Incorporating Calculators into Primary School Mathematics: Prospective and Practicing Teachers' Beliefs about Their Role

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Abstract: *Singapore recently mandated the use of scientific calculators in the curriculum for students in upper primary grades. The current sought to gain an understanding of prospective and practicing primary school teachers' beliefs of their role in the implementation of the new curriculum as well as the impact of the scientific calculator on the teaching and learning of primary school mathematics. Survey participants were enrolled in courses or a workshop at Singapore's National Institute of Education and each participant completed a survey consisting of both scaled response items and open-ended commentaries. Analyses of the survey indicated that the pre-service primary school teachers were more inclined to regard calculators as a crutch whereas practicing teachers' responses indicated that calculators served as a catalyst for enhancing students' mathematical achievement. Responses by the prospective and practicing teachers also differed with respect to belief categories related to teaching knowledge and practices with the future teachers expressing less confidence in their capabilities to teach with the technology and practicing teachers indicating beliefs more supportive of calculator-enhanced instructional practices. Conclusions include recommendations for increasing future primary school teachers' (1) exposure to, and knowledge of, teaching mathematical topics through the use of the scientific calculator, and (2) pedagogical knowledge pertaining to the use of the scientific calculator in promoting critical thinking, problem solving, and reasoning skills for their students. Since practicing teachers expressed greater confidence in being able to integrate the scientific calculators into their future teaching, it is suggested that teacher education institutions consider using practicing teachers as resources in improving the technological expertise of new teachers.*

1. Introduction

Recent research on calculators in mathematics education has recently taken two directions. First, there have been meta-analyses of the impact of calculators on student achievement in mathematics and second, there have been studies intent on understanding educators and other community members' beliefs on using calculators in the curriculum. Examples of the first direction include research by Ellington [2] and Hembree and Dessert [3]. In both of these meta-analyses the emphasis was on the calculator use of students in mathematics classrooms and results indicated that there were improvements in operational, computational, conceptual, and problem-solving skills as well as in attitudes towards mathematics. Research about beliefs regarding calculator use include a recent study by Brown, Karp, Petrosko, Jones, Beswick, Howe, and Zwanzig [1]. This study investigated beliefs about

calculators and about teachers' knowledge about calculators as a means to better understand teachers' practices and instructional expectations when using calculators. In particular, this study extended previous research on teachers' beliefs about calculator use by comparing responses of teachers in different grade levels.

Studies of calculators in mathematics education are particularly pertinent when calculators are newly introduced into the curriculum such as the case in Singapore where calculators are being integrated components of the curriculum of the upper elementary grades. Like any innovation in the curriculum, calculators accentuate the importance of future teachers' beliefs, knowledge, and competence pertaining to this handheld technology.

2. Methodology

In order to better understand both future and practicing teachers' beliefs about calculators in the school curriculum, a survey was undertaken to gain information about these beliefs. The participants in the survey were both pre-service teachers and experienced practicing teachers who were completing coursework or a workshop at the National Institute of Education (NIE) in Singapore. Brown et al [1] compared the beliefs of practicing teachers in different grade levels. In the present study, we compared the beliefs of practicing teachers against those of future teachers in the elementary grades.

The survey in this study was based on a questionnaire of beliefs about calculator use in a study by Brown et al [1] in which survey items revealed that four belief factors accounted for the majority of the variance in the ratings. These four factors were catalysts and crutch beliefs, and beliefs related to teaching knowledge and practices. The survey items used in the current study included 20 items indicative of crutch or catalyst beliefs, or related to teaching practices and knowledge. Permission to use these items was provided for this study by the authors of Brown et al [1].

For the survey instrument in this study, there were a total of 21 items in which the respondents indicated whether they either strongly agreed, agreed, neither agreed or disagreed, disagreed, or strongly disagreed. The additional item, not found in the questionnaire used in Brown et al [1], is "I believe I have had an adequate amount of training to use calculators in my teaching." In addition, the survey included one open-ended item in which the respondents commented on how calculators are now used in the schools and changes they expected to occur in the future. A second open-ended item asked respondents to indicate what they would like to know more about teaching with calculators.

