EXPLORING SCHOOL CHILDREN'S OUT OF SCHOOL MATHEMATICS

Arindam Bose, K Subramaniam

Homi Bhabha Centre for Science Education, TIFR, Mumbai, India

The study reports on the preliminary part of an ongoing research study aiming at exploring and characterising the nature and extent of everyday mathematics knowledge amongst middle grade students and their involvement in economic activities. Students' knowledge of numbers related to their currency-denomination knowledge was prominently visible even though they had difficulty in representing positional values of numbers. Students did operations on multi digit numbers on oral mode but not on the school taught methods. Data were collected through interactions with 25 students of grades five and seven in two public schools located in one of the biggest slum dwelling in India that has apparent vibrant house-hold based economy. Categories were created from the obtained data and implications drawn.

INTRODUCTION

The out-of-school mathematical knowledge of children has been studied extensively beginning with the pioneering work of Nunes, Carraher and Schliemann (1985) since it is thought that such knowledge can support the learning of school mathematics. In India, a study of children's knowledge of out-of-school mathematics has been carried out by Farida Khan (2004), in which she explored the mathematical knowledge of child vendors who sold newspapers and betel leaves (*paan*). To our knowledge, there are few studies of children's out-of-school knowledge of mathematics in Mumbai, although it has a large population living in slums (shanties), which are often active centres of house-hold based industry. An exception is the study by Sitabkhan (2009), who interviewed child vendors who sold articles in the local trains in Mumbai.

In this paper we attempt a preliminary characterisation of the knowledge of 'everyday mathematics' prevalent among school going middle grade children (working and non-working) living in a large Mumbai slum that has a vibrant house-hold based economy and offers unique opportunities to its resident children to learn from their environment as well as from their schools. We begin by discussing some of the current literature on 'everyday mathematics' and follow it up with our observations from our interaction with the chosen sample of students. The main part of the paper includes the presentation, discussion and analysis of our observations aimed at exploring the nature, extent and use of oral techniques of solving daily-life problems making use of everyday mathematical knowledge.

2011. In Ubuz, B. (Ed.). Proceedings of the 35th Conference of the International Group for the Psychology of Mathematics Education, Vol. 2, pp. 177-184. Ankara, Turkey: PME.

THEORETICAL ORIENTATION

Empirical studies have shown that problem solving in out-of-the-school settings intertwined in everyday activities is quite different from the formal ways of solving them using school taught techniques. The difference also lies in the structure of knowledge and the social conditions of their use. Carraher, Carraher and Schliemann (1987) suggest that situational variables often influence school students' tendencies of using oral calculation procedures based on their everyday knowledge to find solutions and not the strategies learned at school.

School mathematics entails written mathematics while the 'everyday mathematics' involves oral techniques in calculations (Nunes, Carraher & Schliemann, 1985; Resnick, 1987; Saxe, 1988). In 'everyday mathematics', the doer has a continuous engagement with the objects and the situations and she does not burden herself with the extra effort to remember the algorithms, calculation-techniques and the reasoning used – a characteristic that Resnick (1987) pointed out as well. This characteristic of 'everyday mathematics' is in contrast to school mathematics where one does not usually have a freedom of making a choice of using alternate techniques other than those taught in the classrooms. In schools, mathematical activities are based on symbols which get detached from any meaningful context. More stress is usually on symbol manipulation and following rules. School mathematics is aimed at improving individuals' performances and skills, whereas, out-of-school mathematical activities are socially shared. While school mathematics focuses on generalised learning, everyday mathematical ability grows from situation-specific competencies (Resnick, 1987; Resnick & Ford, 1981). The difference also lies in the structure of knowledge and the social conditions of their use.

Most of the studies indicate that participants who were untrained in school mathematics could competently perform the calculations needed in their workplace activities. In contrast, the school students, trained in school mathematics when presented with such problems came up with incorrect solutions or even absurd solutions. School students concentrated more on the numbers given in the problems and paid little attention to the meanings of the problems. (Nunes, Schliemann, and Carraher, 1993, 1985; Lave, 1988). On the other hand, street vendors who with 'impressive ease' solved their routine problems in everyday settings, could not solve the same types of problems which they had earlier solved in their workplace contexts when presented to them as formal word problems without any contexts. Sometimes they gave insensible solutions, for example, getting as an answer a number in a subtraction problem that is bigger than the minuend (Nunes, Schliemann and Carraher, 1993).

