Characterising Work-Contexts from a Mathematics Learning Perspective

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Based on an ongoing larger study the present paper makes an attempt to develop a framework for characterising the work contexts of school going working students, which create affordances for learning mathematics. The paper argues that the characteristics of work contexts that have a bearing on learning mathematics include the diversity of goods that students handle as workers, the linkages on the production network that are visible to them and the sense of ownership that they have for the work. The analysis is drawn from semi-structured interviews with students. Students' awareness and knowledge about the earnings from their work and responses to questions about the fairness of earnings varied and could be related to the three characteristics identified.

Introduction

Research studies in the past on everyday mathematics have documented that mathematics learning and problem solving ability among school students develop also from their participation in small scale economic activity (Abreu, 2008; Bose & Subramaniam, 2011; Nunes, Schliemann & Carraher, 1993; Rampal, 2003; Resnick, 1987). Researchers have argued that children and adults who are engaged in everyday mathematical activities and commercial exchange often develop effective context specific problem solving ability that could be used for effective mathematics learning in the classrooms. The contexts of such engagement are diverse and consequently, the extent and type of mathematical knowledge that students acquire outside school can be expected to show diversity. For example, Khan's comparative study (2004) on the strategies used by *paan* (betel leaf) and cigarette sellers, newspaper vendors and school-students, indicated that of these three groups, *paan*-cigarette sellers had to negotiate diverse kinds of calculation because of the diversity of goods and quantities that they sold involving different units which helped them gain better computational facility.

In this paper we address the issue of diversity of experiences of out-of-school work contexts and its relation to mathematical knowledge. We draw on findings from an ongoing research study aimed at characterising out-of-school mathematics knowledge and its relation to mathematics learning in school. Our study was of Grade 6 and 7 students from two municipal corporation-run schools located in a large low-income area in Mumbai. As a unique feature, this area has a vibrant economy in the form of house-hold based workshops and small scale factory and manufacturing units, which provide employment to the dense population living in the locality. Even within a single class, we find students engaged in a variety of income-generating work both within the house-hold and in the neighbourhood. The question that we address here is how do different kinds of work create affordances for learning in general and learning mathematics in particular.

House-hold based small scale production, like factory based production, is also subject to the processes of fragmentation, routinisation, mechanization, and deskilling, resulting in consequent demathematisation of the knowledge within the community. At the same time, there is a counter trend to these processes through the enterprise of individuals and groups seeking out avenues for making a living (Subramaniam & Bose, 2012). Some kinds of work involve diverse interactions with people and material, leading to greater opportunities to acquire knowledge and skill. Thus we find economic activity that is varied and calls on a range of knowledge and skills as well as activity that is routinized, making little demand on skills and knowledge. One of the factors is the nature of work itself, which may be difficult and demanding, or repetitive and mechanical, or characterized by diversity. As mentioned earlier, it has been found that diversity in the type of goods sold allows paan-cigarette vendors to acquire greater proficiency in arithmetic skills (Khan, 2004). Another factor, which is especially relevant with regard to the affordances that the work provides for mathematical learning, is the extent of exposure to the network of production that the work is embedded in. Each work is part of a production chain or network and participants in the work have awareness and knowledge to different extents of the forward and backward linkages in the production network. A third factor is the feeling of ownership that participants have towards the work that they are involved in. Children whose close relatives, friends or families own businesses have a stronger sense of ownership of the work, in comparison to those who work merely for wages. We hypothesize that the greater the exposure to the production network, the more the opportunities to acquire

mathematical knowledge. Similarly, the stronger the sense of ownership, the greater is the exposure to linkages in the production network, and more the opportunities to acquire mathematical knowledge. All the three factors of diversity of the nature of work, extent of exposure to linkages and feeling of ownership, can be expected to determine the nature and extent of mathematical knowledge that children acquire. In this paper, using qualitative ethnographic data collected in the study, we explore these three factors in order to understand the opportunities that diverse work environments create for learning mathematics. Finally we analyse students' responses to one domain where mathematics is invariably applied, namely, to estimate or calculate earnings and to determine if a piece of work has a fair earning outcome.

Methodology

The larger ethnographic study, which forms the setting for this article, was conducted in several phases. In the beginning, the researcher (i.e. the first author) started with the classroom observations of Grades 5 and 6 of two municipal corporation-run schools. This was followed by informal discussions with the students to get a broad picture of the nature of their daily activities that have aspects of mathematics and the nature and extent of their everyday mathematical knowledge. This helped in getting an initial understanding of the variation in children's out-of-school mathematical knowledge, opportunities available to gather such knowledge as well as the extent of their involvement in economic activities.