Respondents in the current study were 117 pre-service primary school teachers and 32 practicing primary school mathematics teachers all of whom were enrolled in classes or a workshop at Singapore's National Institute of Education (NIE). Participants completed the surveys at NIE where their classes included mathematics for prospective primary school teachers or professional development, or a calculator workshop.

3. Results

Results indicated that these current and future educators shared a number of common beliefs about calculator use. In particular, the median ratings for 8 of the 21 scaled survey items were identical for both pre-service and practicing teachers. Table 1 shows the median responses for pre-service and practicing teachers on the 8 survey items for which the medians were the same.

Table 1 Median Response on Survey Items with Identical Medians

Item Number	**1**	**4**	**5**	**6**	**8**	**13**	**16**	**19**
Preservice	3	3	4	4	4	4	4	2
Practicing	3	3	4	4	4	4	4	2

Table 2 shows the median ratings on survey items for which the medians were different for the pre-service and practicing teachers. On only one survey item (Item 9: "The use of a calculator enables students to get answers without understanding the process") did the median rating by one group of respondents differ by more than one unit on the rating scale. On this item the median rating by the pre-service teachers was one and a half units higher than the median rating by the practicing teachers. This higher median rating by the pre-service teachers provided evidence that they, as a group, were more prone to agree with item 9 than were the practicing teachers. On the remaining 12 survey items, the median ratings differed by one unit on eight items (wherein the number of these items with a higher median was the same for both groups) and the median ratings differed by one-half unit on four items (wherein the number of these items with a higher median was again the same for both groups).

Table 2 Median Responses on Survey Items with Different Medians

Item Number	**2**	**3**	**7**	**9**	**10**	**11**	**12**	**14**	**15**	**17**	**18**	**20**	**21**
Preservice	3	3	3	4	4	3	3	3	3	3	4	3	3
Practicing	4	4	4	2.5	3	2	2	4	3.5	2.5	3.5	2	3.5

Examination of pre-service and practicing teachers' responses using means and a t-test for the interval measure, response mean difference, showed histogram and normal-quartile plots offering only modest evidence of distribution normality. A subsequent single sample t-test, contingent upon normally distributed difference data, produced a *p*-value of 0.277 indicating that a null hypothesis that the response mean differences were zeros could not be rejected. Given the inherently ordinal nature of the response data, further analysis of responses employed the more robust ordinal measure, the median.

With respect to catalysts beliefs about calculator use, that is, beliefs that calculator use leads to better student understanding, the median ratings for practicing teachers exceeded those for pre-service teachers by one unit on three survey items and were less than the median ratings for pre-service teachers by one unit on two survey items. These median ratings are consistent with practicing teachers' beliefs being indicative of a positive affect of calculators on student learning. In particular, survey item 2, "I believe that using calculators during mathematical investigations leads to better

student understanding." survey item 3, "Students using calculators find mathematics more interesting and exciting." and survey item 7, "Research indicates that calculator use enhances students' performance in mathematics." were each items that when rated positively indicated a belief of the positive effect of calculators on student learning. Likewise, survey item 11, "Calculator use lowers students' mathematical achievement.", and survey item 20, "Students who use calculators in class don't perform as well on standardized tests." when rated lower on the 1-5 Likert scale indicated that there was a positive effect of calculators on student learning. Analysis of responses to these items illustrated that pre-service teachers were less inclined to express positive effects for calculators on student learning in items 2, 3, and 7. Figure 1, "Percent of Responses for "Calculator use lowers students' mathematical achievement." shows that more than twice as many practicing teachers disagreed with item 11 and that only 3% of the practicing teachers agreed with the item whereas nearly 20% of the pre-service teachers agreed or strongly agreed with this item.

