Exploring Beliefs and Practices toward the Use of Calculator among Singapore Heads of Mathematics Department

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Abstract: *This exploratory study investigates the heads of mathematics departments' beliefs and practices toward the use of calculator in mathematics instruction. A survey was conducted among the 43 primary schools heads of mathematics department in Singapore. The beliefs and practices toward the use of calculator were measured using Brown et al (2007) survey instrument which consisted of twenty items which were divided into four categories. The categories were Catalyst Beliefs, Teacher knowledge, Crutch Beliefs and Teacher Practices. Descriptive statistics on the four categories were reported. Among the four categories, the perception of calculator use as a catalyst in mathematics instruction was reported the highest. The top three mean scores indicated agreement that students can learn mathematics through calculator use and make mathematics more interesting as well as using calculators in instruction will lead to better student understanding. The survey results shed light on heads of mathematics department self reported beliefs, knowledge, and practices which were consistent with elements of Singapore's Ministry of Education press release statement on the introduction of calculators in Primary 5 - 6 Mathematics in 2007.*

1. Introduction

Calculators have been utilized in the mathematics classroom since the 1980s but their use continues to be contentious (Hembree & Dessart, 1992; McCauliff, 2004; Reys & Arbaugh, 2001; Thompson & Sproule, 2005; Brown, et al., 2007). Many teachers continue to fear computational skills will not be learned if calculators are used (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). Although mathematics educators have long understood the value of calculators in the learning of mathematics, this information may or may not be translated well into classroom practices. The Singapore's Ministry of Education press release statement on the introduction of calculators in Primary 5 - 6 Mathematics stated that:

> Calculators facilitate the use of more exploratory approaches in learning mathematical concepts, some of which may require repeated computations, or computations with large numbers or decimals. With a calculator, pupils can perform these tasks and better focus on discovering patterns and making generalisations without worrying about computational accuracy. Second, the use of calculators also enables teachers to use resources from everyday life, such as supermarket advertisements, to set real-life problems with real-life numbers that may be difficult for pupils to work with without a calculator. Pupils would hence be better able to see the connection between mathematics and the world around them. (Ministry of Education, 2007)

These key components to success rely on teachers' belief systems. 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, after an extensive search by the author, no studies were found in Singapore that investigated beliefs and practices regarding calculator use, which is the main focus of this paper, among heads of primary mathematics department. One plausible reason for this lack of research at the primary school level could be due to the recency of the introduction of the use of scientific calculators in the primary mathematics curriculum in Singapore.

2. A Review of Calculators Use in Singapore Primary Schools

The use of calculators is introduced in the Singapore primary mathematics curriculum in Primary 5 (Grade 5) from year 2008 onwards. The conceptualisation of the Singapore revised mathematics curriculum (Ministry of Education, 2006), is based on a framework where active learning via mathematical problem solving is the main focus of teaching and learning. One of the main emphases of the primary level mathematics curriculum has been the acquisition and application of mathematical concepts and skills. While the revised curriculum continues to emphasise this, there is now an even greater focus on the development of students' abilities to conjecture, discover, reason and communicate mathematics with the aid of calculator. Guidance for teachers must demonstrate how mental facility can be developed alongside calculator use. The appropriate use of calculators in the classroom is the key factor. However, not all primary school teachers are calculator literate or effective users of calculators (Koay, 2006). Anecdotal evidence has shown that heads of mathematics department and teachers need more professional development in the use of the calculator for mathematics instruction in the primary classrooms.

In a recent local study, Toh (2006) conducted a study on the effects of the use of a calculator on mathematics learning for 63 primary six pupils in the primary schools over two weeks. It was found that there was no difference in basic skills and problem solving skills between the calculator and non-calculator groups. In fact, the National Research Council's publication, *Adding it Up* (2001), indicated that calculator use was more controversial in mathematics lessons in primary levels than the use of manipulative materials. They stated that "…persistent concerns have been expressed [by mathematics teachers] that an extensive use of calculators in mathematics instruction interferes with students' mastery of basic skills and the understanding they need for more advanced mathematics (p. 254)". From the TIMSS results it is clear that mathematical competence at the grades K–6 level does not require calculators. Two of the highest-achieving countries at the fourth- and eighth-grade levels, Singapore and Japan, use calculators sparingly in primary schools.

