Primary School Teachers' Perceptions of the Use of Calculators in the Mathematics Classroom

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Introduction

The use of calculators in the mathematics classroom has been a topic of intense debate among educators and policy-makers alike around the world. In Singapore, from 2009, the use of calculators were allowed in the mathematics examination in the Primary School Leaving Examination, a national examination taken by all students near the end of their sixth year in primary schools. Accordingly, since 2008, calculators were introduced to primary 5 pupils in Singapore.

As Hermans, Tondeur, van Braak, and Valcke (2008) have noted, one of the factors affecting the implementation of educational change is teachers' perceptions of the efficacy of that change. Indeed, in every new initiative introduced, one of the factors determining success is the teachers' mindset and attitudes toward it. In implementing this major change in the Singapore Primary mathematics curriculum in which the use of calculators in examinations is expected, the teacher is thus the key to exploiting the potential of calculators in teaching and learning of mathematics. An awareness of teachers' attitudes toward the use of calculators may provide some insights into their perceptions of and concerns about calculator use in schools, thus helping the change manager to adopt appropriate strategies and approaches to improve teachers' receptivity to change and to implement the change successfully.

The purpose of this study was thus to examine primary school teachers' perceptions of the use of calculators in the mathematics classroom. This study is a strand of a larger study which aims to achieve a preliminary understanding of teachers' acceptance of this initiative and their perception of the usefulness of calculators in achieving desirable educational outcomes. Conducting such a study is also timely and relevant, as the effects of using calculators remain an area of great interest to researchers and policy-makers around the world.

A Review on Uses and Roles of Calculators

From 1985 to 1986 the Mathematics Education Centre at Monash University in Australia carried out a survey on using calculators in mathematics teaching. The survey covered years K–12 and sought the opinions of teachers, parents and students. Based on the results of the survey of the primary school years, Blane (1986) found that "students were rated as being strongly in favour of the use of calculators, whereas parents were perceived to be strongly against". Teachers' opinions were spread throughout the scale, but with a slightly larger proportion (44%) being strongly in favour of using calculators (p. 237). The findings indicate that teachers were ambivalent about the role of calculators in the primary mathematics class.

On the other hand, the report on the Calculator-Aware Number (CAN) curriculum in the United Kingdom indicated that after teachers were asked not to teach traditional pencil-and-paper vertical algorithms for addition, subtraction, multiplication, and division, a large amount of time previously taken up with the practice of algorithms was released to work on developing children's understanding of numbers and to give them the opportunity to explore and investigate mathematics and for teachers to develop their own teaching styles (Shuard, 1992). The teachers became more responsive to children's ideas and took the role as participants in the children's work, rather than instructors teaching them how to do mathematics.

The teachers were able to use their previous experience with children of this age to report that the "CAN children show greater competence in mathematics at an earlier age than would normally be assumed. This is particularly true for large and small numbers, negative numbers, the ability to recognize patterns and awareness of their significance, and the understanding of place value. The growth in the children's development of concepts such as fractions, decimals square roots, has also become more evident during the second year of CAN development" (PrIME, 1989, p. 12).

Calculators are powerful learning tools that allow students to experience the richness and value of mathematics by greatly reducing the need for them to execute pencil-and-paper computations and algebraic manipulations. Lambert (1985), writing especially on the primary school mathematics class, identified four roles for calculators. They can be a learning aid to understanding mathematical concepts, a maths-motivator, a means of solving problems in a faster and more efficient way and a device that provides the opportunity for trying to solve more intricate problems. A study by Ellington (2003) demonstrated that students' operational and problem-solving skills improved when calculators were an integral part of testing and instruction. The result of this study was that the use of calculators did not hinder the development of mathematical skills and students using calculators had better attitudes towards mathematics.

