Teacher Presence as a Variable in Research into Students Mathematical Decision-making

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There have been many policy recommendations for students to become more active in their learning of mathematics, and to make sensible choices of computation method. Year 5-7 students were asked to choose among calculator, written and mental computation methods to answer a series of multiplication questions, with a teacher either absent or present. Findings indicate that the students made choices based on what they believed the teacher "really" wanted, rather than on valid mathematical factors.

Rationale

During the 1980s and early 1990s a number of major policy documents for mathematics education were published, including the NCTM's (1989) *Curriculum and Evaluation Standards for School Mathematics*, the National Research Council's [NRC] (1989) report *Everybody Counts*, the UK Cockcroft Committee's (1982) *Mathematics Counts* and in Australia the Australian Education Council [AEC]'s (1990) *A National Statement on Mathematics for Australian Schools*. Given the ongoing technological revolution, it is not surprising that each of these documents should include advice regarding the use of calculators and computers in school mathematics; nor is it surprising to find much similarity in that advice. Overwhelmingly the authors of these reports urged mathematics teachers to include calculator and computer technology in their lessons. Specifically, teachers were encouraged to (a) include calculators as a means of computation; (b) encourage students to engage in learning for themselves, and to take some responsibility for knowledge and understanding gains (NRC, 1989); and (c) teach students to make sensible choices among available methods of computation to use in a variety of situations (e.g., AEC, 1990; NCTM, 1989).

Despite the abundance of advice in the literature to include technological devices in the teaching of computation, anecdotal evidence suggests that many teachers are not following that advice in the manner in which it was intended. It appears that in many classrooms written computation is still the major focus of most mathematics lessons, and calculators are given little place. The study reported on here arose from a perceived need to find more about students' ideas of when the various computation methods should be used. In particular a number of potential influences on student choices were chosen as independent variables: question format (symbols or word problems); student year level; type of number involved; and teacher presence. Though precedence was found for investigating the influence of each of the first three factors listed (question format, year level, and number type), no studies were found which looked at the interaction of a teacher's presence or absence on a student's decisions.

The question of the effect of a teacher's presence on children's choices relates to complex relationships among student, teacher, and subject matter. Four observations seem pertinent at this point. First, there is much evidence that children do not see what happens in school as necessarily making sense, and apparently often do not even expect it to do so (Silver, 1994). Willis's (1990) comment is quite appropriate here:

> Unless students see the relationship between mathematics and its uses as they proceed they may never develop a view of mathematics as making sense in their world and as having relevance to the solution of their problems. (p. 10)

Second, students have traditionally been taught as passive receivers of knowledge "from above," and have not been expected to act or think independently from the way they have been taught (NRC, 1989). Though this is changing, there is much evidence to suggest that echoes of this past model of teaching and learning persist today. In other words, even though teachers have been urged for some years to foster independence in their students (NCTM, 1991; NRC, 1989; Rutherford and Ahlgren, 1990), in many classrooms students are still taught to be unthinking followers of others, and particularly their teachers.

The third point, following from the second, is that children tend to behave in school as they believe they are expected to. McIntosh, B. J. Reys, and R. E. Reys (1992), for example, told the anecdote of a boy who was reluctant to admit to using mental computation to calculate 37 + 25, telling an interviewer it was "Because I wouldn't get a mark then. I can't understand the way she tells us to do it on paper, so I do it this way in my head and then write down the answer and I get a mark" (p. 2). In other words, the child felt the (very real) need to make a pretence of following his teacher's directions. The child did so even though the teacher's directions made no sense to him, and though he was capable of performing better using another method which to him evidently made perfect sense. Willis (1990) likewise described a child who demonstrated a commendable level of skill at mental computation, but got the same questions wrong when they were presented in written form. Willis commented: "All the power was in the teacher's hands . . . it was his teacher's task and his teacher's rule, not his" (p. 3).
The fourth point is that some teachers, parents, and even children see written algorithms as the "proper" way to carry out computation, and believe that using a calculator is somehow "cheating" (Hembree & Dessart, 1992; Price, 1995).

