GRAPHICS CALCULATORS FOR MATHEMATICS LEARNING IN SINGAPORE AND VICTORIA (AUSTRALIA): TEACHERS' VIEWS

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In this paper, findings from a study in which Singaporean and Victorian (Australia) mathematics teachers' views on the use of graphics calculators for mathematics learning were compared. The results indicated that Victorian teachers were more enthusiastic about graphics calculators than Singaporean teachers. It was speculated that one of the main reasons for the differences in the teachers' views stemmed from the fact that graphics calculators are mandated for grade 12 examinations in Victoria while this is not the case in Singapore.

BACKGROUND TO THE STUDY

Graphics calculators first appeared in 1985 (Kissane, 1995). Since then, their use has been included in the mathematics curricula of several countries. According to Waits and Demana (1994), the US National Council of Teachers of Mathematics [NCTM] *Curriculum and Evaluation Standards* for grades 9-12 included the assumption that graphics calculators would be available to all students at all times. Various European countries and some Australian states have similar policy expectations (e.g., Brown, 1999).

As the use of graphics calculators becomes more widespread, it is important to expand beyond studying the effects of calculators on students' learning. In this study, senior secondary mathematics teachers' views on graphics calculators in two regions, Singapore and Victoria (Australia), were compared.

GRAPHICS CALCULATOR POLICIES IN SINGAPORE AND VICTORIA

In 1997, Victoria was the first state in Australia to adopt the use of graphics calculators in grade 12 Victorian Certificate of Education [VCE] external examinations (Brown, 1999; VCAA, 2003). Graphics calculators had been introduced in two stages: a *neutral* format in which students without calculators were not disadvantaged, and *assumed access* in which all students were expected to have access to graphics calculators (Stacey, McCrae, Chick, Asp & Leigh-Lancaster, 2000; VCAA, 2003).

Since 2002, only a small group of mathematically inclined students taking the subject Further Mathematics at the senior secondary levels in Singapore were allowed to use graphics calculators in their examinations (Lee, 2005). The majority of students studied the subject Mathematics, and graphics calculators were not allowed in the

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examinations. Graphics calculators will be introduced more widely into the revised mathematics curriculum at the senior secondary level (Junior College Years 1 and 2) in 2006 (Ministry of Education Singapore, 2005).

OBJECTIVES OF THE STUDY

In this paper, findings are reported from a larger study involving the comparison of Singaporean and Victorian teachers' perceptions towards computers and graphics calculators (Tan, 2005). The objectives of the study included comparisons of how graphics calculators were used in the two regions, and of teachers' beliefs about the usefulness of graphics calculators for mathematics learning.

PREVIOUS RESEARCH

Previous research findings suggest that teachers' educational beliefs shape their lesson planning, instructional decisions, and classroom practices (e.g., Pajares, 1992). In their review of 14 research studies on graphics calculators, Burrill et al. (2002) found that "teachers generally use handheld graphic technology as an extension of the way in which they have always taught" (p. iv), and that their knowledge, beliefs and personal philosophies influenced how they used calculators in their teaching.

Singaporean teachers' use and views of graphics calculators

Possibly due to the recency of the introduction of graphics calculators, there is not much research about their use by Singaporean teachers. It is not generally known how widespread the use of graphics calculators is in Singapore.

Lam and Kho (2002) noted that junior college mathematics teachers were concerned about changes in the types of examination questions if graphics calculators were permitted, and the impact that these changes would have on teaching and learning. In a pilot study on the use of computer algebra system (CAS) calculators with two classes of secondary school students in Singapore, Ng (2003) found no significant achievement differences between students who used and those who did not use the calculators. It was also found that the teacher who taught the non-CAS-based lessons conducted extra lessons between class tests and, according to the Head of Department, might have been trying to "counteract the effect of the intervention" (Ng, 2003, p.242) by setting difficult questions which, it was found, the non-CAS students tended to be able to handle better. While not generalisable, the findings of the two studies reveal some beliefs and reservations Singaporean teachers have with introducing new technology into the classroom.

