CHILDREN'S EXPERIENCES OF MATHEMATICS

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There is universal acceptance that mathematics learnt in school should be useful to the learner, both in other school situations and away from the educational context. However, despite much advice about how to achieve this, little success has been shown to result from schooling. This article reports the findings of a study describing the phenomenon of knowledge utilisation as primary school children experience it. It provides a categorisation of metaphoric descriptions of their beliefs about mathematics, ranging from those that are unhelpful in promoting mathematical knowledge utilisation to those in which it is central and explicit.

USING MATHEMATICAL KNOWLEDGE

The transferability of mathematical learning to new and unfamiliar contexts has long been recognised as a major goal for primary educators. For example, the latest version of the UK national curriculum describes mathematics as a "uniquely powerful set of tools to understand and change the world" (DFEE, 1999b, p60). That such a goal has been difficult to achieve has also been recognised, both in the UK (Askew and Wiliam, 1995; NCEE, 1983; OFSTED, 1999) and internationally (Ellerton and Clements, 1989; Halpern, 1992; NCEST, 1992).

Much well documented research has supported the conclusion that the teaching and learning of useable mathematical knowledge in school is not effective. Research on everyday mathematical problem solving reveals that people rarely use school methods to solve problems encountered out of school (Carraher et al., 1985; Lave, 1988; Nunes et al., 1993; Saxe, 1988). Similarly Saljo and Wyndham (1990) found that children had considerable difficulty in deciding which aspects of their school knowledge they could apply to 'real life' problems.

Verschaffel and his colleagues (1999) have suggested three areas which many upper primary children do not master in order to approach mathematical application problems in an efficient and successful way:

- They lack of domain specific knowledge and skills;
- They have shortcomings in the heuristic, metacognitive and affective aspects of mathematical competence;
- They hold inadequate domain-related beliefs about and attitudes towards mathematics learning, teaching and problem solving.

The present study focuses on the third of these areas, exploring the range of mathematical beliefs which upper primary children hold, from those that are unhelpful in promoting mathematical knowledge utilisation to those in which this is central and explicit.

EXPLORING CHILDREN`'S EXPERIENCES OF MATHEMATICS

A semi-structured interview was used to explore primary children's conceptions of mathematics by eliciting descriptions of their experiences and understandings relating to mathematics in various in school and out of school contexts. Categories of description, representing these conceptions, were then constructed from this data. Those aspects relating to mathematics knowledge utilisation are reported here.

Conception 1: Labourer

The children have a very restricted view of use: the described mathematics is used directly in other mathematics which is exactly the same, or in tests where the tested mathematics is exactly the same. It is not seen as being useful anywhere else:

> I've used these ideas in my maths book, there are lots of questions like these. I haven't used it anywhere else, but it is useful to know so you get them all right. (Colin)

This view of use relates closely to the nature of 'what' is learned and 'how' it is learned in the conception. In working without understanding, children are easily led to make links based on superficially similar but actually unrelated features. For example, sometimes the children latch on to words to associate use with other contexts. On these occasions the only link is the actual word: its meaning and use in the two contexts are otherwise unrelated:

> I used the brackets in English. When we are writing we use brackets for something and if we didn't have enough room in the story you'd put brackets. (Denise)

Conception 2: Mechanic

Mathematics is seen as being used in exactly the same way in different contexts, be they mathematical or otherwise. Thus it is used in exams or tests where there may be a slight change in presentation, wording or context. Similarly the children identify the unproblematic and direct application of basic number, money and measures to situations very similar to those they have encountered in school mathematics. Occasionally somewhat unrealistic school mathematics problems are identified as being possible real-life situations:

> When we went down to the shop the other day Paul was beginning to buy three Refreshers and I said hang on a minute Paul because he was only allowed to spend 30p and they were 12p each and I added them all up and I said that's 36p and he said mum won't mind if I spend 6p extra and I did 12 times 3 is 36. (Denise)

In the same terms the children identify basic number, money and measures as being potentially useful in future life:

> You may have to measure things up when you go to college, and the more you learn at school the better job you'll get. (Daniel)

This is distinct from the Craftsperson because the context of application is less flexible, being like school problems rather than real everyday problems. The latter are more evident in the Craftsperson conceptualisation.

Conception 3: Performer

In this conception children see mathematics as being used to put on a show, to perform and to entertain. In these situations it is always a direct repetition of the practiced 'act'. This is distinct from the Labourer conception because the purpose of the direct repetition is to perform and entertain rather than complete mathematical work or tests.