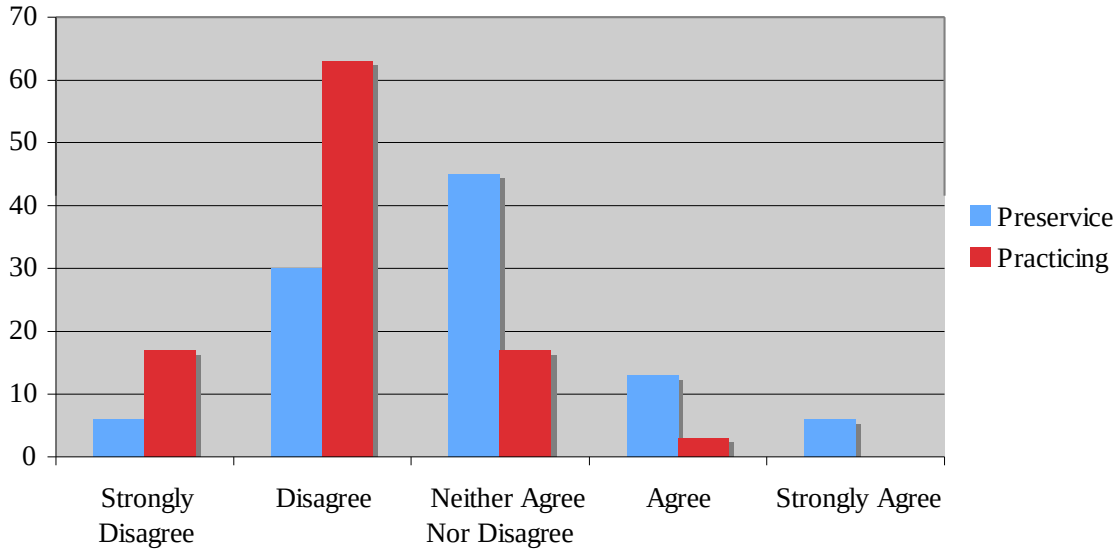

Figure 1 Percent of Responses for "Calculator use lowers students' mathematical achievement."

Regarding beliefs related to calculators as a crutch, survey item 9, "The use of a calculator enables students to get answers without understanding the process." item 10, "When doing mathematics, students who use calculators have an unfair advantage over students who do not use calculators." and item 12, "Since some students have calculators at home and others do not, calculator use in the classroom contributes to inequalities." were each items with a median rating one and a half or one unit higher for the pre-service as opposed to the practicing teachers. Figure 2, "Percent of Responses for "The use of a calculator enables students to get answers without understanding the process." shows that twice the percentage of practicing teachers disagreed with the statement as compared to the pre-service teachers. Also, none of the practicing teachers strongly agreed with the statement, while nearly 20% of the pre-service teachers indicated such agreement.

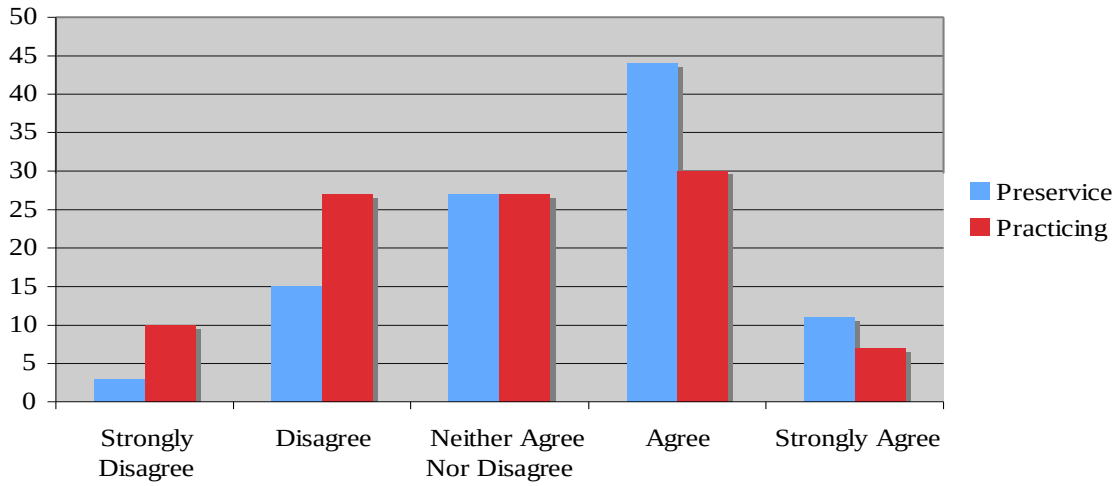

Figure 2 Percent of Responses for "The use of a calculator enables students to get answers without understanding the process."

