5 Culture in the Learning of Mathematics

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At a recent workshop in Ahmedabad, we asked primary school teachers to talk about what their students do outside school, and whether it involves any Mathematics. The teachers spoke a lot. Their pupils, who came from poor urban homes, helped their parents sell vegetables. They made and sold kites, packets of bindi, agarbathis and many other things. They knew the price of vegetables for different units, knew how much profit they would make from selling a 'kori' (unit of 20) of kites. Kites had to be assembled from paper sold in packets and sticks sold in bundles – all in different units. Problems arose naturally while making decisions about how much raw material to buy, how much to make and sell, how much time to spend, and so on. Children, together with older siblings or adults, were finding their own ways of getting around these problems. And all the time, they were dealing with numbers and Mathematics.

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It was not the children telling us these things, it was the teachers. We asked them how they discovered that the children knew so much. They replied that when the children absent themselves from school, they visit their homes to find the reason. They talk to the parents and often find that the child was helping them – perhaps hawking vegetables while the mother went on an errand. We were happy that the teachers took pains to ensure attendance, but we also felt a little uneasy with this reply. When we opened the worksheets prepared for the children – this chain of schools used their own worksheets rather than a regular textbook – we did not find anything of what we had just heard about the children's lives. It struck us that teachers found out about the children's activities outside of the school, and not in the Mathematics classroom.

After some discussion with the teachers, we realized that they held strong beliefs about what counts as 'proper' Mathematics. A problem used in a Dutch study, 'If a polar bear weights 350 kg, about how many children weigh the same as a polar bear', was for them not a good problem, because it did not have all the data needed to solve it. The problems that the children were solving outside school often had incomplete data, did not have a precise single answer, and the children used informal methods of solving them. So the teachers did not think that the children were really doing Mathematics. There seemed to be an invisible wall separating the Mathematics in school and the thinking and figuring that the children did in the context of economically productive activities.

This story is not an unusual one. In many poor urban households, children participate in economic activities. In a different social or geographical context, if one looks carefully, one will discover that here too children have opportunities to engage with Mathematics outside school. Almost no school curriculum gives any place to such 'everyday' Mathematics. At best there may be an attempt to add some contextual details to enhance children's interest. Thus the Mathematics that children learn to do inside and outside school remain separate and disconnected. Of course, the larger issue here is of the relation between the school curriculum and life outside school. Since Mathematics is an abstract branch of knowledge, one may think that there is little to be said about its connection with culture and everyday life. Yet, many researchers have studied the relation between 'everyday' and school Mathematics leading to important insights.

Advocates of constructivism, following Piaget, stress the fact that children don't enter schools with empty minds waiting to be filled – they have already acquired complex knowledge in the domains that overlap with school Mathematics and science. Psychologists studying cognitive development have constructed a detailed picture of the spontaneous conceptions that children acquire. The first wave of constructivism was however criticised for focusing largely on individual learning. The criticism came from a broad range of perspectives that were more sensitive to the influences of culture and society. The implications of these critiques are still being worked out by researchers and thinkers in the Mathematics education community. Here we will look at some of the ideas and possibilities that have emerged from this debate.

The pioneering studies of street Mathematics by Terezinha Nunes and her colleagues, the anthropological studies by Geoffrey Saxe of the Mathematics of the Papua New Guinea communities, the studies by Farida Khan in the Indian context, and many other studies have revealed how Mathematics arises spontaneously in the context of everyday activity. These studies have also shown how 'everyday' Mathematics differs from school Mathematics. In everyday contexts, calculation is 'oral', and mostly uses additive build-up strategies. When an adult from the Mushari tribe in Bihar was asked to give the cost of ten melons if each melon costed Rs 35, he did not 'add a zero to the right' to straight away get 350. Instead, he first calculated the cost of 3 melons as Rs 105. Nine melons were Rs 315 and so ten melons were Rs 350. Exactly the same procedure was used to solve the same problem by a Brazilian child vendor in Nunes' study. The 'add zero to the right' strategy is a part of 'written' Mathematics, and is uncommon in everyday Mathematics. Proportion problems are usually solved in the everyday world through a build-up strategy rather than by using a 'unitary method' or the 'rule of three'. For example, consider the problem 'if 18 kg of catch yield 3 kg of shrimp after shelling, how much catch do you need for 2 kg of shelled shrimp?' A fisherman in Nunes' study calculated it as follows: we get 1½ kg of shelled shrimp from 9 kg of catch, so ½ kg from 3 kg of catch. Nine plus three is twelve. So 12 kg of catch would give you 2 kg of shelled shrimp.

