjoy it a bit more on paper, books.

I: Here you said that using ICT tools helps you to understand maths more. You agree to that?

RG1: ... So it is a bit of wibbly wobbly. I do understand sometimes with computers and sometimes I don’t.

I: You said you disagree that you like your teacher using ICT tools to teach maths

RG1: Sometimes I don’t like it because in some websites we just fall asleep.

These views are supported by several of the other interviewees. For example, RB1 says that he strongly agrees that it is easier to learn mathematics using books rather than ICT tools because “you can actually read it in the book and it gives you example rather than just having question on the computer ... books actually explain”. He goes on to say that he thinks that ICT’s changing the way he learns mathematics:

RB1: Yes, it changes from writing things down on paper and learning things by explaining and drawing. Because when you use ICT, it’s already got all up there, you just answer, you don’t do any research. You only work it out in your head. ...

<sup>3</sup> RG1 refers to Rural Girl 1



UB1 adds that he doesn't really enjoy mathematics lessons when using ICT: "Me and my friend work out with our brain. It's more challenging". These views are not universally held, with UB3 saying that using ICT tools to learn mathematics "helps you to understand a bit better. Sometimes it is ... clearer. It has got a lot more options".

UB5 adds an interesting viewpoint:

I: Do you think there are any benefits of using ICT tools to learn maths?

UB5: If you use ICT on the computer you get glued to it.

I: Is it good or bad?

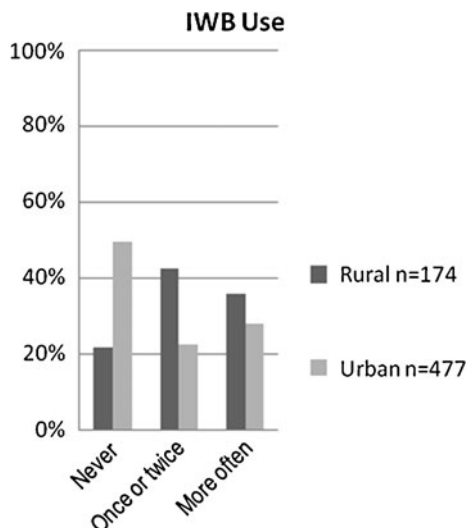
UB5: It's pretty good if you want to learn maths. It's a big advantage to learn maths outside school on the computer.

This comment supports the notion that ICT allows students at the very least more opportunities to learn mathematics than other media.

### Interactive whiteboard use at school

There has been a tremendous investment in interactive whiteboards (IWB) in recent years, particularly in England and Wales (see, for example, Higgins 2010), and, more recently in Australia, where, based on anecdotal evidence, their installation and use seems to be growing at an exponential rate.

Students reports on their teachers' use of the interactive whiteboards demonstrated a significant difference in the frequency of use in the rural and urban schools, with 78.1% of students in rural schools saying their teachers used the IWB at least once in the preceding week compared to just 50.5% of students from urban schools—see Fig. 3. This difference is statistically significant ( $\chi^2=44.064$ ,  $df=2$ ,  $p=0.000$ ). The reason for this difference is not apparent from the responses given by the rural students to either survey or interview questions.



**Fig. 3** Frequency of IWB use by school type

While, as explained earlier, it is impossible to link the student survey results directly to those of the teachers in the teacher survey, this result is consistent with the fact that 75% of the urban and 83.3% of the rural teachers reported that interactive whiteboard were available at their school, while 58.3% of both urban and rural teachers reported that IWBs were available in their classrooms.

The introduction of IWBs does not define pedagogy. However, as Tanner, et al (2005) warn, while “the IWB has affordances to support interactive teaching, offering the opportunity for pupils to be allowed to explore their own ideas and share them with the class in a reflective discourse, such affordances are mediated by teachers” (p. 726) and this introduction has often lead to a return to more traditional modes of pedagogy, at least in the first instance. It is therefore helpful to interrogate the ways in which they are used and by whom.

It is heartening to see in Fig. 4 that, in those cases where the IWB had been reported as used for mathematics in the previous week, overwhelmingly students reported that both the teacher and the students had used it. There was no significant difference between rural and urban students, with approximately 80% of both reporting that both students and the teacher had used it, although a slightly higher percentage of urban than rural students reported that only the teacher had used it.

Figure 5 shows that the most frequent use of the IWB by both teachers and students was to “show things” followed by using it to “write on it”. Only 27% of rural students reported that they watched only, compared to 43% of urban students. This seems consistent with teacher data, which showed that where IWBs were available in their classrooms, teachers in rural schools were more likely to use them for student investigation (86%) than urban teachers (71%). Even where rural teachers did not have IWBs in their own classrooms, but they were located somewhere else in their school, they made arrangements to use them to teach as evidenced by the number of teachers who said they use the IWB for teaching even when it was not available in their own classroom.