Victorian teachers' use and views of graphics calculators

When graphics calculators were introduced into the VCE examinations in 1997, the Victorian Board of Studies supported a state-wide research study to assess the impact of graphics calculators in schools. In a report of the findings, Routitsky and Tobin (2001) reported that a majority (77.6%) of the 1071 mathematics teachers surveyed

indicated that they had used graphics calculators in their classrooms. It was also reported that teachers were generally supportive of the Board's policy to introduce graphics calculators in assessment. When they disagreed, their disagreement was strongly associated with limited graphics calculator access in the classroom for students or teachers. These findings suggested that access to graphics calculators and teachers' support for graphics calculators are strongly influenced by assessment policy.

Kissane (2000) suggested that in Australia graphics calculators were widely available and were used by students in states which allowed or mandated their use in formal assessment, and were rarely used in those states which did not.

METHODOLOGY

The sample of senior mathematics teachers in this study included those teaching Years 1 and 2 in junior colleges in Singapore, and grades 11 and 12 in independent (non-government, non-Catholic) schools in Victoria. Singapore's two years of junior college and grades 11 and 12 in Victoria are similar in that they comprise the final years of schooling leading to university entrance. Five junior colleges out of 15 in Singapore and 14 out of 116 independent schools in Victoria participated. Mathematics teachers from participating schools completed an anonymous survey on their use and views of technology, including graphics calculators.

The survey instrument was designed based on instruments from past research studies on teachers' use and beliefs of technology (e.g., Becker & Anderson, 1998; Fogarty et al. 2001; Forgasz, 2002; Lim et al., 2003; Tobin, Routitsky, and Jones, 1999). A five-point Likert-type response format was used wherever possible. Examples of items are found in the discussion section of this paper.

ANALYSES OF RESULTS AND FINDINGS

Profile of teachers

Thirty-three teachers (16M, 16F, 1?) from five junior colleges in Singapore and 35 teachers (19M, 16F) from 14 independent schools in Victoria participated in the study. The Singaporean teachers were generally younger than the Victorian teachers. Most (n=22, 71%) of the Singaporean teachers were less than 40 years old, with 14 (45.2%) of them between 30 and 39 years old. In contrast, most (n=25, 71.4%) of the Victorian teachers were at least 40 years old, with 16 (45.7%) between 40 and 45 years old.

Number of years of graphics calculator use for mathematics teaching

Teachers were asked to indicate the number of years they had used graphics calculators for teaching mathematics. The data revealed that a higher proportion of Victorian than Singaporean teachers had used graphics calculators for a long time.

Almost half of the Singaporean teachers (15 out of 31, 48.4%) had not used graphics calculators or had only used them for less than a year, whereas all of the Victorian teachers (N=35) had used graphics calculators in their teaching for some years.

Teachers' access to graphics calculators

A majority of the Singaporean teachers (n=24, 72.7%) had personal access to graphics calculators. In Victoria, all 35 teachers had personal access to graphics calculators, sometimes more than one type of graphics calculator and/or calculators with Computer Algebra System (CAS).