SAMPLE & METHODOLOGY

The sample for this study was identified from one grade 7 class of an English medium school and one grade 5 class of a Urdu medium school run by the Municipal

Corporation of Greater Mumbai, located in Dharavi in the north-central part of Mumbai, India. Dharavi is among the largest slums in India. Every third roll number from the attendance register was chosen to form the sample. Most of the students are in the age-group of 10-12 years; different grade years in the English and Urdu medium sections were chosen to achieve parity in age. Discussions were held with 12 students (7 boys + 5 girls) from the Urdu section and 13 students (7 boys + 6 girls) from the English section. Each discussion lasted between 30 minutes and one hour.

The present report discusses preliminary findings from the first phase of the larger ongoing research project aimed at characterising students' knowledge of out-of-school mathematics. The researcher (i.e. the first author) first observed the students in their classrooms and then held informal discussions with them to get a broad picture of the nature of their daily activities that have aspects of mathematics and the nature and extent of their knowledge of everyday mathematics, and to get an initial understanding of the variation among children of out-of-school mathematical knowledge, as well as involvement in economic activity. Hence, an attempt was made to characterise out-of-school mathematical knowledge at the individual level and also form preliminary impressions of the processes by which school-going children acquire them. Attempts were made to identify the opportunities that are available to the children to immerse themselves in elders' pursuits. The discussions were audio recorded after taking the teachers' and each student's consent. The sources of data were students' work-sheets, researcher's field-notes and audio records of the discussions.

LOCATION OF THE STUDY

Dharavi is uniquely different from other slums in the sense that many houses located here run workshops or small-scale factories forming a vibrant economy. Children become engaged in the workshops/factories at an early age. However, there are families which prefer their children to finish studies first before immersing themselves in economic activity. Such parents do not let their children work. However, it is not surprising to find that even such children who are not actively involved in any kind of economic activity have fair knowledge about the activities by virtue of being present in the locality.

Some common house-hold occupations are embroidery, *zari* (needle work), stitching and garment-making, making plastic bags, leather goods (bags, wallets, purses, shoes), dyeing and button-making. Some of these activities are done in the house itself, while some are carried out in “factories” in small-rooms of the shanties. The goods produced are sold not only in Mumbai but sent to many other cities and even exported to other countries, mainly in the Middle East. There are many *bissi* – places where food is prepared in large scale to be delivered to different places. Many children are involved in delivering food (“tiffin”) boxes. Mumbai being the biggest financial hub of India attracts a huge flow of immigrants from different parts of the country, especially from North India. Dharavi is an old, established slum, which continues to receive immigrants and hence has a high population density. The migrant unskilled workers find jobs in the workshops and some of them become apprentices in the small factories. In recent years, there is a move to relocate the population of Dharavi, which is a great source of concern among its residents.

OBSERVATIONS AND ANALYSIS

The interactions with the students indicated that practically all of them have a packed schedule the whole day. The researcher observed the morning-shift school starts at twenty past seven and gets over just after noon at half past twelve. Most students from the English school reported that they go for Arabic classes immediately after school. Many of them go for tuition classes thereafter. Students mostly from the Urdu school are already through with their Arabic lessons and report at their respective workplaces after the school is over. Because of this packed schedule, the students do not get time to play. The lanes and by-lanes of Dharavi are also too narrow for the children to play. However, all students reported that they visit shops in the neighbourhood to buy groceries and other articles that are house-hold daily needs.

Knowledge about currency

All students interviewed had sound knowledge of the various denominations of the currency and could recognise all the currency coins and notes that are currently in use and their conversions. Some students calculated with numbers by thinking of them as money. For example, when asked to divide 981 by 9, one student U1 of grade 5 of the Urdu school looked at the problem as 'equally distributing' Rs 981 among 9 children and arrived at 109 as the answer. His explanation was to divide Rs 900 among 9 children thereby getting Rs 100 for each of them and then divide the remaining Rs 81 among 9 children to get Rs 9 for each. Hence, each child gets Rs 100 plus Rs 9, i.e. Rs 109. Interestingly, when U1 was asked do the calculation on the worksheet he arrived at '19' as the answer, making the common error of omitting the zero (*shown in Fig. 1 above*). When the discrepancy in the answers was brought to his attention, he hesitatingly put a '0' between '1' and '9' probably because he had 'more faith' in the oral procedure than school taught algorithms. The student U1 works in a garment making workshop after the school hours. He had shifted to Dharavi three years ago from Bihar – a North Indian state that is economically backward. His interest in studies brought him

