Technology use in secondary mathematics classrooms: A survey of Queensland teachers

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Throughout Australia there are moves to promote the integration of information and communication technologies into school education through curriculum initiatives, funding for infrastructure, and development of professional standards for teachers. In secondary school mathematics education the various state and territory syllabuses now permit, encourage, or require teachers and students to use technologies such as computers and graphics calculators in both learning activities and assessment tasks. However, research is needed to examine the nature and extent of teachers' actual use of these technologies and identify factors that support or inhibit their effective integration into mathematics classroom practice. Previous research has often looked generally at teachers' technology use across a wide range of school subjects, or, if specific to mathematics education, has limited the investigation to only one type of technology. Our own research is mathematics-specific but broad in its technology scope. This paper presents selected findings of a state wide survey of mathematics teachers' use of computers, graphics calculators and the Internet in Queensland secondary schools. We report on teachers' confidence with and frequency of use of these technologies, and analyse the role of variables known to be related to technology use, such as access, teaching experience, attitudes, and professional development.

Most Australian state and territory education authorities now regard facility with information and communication technologies as one of the essential capabilities that young people should acquire in order to participate successfully in contemporary social, economic and cultural life (e.g., Department of Education and the Arts, Queensland, 2004; Department of Education and Children's Services, South Australia, 2001; Victorian Curriculum and Assessment Authority, 2004). Frameworks for professional teaching standards that describe what teachers need to know, understand, and be able to do also refer to integration of ICTs as an essential aspect of teacher's professional knowledge and practice (for examples, see the standards frameworks developed by the New South Wales Institute of Teachers, 2005, and the Department of Education and the Arts, Queensland, 2003). Significant funding has also been committed to providing better network infrastructure and access to improve teachers' capacity to manage the curriculum through information and communication technologies (e.g., the *Smart Classrooms* initiative of the Department of Education and the Arts, Queensland, 2005).

In the 1990s mathematics curriculum policy in Australia began to promote the use of technology as a focus and aid to students' learning and understanding of mathematics (Australian Education Council, 1990). The intent of this national policy framework is reflected in the various state and territory mathematics curriculum statements and syllabuses that permit, encourage, or expect use of technologies such as computers, the Internet, graphics calculators or calculators with computer algebra systems. In the current context of educational policy making it sometimes seems to be assumed that supplying schools with hardware and software will increase teachers' use of technology and encourage more innovative teaching approaches that produce improved learning outcomes for students. Yet internationally there is research evidence that this is not necessarily the case (Cuban, Kirkpatrick & Peck, 2001; Wallace, 2004). There is a need, therefore, to examine the nature and extent of teachers' actual use of technologies and identify factors that support or inhibit their effective integration into classroom practice.

Background to the Study

This paper outlines selected findings from a state wide survey of Queensland secondary school mathematics teachers that formed part of a larger project investigating teachers' pedagogical practices and beliefs related to use of technology in mathematics education (Goos, 2003, 2005). The main impetus for this survey came from the revision of the Queensland Senior (Years 11 and 12) Mathematics A, B and C syllabuses in 2001. Mathematics A concentrates on applications for daily living and is described in the syllabus as the mathematics required for intelligent citizenship. Mathematics B and C are more advanced calculus and statistics subjects that prepare students for entry to university science and business courses. The original versions of these syllabuses, written in 1992, *encouraged* the use of technology wherever appropriate to support students' learning. In response to the increasing availability of computers and especially graphics calculators, the revised syllabuses made it *mandatory* to incorporate these resources into a school's learning and assessment programs for Mathematics B and C (see, for example, Queensland Board of Senior Secondary School Studies, 2000). Since Queensland uses school-based assessment rather than external examinations at the end of Year 12, compliance with the syllabuses' technology mandate is checked via accreditation of each school's work program and monitoring of students' assessment portfolios. The revised syllabuses were to be implemented for the first time with Year 11 students in 2002, and then with Years 11 and 12 students from 2003. The timing of our survey was intended to capture teachers' experiences and perceptions during this transition period.

