What Effect has Context on the Mental Computation Performance of Students in Years 3, 5, 7, and 9?

Jack Bana

Edith Cowan University

Anne Paterson

Edith Cowan University

Abstract

This paper reports on part of a larger study that investigated this question with students in the Perth Metropolitan area who were given the same mental computation test twice – once with the items in context and once without. Money was used as the context and students' experience with money was also measured. Despite many curriculum documents espousing the importance of teaching and learning mathematics in context, this study found that neither experience with nor use of the context of money had any effect at all, except in Year 3.

Keywords: context, mental computation, number sense, primary school, secondary school

Teaching and learning mathematics in context is often considered to be a significant goal in school mathematics, as confirmed in various curriculum documents (Australian Education Council, 1991; Curriculum Council, 1998; NCTM, 2000). However, it is generally accepted that this goal is given much less prominence in Asian countries. The landmark study by Carraher, Carraher and Schliemann (1985) clearly demonstrated students' higher performance on market-place mathematics – a context within their experience – compared to the same items presented in a 'school mathematics' format. Maier (1980) used the term 'folk mathematics' to define mental computation and estimation that is developed by individuals through self-discovery – as distinct from school mathematics which is often unrelated to real life. The nature of folk mathematics implies that it is embedded in context. A number of researchers have used money as a context – for example, Guberman (1992); Nunes, Schliemann, and Carraher (1993); and Irwin (2001) – but these studies have been somewhat limited in scope.

Current mathematics curricula are devoting greater attention to mental computation. This is stressed by leading researchers in the area of number sense who see mental computation as the way forward in the development of number sense, alongside the need to reduce traditional written computation due to the widespread use of calculators (McIntosh & Sparrow, 2004). In a study in Taiwan, Yang (1995) found that while students performed well in written computation items, they struggled when the same items were presented as requiring an estimate – thus the need to use mental computation and number sense.

Purpose of the Study

This paper reports on parts of a larger study by Paterson (2004). The main purpose of the study was to determine the effect of context, with money as the medium, on the mental computation performance of students in Years 3, 5, 7, and 9. The study also examined the effect of student preferences for either format, the development of mental computation skill across the year levels, the quality of the strategies used, and whether there were differences for gender.

Methodology

The study was conducted in a typical Perth suburban secondary school (Years 8–12 in Western Australia) and two adjacent 'feeder' primary schools (Years K–7). This was to ensure some representativeness as well as a reasonably common background for the students in the schools sampled.

Subjects

Two classes were selected at each year level. Class teachers were asked to select four males representing their class's range of mathematical ability while avoiding the two extremes in the spectrum. They were also to select four matching females. The total sample consisted of eight males and eight females from each of Years 3, 5, 7, and 9.

Instruments

Non-context mental computation tests were constructed with 10 items for Year 3, 12 items for Year 5, and 13 items for Year 7. The Year 7 test was also used for Year 9, since little new material in the topic would have been covered after Year 7. Wherever appropriate, the same items were given across two, three, and even four year levels in order to investigate skill development with age. Most of the items were taken from the sets used in an international study conducted in Japan, the USA and Australia (McIntosh, Bana, & Farrell, 1995). The same sets of items were then placed in the context of money in situations that were considered familiar to the students. Figure 1 shows the two formats for two of the test items – the first of which was used for Years 5, 7 and 9, and the second used for all four year levels.

Items in Context	Non-Context
I want to buy a lollipop for seven children. If lollipops cost 25 cents each, how much will I spend in total?	7 x 25 = ?
It cost $79 for our puppy's injections. It also cost $26 for puppy food. How much is this altogether?	79 + 26 = ?

Figure 1: Examples of mental computation items in contextual and non-contextual formats

Money was used as the context since it was considered to be the only medium that would be familiar to students of all year levels. Because extent of experience with money was likely to vary, an instrument was developed to measure this through an interview. This consisted of nine money-experience questions such as, *How often do you get pocket money or an allowance?* A semi-structured interview schedule was also developed to ascertain students' levels of understanding through the mental computation strategies used, and student

preference for context or non-context items. The mental computation strategy classification outlined by McIntosh, De Nardi and Swan (1994) was used to determine the type and level of strategy used. A pilot study was conducted to refine all the instruments.

Procedure

All instruments were administered through individual interviews of the 64 students by the same researcher. Using a carefully structured protocol, students were rated on a three-point scale on their experience with money. For each class sample, half the boys and half the girls were given the non-context mental computation test first, while the others received the contextual test first, in order to cancel out any test sequence effect. All the mental computation items were presented both visually and orally. This was to guard against the interference of reading difficulties, and also to ensure maximum possible understanding of the items. Students were on a time limit of 30 seconds for each item, and were not permitted to write anything except the answers. Following these two tests each student was questioned on the strategies used and re any preference for context or non-context items. All the data for each student was collected in one interview sitting which was audiotaped for further analysis later. This procedure of a one-off meeting necessitated keeping all instruments somewhat restricted in scope.

Results and Discussion

The mental computation items together with the results for both contextual and non-contextual presentations are shown in Table 1. Surprisingly, the mean performances are virtually identical for the two test modes in Years 5, 7 and 9. Only in Year 3 is there a significant difference, favouring the non-contextual presentation with 50 percent correct compared with only 30 percent correct for the same items presented in a money context. It was also found that there was no significant correlation between the level of money experience and performance on either form of the mental computation test.

