The Effect of Money as a Context on the Mental Computation Performance of Students in Years 3, 5, 7 and 9

Anne Paterson
Edith Cowan University
<annepaterson@dodo com au>

Jack Bana
Edith Cowan University
<j bana@ecu edu au>

This paper reports on part of a larger study that investigated the effect of a single context on students' mental computational performance and strategy choices across a range of school ages in the Perth metropolitan area Money was the context and students' prior experience with money was also considered Students were given the same mental computation test twice – once with the items in context and once without 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

Curriculum documents emphasise the importance of context in teaching and learning mathematics, as is evident in various curriculum documents (Australian Education Council, 1991; Curriculum Council, 1998; NCTM, 2000) Carraher, Carraher and Schliemann's (1985) landmark study 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'– 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 previously 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 also devoting greater attention to mental computation Leading researchers in the area of number sense see mental computation as the key to the development of sound number sense, alongside the need to reduce traditional written computation due to the widespread use of calculators (McIntosh & Sparrow, 2004)

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 ranging from 8 to 14 years-olds This study also examined the level and effect of prior money experience, the range and depth of mental computation strategies used, whether there were differences for year levels or gender, as well as the effect of student preference for either format

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) The use of the 'feeder' schools 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 females of matching ability Thus 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 identical items for Years 7 and 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) Then the same sets of items were placed in the context of money in situations that were considered familiar to the students The items presented were contrived imaginary word problems similar to the applications used in commercial texts Figure 1 shows the contrasting formats for two of the test items – the first of which was used for Years 3 and 5, and the second used for Years 5, 7 and 9

Items in Context	Non-Context
Amy's brother earned $74 in his part-time job He gave his Mum $30 How much did he keep?	74 – 30 = ?
Mum spent $6 20 in the bakery, then she spent $4 90 at the newsagent How much did she spend altogether?	6 20 + 4 90 = ?

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

Money was used as the context since it was considered the only medium that would be familiar to all students of all year levels Because the extent of experience with money was likely to vary, an instrument was developed to measure it during a semi-structured interview This consisted of nine money-experience questions such as, *How often do you get pocket money or an allowance?* Further, data on students' mental computation strategies and their preference for either context or non-context items were collected 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

The same researcher administered all instruments through individual interviews of the 64 students in single sittings A carefully structured protocol was used to rate students 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 to ensure maximum possible understanding of the items Students were given a time limit of 30 seconds per item, and were only permitted to write the answers Following each question for each of the two tests, students were questioned re the strategies used and if they had any overall preference for context or non-context items Interviews were audio-taped for further analysis 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 were virtually identical for the two test modes in Years 5, 7 and 9 Only in Year 3 was 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 However, in this study, all the contextual situations were contrived ones The money examples portrayed realistic settings that would be understood by students Nevertheless, they were only vicarious, and not situations in which students had been actively involved Class teachers indicated that much of the mental computation given to students by them was non-contextual It is quite likely that this is true of most classrooms Thus, students may be more comfortable with the familiar non-context format than with 'wordy' examples – even if these are in a real-life setting Some teachers reported only using context in word applications Therefore, the use of practical examples involving, say a class shop, could well have a different impact

The provision of a variety of contexts is important for students, since what constitutes a meaningful context may vary from individual to individual based on personal interests and experiences For example, one Year 3 became very animated at the item *Amy's brother…* and remarked, *I have a sister called Amy!* Although this student got this particular item correct for context, he did not get all the other contextual items correct He did however, achieve a perfect score for all the non-context items This shows that while he was very good at non-context mental computation, the provision of a meaningful context for him had a positive effect

Although there was no overall difference in mental computation performance between the two formats in Years 5, 7 and 9, some individual items did not fit this pattern As shown in Table 1, with the items involving 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 The following 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