Figure 3, Percent of Responses for "When doing mathematics, students who use calculators have an unfair advantage over students who do not use calculators." shows that more than twice the percentage of practicing teachers disagreed or strongly disagreed, while a higher percentage of pre-service than practicing teachers agreed with the item. Similarly, Figure 4, Percent of Responses for "Since some students have calculators at home and others do not, calculator use in the classroom contributes to inequalities." shows that the percent of practicing teachers who disagreed with the item was more than twice the corresponding percent of pre-service teachers. Also, the percentage of pre-service teachers who agreed or strongly agreed with the item exceeded the corresponding percentages for practicing teachers.

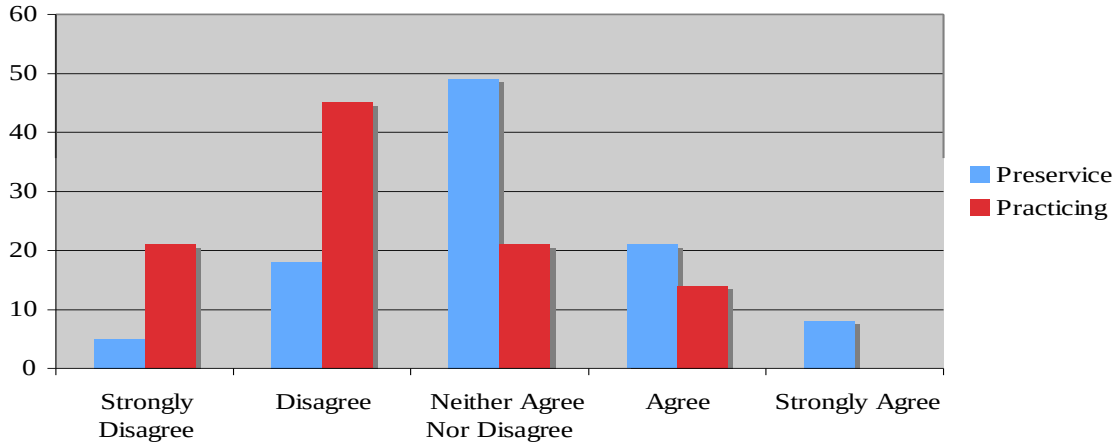

Figure 3 Percent of Responses for "When doing mathematics, students who use calculators have an unfair advantage over students who do not use calculators."

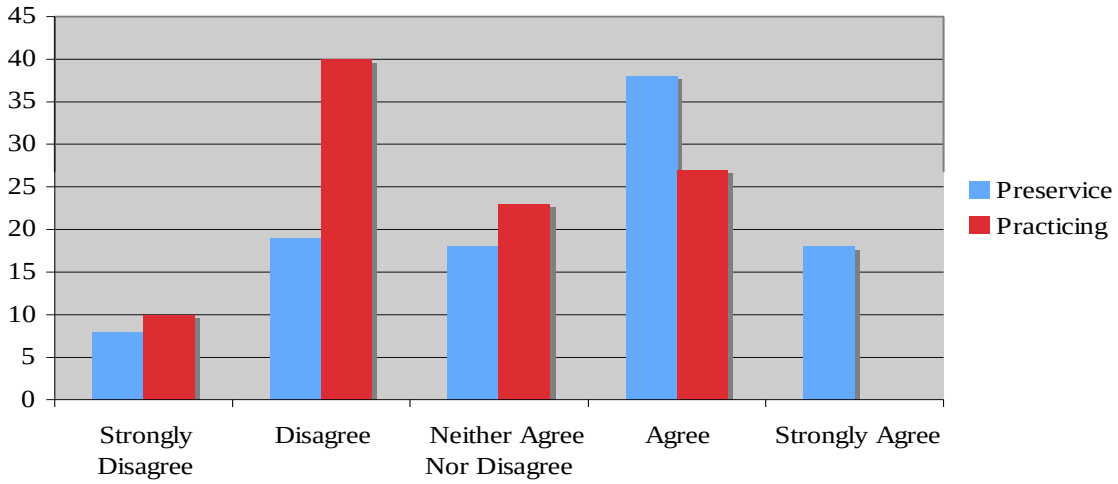

Figure 4 Percent of Responses for "Since some students have calculators at home and others do not, calculator use in the classroom contributes to inequalities."