In terms of teachers and students doing “something else”, responses fell into three categories: mathematics games (most frequent use for students and urban

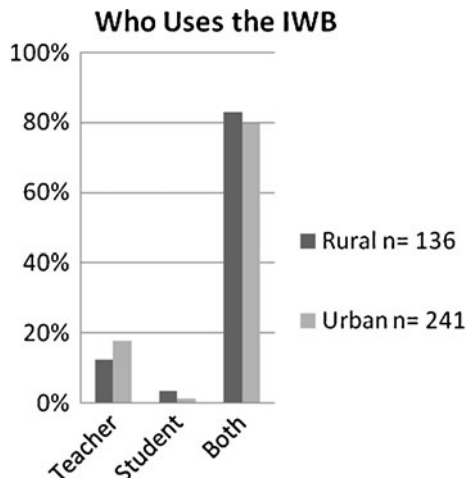


Fig. 4 Who uses the IWB by school type

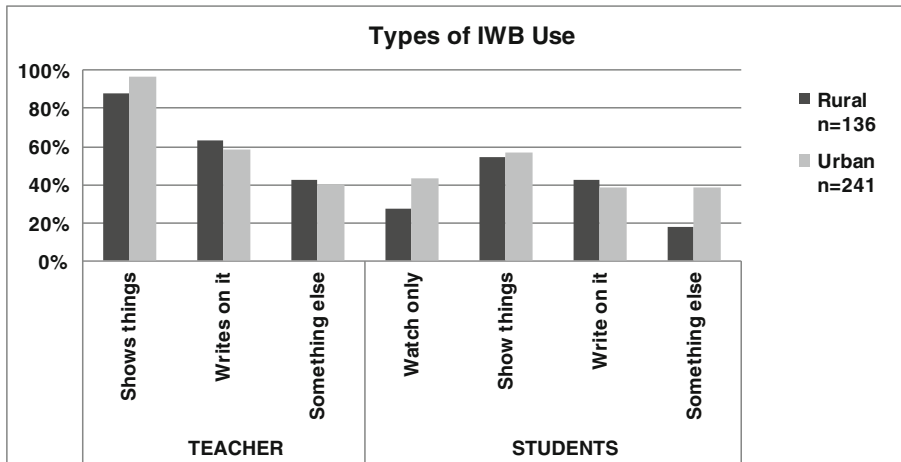


Fig. 5 Types of IWB use by school type

teachers), homework and solving problems (only used rarely except by rural teachers for whom it was the most frequent “something else”), and for presentation of a PowerPoint or showing mathematical tables (infrequent use by teachers only).

Some students, such as RG3, reported that the IWB was new that year, whereas for others such as UB2 it was the second year they had been using them. While UB2 was generally positive about the use of the IWB and stated that he used it to search the Internet, as well as with a “music program, where you can tap the piano keys and it make the sound”, he was one of a number of students who, like the students surveyed by Selwyn, et al (2009) was frustrated by the time it took the IWB “to load up”. UG2, however, was entirely positive about its use:

UG2: The electric whiteboard helps a lot. The teacher does stuff on it and you can go on websites. Just type in something like “what the perimeter of this” and it will come out.

I: Is that better than teacher telling you?

UG2: It is a bit better. You can do it straight away. But with the teacher, she had to explain whole thing, so it takes sort of time. With the whiteboard, if you don’t know the shape, you just go on the Internet and [it tells you] what shape it is. ... It’s cool and I love it.

#### Audio-visual equipment use at school and at home

A surprising number of students reported using various types of audio-visual equipment for mathematics during the previous week—see Table 2. There was no significant difference between rural and urban use reported for any of the types. As there were no open-ended responses for this section and no student commented on this aspect in the interviews, it is difficult to determine how these types of equipment were used or how students interpreted the questions. For example, videos watched may well have been video clips shown on the IWB, while CDs may have been ones contained in text books and other student and teacher resources—these are quite different but were

**Table 2** Audio-visual equipment used for mathematics at school and at home by school type

		At School		At Home	
TV	Never	Rural <i>n</i> =180 81.7%	Urban <i>n</i> =473 79.3%	Rural <i>n</i> =181 75.7%	Urban <i>n</i> =467 69.2%
	Once or twice	15.6%	15.9%	18.8%	21.6%
	More often	2.8%	4.9%	5.5%	9.2%
Video/DVD/CD	Never	Rural <i>n</i> =178 74.2%	Urban <i>n</i> =472 75.4%	Rural <i>n</i> =171 79.5%	Urban <i>n</i> =459 79.7%
	Once or twice	21.3%	22.5%	15.8%	15.9%
	More often	4.5%	2.1%	4.7%	4.1%
Radio	Never	Rural <i>n</i> =178 89.9%	Urban <i>n</i> =455 92.3%	Rural <i>n</i> =176 86.9%	Urban <i>n</i> =453 84.1%
	Once or twice	7.9%	5.3%	9.1%	11.7%
	More often	2.2%	2.4%	4.0%	4.2%

grouped in the same survey question. Unsurprisingly, there was little reported use of the radio for learning mathematics, but it would be interesting indeed to learn how it was used by the few who made a positive response to this question.