In my work with heads of primary mathematics department in Singapore, I frequently hear the beliefs about incorporating calculators into the mathematics curriculum. The changes that the heads of mathematics department need to manage for successful integration of calculators into the primary mathematics curriculum clearly bring a number of challenges along with them. Therefore, this exploratory study investigates the heads of mathematics departments' beliefs and practices toward the use of calculator in mathematics instruction. The purpose of this study was to examine: What are the heads of mathematics department reported beliefs and practices toward the use of calculator?

3. Research Methodology

The survey by means of self-reporting questionnaire was carried out among 43 heads of primary mathematics department in Singapore.

Sample

The population of this study was Singapore primary schools mathematics curriculum leaders which are also the heads of mathematics department. Every Singapore primary schools has one or two mathematics curriculum leaders in the schools which has one of these job titles: Head of Department, Subject Head (Mathematics) and Level Head (Mathematics). For ease of referencing in this paper, the sample will be referred to Heads of Mathematics Department. Due to practical limitations, convenience sampling was used to select the primary schools heads of mathematics departments for this study. These heads of mathematics department were approached via telephone, email or personal visit. Finally, 43 heads of mathematics department agreed to participate in the study. The heads of mathematics department came from different parts of Singapore: 12 in the North, 10 in the South, 11 in the East and 10 in the West zone. All the sampled heads of mathematics department are also mathematics teachers who taught at least one class of upper primary mathematics.

Instrument

Brown et al. (2007) and her research team specifically designed a questionnaire to explore teachers' reported beliefs, knowledge and teaching practices regarding calculator use in classrooms. This calculator instrument had been used before and would not need any test for validity (Brown et al., 2007). The instrument included demographic questions and 20 statements which heads of mathematics department responded to on a five point Likert scale (5 strongly agree, 4 agree, 3 neutral, 2 disagree, 1 strongly disagree). Twenty core statements appearing on the instrument were placed first followed by two open-ended items. The 20 statements have four categories: Catalyst Beliefs (8), Teacher knowledge (3), Crutch Beliefs (5) and Teacher Practices (4). The first category was Catalyst Beliefs (see Table 1, items 2, 3, 4, 5, 6, 7, 11, 20) and described beliefs in the positive effects of calculators on pupil learning (e.g., that calculator use leads to better student understanding). The second category was Teacher Knowledge which consisted of three items (see Table 1, items 14, 15, 16) measuring the perceived adequacy of the teachers' training in using calculators. Category three was Crutch Beliefs and consisted of five items (see Table 1, items 8, 9, 10, 12, 13) related to using calculators as a tool that: (a) helps students escape the necessary hard work of learning mathematics, and (b) inappropriately favours students who use them versus those who do not use them. Finally, category four was Teacher Practices which comprised four items (see Table 1, items 1, 17, 18, 19) measuring teacher's using calculators as a limited classroom tool (e.g., as a check on hand computations).

Data Collection

After all the 43 heads of department agreed to participate in the survey, an email providing the rationale and instruction of the questionnaire was sent to all 43 heads of mathematics department. Heads of department anonymously completed the questionnaires online and submitted completed survey through the online website. Heads of department generally took about 15 minutes to complete the questionnaire.

4. Results and Discussions

In this section, the results of the questionnaire pertaining to heads of mathematics department reported beliefs and practices toward the use of calculator are reported through the use of frequency tables of the heads of mathematics department responses to the various statements. Table 1 below shows the description of all the items as well as the summary of the findings regarding the heads of mathematics department surveyed. The descriptive statistics are reported in Table 1. High means indicate high level of beliefs.