The present work is backgrounded by the researcher's (i.e., first author's) extended interaction with the community for about two years. A total of 31 students were chosen randomly from Grade 6, to form the original sample out of which a detailed study was carried out with a sub-sample of 10 students. The present data is drawn from semi-structured interviews with 17 students (all 10 students from the sub-sample + 7 students who were keen to take part, but were not part of the original sample). The interviews focused on their knowledge about the work that they were engaged in. The interviews lasted between 24 minutes to 52 minutes. For the preliminary analysis of these interviews, we chose 8 students who had varying extents and kinds of engagement with the work contexts. All the 8 students whose involvement in work is discussed below, had just finished Grade 7 at the time of the interviews. Interviews were transcribed and transcripts reviewed for what they indicate about the nature of work students are involved in, and what they know about aspects of the work. The analysis and discussion below is drawn largely from interviews, supplemented with data gathered during visits to the work places. Pseudonyms have been used throughout.

Characterising Work-Contexts

In this section we discuss the different kinds of work in which the sample students are engaged with respect to the following three aspects: (i) diversity in the work in terms of articles made or sold, and diversity of customers dealt with (ii) awareness of linkages within and across the work-domain, and (iii) sense of ownership of the work.

Mobile Phone Repairing (Salim, 14 Year Old Boy)

Several young men in the neighbourhood are involved in this work. Salim got into this work by spending time in his friend's shop observing him repair phones. His work-context requires him to interact with different people starting from negotiations with a variety of customers who bring the defective mobiles. Salim is led to diverse sites in connection to his work, for example, to places where he buys mobile phone spares, parts, repairing tools, electrical appliances like soldering machine, etc. He has knowledge of different mobile-parts and their functions; he knows the costs of both original spare parts and low-cost substitute parts that are made locally. He travels to distant markets in the city which sell spares at lower prices than the neighbourhood shops. Knowledge of a range of products and brands and their prices is required for his work. He has to quote a price for a job by guessing the customer's paying capacity. This helps in deciding whether to use an original part or a low-cost substitute, keeping in mind the expected profit. Quoting a price may often call for mental computation of quantity and price of required parts and the time required to carry out repairs. Salim also has to keep in mind what other shopkeepers in the vicinity are charging for the repair work. Thus Salim's decisions are similar to the ones made by his friend, the repair shop owner.

We find that Salim has an awareness of different aspects of the entire job and has had exposure to linkages in which the work of mobile phone repairing is situated. At present he works with his shop-owner friend, but he plans to run a similar business all by himself.

Dyeing work (Rizwi, 13 year old boy)

Rizwi helps his elder brother and father in their 'dyeing' workshop where three more employees work. The workshop is located in a tiny first floor room of a rented house while the ground floor room is used as the living room and kitchen for the family of seven. The work involves block printing of patterns or "logos" on textiles, school bags and gunny bags or sacks and is referred to as dyeing work. Rizwi showed awareness of linkages in which this work is situated, which include the place from where the printing orders come, place where the design is drawn using computer graphics based on the logo template, the place from where raw materials are procured, and the place where delivery of the printed material is made.

Rizwi knows about the different raw materials used in the work, viz., stoppers (blocks used in printing the design), dyeing frames of varying sizes, different dye colours, thinner, adhesive, etc. He explained that different sizes of the dyeing frames and stoppers are made by carpenters on order. Rizwi explained that the typical frame-sizes are 16"x12", 28"x12" making of which cost between Rs 2000-3000. Two types of colouring material producing either shining or mat-finished effect are used. Rizwi knows the prices of the colours, thinner, coating material, etc. He knows which colours are to be mixed for a particular colour or shade to emerge and the proportion in which they are mixed.

Bulk orders for printing logos on the school bags for municipal corporation run schools in Mumbai are usually placed in the months of March, April and May. For Rizwi, this heavy work pressure coincides with the preparation for the year-end examinations. In the peak season of work, the daily turnover varies between Rs 2000 to 3000. The workers get a monthly salary of Rs 4500 with an option of withdrawing upto Rs 500 per week which is then adjusted against the salary. Rizwi gets around Rs 100 per week for pocket expenses.