#### Calculator use at school and at home

There have been significant differences in the use of calculators between Australian states for some time. In Victoria, the use of calculators has been encouraged from the first year of school, while in New South Wales, calculators are only introduced in the last year of primary school or even the first year of secondary school. As a result of the consultation phase of the introduction of the Australian Curriculum, the mandatory introduction of calculators has been delayed from the first year of schooling, while the term “calculator” has been replaced by the expression “digital technologies” in Years 3, 4 and 5. According to ACARA Chair, Barry McGaw, a major change has been:

In the case of the use of calculators this has involved a formulation that will support the variation in practice that currently exists across the states and territories. The Australian Curriculum insists that students develop fluency in calculations without the aid of calculators and provides that calculators not be introduced before year 3 while also allowing for a delay in introduction to year 6 where that is the current practice. (McGaw 2010, p. 2)

In our view, this is a clearly retrograde step as extensive research, such as that carried out by, amongst others, one of the present authors, suggests that there are no detrimental effects attributable to the introduction of calculators in the early years of schooling (see, for example, Groves and Cheeseman 1995; Groves and Stacey 1998).

Figures 6 and 7 show that there was very little difference between the percentages of students reporting no use of calculators in the previous week at school (approximately 30% in both cases) and at home (just over 60% in both cases). However there was a significant difference in the frequency of use at school ( $\chi^2=$

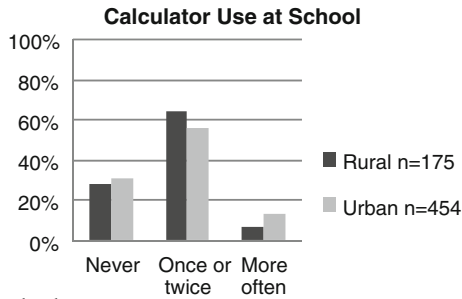


Fig. 6 Calculator use at school

6.837,  $df=2$ ,  $p=0.033$ ), with more urban students using calculators more than twice a week. No such difference occurred for home use.

Findings from the *Calculators in Primary Mathematics* project (see, for example, Groves and Cheeseman 1995) showed that calculators could be used for a wide range of purposes. This student survey, therefore, asked students to explain how they used calculators, both at school and at home. Figures 8 and 9 summarise the results.

Rural and urban results are similar, with checking answers, followed by finding answers and solving problems as the most frequent uses both at school and at home. For example, UB2 reported that “Generally with maths we use calculator just to figure out the answers and check our answers while UB1 reported “I use calculators for fractions and percentages. Sometimes for harder kind of things which you can’t always workout in your brain, like big sums, 10 digit numbers, multiplication sums”.

It was, however, heartening to see that approximately 25% of both rural and urban students reported using their calculator to explore number at school and at home, as can be seen in the following excerpt from UB3’s interview.

I: What do you do with the calculator?

UB3: Numbers and pi (we are doing it in class)

I: Can you explain?

UB3: Calculator has got square root button. I put pi in that and press square root button and find new things about it.

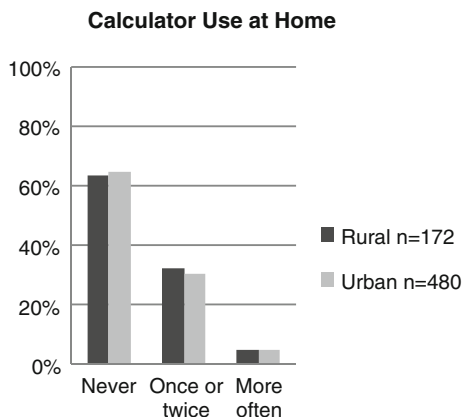


Fig. 7 Calculator use at home

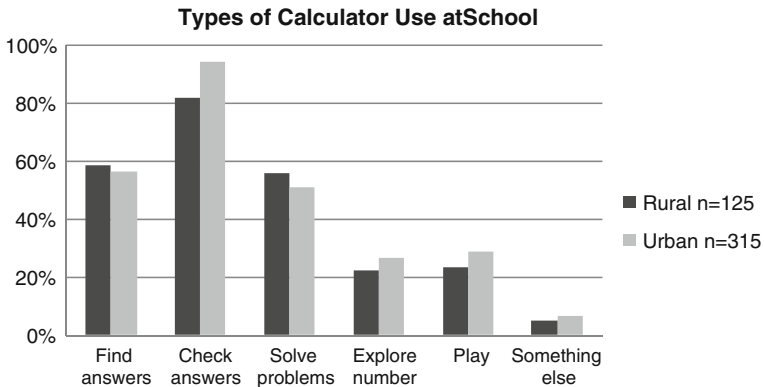


Fig. 8 Types of calculator use at school

I: Have you made any new discovery?

UB3: Not yet.

