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## **Teachers' views of calculators for students with learning disabilities**

**Anne Bayetto and Shirley M. Yates**

**Flinders University • Adelaide • Australia**

*Although calculators were introduced into Australian primary schools in the 1980s, their use in mathematics lessons by students with learning difficulties (LD) remains controversial. Teacher opinion is sharply divided, ranging from those who believe calculators limit development of computational skills which can only be acquired through pencil and paper practice to those who consider calculators reduce the burden of computation, provide opportunities for mathematical thinking and enhance confidence and achievement for students with LD. However, despite sound research evidence of the efficacy of calculators for students with LD, calculators continue to be underutilised in mathematics. Forty-nine primary teachers who had voluntarily enrolled in a professional development (PD) programme focused on using calculators with LD students were surveyed in relation to their views about calculators for students with LD and beliefs about mathematics and its teaching and learning. Results confirm a breadth of teacher opinion about calculators, with those scoring high on constructivist approaches to mathematics teaching expressing more favourable attitudes towards calculators as did those espousing strong beliefs about the beauty and meaningfulness of mathematics. These findings have implications for teacher PD and decision making, particularly in relation to teachers who are reticent about using calculators with students with LD.*

Calculators have been available in schools since the 1980s but their use continues to be controversial (Hembree & Dessart, 1992; Horton, Lovitt & White, 1992; McCauliff, 2004, Reys & Arbaugh, 2001; Seeley, 2006; Southwest Educational Development Laboratory (SEDL), 1998; Sparrow & Swan, 2004; Thompson & Sproule, 2005). The initial introduction of calculators into primary schools was met with strong opposition in Australia and overseas and the evidence suggests that this early opposition has continued to exert an influence in the classroom (Howard, 1992). While increasing numbers of calculators have become available in schools (Burke, 2001; Mousley & Herbert, 2000), evidence from research studies indicates they are underutilised as teaching resources for all students in mathematics classrooms (Burke, 2001; Groves, Mousley & Forgasz, 2006). Furthermore, many teachers continue to fear traditional skills will not be learned if calculators are used (Bos & Vaughn 2006; Burke, 2001; Horton et al., 1992), that students will become over-reliant on them (Dresdeck, 1995) and that access to calculators gives students an unfair advantage and is a form of cheating (Reys & Arbaugh, 2001). The latter view is shared by some children who consider using calculators is *not really doing mathematics* (Reys & Arbaugh, 2001, p. 91). While numerous studies have explored teachers' beliefs about mathematics and the teaching and learning of mathematics (Leder & Grootenboer, 2005), few have investigated relationships between their beliefs and views about calculator use (White, 2000). Moreover, there is a paucity of studies in which

teachers' beliefs and views about the use of calculators with students with learning difficulties (LD) have been considered.

In 1987 a *National Statement on the Use of Calculators for Mathematics in Australian Schools* was released by the Australian Association of Mathematics Teachers (AAMT) and endorsed by all Australian education systems. A key recommendation was that teachers should make calculators readily available and *ensure that all* (emphasis added) *students use calculators at all year levels, K-12* (AAMT, 1987, p. 1). For students with learning difficulties (LD) it was stated that calculators provide lower-attaining students with an opportunity to think about mathematical relationships, without the burden of computation. A Statement update affirmed the importance of this earlier position and stressed the need for all students to become *intelligent and critical users of calculators* ((AAMT, 1996, p. 5), particularly as technology is part of students' worlds (Booker, Bond, Sparrow, & Swan, 2004; Meese, 2001). A similar position statement entitled *Computation, Calculators, and Common Sense*, issued in the United States by the National Council of Teachers of Mathematics (NCTM, 2005) stressed the need for *all* (emphasis added) students to have ready access to calculators in schools. This statement reaffirmed the earlier position adopted by NCTM in 1974 that calculators be used at all grade levels. The expectation that the tool would aid algorithmic instruction, support concept development, reduce demand for memorization, enlarge the scope of problem solving, provide motivation, and encourage discovery, exploration and creativity cited by NCTM in 1974 has been borne out by numerous studies (see meta-analyses by Hembree & Dessart, 1986 and Smith, 1997; see also Groves, 1997; Porter, 1990; Stacey & Groves, 1994). Furthermore, use of calculators has not been found to hinder the development of pencil-and-paper skills (Dessart, DeRidder & Ellington, 1999; Smith, 1997; Groves & Stacey, 1998), with some studies reporting children's preference for pencil-and-paper computational methods over calculators or mental computation (Reys, Reys & Hope, 1993; Price & Irons, 1995). While children have diverse views about how and when calculators should be used (Doig, 1993), studies have found most of those who had easy access to calculators enjoyed using them, considered learning mathematics to be more fun with them and perceived use of them to be relatively easy (Hembree & Dessart, 1986). By contrast students with restricted access were more likely to be unsure of the legitimacy of using a calculator.