Previous Research on Mathematics Teachers' Use of Technology

A recent large scale survey of US teachers' use of computer-based technology across all levels of schooling (K-12) and a wide variety of subjects found that access to technology, pedagogical beliefs, and exposure to particular technologies were the strongest predictors of how frequently teachers incorporated technology into their lessons (Russell, Bebell, O'Dwyer & O'Connor, 2003). These findings are generally consistent with previous research on how *mathematics* teachers use a broader range of technologies that includes arithmetic and graphics calculators in addition to computers. For mathematics teachers, factors that influence uptake and implementation include: skill and previous experience in using technology; time and opportunities to learn (pre-service education, professional development); access to hardware and software; availability of appropriate teaching materials; technical support; knowledge of how to integrate technology into mathematics teaching; and beliefs about mathematics and how it is learned (Fine & Fleener, 1994; Forgasz & Prince, 2001; Manoucherhri, 1999; Simonsen & Dick, 1997; Walen, Williams & Garner, 2003).

Over the last ten years, several Australasian studies have investigated mathematics teachers' use of technologies such as computers, graphics calculators, and the Internet. Generally these studies have surveyed teachers to investigate issues as access, use, attitudes, and professional development opportunities, and the relationships between these. For example, Thomas (1996) distributed a questionnaire on use of and attitudes towards calculators and computers to every primary and secondary school in New Zealand. Information was sought on frequency of use, the kinds of mathematics topics that involved teaching with computers, types of software available, and reasons for both use and non-use of computers. The major obstacle reported by teachers was lack of access to computers and software, while lack of training and lack of confidence were also identified as significant barriers inhibiting use.

Graphics calculators began to appear in Australian secondary school classrooms in the early 1990s; however, their use by students in high stakes assessment at the end of Year 12

remained problematic for some time. In Victoria, the Board of Studies lifted the ban on students using graphics calculators in the Year 12 external examination in 1997, and Western Australia permitted their use in the corresponding examinations from 1998. The impact of this decision on schools was closely examined in the late 1990s, particularly in relation to student access and teacher beliefs about the benefits for student learning. Tobin, Routitsky and Jones (1999; see also Routitsky & Tobin, 1998) conducted a state wide survey of Victorian secondary schools towards the end of 1997 to assess how teachers viewed graphics calculator use. The aims were to determine the level of ownership or access by students, and to investigate teacher attitudes towards and use of graphics calculators in various mathematics subjects and topics. At the time of the survey about 80% of schools had class sets of calculators, and this and other results suggested strong teacher support for the policy of introducing graphics calculators. Teachers' perceptions of usefulness generally depended on the level of access to the calculators in classrooms.

Very little research has been conducted on Australasian mathematics teachers' use of the Internet for instructional purposes (Goos & Cretchley, 2004). Loong (2003) carried out a small scale study that distributed a web-based survey via a conference and a journal, and drew responses from 63 secondary mathematics teachers from around Australia. The survey asked about frequency of Internet use, ways in which teachers and their students used the Internet for mathematics learning, teachers' competency, and their professional development experiences. Respondents tended to use the Internet for finding information such as articles about research or professional issues, or as a source of data for students to analyse in mathematics lessons. No statistically significant relationships were found between use and competency, professional development, or years of teaching experience.

Survey research such as the studies mentioned above is useful to gain an overview of who is using technology, how, and why, especially at a time when there are new external pressures to incorporate technology into teaching practice. This was the context in which we designed and carried out the surveys of Queensland secondary school mathematics teachers that we describe below. Whereas previous studies often focused on one type of technology – either computers, graphics calculators, or the Internet – our own research investigates teachers' use each of these resources. Previously we have analysed relationships between mathematics teachers' attitudes towards technology and their professional development experiences, and discussed teachers' perceptions of their professional development needs (Goos & Bennison, 2004). In this paper we focus on teachers' use of technology and factors known to be related to use. The paper addresses the following research questions:

1. How often do Queensland teachers use computers, graphics calculators, and the Internet in teaching secondary school mathematics?
2. How confident do these teachers feel in using computers, graphics calculators, and the Internet for mathematics teaching?
3. To what extent is teachers' technology use (frequency and confidence) related to their pedagogical knowledge, beliefs and experience, access to technology, and professional development opportunities?