While even more rural and urban students reported using calculators to play, especially at home, and a smaller number reported that they use calculators for something else, there is little information as to what they actually did with calculators in these cases. Only three students elaborated: one saying that they used calculators to “make words with numbers” at school, and the other two saying that at home they used calculators “to check answers” and the other that they used their “parent instead of a calculator”!

Internet use for mathematics at school and at home

A comparison of responses from students in urban and rural schools showed a significant difference between Internet use by rural and urban students at school ( $\chi^2=22.339, df=2, p=0.000$ ), with 82% of students in rural schools using the Internet for mathematics at school at least once during the week preceding the survey and 32% using it more than twice, compared with only 72% of students using it at least once and 16% using it more than twice in urban schools (see Fig. 10).

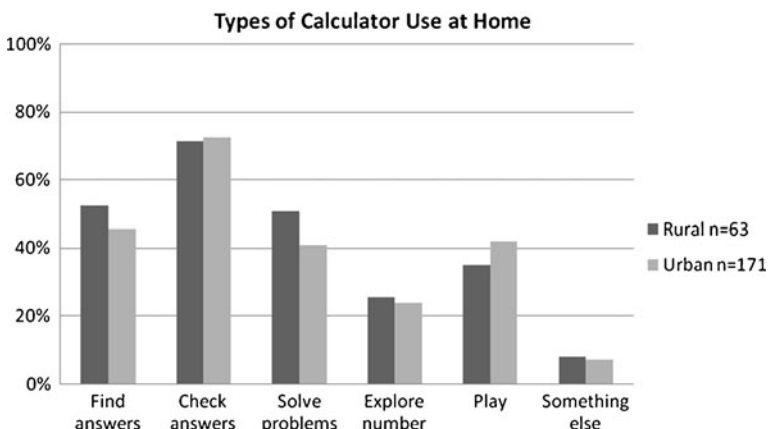


Fig. 9 Types of calculator use at home

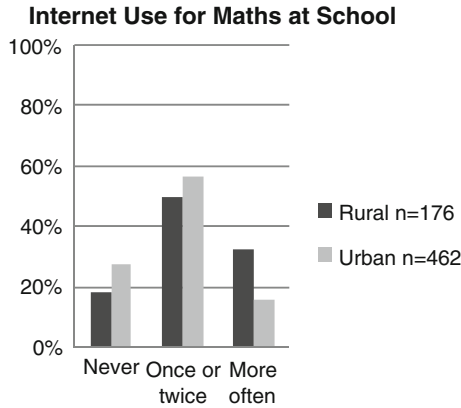


Fig. 10 Internet use at school

On the other hand, Internet use at home was not significantly different for students in the two locations, with 44% of rural students saying they used the Internet at home at least once during the preceding week and 14% using it more than twice, compared with 53% of urban students using it at least once and 18% using it more than twice in urban schools (see Fig. 11).

This seems to suggest that where there is access to the Internet in rural locations, students are in no way less engaged with the Internet at home than their urban counterparts. What is surprising is that the use of the Internet at school was significantly higher for rural students compared to urban students, although this ties in with the IWB situation discussed earlier. This could, perhaps, indicate that rural students and their teachers are more inclined to use the Internet in the teaching and learning of mathematics given the ease of access to information via the Internet, as opposed to information from more traditional sources such as libraries.

Figures 12 and 13 show a comparison of the types of Internet use reported for mathematics at school and at home during the week preceding the survey. In both cases the most frequently reported use was for access to mathematics websites, followed by Internet searches. More students used the Internet for searching, e-mail

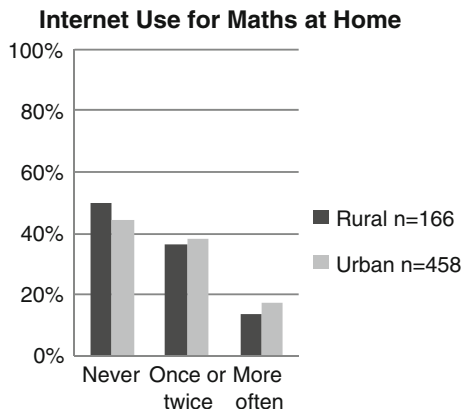


Fig. 11 Internet use at home

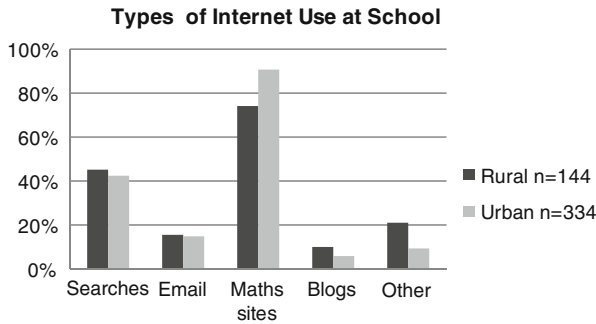


Fig. 12 Types of internet use for mathematics at school

and blogs at home than at school. This may not be surprising given that students have more time at home to do searches, send emails and write blogs.