As suggested by Del Campro (1986), "it no longer seems a question of whether calculators should be used along with basic skills instruction, but how" (p. 240). According to Howson and Wilson (1986), "calculators enable many children to use arithmetic for real situations, to generate number patterns, to explore number properties and to make and test hypothesis…. Calculators aid in the acquisition of the important skills of estimating and approximating. Nevertheless, there is still no consensus on exactly how the calculators' capabilities can be best exploited in early mathematics teaching" (p. 67). Yvon (1987) supported these remarks by suggesting that students need to be shown when it is not appropriate to use calculators, and how to use mental or paper-and pencil calculations when calculators are not available. McIntosh (1990) also agreed that children need to be able to select the appropriate calculation method and commented that calculators have a role in complementing mental calculations.

Conclusively, there has been a gradual international move towards recommending the student use of calculators from primary school upwards, and clear directions have been given on the place of calculators in mathematics classes (Hembree & Dessart, 1986; NTCM, 1987; Graham & Smith, 2004; Meissner, 2007). Presently, there is an increasing curriculum policy direction for the student use of calculators, while at the same time there continues to be a controversy about it in the community and an apparent divergence of opinion amongst teachers over the calculator's use. Thus, it is important to gauge teachers' current perceptions toward the use of calculators in primary mathematics classes.

Methods

The target group for this study comprised 32 primary mathematics teachers in a primary school in Singapore, of whom six teach Primary 3, ten teach Primary 4, nine teach Primary 5 and seven teach Primary 6 mathematics. The nine Primary 5 teachers

and seven Primary 6 teachers have used calculators in their classrooms since the introduction of calculators into the Singapore Primary 5 and 6 curriculums in 2008.

A questionnaire which comprised 17 items was administered to the above-mentioned 32 primary mathematics teachers to gather data on their perceptions toward their students' use of calculators in primary (Primary 5 and 6) mathematics classrooms.

Questions 1 to 4 elicited the following demographic information from the respondents:
Question 1: Gender
Question 2: Years of teaching experience
Question 3: Present teaching level
Question 4: Level(s) taught

Questions 5 to 17 made up the rest of the questionnaire and were directed at issues involving the student use of calculators in primary mathematics classes.

- Current use
  Question 5: Do you presently have students using calculators in your mathematics classes?
  Question 6: If Yes to Question 5, how do the children use their calculators?
- Teachers' support for calculators in terms of their benefits and limitations
  Question 7: Do you think using calculators in primary (P5 and P6) mathematics classes will benefit all students?
  Question 8: If Yes to Question 7, why? What are the benefits of calculators?
  Question 9: If No to Question 7, why? What are the limitations of calculators?
- Year of introduction of calculator s
  Question 10: From which level do you believe students should use calculators?
- Uses of calculators
  Question 11: How do you think calculators can be used by students in primary (P5 and P6) mathematics classes?
- Influences on teachers' perception on the use of calculators
  Question 12: What factors have influenced your perceptions on students' use of calculators in primary (P5 and P6) mathematics classes?
- Professional development and resources
  Question 13: Have you attended any school-based professional development courses on the use of calculators in primary (P5 and P6) mathematics classes?
  Question 14: If Yes to Question 13, when did you attend the courses?
  Question 15: If No to Question 13, would you attend such courses?
  Question 16: In your opinion, in which areas do teachers need more support for enhancing their teaching and use of calculators in primary (P5 and P6) mathematics classes?
- Open comment
  Question 17: I would appreciate any other comments that you would like to make about the students' use of calculators in primary (P5 and P6) mathematics classes.

At the end of the questionnaire the teachers were given the opportunity to make any comments that they wished about students' use of calculators in their primary mathematics classes. The purpose of this comment was to give the teachers the opportunity to express themselves more fully on any issue related to students' use of calculators. Before it was administered, a soft copy of the questionnaire was emailed to the principal and vice-principal of the school involved to seek their permission to

administer it. Once approval had been granted, the questionnaires were given to the school level representatives to be distributed to their mathematics teachers. The questionnaire was administered in February 2012.