Conception 4: Craftsperson

The children identify simple application in measures and money in a variety of everyday contexts. The focus is on expert tool use:

> Dad has put in a new carpet in Helen's room and I helped dad measure it all up and we had to measure really carefully so that there would be no gaps in the carpet. If you want to find the perimeter of a room you can do one side and then another side and work out the rest. That's what Mr Norman told us. Dad told the people at the carpet shop so they could get the right measurement for Helen's room. (Barbara)

The children also show evidence of a wider view of number, for example, they know when to use multiplication:

> It's like when you want to make things bigger, say five times bigger, so if it's three then five times bigger is 15, and if it's four centimetres then five times bigger is 20 centimetres, so to make a picture five times bigger you'd times all the measurements by five. (Ben)

This differs from Mechanic because with the Craftsperson it is understanding which leads to use in everyday problems rather than clues in the layout or wording of school mathematics problems.

Conception 5: Academic

In terms of use, identifying patterns and generalising are seen as separate strategies and skills that can be applied in other tasks and contexts:

> I have used these ideas when we have done another sheet, and we've done pattern as well, and I've drawn tables. When playing football games I need to draw out a table. I've used other ideas in a piece of work we did a few days ago when we had to make a formula. (Ben)

The value of describing situations mathematically is also recognised:

> When you look at something then, if you look for patterns and then find a formula, you can say what will happen if it's a bit different, like you've got more trains or cars or something, so it will help you see what will happen. (Ben)

Occurrence of conceptions of mathematics within this study

In 88% of instances in mathematics contexts, high-attainers in mathematics in their final year of primary school indicate that their experiences of mathematics are those described in the 'Labourer', 'Mechanic' and 'Craftsperson' conceptions. In these

conceptions, use centres on counting, simple number operations, money and measures. Further, in 72% of instances, these children indicate that their experiences of mathematics are those described in the 'Labourer', 'Mechanic' and 'Performer' conceptions. In these:

- use is inflexible, being seen as being a direct repetition of that which has been taught;
- use can occur either in further mathematical exercises, in performing or in very similar out of school contexts such as adding money;
- when the context is different, clues are often used to determine the approach chosen, rather than understanding. These clues might be inappropriate and mislead.

In only 19% of instances did children indicate that their experiences of mathematics are those described in the 'Craftsperson' conception. In this conception understanding determines the mathematics used, and mathematics is used flexibly in appropriate contexts. Further, there is a very low occurrence of instances of children indicating that they have experienced mathematics as suggested by the 'Academic' conception: as a useful way of describing the world.

CONCLUSION

The findings presented above provide a somewhat depressing picture: in almost all cases, high attainers in mathematics in their final year of primary school do not see mathematics as being a significant feature of the world beyond school; as a "uniquely powerful set of tools to understand and change the world" (DFEE, 1999b p60). Instead they have a superficially descriptive view of mathematics.

Returning to the suggestions made by Verschaffel and his colleagues (1999) and cited at the start of this paper, curriculum reform in the UK has to a large extent focused on improving students' domain specific knowledge and skills. Regardless of how successful educational reforms have been in achieving this, the findings of the present study suggest that there will have been little impact on students' success in approaching mathematical application problems because students still hold inadequate domain-related beliefs about and attitudes towards mathematics learning, teaching and problem solving. In order to improve application we must promote more productive beliefs in terms of mathematical knowledge utilisation.

What might we do? If we accept that such beliefs result, in part, from different pedagogical practices we might adopt approaches which emphasise:

- links between understanding mathematics, recognising when it might be useful and using it;
- a view of mathematics as a useful way of describing the world in terms of relationships and not simply superficial features;
- the ability to see and search for mathematics in the world around.

So, for example, for the UK's National Numeracy Strategy (DFEE, 1999a) to result in utilisable mathematical knowledge:

- children should have considerable experience of the practical use of all aspects of the mathematics curriculum, not just numerical operations, money and measures;
- children should be taught to use strategies and numerical concepts and operations with understanding as well as with pace;
- children's reasoning for their approaches to word problems should be explored with them;
- children should have considerable experience in searching for mathematics and relationships in the world around them;
- children should be helped to see themselves as mathematicians and mathematics as a useful way of describing the world.

Indeed, it may be that derived categories describing children's experiences of mathematics in the present study are also useful in helping learners engage with the metacognitive and affective aspects of mathematical competence.

Without such action it is likely that any improvement in children's attainment as measured by their performance in tests and examinations will not be matched by an improvement in their achievement of mathematical knowledge utilisation beyond the mathematics classroom.

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