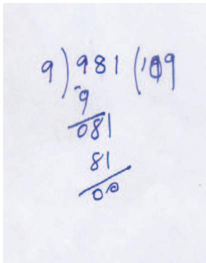

Fig. 1

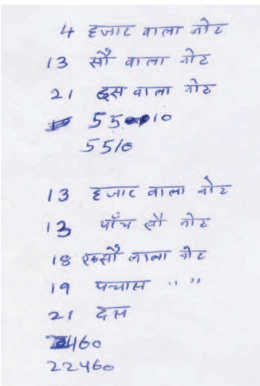

Fig.2

back to studies after a two-year gap when his financial condition of his family forced him to work than attending school. Discussions with U1 had earlier shown that he can add currency-values sometimes involving 5 digit numbers purely mentally. For example, when asked how much money would be, if taken together 4 thousand rupee notes, 13 hundred rupee notes, and 21 ten rupee notes, U1 correctly replied, '*five thousand five hundred ten rupees'* but initially wrote the sum as 550010 and subsequently corrected it to write 5510. When asked to add 13 thousand rupee notes with 13 five-hundred rupee notes, 18 one-hundred rupees notes, 19 fifty rupees notes and 21 ten rupees notes, U1 had the accurate answer as, '*twenty two thousand four hundred sixty*' (*As shown in Fig. 2 in the previous page*).

Number Knowledge

The range of number knowledge varied among the students. This may be related to the extent of engagement in economic activities, but this needs further exploration. Of the 23 students in the sample, 21 had difficulty in writing the numbers dictated to them correctly, making place value errors, especially for numbers bigger than 100. They wrote the numerals reflecting the number-names, i.e. 1001 for 'one hundred one', 10010 for 'one hundred ten', 10051 for 'one hundred fifty one', 20060 for 'two hundred sixty', 10001 for 'one thousand one', etc. Numbers which were multiples of hundred or thousand like 5000 for 'five thousand' were written correctly. However, irrespective of the place-value errors that students made while writing the numbers in figures, they seemed to understand the numbers through their names. This knowledge probably is rooted in their regular use of money.

Interestingly, children expressed the non-integral amount of money (amount that involves 'rupees' and 'paise'; 100 paise = 1 rupee) by juxtaposing the rupee amount and the paise amount by using a 'dot' or 'point' in between to mark the distinction. This is done apparently without the formal knowledge of decimals. Probably, this is based upon the socially accepted meaning drawn from the shared experience while dealing with money in everyday commercial interactions.

Arithmetic Operations on Numbers

Although students in the sample regularly attend school, in several instances they used their out-of-school knowledge of mathematics while solving problems. For example, the student E-10 from grade 7 of the English Medium School belongs to a low socio-economic family of five including her parents. Her father does scavenging work and removes debris from the road sides while her mother works as a domestic help. The student often goes to the shop to buy everyday articles such as kerosene oil for cooking (sold in bottles), milk and other groceries. She informed the researcher that milk is sold for Rs 12 per packet. On asking how much milk a packet contains, she quickly replied *"aadha litre"* ("half a litre"). When asked for the price of 2 packets, she immediately replied, *"24"*. She claimed that she knows this as she often hears the milk-seller telling this to the customers. When she was asked to find the price of 5 packets, she paused and started thinking. She then added 24 and 12 and arrived at 36 and then added 36 and 24 and arrived at 60.

Her strategy was to use to the known values, viz. 12 and 24, adding them to first arrive at the price of 3 packets, and then to add 24 to find the price of 5 packets.

E-10 told the researcher that a bottle of kerosene comes for Rs 28, who asked her to find the price of 5 bottles. She calculated mentally and came up with *"one forty rupees"* as the answer. Her argument was, *"bees ke hisaab se paanch bottle ka hundred aur aath ke hisaab se paanch ka forty"* ("price of five bottles at the rate of twenty is hundred and at rate of eight is forty"). Then for 15 bottles, she added 140 twice and again added 140 to the sum to get 420. To find the price of 7 bottles, she added 28 twice and then added the sum (i.e. 56) to 140 thereby getting 196 as the answer. Similarly for 22 bottles she added 280 twice and got 560 and then added 56 to it to get 616 as the answer.

The strategy to use addition that included 'continuous monitoring' about 'where she is' in the midst of a calculation and gave her confidence in the procedures and meaningfulness in the results obtained.

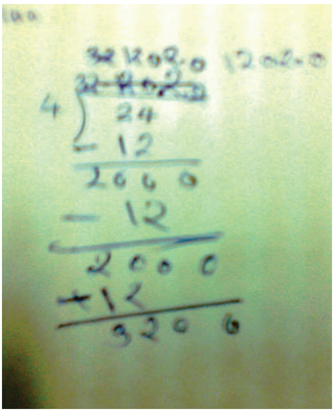

Fig 3

Interestingly, all the students claimed difficulty in the division algorithm though many of them could orally divide two numbers considering them as referents of some familiar contexts. For example, one student (E11) repeatedly obtained absurd results like getting quotients bigger than dividends (for all positive dividend, divisor and quotient). She however, did the seemingly easy division orally in a contextual problem situation instantaneously (As shown in Figs. 3 & 4).