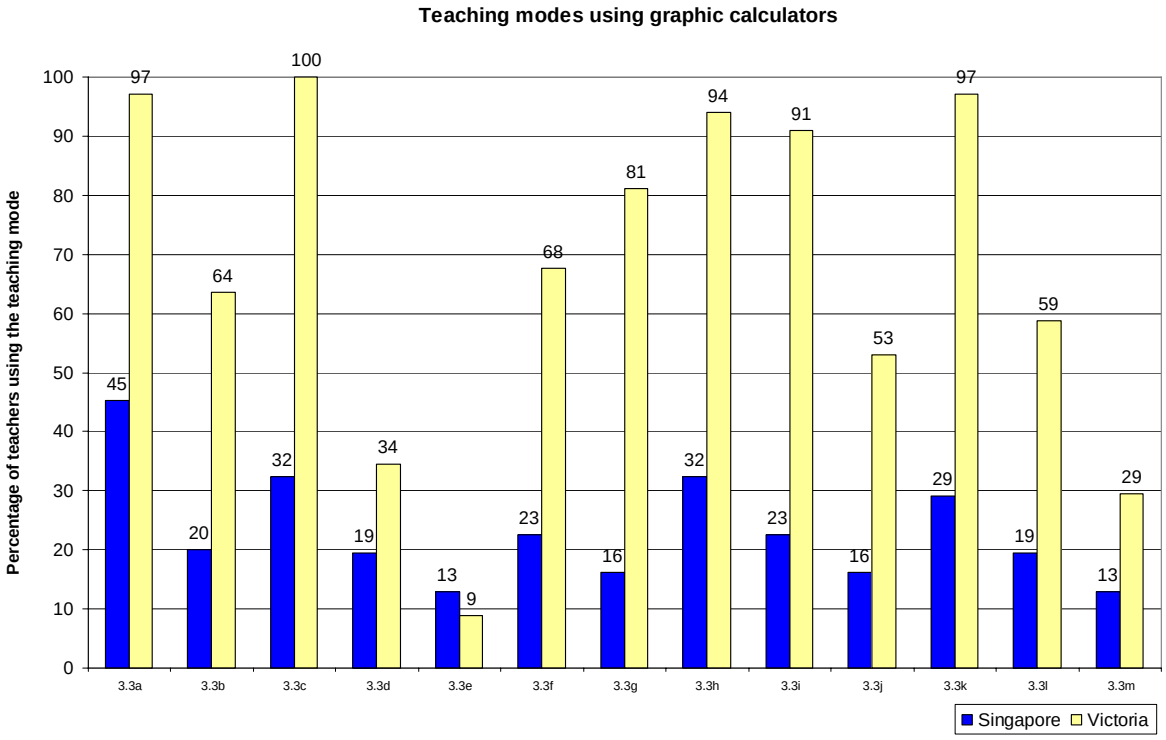
Teachers' graphics calculator skills

When asked to rate their current level of graphics calculator skills, using three categories (Beginner/ Average/ Advanced), Victorian teachers' perceptions of their skills were much higher than those of the Singaporean teachers. More than half the Singaporean teachers (n=19, 57.6%) claimed to be at Beginner level, and only two teachers (6.1%) at the Advanced level. In contrast, only one Victorian teacher (2.9%) indicated being at Beginner level, with more than half of the Victorian teachers (n=18, 51.4%) claiming to be at the Advanced level. This difference in perceived competency resonated with other findings from the study which showed that a higher proportion of Victorian than Singaporean teachers had personal access to graphics calculators and had used them for a long time.

How are graphics calculators used in the two regions?

Survey question 3.3 asked teachers to indicate their frequencies of technology use in 13 different teaching modes, ranging from teacher demonstration to cooperative learning. The frequencies were recorded as follows: 1=not used, 2=once in 6 months, 3=once in 3 months, 4=once in a month, 5=once a week, and 6=more than once a week. To simplify comparisons, the responses were re-coded into "Used" (Responses 2 to 6) and "Not Used" (Response 1) for each teaching mode. Figure 1 shows the valid percentages of teachers who indicated having used calculators for each teaching mode.

From Figure 1 it can be seen that except for using calculators "as a reward" (3.3e), higher proportions of Victorian than Singaporean teachers had used graphics calculators in the remaining 12 teaching modes. It can also be seen that more than 90% of the Victorian teachers had used graphics calculators for: teacher demonstration (3.3a), students working individually (3.3c), students checking their working and answers (3.3h), students doing more challenging questions (3.3i), and as a problem-solving or decision making tool (3.3k). Fewer than 50% of the Victorian teachers had used graphics calculators for: cooperative learning (3.3d), as a reward (3.3e), and as a classroom presentation tool by students (3.3m).



Teaching modes:

3.3a Teacher demonstrations/lectures
3.3b Students work in small groups
3.3c Students work individually
3.3d Cooperative learning
3.3e As a reward for students
3.3f Individual instruction for weaker students
3.3g Individual instruction for better students
3.3h Students use graphics calculators to check their working and answers
3.3i Students use graphics calculators to do more challenging questions
3.3j Students use graphics calculators as a research tool

Figure 1. Percentages of teachers using graphics calculators in various teaching modes.

As discussed earlier, graphics calculator use is mandated in the VCE examinations. This could explain why there were exceptionally high proportions of Victorian teachers (more than 90%) using graphics calculators in the five ways listed above. These modes of teaching appear to be examination-focused, since students taking VCE examinations have to work individually to solve difficult and challenging mathematics problems using graphics calculators. Interestingly, the three teaching modes that were used by fewer than 50% of the Victorian teachers appear to be non-examination related.