The combination of the above propositions leads to the following conjecture: If children believe (a) that mathematics does not make sense, (b) that they should follow their teachers' directions even if they do not make sense, and (c) that they are expected to carry out computations "properly" without using a calculator, then the presence or absence of a teacher *will* affect children's choices, especially concerning the use of a calculator. The research reported here set out to investigate this hypothesis.

Aims

The aim of the study was to discover factors having an influence on upper primary students' decisions about which method of computation to use to answer multiplication questions. It was hypothesised that students' choices of computation method would be influenced by the form of presentation of the questions, the students' age or maturity and the presence or absence of a teacher.

Independent variables chosen were: students' year level; number type (extended basic facts, aliquot parts, or other two digit numbers); question format (word problem or symbols); and teacher presence. Only the last variable, *teacher presence* is reported on here. As mentioned above, this variable had not previously been included in research of this sort.

Method

A random sample was chosen from students in years 5 to 7 (ages 10 to 12 years) at an independent school north of Brisbane, Queensland. The school in question tends to promote a style of teaching and learning that is teacher-directed, with an expectation that students will respect teachers' directions and follow them closely. This point will be seen to be relevant to the study's findings below. The sample was stratified to include equal numbers of both genders and equal numbers of students of high, medium, and low mathematical ability, based on assessments made by class teachers. The sample comprised 18 students from each of years 5 and 6, and 16 students from year 7. There were fewer students from Year 7 owing to there being too few students available for selection.

Each student was observed individually as he or she answered a series of 12 multiplication questions printed on cards. The questions were written either in symbols or as word problems. Numbers included were in three categories: extended basic facts (e.g., 20 x 50); aliquot parts (e.g., 25 x 16); or other two-digit numbers (e.g., 31 x 29). A calculator, pencil and paper were provided, and each student was instructed to use whichever method of computation he or she desired for each question. Each session was videotaped.

Rather than merely asking students to nominate or describe the computational method they would use to answer each question (as used by B. J. Reys, R. E. Reys & Hope, 1993), the student actually carried out the computation. This method introduced an obvious difficulty, namely that of determining when mental computation was used. This was handled by assuming that if a student paused in the answering of a question without writing anything, and then wrote the answer, that student had used mental computation. Conversely, the benefit from using this method was that the setting was more authentic, being closer to that of actual practice in a classroom. In particular, if a student planned to use a certain method (mental, for example), and found the calculation too difficult, then the student was free to change to another method. By only asking the students how they *intended* to answer questions, B. J. Reys et al. (1993) found it difficult to interpret some students' claimed computational choices. For example, some students stated they would use mental computation to answer a question such as "29 x 31"; the authors offered the opinion that some students may have viewed as the same as "30 x 30", but admitted this could only be found out by using an interview.

To include the variable of teacher presence, for half of each interview the interviewer (a teacher at the school, and known to all the participants) left the room, asking the student to complete the remaining six questions alone. Each interview was videotaped for later analysis.

Results

Table 1 records the participants' choices in the presence of the teacher-interviewer, and in his absence. There was very little difference in the use of mental computation between the two situations; the main difference was in written and calculator computation methods. There was a switch of approximately 10% of all choices from use of paper and pencil to calculator when the teacher was absent which, based on the chi square test, was statistically significant at the .05 level.