Interviews were then held to gather additional information or data to gain a deeper insight into three different aspects, namely the year when calculators were introduced, the factors that influence the teachers' perceptions of the calculator use as well as the need for professional development and resources. The interviews comprised three questions with sub-parts to each question. Twelve of the 32 teachers, three from each level, who attempted the questionnaire were randomly chosen for follow-up interviews. Each interview took an average of 20 minutes and all interviews were administered within one week in March 2012.

Permission to conduct the interviews was not easily obtained due to the sensitivity of the research issue, but permission was granted after two weeks of consideration by the principal and vice principals. Some teachers had difficulty in fully understanding the questionnaire, and thus some of the mathematical terms such as "individual differences" and "algorithms" were explained to these teachers. In addition, two randomly selected teachers turned down the follow-up interviews for fear their comments would be made public.

Results and Discussion

This study attempts to answer the following research questions:
1. What are teachers' perceptions of calculator use in the primary curriculum?
2. What do teachers need to enhance their teaching and using of calculators in mathematics to achieve the desired outcome?

The questionnaire was administered to 32 primary mathematics teachers. All of the completed questionnaires were collected and then analyzed using descriptive statistics in the following ways:
1. A frequency count of responses for each item was analysed to suggest possible findings of significance.
2. All open comments and interview responses were collated and classified according to the major focus of the comment.

Analysis of Each Question by Frequency Counts

The analysis begins with a report on the characteristics of respondents collected from questionnaire items Q1 to Q4. The frequencies of response rates are presented in percentage tables where relevant. The absolute number, which accompanied the percentage, was given for questionnaire items in two broad categories. The first category comprises questions 4, 11, and 12, where the respondents were allowed to tick more than one response. The second category consists of questions 6, 8, 9, 14, and 15, where not all respondents answered each of these questions. Responses to these items were based on the respondents' answer to questions 5, 7, and 13. It would be inappropriate to give just the percentages as they could lead to confusion to the reader.

Demographic Information: Questions 1 to 4

Table 4.1

Question	Percentage (%)	Absolute number	Total (N)
1. Gender:			32
a) male	37.5	12	
b) female	62.5	20	
2. Teaching experience:			32
a) 0–3 years	34.375	11	
b) 4–6 years	25	8	
c) 7–10 years	15.625	5	
d) more than 10 years	25	8	
3. Current teaching level:			32
a) Primary 3	18.75	6	
b) Primary 4	31.25	10	
c) Primary 5	28.125	9	
d) Primary 6	21.875	7	
4. Levels taught:			32
a) Primary 3	75	24	
b) Primary 4	75	24	
c) Primary 5	71.875	23	
d) Primary 6	46.875	15	

These data show that 37.5% of the respondents were men and 62.5% were women. Approximately 60% of the respondents had six years or less of teaching experience (estimated from the profile of the school, in which approximately 80% of the teaching staff were under 30 years of age). At least 70% had taught Primary 3 to 5, indicating that most of the respondents had some idea of the subject content as well as the readiness of students in these three levels to use calculators.

Research Issues: Questions 5 to 17

Two research questions in this study concern teachers' perceptions towards the use of calculators in the primary (P5 and P6) mathematics classes. These questions were grouped under the issues of:

- Current use (Q5 and Q6)
- Teachers' support for calculators in terms of their benefits and limitations (Q7 to Q9)
- Year of introduction of calculators in the classroom (Q10)
- Uses of calculators (Q11)
- Influences on teachers' perceptions of the use of calculators (Q12)
- Professional development and resources (Q13 to Q16)

Current Use

Table 4.2

Question	Percentage (%)	Absolute number	Total (N)
5. Currently using calculators:			32
a) Yes	28.125	9	
b) No	71.875	23	
6. Usages of calculators:			9
a) as the need arises	66.67	6	
b) for specific lessons on using calculators	100	9	
c) as a tool for problem-solving	77.78	7	
d) for computation work	55.56	5	
e) to reinforce estimation skills	55.56	5	

Only 28% of the teachers, all nine P5 mathematics teachers, allowed their students to use calculators in their mathematics classes. The responses for Question 6 were taken only from the P5 teachers, all of whom said that their students used calculators for specific lessons in the school textbooks. The next highest response was the use of calculators as a tool for problem solving. This was due to the fact that calculators are used only in Paper 2 of the Primary School Leaving Examination, where all the word problems are tested.