Students with LD have had varied access to calculators in mathematics lessons depending upon teachers' beliefs, but there is little evidence to suggest that appropriate use of calculators limits development of computation skills in students with LD (Gilliland, 2002; Westwood, 2003). Calculators are an important teaching tool for students with LD as they can relieve the drudgery and tediousness of computation (American Federation of Teachers (AFT), 2001; Gilliland, 2002; Podlesni, 1999) and free up students to develop counting skills and conceptual understandings, learn basic facts, see patterns, check estimates, and allow engagement with real-life problems rather than contrived examples (AFT, 2001; Carnellor, 2004; Reys & Arbaugh, 2001; SEDL, 1998; Winebrenner, 1996). Furthermore, calculators negate the need for students to remember how to write numerals and symbols and support them with recording (Carnellor, 2004; Huinker (2002). This in turn gives students with LD more time to reflect on processes, reasoning, and to select the appropriateness of answers (Reys & Arbaugh, 2001). Calculators are seen as a *way out and up in the curriculum* for students with LD (Horton et al., 1992, page 58) and are also useful from a social learning perspective as they allow students with LD to work with, and learn from, other class members (Carnellor, 2004; Meese, 2001).

Despite the endorsement from policy statements, evidence of the positive value of calculators and their potential to transform teaching (Groves, 1997), teachers have been *in two minds* about the use of calculators with students (Bracey, 1998, p. 473). While some have argued that pencil-and-paper methods should be abandoned altogether in favour of mental computation and calculators (Brown, 1981; Girling, 1977; Maier, 1980; McIntosh, 1990), others have ignored the technological tools available and continued to teach as they have always done (Bates, Greiner, Hampshire, Jolly, Keel, Lancaster, Leake, Locum, Moore, Morton, Moser, Peterson, Simmons & Stewart, 1998). Some have gone as far as to ban calculators from their classrooms, believing that they do not contribute to mathematics learning (Brosnan, Edwards & Erickson, 1996; Ford, 1994; Howard, 1992; Reed, 1986; Rogers, 1983; Schmidt & Callahan, 1992). Many explanations for teachers' reluctance to use calculators with students have been offered ranging from suggestions teachers lack knowledge about how to use calculators (Booker et al., 2004), how to incorporate their use into teaching programs (Bates et al., 1998) and how to extend their use beyond checking answers (Burke, 2001) to thinking and understanding (Bates et al., 1998; Goya, 2006; McCauliff, 2004; Reys & Arbaugh, 2001). Others suggest most teachers did not encounter this technology when learning mathematics at school and *need time to adjust to both a new learning environment and a new teaching one* (Usnick, Lamphere & Bright, 1995, p. 11).