The studies by Carraher et al. (1985) compared computation performance between classroom-type examples and market place examples in which the students had been actively involved. In this study all the contextual situations were contrived ones. Although every effort was made to ensure that the money examples portrayed realistic settings that would be understood by students, they were nevertheless only vicarious, and not situations in which students had been actively involved. The class teachers also indicated that much of the mental computation work which they gave to their students was non-contextual. It is quite likely that this is true of most classrooms. Thus students are probably more comfortable with the familiar non-context format than with ‘wordy’ examples – even if these are in a real-life setting. However, the use of practical examples involving the students themselves, such as a class shop, could well have a different impact. The very different results for the Year 3 students deserve special comment. They performed much better in the non-context test. This was the case with all items but one, *Double 26*, where there was no difference. This was possibly because they found the additional language more difficult to deal with than did their older counterparts. Also, they had had less experience with money. Although there was no overall difference in mental computation performance in Years 5, 7 and 9, there were some individual items that did not fit this pattern. As shown in Table 1, on the items involving

Table 1

Numbers of Students with Correct Answers across Year Levels

Item by Operation	Year 3 (N=16) C	Year 3 (N=16) NC	Year 5 (N=16) C	Year 5 (N=16) NC	Year 7 (N=16) C	Year 7 (N=16) NC	Year 9 (N=16) C	Year 9 (N=16) NC
60 + 80	9	12	13	14				
68 + 32	6	9	14	14				
79 + 26	4	8	9	10	14	16	14	15
165 + 99			9	9	14	11	13	14
6.20 + 4.90			13	8	16	12	13	13
80 – 24	0	3						
140 – 60	3	6						
74 – 30	4	8	15	11				
105 – 26	2	3	6	8	12	12	11	12
6 – 4.50					14	11	15	14
264 – 99					6	6	8	7
Double 26	9	9	16	16				
7 x 25			7	8	12	14	12	11
60 x 70			2	2	8	10	9	12
38 x 50					7	6	8	4
0.1 x 45					6	8	6	4
150 ÷ 25			5	9	8	14	7	8
Half of 16	11	13						
Half of 30	0	9						
3500 ÷ 35			6	5	13	13	9	10
25% of 48					8	7	7	8
Means (%)	30	50	60	60	67	68	64	64

Note: C = Context; NC = Non-context

decimals – *6.20 + 4.90* and *6 - 4.50* – students performed better in the contextual situation. This is most likely due to the close link that these students made between decimals and money. Here is an excerpt from the interview with a Year 7 student who used a sophisticated strategy for the item *6.20 + 4.90* presented in context:

4 plus 6 is 10 and then 90 add 20 is 110 so that was over 100 so add another whole dollar to the 10, 11 and then 10 cents change. $11.10.

Interview data revealed that performance levels were more likely to vary because of the students' individual strengths and weaknesses with computational strategy knowledge, or number sense, rather than their past experiences with money. Some students mentally rearranged the numbers presented in a horizontal format into a vertical one, then used school-taught written methods mentally, which are not efficient mental strategies. Here is an example of a confused attempt by a Year 7 student at the non-context item, *6 - 4.50*:

Zero. Six take four you can't do and the rest is not a whole number.

However, some students were quite successful with such strategies. This mental agility of considering the written format equivalent has also been reported by McIntosh and Dole (2000). An over-reliance on school-taught methods implies a lack of experience with mental methods both in and out of school. Interviews also revealed that there were a number of students who gave correct answers but were uncertain about the correctness of their answers. It is appropriate to recall Sowder's (1988) comment when she advised that "teachers must examine more than answers and must demand from students more than answers", since "correct answers are not a safe indicator of good thinking" (p. 227).

Preferences for context versus non-context items were almost equally matched, although Year 3 students tended to prefer non-context, and this is reflected in the results in Table 1. However there was no significant correlation between preference mode and performance in mental computation in either format. There were small gender differences in money experience, mental computation performance, and types of strategies used, but none of these were significant.

There were marked increases in performance from Year 3 to Year 5 to Year 7. However Year 9 scored lower than Year 7 students. Discussion with teachers indicated that the Year 9 secondary school students spent less time on mental computation than the primary school students. They devoted more time to other topics such as algebra and therefore their practice of mental computation lessened through the secondary school.

Conclusion

It seems that the use of context in mental computation examples has little or no effect – at least when the contextual situation is a contrived or vicarious one. This is not to suggest that the same context would not make a difference if presented in a more engaging manner, such as in a simulated shop or with real shopping experiences. Nunes et al. (1993) found improved performance for mental computation items in simulated shopping experiences with associated motivational devices such as play money and objects to purchase. Such approaches have also been recommended by other researchers (Dehaene, 1997; Thompson, 1999; Beishuizen, 1999). Other contexts involving measurement or any real situations also need to be considered.

It appears that any context to be used has to be directly related the each student's personal experiences in order to be very effective. However, it must be recalled that much classroom mental computation is non-contextual. Thus it may be that any increase in the use of real-life contexts –

even contrived ones – will have a positive effect. At the very least it should add meaning to what students do in school mathematics.

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