Table 1
Items arranged in Descending Order by Means

Item No.	Items	Mean	SD	Catalyst Beliefs	Teacher Knowledge	Crutch Beliefs	Teacher Practices
6	I think students can learn mathematics ideas through the use of calculators.	4.12	0.45	√			
3	Students using calculators find mathematics more interesting and exciting.	4.07	0.70	√			
2	I find that using calculators during mathematical investigations leads to better student understanding.	4.02	0.74	√			
5	The use of calculators has an effect on my mathematics instruction.	3.93	0.67	√			
16	I teach students how to decide when a calculator should be used.	3.88	0.63		√		
7	Research indicates that calculator use enhances students' performance in mathematics.	3.77	0.65	√			
8	Teachers should avoid having students use calculators until they know their basic facts.	3.74	1.05			√	
15	I feel competent to teach students how to use calculators effectively.	3.70	0.80		√		
14	I have had adequate training and/or professional development in the use of the calculator for mathematics instruction.	3.51	0.91		√		
1	Students in my classroom have unlimited access to calculators during mathematics instruction.	3.44	1.24				√
13	Students who use calculators blindly accept the results.	3.35	0.92			√	
4	In my class, students who have used calculators for more than one year perform better in mathematics than students without such experience.	3.12	0.50	√			
10	When doing mathematics, students who use calculators have an unfair advantage over students who do not use calculators.	3.12	0.91			√	
9	The use of a calculator enables students to get answers without understanding the process.	2.84	0.97			√	
18	I do not allow students to use a calculator for mathematical processes that they have not already learned to do with paper and pencil.	2.60	0.79				√
20	Students who use calculators in class don't do as well on standardized tests (Continual/Semestral Assessment)	2.42	0.59	√			
17	I only allow students to use calculators to check computation.	2.35	0.78				√
12	Since some students have calculators at home and others do not, calculator use in the classroom contributes to inequalities.	2.28	0.77			√	
11	Calculator use lowers students' mathematics achievement.	2.26	0.69	√			
19	I mainly use calculators with students with special needs.	2.14	0.64				√

From Table 1, it seems to show high level of Catalyst Belief, with the top four means in the list belonging to the "Catalyst Belief" category. Based on descriptive data from the surveys, heads of mathematics department recognise that calculators can enhance student learning. Those survey items related to the category on Catalyst Beliefs had relatively high mean scores. For example, item 6, "I think students can learn mathematics ideas through the use of calculators" had mean scores above 4, which indicated the mean was toward the "strongly agree" point of a five-point Likert scale. The heads of department in the present study also agreed that calculators as an effective tool for mathematical investigations. Across items, heads of department agreed that the use of calculator led to better understanding, generated interest and enhanced student performance. These results regarding heads of department beliefs about calculators enhancing student understanding are aligned with previous findings (Ellington, 2003; Hembree & Dessart, 1992; Smith, 1997). When asked about student access to calculators, teachers agreed that although some students have access to calculators at home and some did not, this situation did not contribute to classroom inequities (see Table 1, item 12). Heads of department stated that calculator use does not lower student mathematics achievement and does not lower their performance on standardized tests. They also responded that calculators are not just used in their classrooms by students with special needs but are available to the whole class (see Table 1, item 19). As it appears from Table 1 that the top two categories are Catalyst Beliefs and Teacher knowledge, the responses on the Likert scale to the Catalyst Beliefs and Teacher knowledge categories are tabulated in Table 2 and 3 respectively.

Table 2
Frequencies of Responses in the "Catalyst Beliefs" Category

Item No.	Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
6	I think students can learn mathematics ideas through the use of calculators.	0	0	2	34	7
3	Students using calculators find mathematics more interesting and exciting.	0	1	6	25	11
2	I find that using calculators during mathematical investigations leads to better student understanding.	1	1	2	31	8
5	The use of calculators has an effect on my mathematics instruction.	0	3	2	33	5
7	Research indicates that calculator use enhances students' performance in mathematics.	0	1	12	26	4
4	In my class, students who have used calculators for more than one year perform better in mathematics than students without such experience.	0	3	32	8	0
20	Students who use calculators in class don't do as well on standardized tests (Continual/Semestral Assessment)	1	24	17	1	0
11	Calculator use lowers students' mathematics achievement.	3	29	8	3	0