While teacher professional development (PD) has a clear role in fostering the implementation of calculators in mathematics (Porter, 1990) and increasing teacher confidence in their use (Houssart, 1997), attention to teacher beliefs about mathematics and its teaching and learning and their views about the place of calculators in that learning is crucial. Teachers' instructional beliefs affect their classroom practices (Handal & Herrington, 2003; Pajares, 1992; Thompson, 1992) and act as significant mediators in curriculum implementation (Fullan & Stiegelbauer, 1991). Teachers espousing traditional transmission beliefs about mathematics teaching and mathematics learning view mathematics *as a rigid system of externally dictated rules governed by standards of accuracy, speed and memory* (National Research Council, 1989, p. 31) and continue to teach mathematics as they have been taught themselves. Teachers espousing more contemporary constructivist approaches to the teaching and learning of mathematics use calculators more frequently and in student centred lessons (Burke, 2001). Use of calculators for students with LD is imperative if they are to be freed from the mechanics of computation, attendant difficulties of retrieving basic number facts from memory (Russell & Ginsburg, 1984; Torgeson & Young, 1983) and to have opportunities to think mathematically and solve problems (Relich, Badenhop & Martin, 1992). There is an urgent need to investigate ways in which classroom teachers can be assisted to incorporate calculators into their everyday teaching practices (Groves, et al., 2006) particularly with students with LD.

## **THE PRESENT STUDY**

### **Aims of the study**

The study had two aims:

- 1 To investigate experienced teachers' espoused beliefs about mathematics, the teaching of mathematics and the learning of mathematics;
- 2 To examine teachers' views about the use of calculators in mathematics by students with learning difficulties.

## METHOD

### Participants

Fifty experienced teachers who had voluntarily enrolled in a PD programme about the use of calculators by students with LD were approached to participate in the study. One teacher declined to complete the survey but the remaining 49 teachers participated. Of these, 41 were primary teachers, 2 were secondary teachers and the remaining 6 teachers did not indicate whether they taught primary or secondary students. The 47 female and 2 male teachers ranged in age from 28 to 63 years with a median age of 52 years. Twenty-three teachers had a basic teaching qualification, 19 held a Bachelor degree and 7 teachers did not indicate their qualifications. One teacher had completed a major in mathematics in her degree and a second teacher had studied mathematics at the tertiary level. Six teachers indicated that they had previously undertaken some PD about the use of calculators.

### The Survey

The survey consisted of items measuring teachers' age, gender, qualifications, years of teaching mathematics, previous PD about the use of calculators, beliefs about mathematics, beliefs about the teaching of mathematics and learning of mathematics and views about the use of calculators with students with LD. Teachers recorded a unique four letter code on the first page of the survey which was used for data matching purposes and identified their qualifications and length of time teaching mathematics from tables provided. Their beliefs about mathematics and the teaching and learning of mathematics were measured by 11 items selected from a 20 item questionnaire originally developed by Perry, Howard & Conroy (1996) from various mathematics education reform statements (Australian Education Council, 1991; Mumme & Weissglass, 1991; Wood, Cobb & Yackel, 1992) to identify traditional transmission and child centred beliefs about mathematics and its teaching and learning. The 11 items were selected for this study as they had been found to form two factors in a prior study of experienced primary teachers' beliefs about mathematics and its teaching and learning (see Yates, 2006a; 2006b; 2007). In the Yates studies, the response format was amended from the three point rating scale used by Perry *et al.* (1996) to a four point scale ranging from 1 (*strongly disagree*), 2 (*disagree*), 3 (*agree*) to 4 (*strongly agree*). The same 4 point scale was utilised in the current study. Teacher views about the use of calculators by students with LD were measured with 9 items drawn from previous research of teachers' attitudes towards calculators and anecdotal evidence from teacher PD workshops on the use of calculators with students with LD. Teachers rated their agreement with each of 9 statements on the same 4 point scale which ranged from 1 (*strongly disagree*) to 4 (*strongly agree*).

### Procedure

Teachers voluntarily enrolled in a workshop entitled *Using calculators to develop number sense and mathematical thinking* which was offered out of school hours by Specific Learning Disabilities (SPELD) South Australia Incorporated. Surveys were distributed to the 49 teachers immediately prior to the start of the workshop. Completed surveys were collected individually from participants and placed in a sealed envelope.