Teachers' Support for Calculators

Table 4.3

Question	Percentage (%)	Absolute number	Total (N)
7. Support for the use of calculators:			32
a) Yes	65.625	21	
b) No	34.375	11	
8. Benefits of using calculators:			21
a) speed up children's work (saves time)	71.43	15	
b) as a technology tool for use in mathematics	90.48	19	
c) help to reduce individual differences	76.19	16	
d) help to develop problem solving skills	76.19	16	
e) increase students' confidence	80.95	17	
f) take the focus off computation	90.48	19	
g) increase students' motivation	90.48	19	
9. Limitations of using calculators:			11
a) reduce the need to learn basic facts	90.91	10	
b) discourage mathematical thinking	81.82	9	
c) should only be introduced in secondary school	81.82	9	
d) prevent the learning of pencil-and-paper computational skills	90.91	10	
e) calculators are too complicated and difficult for students	9.09	1	

Approximately 65% of the respondents supported the use of calculators in the primary (P5 and P6) mathematics classrooms and felt that calculators would benefit the

students greatly. In total, 19 of them indicated that the calculator is a technological tool that reduces time spent in tedious computational work and in turn increases students' motivation in mathematics. Most of those who had reservations felt that calculators would hinder the learning of pencil-and-paper computational skills and algorithms, though they realized that calculators are not too complicated and difficult for the students to handle.

Year of Introduction of Calculators in the Classroom

Table 4.4

Question	Percentage (%)	Absolute number	Total (N)
10. Level when calculators should be introduced:			32
a) Primary 1	0.0	0	
b) Primary 2	0.0	0	
c) Primary 3	3.125	1	
d) Primary 4	9.375	3	
e) Primary 5	50.0	16	
f) Primary 6	0.0	0	
g) Secondary school	37.5	12	

Half of the respondents felt that Primary 5 was a suitable year for introducing calculators to students. The percentages for Primary 1 to 4 and 6 are extremely low compared to the 37.5% who supported using calculators in secondary school.

Uses of Calculators

Table 4.5

Question	Percentage (%)	Absolute number	Total (N)
11. Uses of calculators:			32
a) in problem-solving activities	62.625	21	
b) in doing algorithms	31.25	10	
c) in exploring activities	59.375	19	
d) for number pattern work	56.25	18	
e) unsure	0	0	
f) should not be used	15.625	5	
g) others	0	0	

There was a strong indication that calculators should be used in problem-solving activities, followed by exploration activities and number patterns, indicating that the respondents knew that calculators are meant for higher level activities rather than just for doing algorithms, which students could achieve with a pencil and paper.

Influences on Teachers' Perceptions of the Use of Calculators

Table 4.6

Question	Percentage (%)	Absolute number	Total (N)
12. Factors:			32
a) their own professional reading	21.875	7	
b) their own teaching experience	87.5	28	
c) other teachers	18.75	6	
d) in-service courses	15.625	5	
e) parents of students	3.125	1	
f) others, e.g., personal experience	3.125	1	

The main influence in forming the teachers' perceptions towards students' use of calculator in primary mathematics classes was thus their teaching experience. Only seven depended on their own professional reading, six depended on other teachers and five depended on in-service courses.

Professional Development and Resources

Table 4.7

Question	Percentage (%)	Absolute number	Total (N)
13. Attended calculator courses			32
a) Yes	28.125	9	
b) No	71.875	23	
14. When			9
a) Past 6 months	11.11	1	
b) Past 1 year	55.56	5	
c) Past 2 years	33.33	3	
d) More than 2 years ago	0	0	
15. Intend to attend such courses			23
a) Yes, within school hours	73.91	17	
b) Yes, outside school hours	13.04	3	
c) No	13.04	3	
16. Areas in which support is needed			32
a) Related training	81.25	26	
b) Related resource	78.125	25	
c) Other areas	0	0	

More than 70% of the respondents had never attended a calculator course, which explained why a low percentage of respondents depended on in-service courses as a factor influencing their perceptions on the use of calculators. All nine teachers who had attended these courses had done so during the previous 2 years. The courses were organized by the Ministry of Education to prepare P5 and P6 teachers for the introduction of the calculators into the mathematics new syllabus.

