Calculator Use in Number: A Teacher's Change in Curriculum Goals for Year One.

Joyce M. Dale

Deakin University

This paper reports on research in progress as part of a study of children using calculators in their mathematics learning during their first two years at school. The focus of this paper on teacher change in curriculum goals uses data from an extensive interview with one teacher to report on the challenge for her to change her goals for the development of number knowledge by year 1 children as a result of classroom availability of calculators. The teacher reports that the effect of the introduction of calculators has allowed these children to extend their number knowledge beyond traditional goals, thus resulting in her re-examining her beliefs and expectations of children's development of number concepts. In this paper the teacher's expectations are mapped against a traditional common curriculum statement and the children's actual achievements. Reasons for differences in teacher expectation, the curriculum statement and the children's actual achievements are explored.

Introduction

Until recently there has been little research into the effects of calculator use being systematically incorporated into the core mathematics curriculum in primary schools. One example of recent research has been the Calculators in Primary Mathematics project funded by the Australian Research Council, Deakin University and the University of Melbourne (see, for example, Groves & Cheeseman, 1993; Groves, 1993b, 1994), which investigated the effect of the introduction of calculators on teacher practice and long term learning outcomes of children.

This present study investigates the extent to which calculator use, in classrooms which encourage exploration of number in open-ended situations, allows children to demonstrate mathematical learning in advance of standard curriculum policy statements at kindergarten (prep in Victoria) and year 1. The first stage of this study was to establish the extent of number knowledge the children had on entrance to formal schooling, in order to determine the effect of classroom learning on their mathematical knowledge later in the two year period (Dale, 1995).

Six girls and six boys were randomly selected for an initial interview from the class commencing formal schooling in 1993. A girl and boy were chosen from the highest, average and lowest performers to take part in
the full study. These children were again interviewed individually in June and December of their first year at school and in March and December of year 1.

Their progress was observed during weekly number activity classes in 1993 and 1994. The teachers in the classrooms where the research has been carried out had previously participated in the Calculators in Primary Mathematics project. This paper reports on the change in curriculum goals by the year 1 teacher since her involvement in the Calculators in Primary Mathematics project (1990 to 1992) and in 1993 and 1994. The conclusions are based on questionnaire data, interview data and are supported by classroom observations.

Research Method

The Victorian Curriculum and Standards Framework: Mathematics (Board of Studies, 1995) provides seven levels for the reporting of student achievement over eleven years of schooling. These levels were used to compare curriculum level expectations with teacher expectations and the actual levels of attainment by children in the study. Table 1 shows curriculum levels associated with years of schooling.

Table 1: Victorian Curriculum and Standards Framework: Mathematics Levels

| Level 1 | End of Prep Year |
| Level 2 | End of Year 2 |
| Level 3 | End of Year 4 |
| Level 4 | End of Year 6 |
| Level 5 | End of Year 8 |
| Level 6 | End of Year 10 |
| Level 7 | Enrichment of those exceeding level 6 |

Source: CSF, p. 5

Data from the observation of and interviews with the children were used to establish children's levels of achievement and to compare these with the teacher's expectations as obtained from the questionnaire. Changes in teacher expectations, which may in turn lead to changes in curriculum goals for year 1, were also determined from the questionnaire data. An interview which allowed for collection of comprehensive data on the developing number knowledge of each child, the nature of children's thinking and the ways they approached set tasks was developed for use
with the six children in the overall study. The interview tasks reflect expectations of year 1 curriculum statements and beyond. An interview was held in March and again in December of 1994 and the number attainment levels of each child were mapped against CSF recommended curriculum levels. An observation schedule was developed to record responses from the six children to the number activity taking place during weekly observation sessions. This data was initially mapped against a common curriculum statement which listed expectations for year 1 and beyond. As these six children represented a cross section of class ability level, outcomes were useful for supporting data analysis resulting from the questionnaire and the teacher interview.