## RESULTS

All survey data for the 49 teachers were entered into an SPSS programme and measures of central tendency and analyses of variance (ANOVA) conducted. Years of teaching mathematics were categorised in five yearly increments, ranging from 1 - 5 years to the final increment measuring 31 or more years of teaching (31+). Teachers who participated in the study had been teaching mathematics from 1 - 5 years (6 teachers) to 31+ years with a median range of 31+ years. As the sample size was too small for meaningful factor analyses to be conducted, the 11 items measuring teachers' beliefs about mathematics and about the teaching and learning of mathematics (Perry *et al.*, 1996) were aggregated into the two factors that had been identified in a previous study with Principal Components Analysis using an Oblimin two factor resolution (Yates, 2006a). Factor 1 was composed of seven items reflecting teachers' constructivist beliefs about the teaching and learning of mathematics and Factor 2 four items reflecting teachers' beliefs about the beauty and meaningfulness of mathematics. In the Yates (2006a) study, Factor 1 was composed of 8 items, but one of the three reversed items was omitted as its factor loading was identical to that of another item. The distribution of Factor 1 teachers' constructivist beliefs about mathematics teaching and learning is presented in Figure 1 and the distribution of Factor 2 teachers' beliefs about the beauty and meaningfulness of mathematics is presented in Figure 2.