Since these procedures were oral, sometimes respondents forgot to complete a step of the calculation, but the errors were usually small and the answers reasonable. Nearly always, the calculation model was accurate. In contrast, school children often use the wrong operation for a problem and produce unreasonable answers. Culture and cognition seem to work together in everyday Mathematics to create a robust sense of appropriate modelling. When children are presented with a problem that they can understand, and are encouraged to find their own way of solving them, we see that their spontaneous solution procedures are often like those of everyday Mathematics. These findings have important implications for teaching and learning Mathematics. One can, for example, re-conceptualize learning trajectories so that the problems, concepts and procedures of everyday Mathematics provide the springboard for more powerful mathematical concepts. The rich contexts that are familiar to children provide valuable scaffolding while solving a problem, verifying that its solution is reasonable and looking at a problem from different angles.

If we see cultural knowledge as merely a vehicle to deliver formal Mathematics that is otherwise 'difficult-to-swallow', then we may be adopting a view which is too narrow. We cannot simply mine what is present in the culture as a resource to push a particular curricular agenda. Putting cultural knowledge alongside formal knowledge leads us, as educators, to reflect more deeply about their relation. We need to not only take from the culture sources of mathematical thinking, but also give back to the culture what it values highly. In the long run, if a form of knowledge is to survive and flourish, it must have deep roots in the culture. We don't understand well the meeting points between disciplinary knowledge and knowledge that is dispersed as part of culture. Is such culturally dispersed knowledge incommensurable with the academic knowledge of the universities, as some thinkers in education have argued (Dowling, 1993)? Can the familiar dichotomies of folk vs formal knowledge, or traditional vs. modern knowledge capture the relationship between the two kinds of knowledge? In some domains of knowledge, cultural dispersion and transmission through formal institutions have both had a strong presence over long periods. A good example is classical Indian music. Another example is traditional medical knowledge, which is now reproduced through modern educational institutions. Both music and medicine as formal systems preserve a connection to the diversity of cultural forms – to popular music or to the many local and specific healing traditions. Much of the knowledge that we seek to impart in school has no comparable cultural presence or diversity of forms of expression.

Mathematics may have deep roots in our culture that we are still to become aware of. Among some members of the Mushari community, there is an impressive knowledge of mathematical puzzles or riddles and their solutions. These puzzles are called 'kuttaka', which is the name of a mathematical technique, whose oldest description is found in the Aryabhatiyam of the 5th Century CE. The 'kuttaka' is an important and powerful technique, which led to important developments in Indian Mathematics. Brahmagupta, in the 6th Century CE referred to algebraic techniques in general as *'kuttaka ganitha'*. The Mushari puzzles, which involve the solution of equations, may preserve a connection to this deeper tradition of Mathematics. It is intriguing that such knowledge exists among a community which is very low in the social hierarchy. We need a better understanding of the cultural transmission of mathematical knowledge between communities at different social strata. Culture can support the reproduction and circulation of mathematical knowledge not just through work, but also, as the puzzles indicate, through play. The revival of traditional art forms like music and their reshaping through digital technologies point to the possibilities of connecting art and Mathematics that are still to be explored.

Viewing the relation between 'everyday' and formal Mathematics through a different lens shows that political considerations are also relevant. As several writers have argued, with the growing dependence on mathematical science of modern technological societies, there is an increasing withdrawal of Mathematics to more hidden layers distant from everyday life. Not only is the complex Mathematics that underlies technological devices inaccessible to a lay person, but even everyday commerce may become emptied of mathematical thinking.With regard to everyday finance, which is relevant to nearly everybody, technology seeks to make Mathematics redundant. Calculators, EMI tables for loans, and other aids function as black-boxes that replace reasoning and calculation. This results in deskilling, and also takes attention and interest away from the underlying Mathematics. In a small study that we did, we found profound lack of awareness among educated users about how the credit card system operates and such critical issues as the effective rate of interest. Thus the increasing mathematization of society is accompanied by the growing de-mathematization of its citizens. Since Mathematics is entrenched as an essential part of the school curriculum, it begins to serve a different social function – that of weeding out large numbers from obtaining any access to the Mathematics and science that decisively shape modern society.

The emergence of small-scale production activities as a part of the informal sector, offers to poorer households a means of subsistence and resistance against the harsh impact of changes in the organized economy. One cannot resist drawing a parallel in the light of the discussion on de-mathematization. Against the increasing trend of de-mathematization, the emergence of Mathematics on the street or in the workplace is a counter trend that resists the complete exclusion of the under-privileged from Mathematics. Of course such emergence by itself has no power to provide access to significant Mathematics. But the institution of education can amplify this possibility; bringing everyday Mathematics into the curriculum may prepare the way for bringing more Mathematics to wider sections of society.

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