Methodology

Participants

All secondary schools listed in the Schools Directory of the Education Queensland website in August 2002 were sent a School Technology Survey and Teacher Technology Surveys in September 2002. The number of Teacher Technology Surveys sent was determined by the enrolment shown on the Education Queensland website. Schools with less than 100 students received one Teacher Technology Survey, those with enrolments between

100 and 299 received two, those with enrolments between 300 and 799 received five and those with enrolments of more than 800 received ten. Surveys were sent to the Head of the Mathematics Department in each school. The accompanying letter asked these people to complete the School Technology Survey and a Teacher Technology Survey and to distribute the Teacher Technology Surveys to all teachers currently teaching mathematics in their schools. A Reply Paid envelope was enclosed for the return of the surveys.

Instruments

The surveys were based on instruments used in previous Australasian studies and on international research on factors known to influence mathematics teachers' use of technology. The School Technology Survey was designed to collect information on the mathematics subjects offered by the school, the number of teachers currently teaching mathematics and the availability of technology. For example, respondents were asked to indicate what type of software was available for teaching mathematics, whether students had access to graphics calculators and if so whether this was via class sets, a hire scheme or personal ownership.

The Teacher Technology Survey investigated teaching practice with respect to three types of technology: *computers* (software packages, both general and mathematics specific), the *Internet*, and *graphics calculators*, under the general headings of *Use*, *Access*, *Experience*, *Attitudes*, and *Professional Development* (19 items; 18 asked for a response from the choices provided, one was open ended). The survey also collected demographic information such as gender, tertiary qualifications, years of teaching experience, and current mathematics teaching assignment.

In the section on *Use*, the survey asked teachers how often they used computers, the Internet, graphics calculators, and graphics calculator peripherals such as screen projection units and data logging equipment. They were then asked to indicate their reasons for using technology, and the mathematics topics for which they used it. The section about *Access* to computer laboratories and graphics calculators included questions about student use of technology for assessment tasks. Items in the section on *Experience* with technology sought information on how long teachers had been using computers, the Internet and graphics calculators and how confident they felt in using these forms of technology. *Attitudes* towards technology were investigated by having teachers respond to statements about advantages and disadvantages using a Likert-type scale based on scores of 1 (Strongly Disagree) to 5 (Strongly agree), with a score of 3 corresponding to Undecided. Teachers were asked about their *Professional Development* experiences on the use of computers, the Internet and graphics calculators in mathematics teaching: whether they have had professional development in these areas, how it was delivered, and how useful they found it. They were also invited to describe what they saw as their current need for professional development in the area of using technology in teaching mathematics.

Both instruments were piloted with a group of ten secondary school mathematics teachers, some of whom were Heads of Department. Many of these teachers also distributed copies of the Teacher Technology Surveys to colleagues in their schools. Pilot respondents considered that the items were generally clearly worded and the time taken to complete the surveys was reasonable. The surveys were then distributed to schools as described previously.

Results

Response Rate

School Technology Surveys were sent to 456 schools (257 government, 199 non-government) in all 33 Education Districts throughout Queensland. Of these, 89 (20%) were

returned. The response rate for government and non-government schools was identical (20%). A total of 2594 Teacher Technology Surveys was also sent to these 456 schools, with 485 surveys being returned by teachers in 127 schools. These returns represent 19% of the surveys distributed, and 28% of the schools. Again, the same response rate was recorded for government (283, 19%) and non-government (203, 19%) schools. Responses were received from schools in all Education Districts except Chinchilla and Torres Strait Islands.

School Technology Contexts

As the year in which the data were collected was the first in which the new Senior Mathematics syllabuses were implemented, it is useful to look at the number of Year 11 Mathematics B and C classes in each school, since these are the subjects for which use of higher technologies was now mandated. A total of 82 out of the 89 schools in the sample offered Year 11 Mathematics B, with most of these schools (86.5%) having between one and four classes. Only 68 schools offered Year 11 Mathematics C, and almost all of these (65 schools) had only one class. Thus the majority of schools returning surveys had three or more Year 11 classes needing access to computers or graphics calculators in order to satisfy syllabus requirements. (In subsequent years this figure would double as the syllabus moved into full implementation in both Years 11 and 12.)

Most schools reported using graphics calculators (77, 86.5%); however, student access was more often than not via class sets (65 schools, 73.0%) rather than hire schemes (28 schools, 31.5%) or personal ownership (22 schools, 24.7%). Two-thirds of teachers using class sets reported having good access, saying they could obtain calculators often or always when needed. It is clear from these figures that schools were using a combination of approaches to providing students with graphics calculators. Nevertheless it is of some concern that significant numbers of students did not have continuous personal access this inexpensive, portable technology, especially when one-third of teacher respondents stated that they could never or only rarely get access to computer laboratories for their mathematics classes when they wanted to.