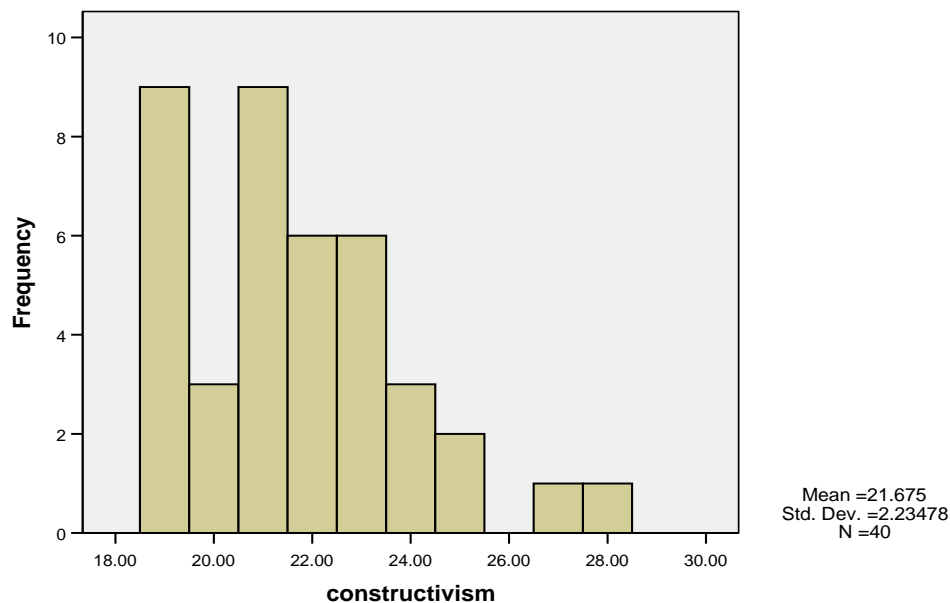


Figure 1 Teachers' constructivist beliefs about mathematics

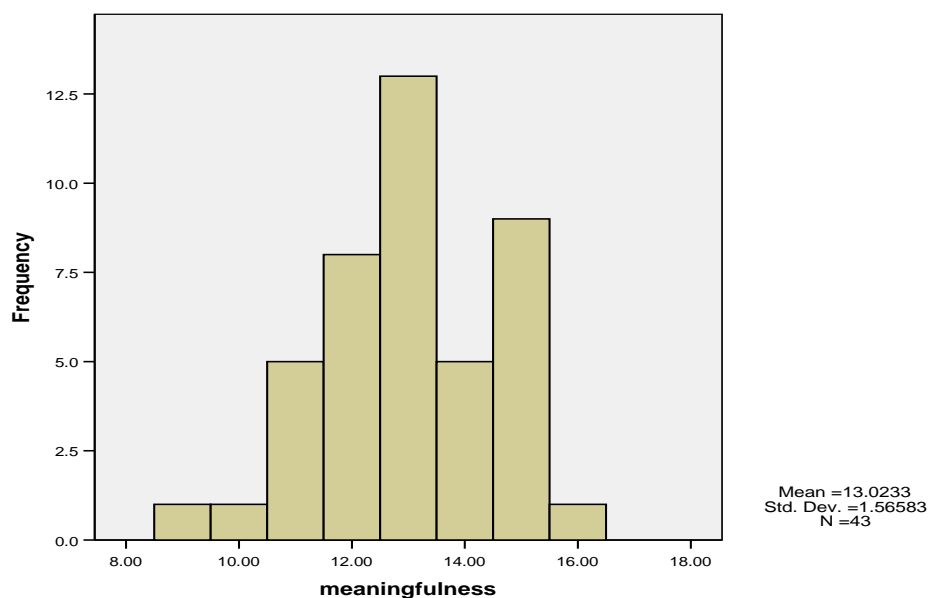


Figure 2 Teachers' beliefs about the beauty and meaningfulness of mathematics

Factor 1 and Factor 2 were then used to explore relationships between teachers' espoused beliefs about mathematics and mathematics teaching and learning and their views about the use of calculators for students with LD. Teachers were grouped in relation to Factor 1 by means of a median split, with 13 teachers scoring in the upper median (scores above 22 out of a possible 28) and 36 teachers in the lower median. Relationships between teachers' constructivist beliefs about the teaching and learning of mathematics in the two groups and their views about the use of calculators by students with LD measured by the nine items were investigated with ANOVA, with the results presented in Table 2. Significant differences between the two groups of teachers were found in two of the nine items (see Table 2). Teachers holding stronger beliefs about constructivism expressed the view that students with LD were more likely to try different approaches to mathematics and were more able to think mathematically when calculators were used.

Table 2: ANOVA of teacher constructivist beliefs and views about calculators

Views about the use of calculators	High v's low constructivist teacher means
Having calculators do routine work makes students more likely to try different approaches to mathematics	3.69 versus 2.89 F (1,32) = 17.21, p = 0.01
Using calculators makes it easier for students to think mathematically	3.3 versus 2.70 F (1,31) = 8.2, p = 0.07

Teachers were also grouped in relation to Factor 2 by means of a median split, with 15 teachers scoring in the upper median (scores above 13 out of a possible 28) and 34 teachers in the lower median. The ANOVA indicated statistically significant relationships between teachers' beliefs in the beauty and meaningfulness of mathematics and two of the nine items measuring teachers' views about the use of calculators with students with LD (see Table 3). Teachers with stronger beliefs about the beauty and meaningfulness of mathematics expressed the view that students were more able to think mathematically when calculators were used but were less likely to consider that students needed to learn algorithms first before using a calculator.

*Table 3: ANOVA of teacher beliefs about maths beauty and views about calculators*

Views about the use of calculators	High v's low mathematics beauty means
Using calculators makes it easier for students to think mathematically	3.21 versus 2.54 F (1,25) = 8.0, $p = 0.009$
Students should learn algorithms before they use calculators	2.13 versus 2.71 F (1,27) = 5.24, $p = 0.03$