Rizwi informed the researcher that he makes a choice of the suitable dye-frame and stopper of a particular size by looking at the logo design to be printed in a given task. The unit used for measuring is inch. When the interviewer (researcher) asked Rizwi to make a 'guess' of the dimensions of few objects lying around, viz. voice recorder, desk, note-books, he gave nearly accurate answers – all in inches. It is interesting to note that inch is a measuring unit that is not taught in schools.

It was evident from Rizwi's response that he felt a sense of ownership over the work. When asked if he helps the workers, he said, "*apna kaam hai to madad to karna padega na*" [*it's our work so need to help*]. His statements also indicated a concern about optimal use of resources and time, "*colour-valor jo hai, cutter-wutter saman laker de deta hoon, karigar jayenge to time laga dete hain na... isiliye humlog jate hain saman kharidte hain...pagar chalu hai na...*" [*I go to buy colour, cutter, whatever, if the workers go they take long and they are being paid (for their time)... so we go and buy stuff*].

Ready-made garment selling (Dameen, 13 year old boy)

Ready-made garment selling is a popular business that is seen in most localities. We interviewed with Dameen who visits his father's ready-made garment shop in downtown Mumbai on Sundays and on holidays. Dameen knew the connection between garment size and age: that frock-size 22 is for 4-year olds while, size no. 30 for 10-12 year old girls and 32 for girls who are 13-14 years old. Knowledge of profit margins of different sizes helps in making decisions about quoted price and discount at the time of bargaining with customers. The frocks that he deals in sell for about Rs 70-160 with a profit margin of Rs 5 to Rs 40 depending upon the sizes. He claims that sizes like 30, 32 incur loss because their making charges are more in comparison to other sizes and hence the profit margin is less. Dameen's job hence entails quoting price and discount to customers while ensuring a reasonable profit. He also takes up other responsibilities in the job: keeping track of stocks and sales, and maintaining accounts. Dameen is familiar with some of the backward linkages: his uncle runs a *zari* workshop where designs are made and stitched on to clothes. The newly-stitched dresses are then sent for "thread-cutting" (also called "*fees*" cutting) and subsequently come to Dameen's shop for packaging and selling.

Tailoring (Sohrab and Perzo, 14 year old boys)

Tailoring is one of the most common occupations in the locality. The work of tailoring as a whole is complex and involves stages of skill development from novice to apprentice to master. During the interview, Sohrab described how a novice first develops hand-stitching skills and then learns to use a sewing machine. Sohrab explained that he worked in a tailoring workshop to learn stitching following his father's suggestion as a way of productively using his spare time. He described that novices begin as 'helpers' who assist other workers before they are given stitching work. Although Sohrab did not earn anything from the work initially till he learnt stitching, all this was taken as part of his learning.

Tailoring is also a work that is compartmentalised and fragmented. For example, in garment stitching work, a group of people (mostly novices) would stitch only collars and cuffs of a shirt, while others with more experience (apprentices), do complex work like stitching all the parts together, while a third group puts buttons and yet another group removes threads (discussed below) from the newly stitched shirts. This is followed by ironing of clothes and packaging work. Unlike dyeing and mobile phone repairing work, garment stitching work is completed by putting together smaller, compartmentalised tasks which are done at different workshops with owners having linkages only to the next stage of the work and practically no linkage with the market network.

A worker usually works at a location with materials that are provided to him. He does not deal with the customer. *Masters*, who get the orders, cut the cloth in bulk and distribute the pieces to 'compartmentalised' workshops. Raw-materials like threads and needles are provided to the workers. The stitching work chain ends with the delivery of stitched materials to the dealers.

Workers like Sohrab get wage based on the number of pieces they stitch, for example, 50 *paise* to a *rupee* per piece of work, while there are workers who get monthly wages, which may still be quite meagre. For example, Perzo explained that he worked in a tailoring workshop along with 4 other children of similar age whose work involved stitching garments. Perzo explained that their monthly salary ranged between Rs 1200 to 1500 depending upon how fast they could stitch. Neither Sohrab's nor Perzo's work required knowledge of linkages on the production chain or handling diverse goods. They were paid workers almost at the bottom of the hierarchy of workers and unlike Salim, Rizwi and Dameen, did not have a sense of ownership of the work.

One of the most common house-hold occupations for women is thread cutting (or "*fees*" cutting) work referred to above – a part of the garment manufacture chain. This work involves removing the extra threads from the newly-stitched garments. This does not require training, bigger space or equipment. Generally sharp-edged cutters/knives are used. This is an example of a task on the garment manufacture chain that does not require awareness about other tasks beyond the immediate engagement. It is a routinised activity that does not demand skills or knowledge from the workers.