Teacher Characteristics

Of the 485 teachers who returned surveys, 55.2% were male and 44.8% female. Around half were teaching a junior secondary class, 30-35% a senior secondary Mathematics B class, and 13-14% a Mathematics C class. Thus around one-third of respondents taught classes for whom higher technologies were now a mandatory part of learning and assessment experiences, as prescribed by the Senior Mathematics syllabuses. Most (79.4%) respondents had specialised in mathematics curriculum in their pre-service program, with the remainder having no formal qualifications for teaching secondary mathematics (including 4.3% who had a primary school teaching qualification). Participants were asked to state the number of years they had been teaching, and for convenience their responses have been grouped into the categories shown in Table 1. People who had been teaching for more than 15 years (57.3%) probably would not have been introduced to educational uses of computers in their pre-service programs, and those teaching for more than 5 years (84.6%) would not have learned to how to use graphics calculators before starting their teaching careers. This places a premium on effective professional development that focuses not only on the procedural aspects of learning to use technology, but also on how to integrate technology into classroom practice in ways that enhance students' mathematics learning.

Table 1
Years Teaching Experience of Respondents to Teacher Technology Questionnaire

Number of Years	Number	Percentage
< 5	70	14.4
5-9	66	13.6
10-14	66	13.6
15-19	61	12.6
≥ 20	217	44.7
missing	5	1.0
Total	485	100.0

There were differences in teachers' levels of experience in using different kinds of technology to teach mathematics (as shown in Table 2). While only 12.3% of respondents had been using the Internet with mathematics classes for more than five years, 26.6% had begun to use graphics calculators and 42.7% computers within this time frame.

Table 2
Teachers' Years of Experience in using Technology in Mathematics Teaching

	Years Experience (Number and *percentage* of respondents)				
Type of Technology	<1 year	1-2 years	2-5 years	5-10 years	>10 years
Computers	69	57	138	115	92
	(14.2)	*(11.8)*	*(28.5)*	*(23.7)*	*(19.0)*
Internet	115	104	162	55	5
	(23.7)	*(21.4)*	*(33.4)*	*(11.3)*	*(1.0)*
Graphics calculators	85	83	149	111	18
	(17.5)	*(17.1)*	*(30.7)*	*(22.9)*	*(3.7)*

Note. n = 485. Missing data not tabulated.

Confidence in Using Technology to Teach Mathematics

Table 3 shows that more teachers expressed lack of confidence in using graphics calculators (28.0%) than the Internet (23.9%) or computers (18.8%). Teachers may be more comfortable using computer-based applications because they are accustomed to using computers in other subject areas, for planning and administrative tasks, and in their daily lives outside school; on the other hand, graphics calculators are used specifically for mathematics teaching and it takes time and effort to learn how to use them effectively. This observation may explain teachers' greater uptake of professional development on the use of graphics calculators for mathematics teaching (70.9% of respondents) than for computers (63.5%) and the Internet (33.4%) (although uptake may also reflect availability of professional development targeting the various types of technology).

Table 3
Teachers' Levels of Confidence in using Technology in Mathematics Teaching

	Level of Confidence (Number and *percentage* of respondents)		
Type of Technology	Not confident	Confident	Very confident
Computers	91	164	228
	(18.8)	*(33.8)*	*(47.0)*
Internet	116	143	222
	(23.9)	*(29.5)*	*(45.7)*
Graphics calculators	136	116	230
	(28.0)	*(23.9)*	*(47.4)*

Note. n = 485. Missing data not tabulated.

How Often Technology is Used in Teaching Mathematics

Teachers were asked to indicate how often they used computers, the Internet and graphics calculators for each year level and mathematics subject they taught. Results, expressed as the percentages of respondents teaching each subject and year level combination, are shown in Tables 4, 5 and 6. Some response categories were collapsed as follows to simplify analysis and presentation of results: the "Never" and "Rarely" categories were combined to indicate that technology was used infrequently, and the "Often" and "Almost Daily" categories were combined to indicate frequent use.