Other specific uses of the Internet at school and at home reported by students were mathematics games in general, and *SmartKiddies*, while at school these also included fraction games.

Students interviewed were particularly vocal about their use of the Internet for the learning of mathematics. They said they accessed mathematics sites such as *A Maths Dictionary for Kids*, *Coolmaths for Kids* on the Internet, as well as using blogs—although they were not always unequivocal about the benefits of the Internet, as illustrated by the following interview extracts.

I: What do you use the computer for?

UB1: I use the computer for checking up stuff like for maths dictionaries. At home I just go to the maths dictionary, open it and look around. I search for fractions, adding, subtraction, and multiplication because I didn't know how to do that. Dad bought a \$6,000 tutoring program.

I: You have installed this program on your computer?

UB1: Yes. It is called the *Mathemagic Computer Tutor*. It helps you with algebra, percentages. Then we have English, it helps you with spellings, vocabulary.

I: Do you normally do that at home?

UB1: Three times a week

I: Do you feel you are learning better with ICT tools

UB1: Sometimes.

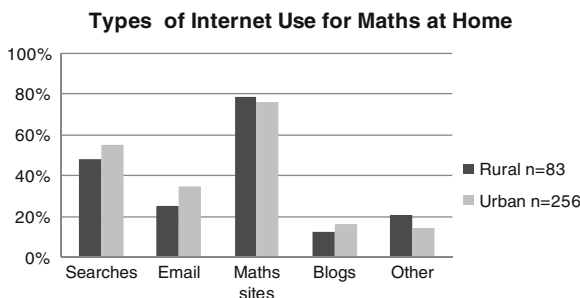


Fig. 13 Types of internet use for mathematics at home



UG1 highlights some issues for her in using Internet searches, stating that: “Sometimes, if you find two different answers and you don’t know which one to choose, if there are equal amounts of both answers on the Internet. Say for example one from Wikipedia and another from *about.com*. However she went on to add that ICT helped her understand because reading “something three times instead of once helps you to understand more...just to make sure everything on the Internet is true:.

However, UB5 declared that his use of the Internet was “Not for maths. I look up other stuff like my favourite AFL team”.

Others, however, were more positive. UB3 said he used the Internet every day at home, for perhaps an hour.

I: With the maths dictionary what do you do with it?

UB3: My grandpa was here. He used to teach me a lot every night so I was looking for these stuff.

I: What do you learn from maths dictionary?

UB3: Like things I haven’t heard of it yet.

I: Give me some examples

UB3: Axis and those kinds of things.

Another student, UB6, illustrates the interactive power of the Internet.

UB6: At home I go on the computer on maths websites.

I: What else do you do besides maths?

UB6: We have game on the Internet. All my friends have. We can interact with other people.

I: What is it called?

UB6: It’s called Club Penguin.

I: What do you do in this game?

UB6: There is a little mini game like snow boarding and surfing and you can also play car games.

I: You said, you play with your friends. Are they somewhere else or are they are with you at the same place?

UB6: I could be at my house playing and someone else could be at their house playing. We could meet on it.

I: Do you do it often?

UB6: Yes, once a week.

I: Is that something for fun?

UB6: Yes for fun.

I: Are there any sites on the web you use for mathematics?

UB6: Maths 3000 that we have on school computer. It has fun maths games. There is one *Funbrains*.

It is not surprising that more students used mathematics sites at school than at home, but what was surprising was that approximately 75% of both rural and urban students used mathematics sites at home, and that they used the Internet in such a variety of ways at home. Although the numbers are small, students also used blogs. RB2 said “We have just started using *Glogster* in the last couple of days ... you can make many projects on it. It is like a typical book but you can do more on it”—referring to the fact that students were making posters relating to their favourite numbers.

Computer software use for mathematics at school and at home

Almost two thirds of both rural and urban students reported that they had used computer software for mathematics at school at least once in the previous week. However, almost twice as many (24%) of rural students reported using it more than twice, compared with 12.4% of urban students—a statistically significant difference ( $\chi^2=15.057, df=2, p=0.001$ )—see Fig. 14.

The use of computer software at home did not differ significantly between rural and urban students, with 47% of urban students saying they used computer software for mathematics at least once during the preceding week, compared with 55% of rural students, and approximately 11% of both reporting that they had used it more than twice—see Fig. 15.

While it is not surprising that a greater percentage of students used the computer for mathematics at school than at home, a surprisingly large number of all students (50%) said they used computer software for mathematics at least once at home in the preceding week.

Students were asked about their use of mathematics specific and generic software. The most frequently used category of mathematics specific software reported used was games, with approximately 75% of all students reporting this use at school and home, but interestingly, considerably less so for rural students than urban ones—see Figs. 16 and 17.

*Mathletics*, a web-based mathematics educational site, was used at home by almost 30% of students. Although this proportion may not seem large, it is interesting to note this number of students were engaged in doing mathematics at home on-line. A smaller percentage (19%) of students also used tutor programs at home for mathematics. In both cases, rural students were less likely to use these than urban students.