Concerning beliefs about teacher knowledge, that is, the perceived adequacy of teacher training on using calculators, the median responses by practicing teachers for survey item 14, "I have had adequate training and/or professional development in the use of calculators for mathematics instruction." was one unit higher than that for pre-service teachers. However, there was less difference (one half unit higher for practicing than for pre-service) in the respondents' median responses for item 15, "I feel competent to teach students how to use calculators effectively." Figure 5 shows the percent of responses for item 15, and provides graphical support for the contention that, despite the smaller median difference, practicing teachers expressed more confidence in their ability to use calculators in instructional settings. Particularly, more than 55% of the practicing teachers agreed with item 14, whereas only 26% of the pre-services teachers expressed similar agreement. On the other hand, figure 6 indicates that similar percentages of the current and future teachers expressed a lack of instructional competence with calculators.

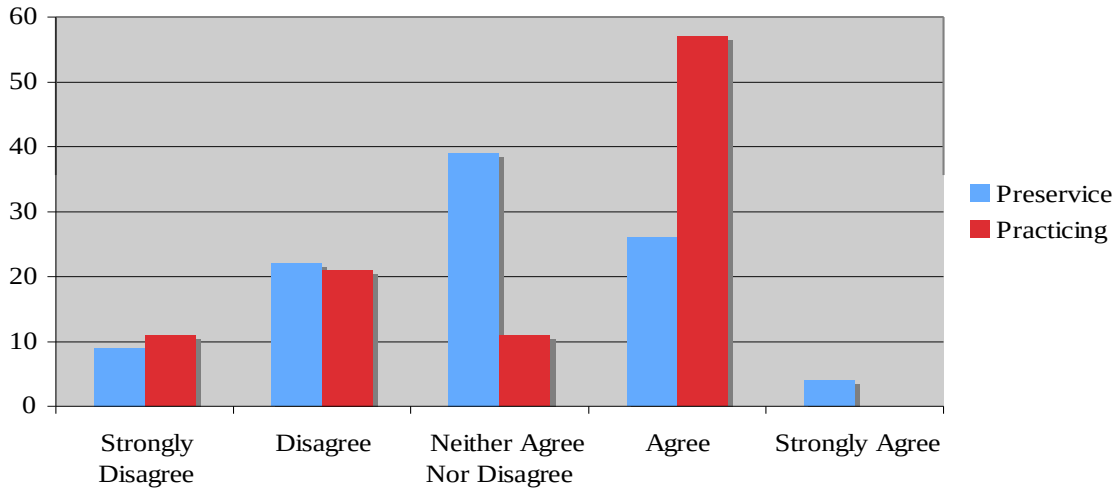

Figure 5 Percent of Responses for “I have had adequate training and/or professional development in the use of calculators for mathematics instruction."