Twenty of the 23 teachers who had never attended calculator courses commented that they would like to attend such courses, either within or outside school hours. This trend was in line with the areas in which the teachers would like to have support to enhance their teaching and use of calculators in classrooms. Another area that required support was the availability of calculator-related resources.

Classifications of Open Comments and Interviews

Overall, 25% of the respondents took the opportunity to write comments. Twelve teachers, constituting 37.5% of the respondents, were invited for follow-up interviews as described above. The interview questions and the responses are as follows:

1. Pertaining to questionnaire Q10
a. Why do you think calculators should not be introduced in primary school?
b. Are they any particular reasons that you think calculator should be introduced in Primary 5 and not in Primary 6 or another level?

Besides the fact that this was Ministry of Education policy, many interviewees suggested that by Primary 5, students had more or less learnt the computational skills as well as the algorithms needed to solve mathematics problems with pencil and paper, hence the use calculators at this level would enhance the learning and teaching of mathematics. That also explained the low percentages of teachers who thought calculators should be introduced at Primary 1 to 4 levels. As for Primary 6, many felt that the last year of primary education was crucial for preparing graduating students for Primary School Leaving Examinations and that thus learning a new tool such as a calculator at this stage would divert their attention and focus on the mastery of content.

Those who were not supportive of calculators use in primary mathematics classrooms insisted that secondary school is the most suitable level for the introduction of calculators, where the students are more mentally ready and this would inevitably reduce the limitations of using calculators to a great extent.

Open comments:
- Calculators should be introduced in secondary schools. However, mathematical questioning should be based on skills and concepts, rather than pupils spending time on computation.
- Pupils must show the processes involved in arriving at the answer.

2. Pertaining to questionnaire Q8, Q9, Q11, and Q12
a. Do you support the use of calculator in the primary mathematics classroom?
b. What are the factors that influence your perceptions for accepting and rejecting the use of calculators?
c. Why do you think one's own teaching experience is the most important influence on your perception on the use of calculators?

All 12 interviewees admitted they lacked the time to do their own professional reading and based their acceptance and rejection of using calculators in the primary and mathematics classroom on their teaching experience, though they knew their experience may not have been totally representative or relevant. Based on their teaching experience, they felt the need to teach students the basic facts and skills of mathematics before introducing them to calculators because calculators mostly serve as a tool for tedious computation. The interviewees did not really know the ways in which calculators could benefit students in terms of exploration activities or even number pattern work.

Among the interviewees, only four had undertaken a calculator course during the past two years. They commented that the power of calculators cannot be underestimated if teachers were able to use the correct methods and activities to teach students how to use them. Professional reading and in-service courses serve as important platforms for educating and creating awareness among teachers so as to dispel the negative myths surrounding calculators. These myths greatly impede the universal acceptance of calculators in the classroom and they only serve to slow down the inevitable implementation of technology in the classroom and put students at a disadvantage in a world that is rapidly embracing technology.

Open comments:

- Calculators are an additional source of distraction from learning basic mathematical skills. They make students too dependent on them, even in simple calculations that can be solved mentally.
- Calculators allow students to check answers and help slow learners to gain confidence at the initial stage. If they are misused, however, they may do more harm than good.
- Students do not learn basic multiplication tables if they are allowed to use calculators.

3. Pertaining to questionnaire Q11 and Q16

a. Have textbooks been useful tools in enhancing the teaching and the use of calculators in the primary mathematics classroom?
b. Do you need other resources?
c. What kind of resources or training would support your teaching and use of calculators in the classrooms?