Several trends are apparent by examining the percentage of teachers who sometimes or frequently use each type of technology and comparing use between and within year levels and subjects. First, it seems that teachers use *computers* more often with senior secondary mathematics classes than with junior secondary classes; they use the *Internet* more often with senior Mathematics A and C classes than with Mathematics B or junior secondary classes; and they use *graphics calculators* more often with senior Mathematics B and C classes than with Mathematics A or junior secondary classes. Second, computers are generally the most commonly used technology in the *junior secondary* years (although graphics calculators are being introduced in many Year 10 classes) and in senior *Mathematics A*, while graphics calculators are the dominant technology in *Mathematics B and C*. These trends may reflect the allocation of scarce resources, in the form of access to computer laboratories, to classes that are deemed to have priority because of syllabus requirements (i.e., senior classes), and the nature of topics taught in the senior secondary mathematics subjects (graphics calculators are most useful for the algebra/calculus/statistics topics taught in Mathematics B and C). Third, there is generally more frequent use of technology in *Year 11* than Year 12 mathematics classes, possibly because the revised syllabuses that mandated technology use were being implemented only in Year 11 at the time the survey was completed.

Table 4
How Often Computers are Used in Teaching Mathematics

	Percentage of Respondents		
Year level and Subject	Infrequently	Sometimes	Frequently
Year 8 mathematics	67.4	27.4	5.3
Year 9 mathematics	73.2	24.8	2.0
Year 10 mathematics	66.4	29.6	4.0
Year 11 Mathematics A	44.5	45.2	10.3
Year 11 Mathematics B	46.3	40.8	11.9
Year 11 Mathematics C	52.3	38.5	9.2
Year 12 Mathematics A	64.0	30.9	5.1
Year 12 Mathematics B	54.1	38.1	7.7
Year 12 Mathematics C	47.4	45.8	6.8

Table 5
How Often the Internet is Used in Teaching Mathematics

	Percentage of Respondents		
Year level and Subject	Infrequently	Sometimes	Frequently
Year 8 mathematics	88.1	11.0	1.0
Year 9 mathematics	89.7	9.8	0.4
Year 10 mathematics	87.6	12.0	0.4
Year 11 Mathematics A	69.2	28.8	2.1
Year 11 Mathematics B	81.5	17.3	1.2
Year 11 Mathematics C	70.3	25.0	4.7
Year 12 Mathematics A	76.2	21.6	2.2
Year 12 Mathematics B	87.9	12.0	0.0
Year 12 Mathematics C	72.5	24.1	3.4

Table 6
How Often Graphics Calculators are Used in Teaching Mathematics

	Percentage of Respondents		
Year level and Subject	Infrequently	Sometimes	Frequently
Year 8 mathematics	91.3	5.3	3.3
Year 9 mathematics	81.9	13.6	4.5
Year 10 mathematics	58.6	26.1	15.3
Year 11 Mathematics A	62.3	26.0	11.6
Year 11 Mathematics B	5.3	14.7	80.0
Year 11 Mathematics C	4.5	7.6	87.9
Year 12 Mathematics A	77.6	12.7	9.7
Year 12 Mathematics B	14.0	28.7	57.3
Year 12 Mathematics C	5.0	18.3	76.7

Factors Related to Technology Use in Mathematics Teaching

Drawing on previous research in this area, we investigated possible relationships between mathematics teachers' use of technology and three sets of factors known to affect this use: pedagogical knowledge, beliefs, and experience; access to technology; and professional development opportunities. Table 7 shows the data sources for each of these factors and the nature of responses.

Table 7
Data Sources – Factors Affecting Technology Use

Factors affecting technology use	Data sources from Questionnaire	Response categories
Pedagogical knowledge, beliefs, and experience	Years teaching experience	<5, 5-9, 10-14, 15-19, ≥20
	Years experience using technology in teaching mathematics	<1, 1-2, 2-5, 5-10, >10
	Attitudes towards technology (4 statements)	Disagree, Undecided, Agree
Access to technology	Access to computer laboratories or class sets of graphics calculators	Poor (never or rarely), Fair (sometimes), Good (often, always)
	School size	Small (<500 students), Medium (500-999), Large (≥1000)
	School sector	Government, Catholic, Independent
Professional development opportunities	Have had professional development in using computers or graphics calculators in teaching mathematics	Yes/No