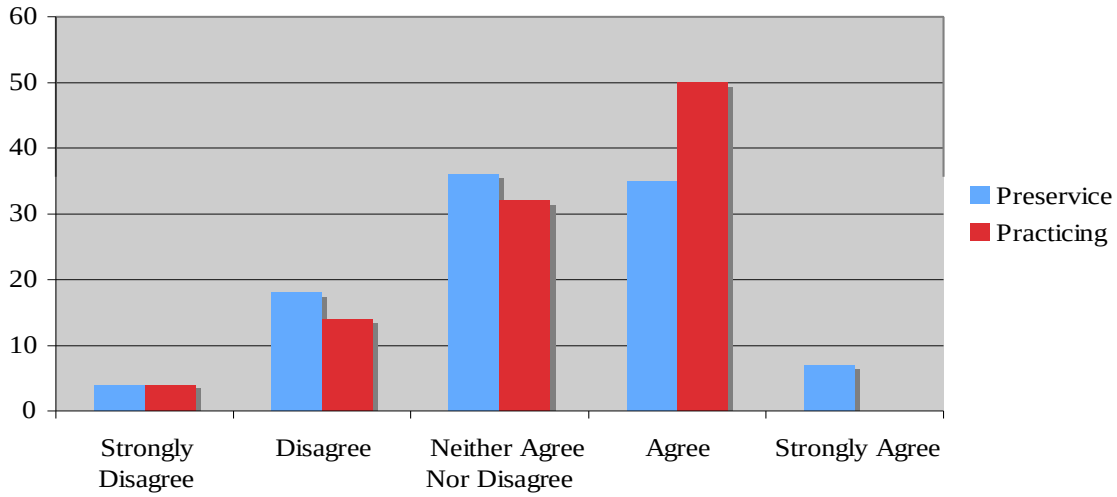

Figure 6 Percent of Responses for “I feel competent to teach students how to use calculators effectively."

Figures 7 and 8 show the responses to survey item 1, "Students in my classroom (will) have limited access to calculators during mathematics instruction.", and survey item 18, "(I expect that) I will only allow students to use a calculator for mathematical processes that they have already learnt to do with paper-and-pencil.". Both of these items are indicative of teachers’ practices with calculators, and in item 1 the medians of the responses were the same (indicating neither agreement nor disagreement), whereas figure 7 shows that more than four times as many practicing teachers strongly disagreed with the item as compared to pre-service teachers. Figure 8 illustrates that almost three times the percentage of practicing teachers disagreed with item 18, while the medians of the responses for the two groups showed a median rating by pre-service teachers that was one half unit higher than that of the practicing teachers.

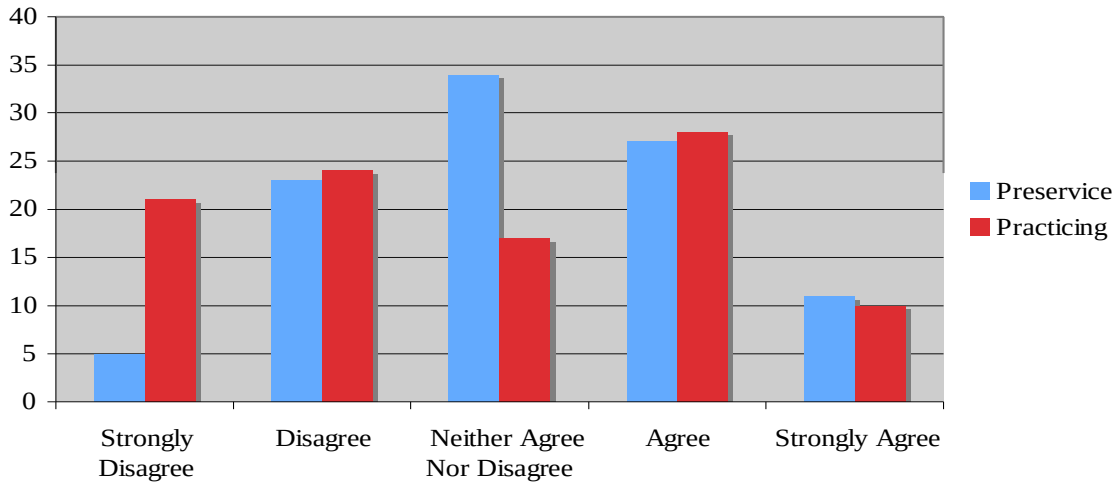

Figure 7 Percent of Responses for "Students in my classroom (will) have limited access to calculators during mathematics instruction."