Of perhaps more interest is the proportion of both *Mathletics* and tutoring programs that are being bought and used by schools (about 30% of rural and 20% of urban). It raises the question, for teachers, of how consistent children’s mathematical advice really is, and who is the main source of their learning: the home tutor, or the classroom teacher!

Among the other mathematics specific software used at school, students listed the IWB and PowerPoint, while at home they listed *SmartKiddies* and PowerPoint,

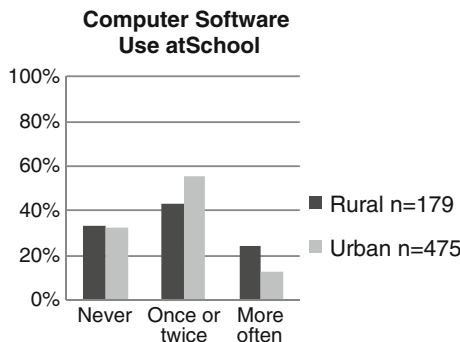


Fig. 14 Computer software use at school

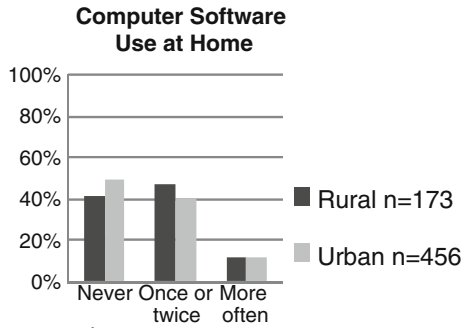


Fig. 15 Computer software use at home

possibly indicating a lack of understanding of the nuanced nature of the survey and interview questions.

Many students claimed to use generic software for mathematics both at school and at home, as shown in Figs. 18 and 19. The most common software programs used both at school and at home were MicroSoft *Word* and *Excel*, with use at school slightly exceeding use at home and rural use again slightly exceeding urban use.

As an example of how these were used, UB6 reported that

Last term we used *Excel* to find out what country most people originated from in our grade. ... We printed out all sheets. We had to write down what country most people came from in our books. ... We made the graph on *Excel*. ... Like, what percent of people.

A small percentage used *Microworlds* and other generic software for mathematics, such as Microsoft *PowerPoint*. UG1 said “We use *Word* at home for writing stories and *PowerPoint* at home for making slide-shows about myself telling everything about me, what I like doing ... [for mathematics]. In *Word*, I make a chart as well as *Excel*”.

**Conclusion**

The few significant differences between rural and urban students experiences with ICT tools, either at school or at home, suggest that equity of access is not affected by location. However, this does not mean that all students have similar experiences within their classroom, in either type or quality. As Jamieson-Proctor et al (2006)

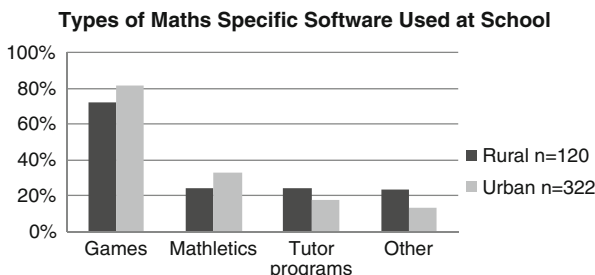


Fig. 16 Types of mathematics specific software used at school

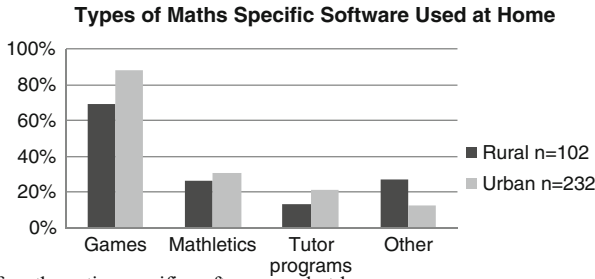


Fig. 17 Types of mathematics specific software used at home

pointed out, differences in ICT uptake are mediated by factors such as teacher confidence with ICT, and what constitutes good pedagogy. This issue will need further investigation of both student and teacher perspectives.

With respect to the question of equity of access and use for rural and urban students, it is clear that differences, both at home and at school, are not significant. Further, students' perceptions and attitudes toward the use of ICT in teaching and learning mathematics is virtually identical between the two groups of students. Additionally, the ways in which ICT tools are being used for teaching and learning primary mathematics in rural and urban schools, show a remarkable degree of similarity.

While not suggesting that the software used by students at school or home is of any particular quality, there appears to be a narrow range of software being used (for example, *SmartKiddies*, *Coolmaths for Kids*, *Maths 300*). It is unlikely that this is due to a lack of suitable software, but may instead be an indication of that perennial issue for schools, a shortage of funds for recurrent expenses, such as software purchases. Also, it seems that parents tend to purchase the software being used at school.