Most of the interviewees responded that textbooks tend to be their main or only resource for teaching students how to use calculators, but they do not really provide different types of activities to allow teachers and students to make optimal use of the calculators. Teachers also lack the time and knowledge or even the skill to come up with useful resources to enhance their teaching and their students' use of calculators.

All interviewees welcomed in-service training as well as more materials in terms of guides or assessment books. They saw a need to acquire the knowledge and the skills to handle calculators, which would in turn benefit their students. In fact, they needed to draw confidence from experts to ensure that they were on the right track and that they were not alone, struggling helplessly to teach and use a new technology tool. They would also like to have more resources to tap into, so as to reinforce the teaching of problem-solving skills, exploration skills and number pattern work or even estimation skills to their students.

Open comments:

- Develop a simple checklist for both teachers and students on the use of the calculators.
- Though there are many benefits in using calculators, a focus on pupils' basic foundations in calculations is still needed. Perhaps a test could be developed to ensure they had acquired these foundations.
- There are reasons for using calculators, but I'm not sure that they really benefit the pupils greatly.

Conclusion

For the purposes of this study, all Primary 3 to 6 mathematics teachers in a primary school in Singapore were asked for their responses to a questionnaire designed by the author to investigate primary teachers' perceptions toward the students use of calculators in primary (Primary 5 and 6) mathematics classroom.. Twelve follow-up interviews were conducted to get more insights into some of the issues.

About two-thirds of the respondents supported the use of calculators in the primary mathematics classrooms and indicated that the calculator is a technological tool that reduces time spent in tedious computational work and in turn increases students' motivation in mathematics. Most of those who had reservations felt that calculators would hinder the learning of pencil-and-paper computational skills and algorithms, though they realized that calculators are not too complicated and difficult for the students to handle.

Teachers who strongly supported the introduction of calculators into the primary mathematics classroom acknowledged that calculators were a powerful learning tool that allows students to experience the richness and value of mathematics by greatly reducing the need to do paper-and-pencil computations and algebraic manipulations. Teachers who did not support students' use of calculators expressed concern that they reduced the need for children to learn basic mathematical facts and might prevent children from acquiring paper-and-pencil computational skills.

There have been no negatives results reported on students' knowledge of basic facts or computational ability in any study on calculators in the classroom. Teachers need to be made more aware of the findings of research studies such as those of PrIME (1989) and Hembree and Dessart (1986), which focused on the use of calculators and their effects on student achievement. There is evidence of an increasing trend in teacher support as more than 85% of the teachers who had not attended any calculator courses, stressed the importance of school-based professional development courses and their own willingness to attend if such courses were provided.

However, there was an obvious divergence of opinion amongst teachers concerning the year in which calculators should be introduced at primary school. This has reinforced the need for clearer directions from educational authorities and the need for the ongoing professional development of teachers to disseminate research findings.

Calculators are here to stay in Singapore as a new initiative, but most importantly, as the fear of technology is overcome and it is accepted that technology is changing the way that mathematical computations and manipulations are executed, mathematics instruction will begin to take tremendous strides in a push towards a future of new and better opportunities for student learning.

Recommendations

Teachers should be encouraged to read more widely to upgrade not just their pedagogical skills but also their awareness of emerging research findings. They are at the front-line, moulding the future of their nation, and hence it is essential for teachers to keep themselves updated, not just in knowing the role of calculators in the primary mathematics classroom in order to use calculators effectively, but also in dispelling myths about calculators, which only slow down the inevitable introduction of calculators in the primary mathematics classrooms and put students at a disadvantage in a world that is rapidly embracing technology (McCauliff, 2004; Wachira, Keengwe & Onchwari, 2008). Professional publications produced by mathematics educators, for mathematics educators, serve as good resources for expanding teachers' horizons as well as their knowledge base, and provide insights into research findings related to new initiatives or syllabi (Walen, Williams & Garner, 2003).