Table 1 *Choice of Computation Method When Teacher is Present or Absent* (N = 52)

Teacher Presence	Computation Method (%) Written	Calculator	Mental
Teacher Present	55.8	25.6	18.6
Teacher Absent	46.2	36.4	17.5
Chi square: 8.74 ($df = 2$)*			

$^*p < .05$

Table 2 shows the breakdown of choices by year level. It has to be pointed out that the video camera recording the participants' actions was not concealed at all. Thus, though results are statistically not very significant, it may reasonably be assumed that trends evident would have been more pronounced had the camera been concealed. The reasoning behind this is that the absence of the teacher did make a difference in students' choices, even though the video camera was obviously recording the students' actions when the teacher was absent. Thus it was just the *presence of the teacher* that made the difference, despite the fact that the students' actions would be plain to the teacher from the video tapes. It is reasonable to assume therefore that the evidence here demonstrates a factor in the students' thinking that may have been more pronounced had the recording camera been concealed.

Year 5 and Year 6 students chose to use the calculator an average of 13% more often when the teacher was absent, than when he was present. Mental computation was also reduced by students of these two year levels in the absence of the teacher, though not by very much; most of the decrease was in the use of written methods.

Year 7 students' choices did not show a statistically significant difference, though the change that did occur was in the same direction as for the younger students. The reasons for this difference can only be guessed without further investigation, such as through interviews. However it is hypothesised that the older students were more confident than the younger students to choose computational methods for themselves in the presence of the teacher.

Table 2 *Choice of Computation Method When Teacher is Present or Absent, Year by Year*

Teacher Presence	Computation Method (%) Written	Calculator	Mental
	Year 5 (n = **18)**		
Teacher Present	56.5	24.5	19.0
Teacher Absent	44.4	37.9	17.6
Chi square:	4.72 (df = 2)*		
	Year 6 (n = **18)**		
Teacher Present	63.4	18.5	18.1
Teacher Absent	53.7	31.9	14.4
Chi square:	5.19 (df = 2)*		
	Year 7 (n = **16)**		
Teacher Present	46.3	34.9	18.8
Teacher Absent	39.6	39.6	20.8
Chi square:	0.90 (df = 2)**		

*p <.1
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Discussion

These findings raise a number of interesting, and potentially very important, questions regarding the interaction between teacher and students in a classroom. First, it is clear that the students as a group felt constrained to use written methods more, and consequently the calculator less, when the teacher was present. Since the students' decisions altered after the teacher left, it appears that for some reason they felt that the teacher wanted them to use written methods, though they themselves preferred to use the calculator.

The children were not questioned later about their choices, which could have provided valuable data about these constraints. However there is anecdotal evidence of students (a) attempting to conceal their use of the calculator, or (b) making verbal comments about the use of the calculator, that are quite revealing. First, a number of students were observed concealing their use of the calculator. Lucy (not her real name), a high-ability year 7 student, used paper-and-pencil or mental methods for every question in the presence of the teacher. When the teacher had left, however, she hid the calculator buttons with a question card, and while holding her pencil, pressed the calculator buttons behind the card. Thus she attempted to make it appear that she was continuing to use paper and pencil, while actually using the calculator. Another Year 6 student, Julie, casually dropped her hat onto the calculator after the teacher left, and then moved the calculator off the table, and used it below table level, clearly attempting to hide it from the camera. Second, a number of students made verbal comments during interviews indicating that they believed there was a hidden agenda in place. These include comments from Mick that "We're not allowed to [use a calculator]", and Eric's "You can use a calculator, it's your choice, but you get better marks if you're using your head". These actions and comments occurred despite the interviewer twice giving clear permission to use whichever method the student desired. These observations give to support to three hypotheses about the students' decisions. First, students seemed to have the idea that one or more methods were preferable *in the teacher s eyes* to others. Specifically it seems that the students believed that either mental or paper-and-pencil computation was preferable in some way to use of a calculator (as evidence, see Eric's comment above). Since using a calculator is easier, quicker, and more accurate than using written computation, the test in the students' eyes would appear to be about the correctness of the computational choice and perhaps about whether they would be "lazy", or "cheat" (see Hembree & Dessart, 1992, p. 30).