The frequency of use of *Word*, *Excel*, *Microworlds*, and *PowerPoint*, both at home and at school, suggests that students are adept at working across different virtual environments, and are able to select appropriate ICT tools for learning mathematics. This adaptability is unlikely to be found within a text-book based pedagogy.

There are concerns with parent purchases of tutoring programs, as these may be different, or run counter to, school practice. The issue for teachers is who is the source of students' mathematical learning: the home tutor, or their classroom teacher. However, it should be noted that some schools also use *Mathletics* as part of their mathematics learning armoury.

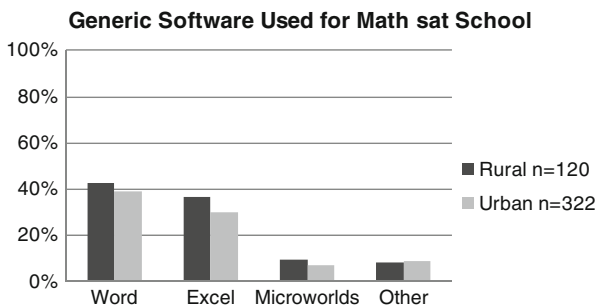
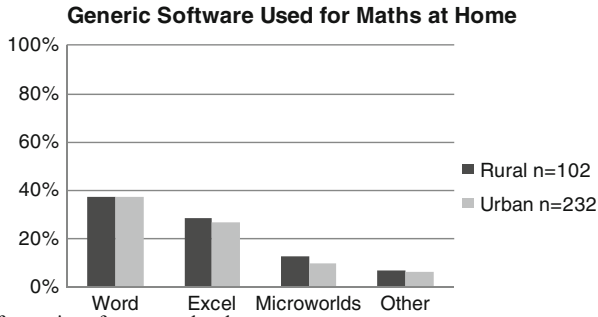


Fig. 18 Types of generic software used at school



**Fig. 19** Types of generic software used at home

A statistically significant difference was found in the use of the IWB, with rural school teachers using this ICT tool much more often than their urban colleagues. The use of the IWB may not be integrated fully into mathematics pedagogy, as reported IWB usage indicates that teachers and students use the IWB to show things, write on it, or for students, to watch only. Further, IWB use in all schools was dominated by games. It would appear that there is a need for professional development of teachers with respect to the “I” aspect of the IWB.

Students reported using a surprisingly wide range of Internet facilities: they used it for searching, blogging, sending email, and even constructing wikis.

Most students reported a very high level of endorsement for their experience of ICT use for mathematics, as well as mathematics *per se*. A particularly interesting endorsement was for the use of ICT rather than books for learning mathematics.

In summary, this small-scale study has shown that schools in both rural and urban regions are well-equipped with ICT tools, and well-connected to the Internet, and that this is reflected in similar usage patterns across all schools. Also, as reported by their students, teachers in all schools are fairly consistent in the manner in which they use ICT tools. This has created positive perceptions and attitudes in students. Parents too have endorsed ICT tools, and many students have mathematics-specific software available to them at home.

This study has also highlighted the need for teacher professional development in order to broaden teachers’ awareness of a greater range of uses for ICT tools, and in particular the IWB. As Hoyles and Noss (2009) point out:

The obvious but often overlooked fact [is] that technology *per se* is unlikely to influence mathematical development in any significant ways; it is how it is designed to support learning and how it is embedded in activities designed with specific learning objectives. (p. 145)

The unresolved questions from this study lie with the integration of ICT tools within the framework of current mathematics curriculum and pedagogy. Unquestionably, further interviews with teachers and students, and observations within classrooms, are needed to explain how ICT tools are helping students learn mathematics, and what pedagogical modifications might be required to maximize this effect to benefit all students.