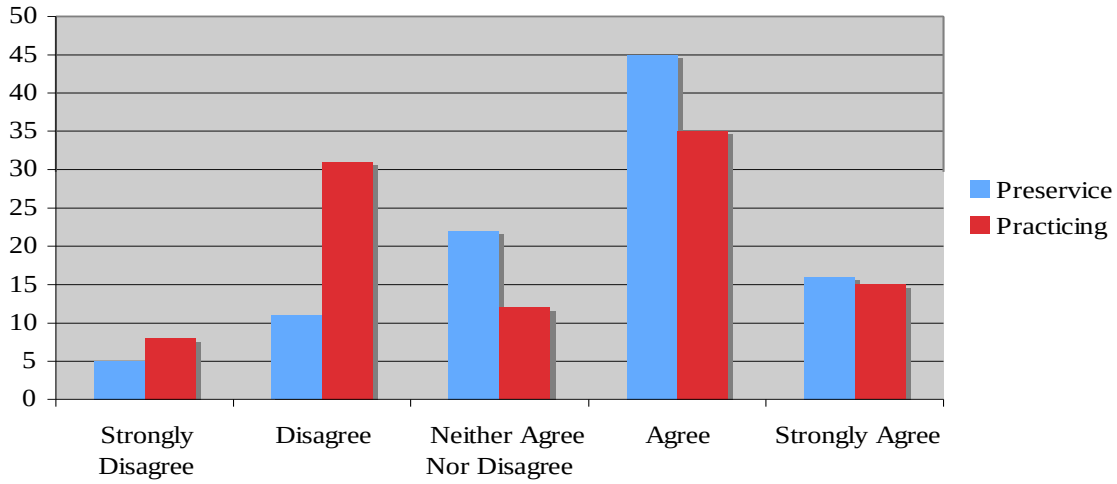

Figure 8 Percent of Responses for "(I expect that) I will only allow students to use a calculator for math processes that they have already learnt to do with paper-and-pencil."

The first of the open-ended survey items had two parts in which the respondents commented on how calculators are now used in the schools and the changes they expected in the future. Responses to these items were analyzed by categories and results for the first item showed that 50% of the practicing teachers believed that calculators currently were used only to check answers to solutions. Also, 30% of the practicing teachers indicated calculators were in current use for tedious or repetitive computations. Roughly 22% of the pre-service teachers agreed that calculators were currently used for tedious or repetitive calculations. But the most common response by the pre-service teachers, a response given by 29% of them, was that calculators were currently discouraged in schools to prevent students from becoming over-reliant on the technology.

Responses to the second part of the first open-ended item revealed disconnects in the beliefs of the pre-service and practicing teachers. Sixty percent of the practicing teachers reported that they expected calculators to be used for problem solving, exploration, and complex topics in the future. This expectation was evident in the responses of fewer than 20% of the pre-service teachers. Moreover, 21% of the pre-service teachers anticipated that calculators would be discouraged in the future, and 21% also responded by indicating that calculators would be used more often, but without specifying how they would be used in schools.

There was some unanimity in the responses of the pre-service and practicing teachers with respect to what they wanted to know more about calculators. One fourth of the pre-service teachers and 22% of the practicing teachers indicated a desire to know more about when to use calculators in the curriculum. This same percent of practicing teachers expressed interest in how to use calculators for puzzles and entertainment, how to integrate calculators in to the curriculum, and how to address issues related to assessment with calculators. About 20% of pre-service teachers gave responses indicating a need to know more about teacher training with calculators and

this same percent related an interest in how to use less well-known keys on the calculator (Figure 9).