Stone fixing work (Sakhi, 13 year old girl)

Stone fixing work involves putting coloured stones (usually up to 4) on ear-rings, pendants, rings, buckles, and *mangal-sutra* (a kind of necklace). Workers involved in this work do not need to have knowledge about other parts of the production network. The worker needs to only focus on her immediate task. It is also routinised work and does not call for skill or knowledge. Sakhi, a 13-year old girl who has been doing this work along with her mother for more than three years, has now become adept with the routine arithmetical calculations involved in the task – generally 6 pairs or 12 pairs of ear-rings are stuck in a card, with total number of pairs being 1 gross (= 12 dozen) bunched together. The wage is calculated per gross of pairs. The order comes from a middle-man who provides all the materials required for the task and also collects the finished-products and makes the payment. The workers do not have to deal with customers separately or sell the goods. This makes such less-paying jobs preferred as it is seen as an opportunity to supplement income by working at home.

Rakhi work (Shahnaz, 13 year old girl)

Rakhi making is a common household seasonal work in which women are mostly involved. *Rakhi* is a decorative wrist-band tied on a brother's wrist by a sister during the *Raksha bandhan* festival in August. The raw material for making *rakhi* is delivered at the worker's home by the middle-man who collects the finished product and sends them for packaging. *Rakhi*-making work begins as early as in February. Similar to stone-fixing work, *rakhi* making work does not require the awareness about the aspects or other linkages on the production network. The workers do not have to deal with retail sellers or retail customers.

Latkan (door-hanging) work (Gulnaz, 14 year old girl)

Latkan is a decorative door-hanging made up of different, colourful sequins of various sizes strung on a thread following certain sequence. Gulnaz visits her aunt's place next door where neighbourhood women are involved in this work. For this job too, middlemen bring the order and raw materials, collect the finished products and make the payment. Workers like Gulnaz only need to focus on the task at hand and not on other linkages on the production chain. Like *rakhi-making* and *stone-fixing* work, *latkan* making is also routinised work and requires knowledge of only a small chunk of a larger process.

Mathematics of Earning

Engagement in economic activity always involves making decisions relating to income: what work to engage in, how much time to spend, what the possibility of income is, how steady or reliable it is and so on. Calculation is an important input in the decision making process: calculating costs, incomes, opportunity costs, optimising earning, etc. Calculation is also involved in making a judgement about the fairness of a deal. These aspects are important to take account of in mathematics education since judgements about personal and public finances often need one to apply mathematical knowledge. In the interviews we asked students about how much they earned and if they were satisfied with the earning. The responses were diverse. We noticed that the responses were related to the three factors that we have mentioned earlier as characterising work contexts, namely, diversity of goods and customers, awareness of linkages and a sense of ownership in relation to the work. Complex mathematical calculations and optimisations are used in work that have more linkages within and across work-domains and deal with diverse goods and prices. Workers with a sense of ownership about their work also acquire a sense of control over their works as was apparent from Salim, Rizwi and Dameen's descriptions. In case of other students, we noticed a reluctance to use mathematical calculation to engage with questions of fairness, and in some cases inappropriate use of calculation.

We reproduce an extract from the student-interviews below. It is taken from the interview with Shahnaz, who was involved in *rakhi* making at home.

[*for all the transcripts given below, alphabets 'R' and 'S' stand for researcher and student respectively; the numbers on the left are the line numbers from the original transcripts while translation into English is provided on the right*]

185 R: To ab, paisa kaise milta hai? — *so now, how much wage is given?*

186 S: paisa gurus ke hisaab se milta hai/ — *wage is given according to "gurus" (i.e., gross)/*

187 R: matlab, ek gurus ka kitna milta hai? — *so, how much for a gurus?*

188 S: ek gurus ka pandrah rupaya, pandrah, barah, aise, dus/ — *for one gurus, fifteen rupees, fifteen, twelve, like this.., [maybe] ten/*

189 R: poore ek gurus ka? — *for a whole gurus?*

190 S: Haan/ — *yes/*

191 R: matlab ek sau chhauuwalis rakhi ka pandrah rupaya milta hai? — *so, for one hundred forty-four rakhis you get fifteen rupees?*

192 S: Haan/ — *yes/*

193 R: achha, yeh, tum iss rate se khush ho? Ya aur kam milna chahiye, jyada milna chahiye, kya lagta hai? — *ok, so are you happy with this rate? or, you should get less, more, what do you feel?*