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## References

- Daher, W. (2010). Building mathematical knowledge in an authentic mobile phone environment. *Australasian Journal of Educational Technology*, 26(1), 85–104. Retrieved 1 December 2010 from <http://www.ascilite.org.au/ajet/ajet26/daher.html>.
- Department of Education and Early Childhood Development DEECD (2009). *Ultranet*. Retrieved 21 May 2010 from <http://www.education.vic.gov.au/management/ultranet/default.htm>.
- Department of Education, Employment and Workplace Relations DEEWR (2010a). *The digital revolution: Overview*. Retrieved 21 May 2010 from <http://www.deewr.gov.au/Schooling/DigitalEducationRevolution/Pages/default.aspx>.
- Department of Education, Employment and Workplace Relations, DEEWR (2010b). *Teaching teachers for the future*. Retrieved 8 November 2010 from <http://www.deewr.gov.au/Schooling/DigitalEducationRevolution/DigitalStrategyforTeachers/Pages/ICTInnovationFund.aspx>.
- Doig, B., & Groves, S. (2006). Easier analysis and better reporting: Modelling ordinal data in mathematics education research. *Mathematics Education Research Journal*, 18(2), 56–76.
- Goos, M., & Cretchley, P. (2004). Computers, multimedia, and the internet in mathematics education. In B. Perry, G. Anthony, & C. Diezmann (Eds.), *Research in mathematics education 2000–2003* (pp. 151–174). Flaxton: Post Pressed.
- Groves, S. & Cheeseman, J. (1995). Beyond expectations: Using calculators with young children. In J. Wright (Ed.). *Set: Research information for teachers*. Number one, 1995. Item 3.
- Groves, S., & Stacey, K. (1998). Calculators in primary mathematics: Exploring number before teaching algorithms. In L. J. Morrow & M. J. Kenny (Eds.), *The teaching and learning of algorithms in school mathematics: 1998 yearbook of the National Council of Teachers of Mathematics* (pp. 120–129). Reston: National Council of Teachers of Mathematics.
- Higgins, S. E. (2010). The impact of interactive whiteboards on classroom interaction and learning in primary schools in the UK. In M. Thomas & E. C. Schmid (Eds.), *Interactive whiteboards for education: Theory, research and practice* (pp. 86–101). Hershey: IGI Global.
- Hoyles, C., & Noss, R. (2009). The technological mediation of mathematics and its learning. *Human Development*, 52(2), 129–147.
- Jamieson-Proctor, R., Burnett, P., Figner, G., & Watson, G. (2006). ICT integration and teachers' confidence in using ICT for teaching and learning in Queensland state schools. *Australasian Journal of Educational Technology*, 22(4), 511–530.
- Kissane, B. (2010). *Technology, research and practice in mathematics education*. Keynote address at the 33rd Annual Conference of the Mathematics Education Research Group of Australasia, Fremantle, WA.
- Loong, E., Doig, B., & Groves, S. (In preparation). *Primary teachers' use of ICT in mathematics*.
- Masters, G. N. (1982). A Rasch model for partial credit scoring. *Psychometrika*, 47, 149–174.
- McGaw, B. (2010). *Finalising phase one of the Australian Curriculum*. Australian Curriculum and Assessment Authority. Retrieved 2 January 2011 from [http://www.acara.edu.au/verve/\\_resources/Statement\\_from\\_Barry\\_McGaw\\_Chair\\_of\\_ACARA\\_29th\\_October\\_2010.pdf](http://www.acara.edu.au/verve/_resources/Statement_from_Barry_McGaw_Chair_of_ACARA_29th_October_2010.pdf).
- Ministry of Education, Victoria. (1989). *Reality in Mathematics Education: Activity bank (RIME Primary Mathematics)*. Melbourne: Ministry of Education.
- O'Brien, T. C. (1983). Five essays on computers in education. *The Phi Delta Kappan*, 65(2), 110–112. Retrieved 7 November 2010 from <http://www.jstor.org/stable/20386929>.
- Pannizzon, D., & Pegg, J. (2007a). Enhancing student achievement in mathematics: Identifying the needs of rural and regional teachers in Australia. In J. Watson & K. Beswick (Eds.), *Mathematics: Essential research, essential practice. Proceedings of the 30th annual conference of the Mathematics Education Research Group of Australasia* (pp. 585–590). Adelaide: MERGA.
- Panizzon, D., & Pegg, J. (2007b). Chasms in student achievement: Exploring the rural-metropolitan divide [online]. *Education in Rural Australia*, 17(2), 3–20. Retrieved 14 December 2010 from <http://search.informit.com.au.ezproxy-m.deakin.edu.au/documentSummary;dn=287612265364606;res=IELHSS>.
- Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. New York: Basic Books.
- Phillips, R. J. (1982). An investigation of the microcomputer as a mathematics teaching aid. *Computers in Education*, 6(1), 45–60.

- Selwyn, N., Potter, J., & Cranmer, S. (2009). Primary pupil's use of information and communication technologies at school and home. *British Journal of Educational Technology*, 40(5), 919–932.
- Straker, A. (1987). The challenge to change: 1987 Presidential Address. *The Mathematical Gazette*, 71(457), 179–193. Retrieved 7 November 2010 from <http://www.jstor.org/stable/3616759>.
- Tanner, H., Jones, S., Kennewell, S., & Beauchamp, G. (2005). Interactive whole class teaching and interactive white boards. In P. Clarkson, A. Downton, D. Gronn, M. Horne, A. McDonough, R. Pierce, & A. Roche (Eds.), *Building connections: Research, theory and practice, Proceedings of the 28th annual conference of the Mathematics Education Research Group of Australasia* (pp. 720–727). Melbourne: MERGA.
- Trouche, L., & Drijvers, P. (2010). Handheld technology for mathematics education: Flashback into the future. *ZDM—The International Journal on Mathematics Education*, 42(7), 667–681.
- Villarreal, M. E., & Borba, M. C. (2010). Collectives of humans-with-media in mathematics education: notebooks, blackboards, calculators, computers and ... notebooks throughout 100 years of ICMI. *ZDM—The International Journal on Mathematics Education*, 42(1), 49–62.