On the other hand, schools should plan and offer structured, school-based professional development courses on the use of calculators in primary school mathematics classrooms. Besides providing teachers with intensive start-up training, regular follow-up activities ensure the sustainability of such training. These courses should be progressive and continuous as some teachers may require refresher course or practical solutions when they encounter problems along the way. The courses and training do not only prepare teachers to teach with calculators but also challenge their beliefs about mathematics and mathematics instruction. Such courses should be a part of a school's staff development plan. The key to successful technology reform in mathematics teaching and learning is assembling a massive network of school leaders capable of providing appropriate training to all teachers.

School can also involve teachers in sharing effective strategies for using calculators as well as encourage teachers to work as teams to create lesson packages as resources for teaching calculators. Last but not least, heads of departments of mathematics should involve mathematics teachers to source useful and relevant books and materials to build up a pool of resources for teachers to tap into. This may also help teachers to decide what materials or resources they require for their teaching and use of calculators in the classroom.

References

Blane, D. (1986). Guidelines for the use of calculators in mathematics teaching in Australia. In Nerida Ellerton (Ed.), *Mathematics who needs what?* (pp. 234-239). Melbourne: The Mathematical Association of Victoria.

Del Campo, G. (1986). Calculators: Vehicles for developing mathematical language infant classes. In Nerida Ellerton (Ed.), *Mathematics: who needs what?* (pp. 240-242). Melbourne: Mathematical Association of Victoria.

Ellington, A. (2003). A meta-analysis of the effects of calculators on students' achievement and attitude levels in pre-college mathematics classes. *Journal for Research in Mathematics Education*, *34*(5), 433-463.

Graham, T. & Smith, P. (2004). An investigation into the **use** of graphics calculators with pupils in Key Stage 2. *International Journal of Mathematical Education in Science and Technology*, 35(2), 227-237.

Hembree, R., & Dessart, D. J. (1986). Effects of hand-held calculators in precollege mathematics education: a meta-analysis. *Mathematics Education*, *17*(2), 83-89.

Hermans, R., Tondeur, J., van Braak, J., & Valcke, M. (2008). The impact of primary school teachers' educational beliefs on classroom use of computers. *Computers & Education*, *51*(4), 1499-1509.

Howson, G., & Wilson, B. (1986*). ICMI study series: School mathematics in the 1990's.* Kuwait: Cambridge University Press.

Lambert, P. (1985). *Teaching with calculators K-6*. Darlinghurst, New South Wales: Primary Association for Mathematics.

McCauliff, E. (2004, Spring). The calculator in the elementary classroom: Making a useful tool out of an ineffective crutch. *CONCEPT: An Interdisciplinary Journal of Graduate Studies*, Article 2. Retrieved July 3, 2005, from http://www.publications.villanova.edu/Concepts

McIntosh, A. (1990). Becoming numerate: developing number sense. In S. Wills (Ed.), *Being numerate: What counts?* (pp. 24-43). Hawthorn Victoria: The Australian Council for Educational Research.

Meissner, H. (2007). *Primary School – Calculators or Paper and Pencil Techniques?* Retrieved on Nov 12, 2009, from http://wwwmath.uni-muenster.de/didaktik/u/meissne/WWW/mei146.doc

National Council of Teachers of Mathematics. (1987). A position statement on calculators in the mathematics classroom. *Arithmetic Teacher*, *34*(6), 61.

Primary Initiatives in Mathematics Education (PrIME) Project. (1989). *The second year of CAN.* Homerton College Cambridge: National Curriculum Council.

Shuard, H. (1992). CAN: Calculator use in primary grades in England and Wales. In C.Hirsch (Ed.), *Calculators in mathematics education*. Reston, VA: NTCM

Wachira, P., Keengwe, J., & Onchwari., G. (2008). Mathematics preservice teachers' beliefs and conceptions of appropriate technology use. *AACE Journal, 16*(3), 293-306.

Walen, S.B., Williams, S.R., & Garner, B.E. (2003). Preservice teachers learning mathematics using calculators: A failure to connect current and future practice. *Teaching and Teacher Education, 19*(4), 445-462.

Yvon, B. R. (1987). A compelling case for calculators. *Arithmetic Teacher*, *34*(6), 16-19.

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