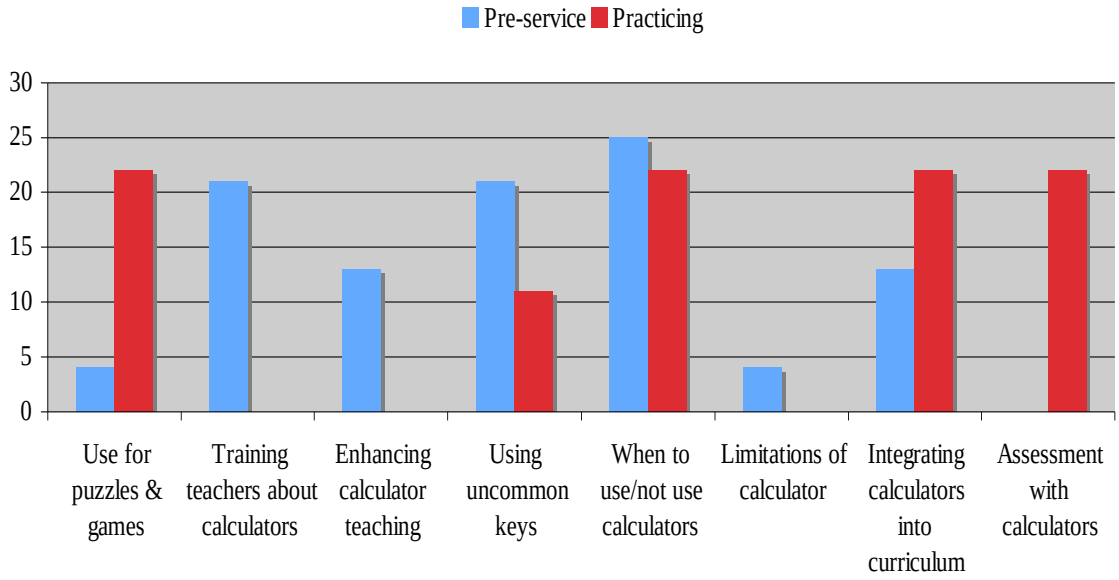

Figure 9 Percent of response categories to "What do you want to know more about teaching with calculators?"

4. Conclusion

Based on the findings of this study, there is evidence that the pre-service primary school teachers were more inclined to regard calculators as a crutch in mathematics learning. This belief that calculators function mainly as a crutch is exemplified in the pre-service teachers' median responses to items 9, 10, and 12 (Figures 2, 3, and 4). One manifestation of this calculators-as-a-crutch mentality is that students will become over-reliant on calculators to the detriment of mathematical understanding. As noted previously, pre-service and practicing teachers explicitly expressed this belief in 29% and 21% of their open-ended comments about future and current uses, respectively, of calculators in the schools.

Practicing teachers, alternatively, gave responses reflective of a belief that calculators served as a catalyst for enhancing students' mathematical achievement. These responses were particularly apparent in items 2, 3, 7, and 11. Further evidence for this belief was shown by the fact that 60% of the practicing teachers in their open-ended comments expected calculators to be used in the future for problem solving, exploration, and more intricate mathematical topics. This finding suggests that teaching experience has an effect on whether teachers perceive calculator use as a catalyst or a crutch in mathematics learning. Brown et al [1] found in their study that high school teachers, who had more content knowledge, were significantly higher in their perception of calculator as a catalyst in mathematics instruction. Perhaps, both content knowledge and teaching experience have significant effects on teachers' perception of whether calculator is a catalyst or a crutch.

Responses by the prospective and practicing teachers also differed with respect to beliefs related to teacher knowledge especially the perceived adequacy of teacher training in using calculators. These distinctions are shown by the higher median ratings by practicing teachers to survey items 14 and 15 (viz., Figures 5 and 6). In this context it is notable that in open-ended responses although nearly an equal percentage of pre-service and practicing teachers expressed an interest about when to use and not use calculators, 42% of the pre-service teachers indicated a need for teacher training with calculators or how to use calculators compared with only 11% of the practicing teachers.

Differences were also evident in the results from the two response groups with respect to teaching practices with the future teachers expressing less confidence in their capabilities to teach with calculators and expressing agreement with survey items indicative of calculators as a limited classroom tool (e.g., to verify computations by hand). In contrast, practicing teachers showed evidence of beliefs that were more supportive of calculator-enhanced instructional practices. Support for this contrast is displayed by the responses to items 1 and 18 in the survey (Figures 7 and 8).

As a result of these different beliefs, there are apt to be disconnects between the use of calculators by teachers presently practicing and those soon to be teaching in primary schools. Given the new emphasis on calculators in the primary schools, it seems appropriate to recommend ways to both enlighten and enhance pre-service teachers' understandings of the need for calculators in the curriculum. One means for enabling pre-service teachers to gain better understanding of teaching with this technology is to increase their exposure to, and knowledge of, teaching mathematical topics through the use of scientific and other calculators. Increasing this exposure is particularly appropriate in the mathematics and mathematics education classes that these future teachers complete in their courses for licensing.
In the same vein, mathematical methods classes taken by teacher candidates during their programs of study can provide an appropriate and effective venue for imparting pedagogical knowledge on the use of calculators in promoting such important topics as critical thinking, problem solving, and reasoning skills. Finally, since practicing teachers in this study expressed confidence in integrating calculators into instructional programs, it is important that teacher education institutions take advantage of this exceptional base of experience as a source of expertise for improving the technological understanding of future teachers.

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