Teacher expectation of children's mathematical performance was mapped by using a questionnaire developed by the Calculators in Primary Mathematics project team. This questionnaire consisted of 121 items based on common curriculum expectation levels for children at primary school and beyond. Table 2 shows some sample items from the questionnaire.

Table 2: Sample items from the teacher questionnaire and corresponding CSF level

The teacher completed the questionnaire in both 1990 and 1994. She was asked to use the following code to fill in two columns headed BEG (for children entering her class at the beginning of the year) and END (for children leaving the class at the end of the year), indicating her expectations of the children's number achievement on the 121 items listed in the questionnaire. By entering 'A' the expectation was that all children would be able to do this, 'M' that most children would be able to do this, 'S' that at least some children would be able to do this and 'N' that normally no children would be able to do this. At the end of the year the questionnaire was returned to the teacher to indicate the actual items (ACT column) the children were able to do. As the questionnaire extended beyond the "normal" primary curriculum it was expected that 'N' would be the answer to many items. A teacher interview was developed to validate children's levels of number achievement, explore reasons for differences between this achievement, teacher expectations and the CSF curriculum levels for year 1 (see Figure 1). The interview also explored possible reasons for changes in the teacher's expectations, the extent to which the calculator caused these changes and consequent changes in curriculum goals.

Figure 1: Relationships explored in the teacher interview

This paper only reports on those aspects related to the relationship between teacher expectations and curriculum goals. Validation by the
teacher of the six children's performance is not discussed here.

Analysis of the Data

Table 3 shows the change from 1990 to 1994 in the teacher expectations at the different CSF levels on the 121 items on the questionnaire.

Table 3:  Change in expectations from 1990 to 1994.

Analysis of the data gathered by the questionnaire indicated there was a considerable change in teacher expectations from 1990 to 1994. A comparison of the teacher's expectations for children at the beginning of 1990 and the beginning of 1994 showed a positive change on 27 items, no change on 87 items, and a negative change on 7 items, where a positive change means that the teacher expected more children in 1994 to be successful on the item than in 1990 (for example, by indicating "most children" instead of "some children"). A similar comparison of expectations at the end of the year, showed a positive change on 58 items, no change on 63 items, and no negative changes. Table 4 shows that by the end of 1994 the teacher expected that all children would complete 20 items, most would complete 34 items, some would complete 37 items and no children would be able to do 30 items.

Table 4:  Year 1 teacher expectations for the end of 1994 on the 121 questionnaire items at various CSF levels

<table>
<thead>
<tr>
<th>CSF level</th>
<th>All</th>
<th>Most</th>
<th>Some</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (n = 11)</td>
<td>10</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 (n = 29)</td>
<td>10</td>
<td>17</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>3 (n = 21)</td>
<td>0</td>
<td>9</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>≥4 (n = 60)</td>
<td>0</td>
<td>725</td>
<td>28</td>
<td></td>
</tr>
</tbody>
</table>

All, Most, Some and None indicate expectations the number of children could complete a given item. Figures indicate the number of items in each category.

Table 5 shows the children's performance as reported by the teacher at
the end of year 1. All children were able to do each item at CSF level 1; all did 17 items, most did 10 items and some could do 2 items at CSF level 2. There were 32 items all or most could do at CSF level 3 or above and 49 items which some or no children could do.

Table 5: Children's actual performance at the end of Year 1, 1994

<table>
<thead>
<tr>
<th>CSF level</th>
<th>All (n = 11)</th>
<th>Most (n = 29)</th>
<th>Some (n = 21)</th>
<th>None (n = 60)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>10</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>21</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>≥4</td>
<td>21</td>
<td>5</td>
<td>18</td>
<td>25</td>
</tr>
</tbody>
</table>

All, Most, Some and None indicate expectations the number of children could complete a given item. Figures indicate the number of items in each category which children completed.