A second conclusion that may be drawn is that at least some children would have made different choices, had they been totally free to do so. Calculator use rose in the absence of the teacher, and students were observed attempting to use the calculator without being seen to do so. Thus it appears that they *wanted* to use the calculator but felt compelled not to. It may be presumed that for some students, at least, their sense of "correct behaviour" prevented them from choosing to use the calculator.

Third, it may be surmised that these children are used to "playing the game" of school, and will quickly and often unobtrusively alter their behaviour to meet certain (real or imagined) criteria. As mentioned earlier, the school in question fosters an environment in which there is a clear expectation that students will follow teachers' directions with little questioning. This may have been a significant factor in the findings, though it is likely that other schools' environments are similar in this respect. The task put to the students in this study was quite straightforward: Answer a series of familiar questions using any of three available methods. In fact some students (using the calculator for all or most questions) answered all the questions in five or six minutes, including time for the interviewer to give instructions. However, this apparently simple task was made much more complicated for some students by the evident inferences made by them, that various "unwritten rules" were in place, and that they should do their best to behave according to these rules, to maximise their "score". This bears out observations reported elsewhere (Morgan, 1989; Silver, 1994; Willis, 1990) that students see mathematics as being about "getting the right answer", and not about making sense or developing skills that are useful outside the classroom.

Conclusions

Implications for Teaching

The history of teaching of mathematics has been one of majoring on the mechanics of carrying out written algorithms, rather than the sensible use of a variety of mathematical tools to solve real world problems. This has produced generations of people who believe that mathematics is about using a single standard method for each type of question, about answers rather than processes, about treating mathematical questions as separate from and largely unrelated to the real world.

This study showed some of today's students behaving in this manner. The participants were observed trying to "play the game" of mathematics, to guess what the teacher *really* wanted, to do mathematics according to what they thought was *expected*, rather than to what was *sensible*. When students have learned that mathematics is unrelated to real life, that it is not supposed to make sense, then their mathematics education has been seriously flawed, and in a manner that impoverishes their future prospects for mathematical thinking.

The evidence described above indicates a clear need for openness and honesty from teachers when discussing computation. The question of how to solve a mathematical problem, including the means of computation to be used, is associated with issues of correct behaviour and student and teacher expectations. Thus it is important that teachers are candid with their students about the issue of how to make decisions in this area. It is important that teachers include in their teaching of computation activities that require their students to make choices between calculator, mental and written methods of computation, and openly discuss factors that influence such decisions. As R. E. Reys (1994) put it, teachers need to develop a "broad conception of computation" (p. 2).

The question of the place of written, mental and calculator computation methods continues to receive attention in the literature (Price, 1997; R. E. Reys, 1994; Sparrow, Kershaw & Jones, 1994); this study shows that we cannot assume that primary students will make sensible decisions in this area without assistance.

Recommendations for Further Research

Two strands of further research are suggested by this study. First, further work is needed in the area of computation in general, and students' use of various methods in particular. The advice regarding the use of technology in computation notwithstanding, much work still needs to be done to answer a number of important questions about the implementation of that advice. A list of many such questions was provided by Robert Reys (1994). Some examples:

> How should computational alternatives (mental computation, estimation, written algorithms, calculators) be developed? When should computational alternatives be introduced? . . . How are wise choices of computational alternatives developed? Do students know when mental computation is appropriate? (p. 5)

The second area of research that warrants further investigation is that of teacher presence, and its effects on students' thinking and decision-making. Answers to questions such as these could reveal important details about the interaction between teacher, student and learning:

- Do teachers' critical notions about mathematics match those of their students? How does the presence of a teacher influence students' problem-solving activity?
- Do students see themselves as being in charge as they answer mathematical questions? How do students construct their role, and that of the teacher, in such activities?
- How does a teacher's attitude to conflict and disagreement in the classroom influence students' attitudes to and learning of mathematics? How is a "mathematical community" (NCTM, 1991, p. 3) developed?

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