## DISCUSSION

The underutilisation of calculators in mathematics classrooms continues to be an ongoing issue (Groves et al., 2006), with many teachers in many countries reluctant to change their traditional teaching pedagogies. Media commentators, advocacy groups, mathematics associations, education systems and teachers have held strong views about whether students should have ongoing access to calculators or if they should only be made available after students have gained mastery of basic skills through pencil-and-paper computations. While some teachers espouse the usefulness of calculators, few actually use them with their students in the classroom (Howard, 1991; Sparrow & Swan, 1997; Stacey & Groves, 1994). Moreover, many students enter teacher education programmes with the view that calculators should be avoided until Grade 7 (Schuck, 1995), with female preservice students in particular more likely to display negative attitudes towards calculators (Bobis & Cusworth, 1994). Teachers who responded to the survey in this study had voluntarily enrolled in an out of school hours PD activity devoted solely to the use of calculators for students with LD. However, although they had declared their interest in learning more about calculators, the majority espoused traditional transmission beliefs about the teaching and learning of mathematics and did not consider that calculator use would free students with LD from routine work so that they could try different approaches to mathematics or make it easier for them to think mathematically. The latter view was also endorsed by the majority of teachers in the sample who did not espouse strong beliefs about the beauty and meaningfulness of mathematics. These teachers were more likely to endorse the view that students with LD should learn algorithms before using a calculator. These results are of significance as although the size of the sample was relatively small, the participants' gender and median age of 52 years is on par with primary school teachers in South Australia (Ministerial Council on Education, Employment, Training and Youth Affairs, 2004; Owens, 2006).

Mathematics was introduced into primary schools in Australia in 1966, so it is likely that the espoused beliefs of most teachers in this study reflect their own primary school grounding in arithmetic which emphasised computational algorithms (Keeves & Stacey, 1999). Almost half of the teachers had only a basic teaching qualification that they would have gained quite some time ago and given their median age, length

of time teaching mathematics and lack of previous PD about calculators, the findings from this study endorse previous suggestions that most teachers would not have encountered this technology when learning mathematics at school and *need time to adjust to both a new learning environment and a new teaching one* (Usnick et al., 1995, p. 11). The *Statement on the Use of Calculators and Computers for Mathematics in Australian Schools* (AAMT, 1996, p.3) specifies *calculators may ... be thought of as specific - purpose computing tools for mathematics which range from simple four-function models to scientific aids, likely to include graphing, equation solving and even symbolic manipulation capabilities*. While calculators have been shown to enhance the development of students' mathematical concepts (Stacey & Groves, 1994) and to minimise the impact of LD (Westwood, 2006) the question of how much time and on-the-job coaching teachers require to catch up with the technology and develop a sufficiently deep level of knowledge to be able to incorporate calculators into their practices with students with LD should be investigated further.

Although the *National Statement on Mathematics for Australian Schools*, (Australian Education Council, 1991), *Mathematics - A Curriculum Profile for Australian Schools* (Curriculum Corporation, 1994), and the *South Australian Curriculum Standards and Accountability* (SACSA) framework (Department of Education and Children's Services, 2001) have highlighted the important role of calculators in an increasingly technological society, schools in South Australia have not been required to have any form of written policy about calculator use. Sparrow and Swan (1997) consider that the development of a whole school policy on calculator use for all students is essential for their use to become widespread. However, it is also evident that more extensive and more effective use of calculators in classrooms with all students is contingent upon shifting teachers' habitual beliefs about mathematics and its teaching and learning from traditional transmission views to more constructivist child centred views, as well as increasing teachers' pedagogical content knowledge about calculators, their functions and uses (Groves et al., 2006; Handal, 2004). The 1996 AAMT *Statement on the Use of Calculators and Computers for Mathematics in Australian Schools* recommended that education authorities provide PD opportunities for teachers to develop the knowledge and skills necessary for the successful use of calculator and computer technologies in classrooms. Siemon (1989) believes that for PD to be effective it needs to go beyond the development of teachers' pedagogical repertoires and embrace a constructivist view of learning in which teachers are recognised as learners in their own right and are afforded opportunities to recognise and challenge their underlying beliefs, attitudes and knowledge bases.

In their review of primary numeracy in Australia Groves et al., (2006) call for further research into ways teachers can be assisted to incorporate calculators into their everyday teaching practice as allowing students to use calculators...*can change teachers' expectations of pupils* (Groves et al., 2006, p. 12) and enhance student mathematical development. This call needs to be extended to include the largely neglected area of research of students with LD and focus on how, when and how often teachers use calculators with students with LD.

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