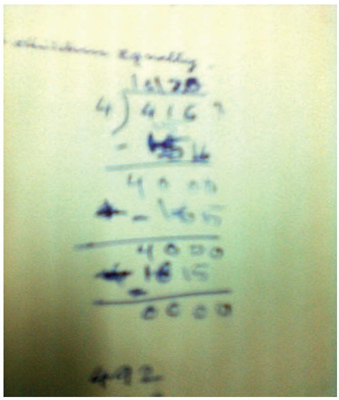

Fig 4

Use of the Units

Discussions with the students showed that children make use of a variety of units mostly based on the convenience and syntactic support from prevalent practices. For example, the student E-12 wrote 'six hundred sixty' as 6005010 and read it as "*chhe sau pachaas aur upar se dus*" ("six hundred fifty and ten more") but for 'one hundred seventy four' she wrote 10074. This probably happens because the student considers the numbers '50' and '10' as 'closed' numbers and took them as units. Several such examples could be seen of different units which bear 'names' in the discourses.

DISCUSSION

Our observations indicate that school going children from Dharavi who have an exposure to currency handling and ensuring its optimal use, can handle operations with multi-digit numbers that represent currency denominations, using the oral mode. Children use different forms of currencies as tools for mental (oral) activities. The resultant cognitive activity of (as in the case of U1, discussed above) involving operations on multi-digit numbers were shaped, dependent and governed by the use of 'currencies' as tools. In lieu of this, when students attempted to write the resultant amount obtained after addition, they expressed the numbers according to the number-names without caring for the multi-digit representations which carry the positional values of the respective digits. This probably happens because of the syntactic as well as semantic differences between the language used in everyday contexts and the language used during classroom-teaching.

CONCLUSION AND IMPLICATION

Multi-digit representation of numbers and algorithms used in the number-operations have remained hard-spots for students in the middle grades. However, in this preliminary work we have found that children having wide exposure of 'everyday mathematics' have sound knowledge about currency handling as well. This includes doing arithmetic operations on the currency denominations including multi-digit numbers. Though the resultant answers were correct when dealt with orally, but their representations in the written form were usually flawed. It remains to be explored how much the teachers are aware about the extent of students' everyday mathematical knowledge and how can such knowledge be brought in the classrooms to facilitate better learning of mathematics.

It also remains to be explored the role of the language in gaining everyday mathematical knowledge in out-of-school contexts and how does language helps in facilitating mathematics learning in the classrooms while drawing upon from familiar contexts. 'Everyday mathematics' (out-of-school mathematics) bears the functional aspect of mathematical knowledge that is available to all and not hidden (Subramaniam, 2010). Bringing together everyday mathematical knowledge and school mathematics possibly can pave way for developing skills and interests in learning mathematics.

ACKNOWLEDGEMENTS

We are grateful to the teachers and the students for allowing us to sit through the classroom sessions and to audio-record the interactions for our work. We are thankful to our colleagues and to Renuka Vithal and Rekha Koul for giving us ideas and suggestions.

References

Carraher, T. N., Carraher, D. W., & Schliemann, A. D. (1987). Written and Oral Mathematics. *Journal for Research in Mathematics Education, 18*(2), 83-97.

Khan, F. A. (2004). Living, Learning and Doing Mathematics: A Study of Working Class Children in Delhi. *Contemporary Education Dialogue, 2*, 199-227.

Lave, J. (1988). *Cognition in Practice*. Cambridge, UK: Cambridge University Press.

Nunes, T., Schliemann, A. D., & Carraher, D. W. (1993). *Street Mathematics and School Mathematics.* New York: Cambridge University Press.

Nunes, T. C., Carraher, D.W., & Schliemann, A. D. (1985). Mathematics in the Streets and in Schools. *British Journal of Developmental Psychology, 3*, 21-29.

Resnick, L. B. (1987). Learning In School and Out. *Educational Researcher, 16*(9), 13-20.

Resnick, L. B., & Ford, W. W. (1981). *The Psychology of Mathematics for Instruction.* Hillsdale, NJ: Erlbaum.

Saxe, G. B. (1988). Candy Selling and Math Learning. *Educational Researcher, 17*(6), 14-21.

Sitabkhan, Y. (2009). The Use of Convenient Value Strategies among Young Train Vendors in Mumbai, India. In K. Subramaniam & A. Mazumdar (Eds.). *Proceedings of epiSTEME-3: An International Conference to Review Research on Science, Technology and Mathematics Education*, pp. 114-118. Mumbai, India: Macmillan.

Subramaniam, K. (2010). Culture in the Learning of Mathematics. *Learning Curve, 14*(2), 25-28.