Fewer than 50% of the Singaporean teachers indicated using graphics calculators for each teaching mode. This finding is consistent with Singaporean teachers having only used graphics calculators for a short time and as being novice users of the tool.

Singaporean and Victorian teachers' views towards the usefulness of graphics calculators for learning Mathematics

Question 1.21 of the survey asked teachers if they believed that using graphics calculators helped their students understand mathematics better (Yes / No / Unsure) and to explain their responses. The percentages of responses for the Singaporean and Victorian teachers are shown in Figure 2.

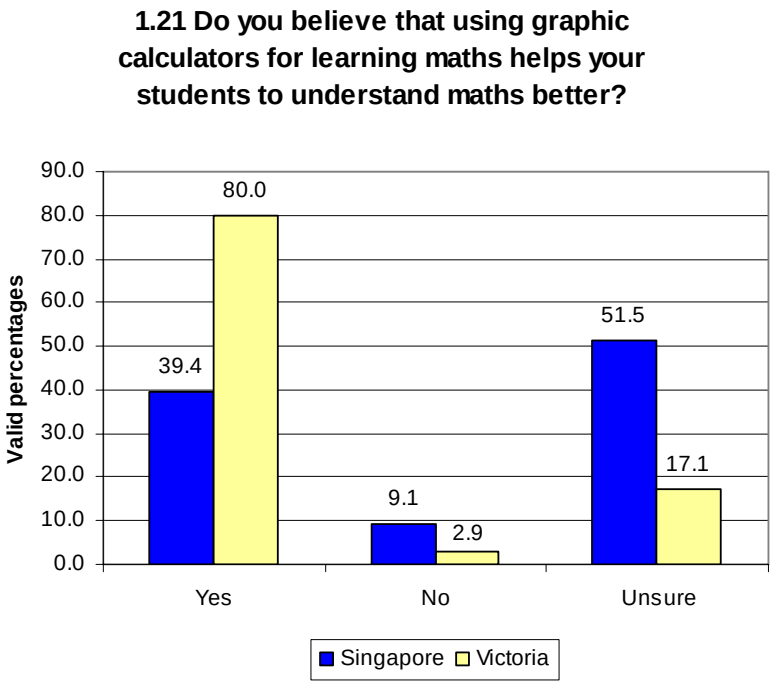


Figure 2. Teachers' beliefs of the usefulness of graphics calculators

It can be seen in Figure 2 that a much higher proportion of Victorian (n=28, 80%) than Singaporean (n=13, 39.4%) teachers agreed that graphics calculators helped students understand mathematics better. The most frequent reasons they provided in support of their views related to the usefulness of graphics calculators in providing graphical representations, saving time from tedious calculations and sketching, allowing students to explore mathematical properties, motivating students, and aiding investigations and explorations by students.

The Singaporean teachers were generally more uncertain about the usefulness of graphics calculators (n=17, 51.5%) than were Victorian teachers (n=6, 17.1%). A few Singaporean teachers explained that they were unsure because they "have yet to use it" and had "no basis for drawing conclusions". These findings are consistent with other findings reported by the Singaporean teachers': their low usage of graphics calculators (48.5% of teachers had not used them), and low graphics calculator skill levels (57.6% at beginner level).

CONCLUSIONS

The small sample sizes limit the generalisability of the findings. Thus only the trends or general directions in which the Singaporean and Victorian mathematics teachers differed or concurred in their use of and views about graphics calculators are commented on. Nevertheless, it was clear from the data that the use of graphics calculators was pervasive in Victoria where their use is mandated, and that the Victorian mathematics teachers were more enthusiastic about them, and used them more frequently and in more varied ways than the Singaporean teachers.

The data from this study strongly suggest that there is a relationship between national or state assessment policy and teachers' use and views of graphics calculators; it will be interesting to see if Singaporean teachers' views change in response to the broader use of graphics calculators associated with changes to the senior mathematics curriculum in 2006. Further research is needed to identify more clearly the relationships between assessment, pedagogical uses of technology, and teachers' beliefs about the usefulness of technology.

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