Tables 4 and 5 show that at all levels the children's actual performance exceeds teacher expectation. At CSF level 1, all children could do all 11 items. At CSF level 2, the teacher reported that most or all children could do 27 of the 29 items, while even at level 3 most or all children could do 15 of the 21 items. At level 4 or above all or most children could do 17 of the 60 items with some children being able to do a further 18 items.

Table 6 was produced comparing teacher expectations with actual performance on each individual item. This table shows that teacher expectations were exceeded on 33 items, were reached on 82 items and were not met on 6 items.

Table 6: Difference between teacher expectation and children's actual performance

<table>
<thead>
<tr>
<th>CSF level</th>
<th>+ ve difference</th>
<th>no difference</th>
<th>- ve difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (n = 11)</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2 (n = 29)</td>
<td>10</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>3 (n = 21)</td>
<td>8</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>≥4 (n = 60)</td>
<td>14</td>
<td>46</td>
<td>0</td>
</tr>
</tbody>
</table>

*+ ve difference indicates that more children were able to complete the item than the teacher expected.
The items children reached in advance of teacher expectation were in the categories of:
* counting
* pattern
* negative numbers
* calculator use
* place value
* recognition of large numbers
* mental calculation
* the knowledge to choose relevant processes in problem solving

The Teacher Interview

The teacher interview explored effects of calculator use in number on the teacher's method of teaching number, on the acquisition of number concepts and skills by the children at year 1 level, as well as on the six individual children (chosen from the highest, average and lowest performers at the beginning of prep), and the school curriculum. The purpose of the first part of the interview is to establish the teaching style of the classroom teacher, discuss the organisation of the class for number activities and to discuss the use of calculators by the children and the outcomes observed.

The second part of the interview is used to validate research findings as to the actual number achievement of the six children in the overall study, to discuss teacher expectations compared to CSF levels (1995), change in teacher expectations from 1990 to 1994 and to compare differences between teacher expectations children's actual performance at the end of year 1, 1994 and with CSF level expectations.

This summary will focus on that part of the interview relating to reasons why the teacher's curriculum goals changed.

The teacher was interviewed on tape at the school during a time when children were attending specialist classes.

The change in teacher expectations from 1990 to 1994 has been considerable. She felt the reasons for her change in expectations stemmed from her change to a more open approach to the teaching of number when she first became involved in the Calculators in Primary Mathematics project in 1990.

The teacher agrees with the premise that the primary mathematics curriculum should provide children with a means of exploring their environment. The availability of calculators in the classroom has enhanced the mathematics curriculum in that it helps to meet the need of all children in terms of their ability, attainment and interests. As
the children's levels of attainment increased the range and depth of activities needed to be extended. This meant the teacher had to cater for unexpected and sometimes amazing results.

Some comments from the teacher were as follows.

"I was a lot more open-ended about it - I let the children run - it wasn't such a problem where they all finished. It made me think more about where they might go ... they still currently surprise me ... allowing for the unexpected."

"Quite often the children amaze me with what they've done and where we end up ... one day we ended up talking about biscuits and parts of biscuits relating to decimals - just their knowledge of what decimal is bigger or smaller amazed me"

"research has shown we are not fully aware of what children know when they come to school or how far they can go."

"They (the children) become instructors and I'm the facilitator of maths or sometimes the motivator or quite often it can be the reverse in that the children are the motivator to me - which is wonderful!"

She found she was no longer concerned as to where a posed problem finished but her interest lay more in the thought processes used by the children to get a result. Children are given meaningful problems to solve, which they can solve in their own way, use whatever materials they choose and record their work as they wish. As long as they can talk about it and explain their recorded work, the teacher accepts it. Number activities are often follow ups of children's ideas based on literature relevant to the focus unit for the term. Focus units such as Me, My Body, Food, Mini-Beasts, Air to Live, Toys, Tools and Water were some of the units used in the infant school in 1994.