Table 1

Numbers of Students with Correct Answers across Year Levels

Item by	Year 3 (N=16)		Year 5 (N=16)		Year 7 (N=16)		Year 9 (N=16)	
Operation	C	NC	C	NC	C	NC	C	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*

On checking each of the 64 individual students, it was found that the money experience rating allocated to each of them did not, except for two exceptional Year 9 students, make a marked difference to either performance or strategy choices Students scored highly if they were experienced in budgeting If a wider range of real-life experiences had been used, then perhaps a more definitive conclusion could have been drawn Thus, the fact that money as a context did not make a difference to performance in the current study does not mean that other contexts would not make a difference The money experience rating procedure may have been too narrow in focus to gauge student performance, and transfer from significant experiences in other contexts may indeed have occurred, such as in sport scoring for example

The fact that experience with money was found to make little difference to the results could have been due to the design of the instrument – especially in not allowing for how recent the experiences were Only two students reported that they had paying part-time jobs where they also worked with money, and both students scored higher for the items in context However, only one student was currently employed and this student scored very significantly better for context with a difference of 23 percent, as well as using higher order strategies Therefore, it may be that for context to make an effective difference to student performance, the experience needs to be recent and personally relevant Responses revealed that several students talked to their adult 'money mentors' on a regular basis and this talk may be an important factor in performance One student stated that, "my Dad's an accountant and (he is) my financial advisor" while a second student reported that "my Grandma and I have *How are your shares going?* chats"

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 as previously reported by McIntosh and Dole (2000), which are not efficient mental strategies This implies a lack of experience with mental methods both in and out of school 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

Generally, the most successful students used mental computation strategies of the highest order, indicating that these students possessed a high degree of number sense Not only did they give better, more definite answers; they were also able to self-correct during their explanations The same students demonstrated high scores for both non-context and context Some top-performing students also noticed similarities in items used between the tests, but students did not notice that the two tests were the same At least one student observed the relationship between the numbers used for items within a test For example, that the items *105 – 26 = 79* and *79 + 26 = 105* are related facts The willingness of some students to use more than one strategy to solve items, and to check their answers, was observed of students in Years 7 and 9 Many of these students were also found to be using the 'chunking' method (Anghileri & Beishuizen, 1998) to solve items For example, two items involving chunking of 25s for Years 5, 7 and 9 were the items, *150 ÷ 25* and *7 x 25* The Year 7s demonstrated that they had an understanding of the fact that four 25s made 100, by referring to this fact before they calculated One Year 9 student calculated seven 25s first by working out two lots of four 25s as two hundred, then subtracted 25

Students readily explained their informal strategies However, where written methods were applied mentally they found explanations to be very difficult Some students made counting errors For example, one Year 3 student counted "80, 90, 100, 110, 120, 130" for the non-context item, *60 +80* While this student had correctly counted on by six tens, he had clearly started from the incorrect ten – from the 80 instead of from 90 Results showed that some students did not use efficient mental computation strategies for the items in context, which may reveal a lack of opportunity for discussion and school practice with such situations Even where context items were presented first, some students mentally used written method strategies for both sets of items Many students did not use efficient mental strategies for either context or non-context items, especially in Year 3 These students predominantly used low-level strategies such as counting aloud and finger counting One Year 5 student stated when answering the practice item (*9 + 15 = ?*) for non-context, "I say, nine plus what makes fifteen…because I play cribbage with Grandma" This represents evidence of student practice of mental strategies in an out-of-school environment where transfer was able to take place between the two settings Both the range and sophistication of strategies was found to increase with age, as would be expected However, some students at all four year levels were almost devoid of any useful mental computation strategies