Table 2 shows that the heads of mathematics department have catalyst beliefs that the positive effects of calculators on pupil learning. This could due to several reasons. Since heads of mathematics department are more specialised in their discipline and teach at least one mathematics class, they are more likely to have experienced a wider range of students' problem-solving experiences. Furthermore, the variety of mathematical topics taught at upper primary levels may lend themselves to a greater variety of applications where calculator use can be a catalyst for learning a concept

Table 3
Frequencies of Responses in the "Teacher Knowledge" Category

Item No.	Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
16	I teach students how to decide when a calculator should be used.	0	3	2	35	3
15	I feel competent to teach students how to use calculators effectively.	0	5	7	27	4
14	I have had adequate training and/or professional development in the use of the calculator for mathematics instruction.	1	7	6	27	2
	Total Responses	1	15	15	89	9
	Percentage Responses	0.8	11.6	11.6	69.0	7

In the "Teacher Knowledge" Category, about 76% of the heads of mathematics department had perceived adequacy of the teachers' training in using calculators. The responses addressed heads of mathematics department reported level of knowledge, training and teaching experience with calculators. As with Catalyst Beliefs, the greater content specialisation of heads of mathematics department is a reasonable explanation for this result. Heads of mathematics department are likely to teach upper primary level classes (e.g., decimals, fractions, percentages and ratios) where students can greatly benefit from using the calculators. The result for the Teacher Knowledge category may reflect professional development initiatives focusing on the use of calculator in Singapore. In addition, the need to use calculators during the national examination prompted heads of department to provide opportunities for pupils to use calculators in classroom activities so that they would not be at a disadvantage during assessment. Before 2007, the heads of department involved in the study had limited professional development in using calculators, but in the last one year prior to the study, Singapore Ministry of Education had provided some form of calculator training for all heads of mathematics department and selected teachers. However, anecdotal evidence has shown that not all heads of department organised their own school-based calculator workshop sessions. Therefore, differences in Teacher Knowledge related to calculator use responses may reflect differences in training and support given to heads of mathematics department.

5. Conclusions and Implications

The heads of mathematics department reported a significantly higher in their perception of calculator use as a catalyst in mathematics instruction as compared to the other three categories. The top three mean scores indicated agreement that students can learn mathematics through calculator use and make mathematics more interesting as well as using calculators in instruction will lead to better student understanding. The survey results shed light on heads of mathematics department self reported beliefs, knowledge, and practices which were consistent with elements of Singapore's Ministry of Education press release statement on the introduction of calculators in Primary 5 - 6 Mathematics (Ministry of Education, 2007).

Results from the data analysis reveal significant implications for curriculum specialists, examination boards and classroom teachers. As stated by Heid (2005), "If teachers are to make the best use of available technologies and tools, they must be able to locate and take advantage of appropriate professional development." (p. 364-365). Since teachers' beliefs are related to their practices (Brown & Borko, 1992), conversations about teachers' beliefs should be a part of professional development in addition to demonstrating activities to try in classrooms. Recognizing that head of departments' beliefs are often resistant to change, efforts must be long-term and consistent. By assessing their beliefs and targeting group discussion to those findings, head of mathematics department can express concerns and debate issues about using calculators guided by an expert who can respond knowledgably. Heads of mathematics department need to become fully aware of the potential of using calculators at all grade levels to enhance student learning. As heads of mathematics department select meaningful instructional tasks for teachers and students, they need to make judicious decisions about the appropriate and effective technology for teaching mathematics. These decisions need to be based on research-based practice supported by heads of department beliefs that calculator can be a powerful learning tool in at the primary level. However, many heads of mathematics department are not aware of the research available about successful technology innovations including calculator use in the mathematics classroom. Therefore, heads of mathematics department at all primary schools in Singapore need to be informed of the latest research through meaningful professional development.

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