These relationships were analysed by conducting chi-square tests of the frequency distributions obtained by cross-tabulating responses to items measuring *how often* technology

is used with responses to the three sets of items listed in Table 7. A similar analysis was also conducted to test the relationships between *confidence* in using technology and exposure to technology as measured by years of experience in using technology to teach mathematics, access to technology, and professional development opportunities. In this paper the analyses focus only on technology use in Year 11 mathematics because it was with this group of students that teachers were implementing the revised syllabuses, with their technology requirements, for the first time. Where questionnaire items referred to particular types of technology we selected responses relating to use of *graphics calculators* in Year 11 Mathematics B and *computers* in Year 11 Mathematics A, as these were the most commonly used technologies respectively (as explained above). Use of technology in Mathematics C classes was not included in this analysis due to the small enrolments in this subject compared with Mathematics A and B (refer to information provided in the section on school technology contexts). Results are presented in Tables 8 and 9.

Table 8
Analysis of Relationship between Graphics Calculator Use (Year 11 Mathematics B), Pedagogical Knowledge, Beliefs and Experiences, Access, and Professional Development

	Use of Graphics Calculators	
Factors affecting use	How often used	Confidence
Years teaching experience	n.s.	n.s.
Years experience using graphics calculators in teaching mathematics	n.s.	χ^2 (8) = 164.4 $p < 0.001$
Attitudes towards technology:		
Technology helps students to understand concepts.	χ^2 (4) = 15.42 $p = 0.004$	N/A
Technology makes sophisticated concepts accessible to students.	χ^2 (4) = 9.18 $p = 0.057$	
Technology helps students to explore unfamiliar problems.	χ^2 (4) = 13.05 $p = 0.011$	
Technology improves student attitudes towards mathematics.	n.s.	
Access to class sets of graphics calculators	χ^2 (4) = 64.52 $p < 0.001$	χ^2 (4) = 14.76 $p = 0.005$
School size	n.s.	N/A
School sector	χ^2 (4) = 12.93 $p = 0.012$	N/A
PD on use of graphics calculators in teaching mathematics	χ^2 (2) = 13.57 $p = 0.001$	χ^2 (2) = 72.58 $p < 0.001$

Teachers who frequently used graphics calculators in Year 11 Mathematics B lessons were more likely than others to have good access to class sets (i.e., could obtain them often or always when needed), to have received professional development on the use of graphics calculators in teaching mathematics, and to be working in an independent school rather than a government or Catholic school. These teachers were also more likely than infrequent users to agree with statements about technology supporting concept learning and exploration of unfamiliar problems; however no causal relationships can be inferred here. It is not clear whether frequent use of graphics calculators in the classroom led teachers to develop these beliefs, or teachers already convinced of the benefits of technology simply embraced graphics

calculators when they became available. No statistically significant differences were found between the observed and obtained classifications of frequency of use against school size, years of teaching experience, or years of experience using graphics calculators in teaching mathematics. However, confidence was related to teaching experience and other measures of exposure to technology. Teachers with as little as two years experience in using graphics calculators in the mathematics classroom were more likely than less experienced colleagues to say they were confident or very confident with this type of technology; nevertheless, achieving these levels of confidence was also related to having good access to class sets and professional development opportunities.

Table 9
Analysis of Relationship between Computer Use (Year 11 Mathematics A), Pedagogical Knowledge, Beliefs and Experiences, Access, and Professional Development

	Use of Computers	
Factors affecting use	How often used	Confidence
Years teaching experience	n.s.	χ^2 (8) = 25.77 p = 0.001
Years experience using computers in teaching mathematics	n.s.	χ^2 (8) = 53.56 p < 0.001
Attitudes towards technology:		
Technology helps students to understand concepts.	n.s.	N/A
Technology makes sophisticated concepts accessible to students.	n.s.	
Technology helps students to explore unfamiliar problems.	n.s.	
Technology improves student attitudes towards mathematics.	n.s.	
Access to computer laboratories	χ^2 (4) = 16.98 p = 0.002	χ^2 (4) = 14.01 p = 0.007
School size	n.s.	N/A
School sector	n.s.	N/A
PD on use of computers in teaching mathematics	n.s.	χ^2 (2) = 6.97 p = 0.031

A somewhat different picture emerges from the analysis of factors related to use of computers, this time in Year 11 Mathematics A classes. Confidence was still related to exposure to computers – teachers experienced in using computers for teaching mathematics, having access to computer laboratories often or almost always when needed, and having received professional development indicated the highest confidence levels – but teachers who were new to the profession (those with less than five years experience) reported greater confidence with computers than their more experienced colleagues. As suggested by Russell et al. (2003), it may be that younger teachers develop comfort with computers while growing up with this technology. Even so, access to computer laboratories was the only factor related to how often computers were actually used in mathematics lessons.