Differences were found for age Year 3 recorded the lowest scores, while Year 7 recorded the highest scores for items set both in context and with no context Despite the fact that all items used for both Year 7 and Year 9 were identical, Year 9 scored lower than Year 7 Discussion with teachers indicated that the Year 9 secondary school students spent less time on mental computation than the primary school students, with more attention being devoted to other topics such as algebra Mental computation practice lessened through the secondary school and it was mainly restricted to lesson introduction There were marked increases in performance from Year 3 to Year 5 to Year 7 The two most improved results were for the two items *60 x 70* and *3500 ÷ 35* Performance improvement for both formats was found to be due to students' better understanding of place value, so that less conceptual errors were made Year 3 students were expected to have received less money context experiences at home, but this expectation was not substantiated by their money experience ratings Despite this, the Year 3 students performed much better in the non-context test This was the case with all items but one, *Double 26*, where there was no difference The difference in performance was possibly because the Year 3 students found the additional language more difficult to deal with than did their older counterparts Some students' verbal responses did not match their written solutions, with the latter more often correct For example, when explaining a correct response to *68 + 32,* one student stated:

> If you double the 8 and the 2, it makes ten…

The low Year 3 results may have been due to the level of difficulty presented, and also to the overall lack of experience with mental computation both at school and elsewhere, as results for both sets of exercises were much lower than for other years However, the higher Year 7 results may have been due to students' real experiences, as some students mentioned collecting school fund-raising donations, giving change and counting the proceeds The fact that the primary schools were feeder schools to the secondary school suggests that quantity as well as recency of quality experiences may be important factors in performance It seems that for Year 3 students the language used in the contextual items created an added difficulty

There were small gender differences in money experience, mental computation performance, and types of strategies used, but none of these was significant The only marked differences for gender appeared in Year 3 When the results were further examined by operation type, it was found that Year 3 females had performed poorly on subtraction items Preferences for context versus non-context items were almost equally matched, although
Year 3 students tended to prefer non-context items as reflected by their performance as shown in Table 1 There was no significant correlation however, between preference mode and performance in mental computation in either format

Interviews also revealed that there were a number of students, who gave correct answers while being uncertain about the correctness of their answers It is timely to recall the comments by Sowder (1988) who claimed that “teachers must examine more than answers and must demand from students more than answers”, as “correct answers are not a safe indicator of good thinking” (p 227) Results suggest a stronger influence of the school setting than first expected Although students gave answers orally, the act of holding a pencil to write their answers may have provided a ‘school cue’ towards using school-taught methods (Carraher et al , 1985) This may be particularly so for students who have had more school mathematics experiences than out-of-school ones In fact it is probably the case that most students have very limited experiences with meaningful computations outside the school classroom, so it behoves the teacher to redress this imbalance in the classroom as much as possible

Conclusion

Overall, results found that the money context presentation in word problem format did not make a significant difference to student performance for mental computation items when compared to a non-context presentation, except in Year 3 Nor was any correlation found between performance and student preference for one presentation or the other A few individual items were found to have a marked positive effect for context, but the difference was not consistent across all year levels or genders, while other items had a marked positive effect for non-context The results of this study were rather unexpected, given Nunes et al ’s (1993) findings that students scored better for applications than straight computation

Although mental computation was timetabled daily, both the time spent and nature of the activities varied slightly between schools, with secondary classes spending less time than primary ones This is the most likely explanation for the Year 9 students scoring slightly lower than the Year 7s The primary school students’ real money experiences were recent and these students spent more class time on mental computation than the secondary students did McIntosh et al ’s (1994) recommendation for 15 minutes of mental computation per day appears to be happening at the primary level, while more mental mathematics time may yet need to occur at the secondary school level

While findings from this study suggest that a money context does not make a difference to performance, simulated classroom shopping experiences are likely to have a more positive effect (Nunes et al, 1993) Such approaches have also been recommended by other researchers (Dehaene, 1997; Beishuizen, 1995; Thompson, 1999) While money is a significant context in all students’ lives, other common contexts such as food, time, sport and measurement should also be used in the classroom to provide a breadth of situational learning experiences Given that much classroom mental computation is not in context, 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, this should add meaning to what students do in school mathematics

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