Teacher curriculum expectations for the end of year 1, 1994 were much higher than CSF level expectations as the teacher was aware of the considerable number knowledge the children had attained in their kindergarten year (which exceeded the CSF level 1 and covered some of level 2 expectations). These children had used calculators for number activities in their kindergarten year and the number curriculum expectations continued on from the level the children had reached on entrance to year 1. The teacher reports she couldn't possibly keep these children at year 1 curriculum policy statement level.

The children's actual performance at the end of year 1 was far in advance of CSF level expectation and teacher expectation. Some of the following teacher comments give her insights into the reasons why change in curriculum goals has been necessary for her.
"I think it comes down to teacher change, calculator use, they're able to do things more freely, they have more control over their own learning and where they're going with it. I think the calculator plays an important part in that they're able to use numbers quickly and go on further than we would have normally thought possible. They're understanding as well has increased dramatically and their confidence. I think if you can give children the means to arrange their own learning like this they become very positive learners and facilitators along with us. You can also allow them to use real life problems in manageable number activities and do them in a reasonable amount of time. They are able to work individually at the level they are at."

"The calculator made a huge difference and had a lot to do with that and obviously I haven't gone far enough with my activities. It just goes to show that each day or each week the calculator's going to change what they (the children) know and how far they can go in their confidence with processes and calculations."

Other factors which were seen by the teacher to influence the children's performance and her change in objectives were outcomes which arose from successful use of the calculator such as the children's increased confidence, self-esteem, a more positive attitude towards number, less formal teaching, more group teaching, more individual interaction and time to share ideas. Their increased independence and confidence encouraged them to try new number activities and to become resourceful problem solvers. All children achieved successfully, even the children in the class with special needs benefited from the use of their calculator.

Summary

The teacher agrees with the premise that the primary mathematics curriculum should provide the children with a means of exploring their environment. She believes the availability of the calculator has enhanced the mathematics curriculum in that it helps to meet the needs of all children in terms of their ability, attainment and interests. As the children's levels of attainment increase the range and depth of activities needs extension. The teacher confirms that the use of the calculator in number has contributed greatly to the levels of achievement by these children who entered year 1 with considerably more number knowledge than traditionally expected at the end of a kindergarten year. The continuing use of the calculator enabled them to extend development of number skills and understanding even further beyond traditional
expected curriculum levels of year 1 children. The children's numerical thinking, their exploration and development of number concepts and their application to everyday situations challenged the teacher to reflect on the extent to which her educational values, changes in beliefs, attitudes and understandings were consistent with her practice and to act accordingly. Reflection on the appropriateness of her teaching method has challenged her to ensure she provides for development of positive attitudes to enhance the children's mathematical learning.

Changing has been a gradual process for her, having been developmental and experientially based over four years. There is now a significant change in her teaching method to implement the curriculum in mathematics.

Reasoning and communication are central to this teacher's curriculum goals which place emphasis on developing children's mathematical ideas through processes, meaningful problem solving and the applications of developing number skills and knowledge. Process has become more relevant than content with the provision of appropriate activities which encourage children to develop their own patterns of thinking about number leading to understanding and the ability to communicate through number. Change in curriculum goals will be a continuous and on-going process dependent upon children's performance.

There are considerable implications for the school curriculum policy in mathematics in that the changes of curriculum goals at this level reveal that overall school curriculum goals need to be addressed to cater for the increased number knowledge these children will have when they enter middle and upper primary levels. The school mathematics policy statement is under review, being in the process of being looked at and adapted but although the teacher does not see a change occurring "overnight" she feels confident a change must occur given the change in the way children are learning and the subsequent increase in the rate of the children's learning. The need for professional development for teachers in the use of calculators to achieve purposeful mathematical experiences at all levels in primary schools is supported by this teacher whose final comment was to indicate her appreciation of the initial input and motivation provided by the Calculators in Primary Mathematics project team.

References


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Calculators have a Role? Mathematics Education Department, Hamilton Teachers' College.
Wright, R. J. (1991b) "What number knowledge is possessed by children entering the kindergarten year of school?" Mathematics Education Research Journal, 3 (1), 1-16.

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