194 S: pandrah, pandrah bees rupaya milna chahiye/ — *fifteen, fifteen twenty rupees should we get/*

195 R: pandrah bees rupaya milna chahiye? Matlab kam milta hai? — *should get fifteen twenty rupees? so, getting less?*

196 S: Haan/ — *yes/*

197 R: accha, to wohlog ek rakhi kitne rupaye mein bechte hain? — *so, how many rupees do they sell one rakhi for?*

198 S: ek rakhi wohlog paanch,dus rupaye mein bechte honge/ — *they must be selling one rakhi for five, ten rupees/*

199 R: Paanch-dus rupaye mein bechte hain? Aur tumko, tumko kitna milta hoga ek rakhi ke liye? — *sell for five-ten rupees? and you, you get how much for one rakhi?*

200 S: humko, ek rakhi to aath aana bhi nahin milta hoga/   *we don't even get eight aana[1] for one rakhi/*

Shahnaz was asked to calculate the selling price of one gross of *rakhi*, but she could only tell the price of one dozen – Rs 60 (one *rakhi* is sold for Rs 5). The researcher helped her in finding the price at which one gross of *rakhi* is sold – Rs 720 for which she only gets Rs 15 or less. She could not calculate the amount she gets for making a single *rakhi* – which is about 10 *paise* (one-tenth of a rupee). The payment for making the *rakhis* is held up till all the *rakhis* are sold out close to the festival, and workers like Shahnaz get payments only after a delay of a few months. She said that a detailed account is maintained in the *chaukri* (diary).

Our discussion with Gulnaz also highlighted the low wage that workers get: she gets Re 1 per *latkan* which is sold for Rs 50 to the customers; but she seemed to be satisfied with the amount she got. Similarly, when Sakhi who is involved in stone-fixing work was asked if what she was paid was satisfactory, she explained that it was since there were other costs added to the final retail price viz. transportation cost, cost of making and polishing the jewellery and finally the retailer only gets 50 *paise* margin per pair of ear-ring. Apparently, Sakhi gets one-fortieth part of the price at which the ear-rings are sold. The fairness issue of wage distribution failed to trigger any definite response from her as well like other students involved only in the low-paid fragmented chunks on the production network.

Discussion

We found among our respondents that some were very aware of different aspects of the work, and felt a sense of ownership with regard to the work. These were also the respondents who spoke in some detail about their work, about prices, earnings, wages, discounts, etc. Examining the characteristics of the different kinds of work revealed that the most important of these from the point of view of opportunities to acquire mathematical knowledge are diversity in the work-context, awareness of linkages in the production network and sense of ownership about the work. For example, Salim, Rizwi and Dameen felt a sense of ownership unlike Sohrab and Perzo and were aware of diverse aspects of their work as well as the forward and backward linkages that their work had. These students did not participate in the work primarily for the income, but also to pick up useful skills which are valued as they are perceived as opportunities to get into income-generating practices in the future. Salim, for example, takes pride in knowing about both kinds of work – mobile phone repairing as well as garment stitching work (Salim's father does the latter work with the help of three employees and Salim visits his father's shop often). Gaining such knowledge is considered to be important. Often children are advised by their elders to use their 'leisure' time for learning new work and for developing new skills and thereby making 'proper use' of the time. Besides the usual reason given that children work to supplement the family income, the goal of learning something through work is important for all the children whom we interviewed.

Women in the community and school going girls are mostly involved in those kinds of work which require working at home without requiring to know about other aspects or linkages on the production chain. The workshops are mostly run by men and interviews with girls like Shahnaz, Gulnaz and Sakhi indicated that work perceived as less 'technical' are given to women who do them at home taking help from other women. 'Isolated' and fragmented tasks are kept for women. Managing house-hold chores is an essential part of the daily routine women and girls and some spare time is used to generate some income on the side.

Thus, for some children, especially girls, the opportunities that the work context provides for learning are severely constrained. We believe that the characteristics that we have identified in this paper are important factors that determine the extent of such opportunities for learning in general as well as learning mathematics. An indication of this is the sparse and limited responses that we got from students with limited exposure and no sense of ownership for the work to questions involving the application of mathematics to questions about income and fairness of earnings.

Acknowledgements

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1   'aana' is an old currency unit no longer in use but still part of daily parlance. 16 aana = 1 rupee = 100 paise; hence, 8 aana is used for 50 paise.

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