Implications

The research reported in this paper has provided information on Queensland secondary mathematics teachers' use of computers, the Internet and graphics calculators at a time when integration of technology into Year 11 and 12 mathematics was becoming mandatory. The

first set of findings sheds light on how often teachers use these technologies and how confident they feel in doing so. In the absence of any technology-related syllabus requirements for junior secondary mathematics, it was perhaps not surprising to find that each type of technology was used more frequently in Years 11 and 12 than in Years 8, 9, and 10. Graphics calculators were a priority for senior Mathematics B and C classes, although use of this technology was also quite high in Year 10. Teachers may be introducing graphics calculators at this point to prepare Year 10 students who are planning to take Mathematics B in Year 11. Computers were the most commonly used type of technology in Mathematics A, a subject usually taken by students who are not intending to study mathematics at university. However, teachers found it difficult to gain access to computer laboratories for mathematics classes and this seems to disadvantage Mathematics A students in particular: around one half of teachers reported that they never or rarely used computers with Year 11 and 12 Mathematics A classes, but only five to fifteen per cent said they never or rarely used graphics calculators with senior Mathematics B and C classes. A substantial majority of respondents felt confident or very confident in teaching mathematics with these three types of technology, although there were differences in confidence levels when using computers, the Internet, and graphics calculators.

A second set of findings is concerned with factors affecting technology use. Previous research in Australia, New Zealand, and the USA has found that mathematics teachers' use of technology is related to several factors that we have categorised as pedagogical knowledge, beliefs, and experience, access to technology, and professional development opportunities. Our analysis showed that confidence in using both computers and graphics calculators (with Year 11 classes) was related to exposure to these technologies, as measured by access, professional development, and technology-specific teaching experience. Access was also important in relation to how often teachers used computers and graphics calculators with their classes; in fact, for computers this was the only factor linked to frequency of use. There were additional connections between teachers' use of graphics calculators, professional development on their use, and positive beliefs about the role of this technology in supporting mathematics learning. Taken together, our findings regarding frequency of technology use and factors related to use seem to suggest that teachers view graphics calculators as a mathematics-specific teaching and learning resource, more readily accessible than computers, but requiring targeted professional development to overcome their lack of experience with this relatively recently introduced technology.

These results also lead us to ask how mathematics teachers might best be supported in using technology effectively with their classes, especially when implementing senior syllabuses that require technology to be used in learning and assessment tasks. Confidence grows with teaching experience, but a more proactive approach to increasing teachers' comfort with and use of technology needs to address issues of access to computers and graphics calculators, and professional development. Previously we reported that teachers' own perceptions of their professional development needs in this area centred on three issues: time, access, and technology integration (Goos & Bennison, 2004). Time was an issue for around 20% of the teachers who responded to an open ended questionnaire item asking about their current needs for professional development – their most pressing need was more time to develop resources, plan lessons and curriculum units, and explore and evaluate the technology, preferably in collaboration with colleagues. Many expressed the desire to simply "play" with the technology to gain a better understanding of its potential uses. Access was also cited as a problem by 12.0% of respondents. For example, one teacher pointed out that it was "pointless to do PD without having regular access to a computer lab and appropriate software". But the most striking aspect of responses to this question was the large number of teachers (33% of respondents) who wanted professional development on how to effectively

integrate technology into the teaching and assessment of mathematics, especially in the context of the syllabus or the school's work program. Most of these were interested in learning how to "plan activities that combine technology with mathematical concepts" in order to meaningfully incorporate technology into lessons.

While simple notions of "use", "confidence", and "access" are inadequate for understanding the roles that technology plays in mathematics teaching and learning, the findings presented here have clear implications for the resourcing of schools with respect to equipment and in-service education and point to the need for further research that investigates how and under what conditions teachers learn to effectively integrate technology into their practice.

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