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Until recently, mathematics was considered universally as a discipline of science dealing primarily with numbers, quantities and space. Therefore, the emphasis in school mathematics was entirely on conceptual understanding, application of mathematical concepts, algorithmic performance, problem solving processes etc. Mathematics was believed to be about the universal, objective and timeless truths, far removed from the affairs and values of humanity (Ernest, 1991, Harris, 1999). After the Kuhnian revolution, the conception of mathematics as a special type of human activity enjoyed a growing popularity in modern thinking about mathematics education. The new paradigm asserted that mathematics was a changing body of knowledge, the product of human inventiveness and, therefore, as fallible as any other knowledge (Ernest, 1991; Harris, 1997 & 1999).

As a fallible social intervention, mathematics is a process of inquiry, 'a coming to know', constantly expanding with human inventiveness, with no end (Harris, 1999). It is different across societies and also differs with changes in values and norms. Activity in which knowledge is developed and deployed is not separable from or ancillary to learning and cognition, nor it is neutral; rather it is an integral part of what is learned (Lave, 1988). In this new paradigm, Piagetian constructivism was criticized for failing to capture the intricate interplay between culture and cognition. Cultural anthropologists, however, criticized constructivist and social constructivist theories of Piaget and Vygotsky as avowedly anti-psychological in their approach, as the accounts they provided were devoid of empirical descriptions of the ways in which active, creative individuals meet the everyday challenges of thinking, feeling, remembering and solving problems and fail to examine the real social systems in which these activities occur or are organized within a culture (Ratner, 2001).

Lave (1988) went to another extreme claiming that 'cognition' observed in every day practice is distributed, stretched over, not divided among mind, body, activity and culturally organized settings.

> *"Why does the mind with it's durable cognitive tools remain the only imaginable source of continuity across situations for most cognitive researches—while we isolate the culturally and socially constituted activities and settings of everyday life and their economic and political structures and cyclical routines from the study of thinking, and so ignore them?"*(Lave, 1988, p.76)

Lave not only provided a major critique of Piaget's constructivist approach to mathematics learning, she advocated strongly a practice theory that emphasized the dialectical character of relations fundamental to the socially constituted world (Ratner, 2001). According to her, mathematical knowledge is produced in the lived-in world of people as a result of complex interaction among various socio-cultural, economic and political factors. Her studies exploring mathematical practices in a variety of common settings explain how various activities come together and shape each other and how, they determine the nature of mathematical knowledge and the problem solving behaviour of people (Lave & Wenger, 1991). The algorithms and the heuristics that the common man uses for carrying out simple arithmetical problems in every day activities are rooted in their eco-cultural activities and practices. It is, therefore, difficult to argue for the separation of cognition and the social world, form and content, persons acting and the settings of their activity, or structure and action. Internalisation of the world, according to Lave, is less important than action in the world. Her assertions that learning and cognition are fundamentally situated (Brown, Collins & Duguid, 1989) and, thus, the situations co-produce knowledge through activities not only redefined mathematics but also provided a legitimate place for everyday cognition in mathematics teaching.

DISCOURSE AND MATHEMATICS LEARNING

Sfard (2000) and Dorfler (2000) took a more dynamic view of the nature of mathematics. They view mathematics as a special form of semiotic activity that includes all forms of discursive acts including language use carried out in a particular culture. Discourses encompass perceiving and doing as well as speaking and writing. The discourse perspective of mathematics learning draws heavily upon Bruner's (1986) work on emphasising the constitutiveness of language wherein what is spoken and the world spoken about are seen to be mutually constitutive. According to Sfard and Dorfler, the mathematical realities/world come into being through discourse, the same mathematical realities constrains what can be said about it and done with it. In defining mathematical discourse and the realities in this broad manner, both seem to be more concerned with the development of mathematical meanings—with what and how parents, teachers and children speak about mathematical objects (Cobb, 2000).

In any society, social exchanges with others constitute a primary occasion in which children represent a reality, mathematize it and manipulate it (Dorfler, 2000). Therefore, mathematical objects come into being (into the realm of experiential reality) exclusively within a discourse that attributes to it the properties and the character of an object. In such a perspective, the meaning of symbols, words and sentences cannot be isolated and described in the same way as the properties of the physical objects. In fact, the meaning of a term is synonymous with how it is used and learning of a mathematical concept is inferred from whether the child/student consistently uses the term in socially accepted ways (Wittgenstein, 1977). Of course, exclusive focus on social usage ignores the experiential aspect of meaning that includes imagery, emotions and values (Dorfler, 2000). Therefore, although mathematical learning in the present paper is defined as enculturation into mathematical discourse, the importance of individual child's experience as s/he participates in mathematical enculturation cannot be ignored (Barber & Estrin, 1995; Dorfler, 2000; Ernest, 1991). Sfard (2000) while dealing with how children experience talking about and acting on mathematical objects, attempts to analyze the metaphorical relationship between everyday discourse about physical objects and the idiosyncratic experiences of the individual.

Analysis of development of mathematical meaning should explain how children come to participate successfully in mathematical discourse (Dorfler, 2000). Mathematics is learned by willingly participating in mathematical discourse. The learner must indulge in mathematical discourse and this participation cannot be forced on them by cogent arguments. Dorfler puts it bluntly:

> *Indulgence in mathematical conventions and ways of speaking is partly an emotional willingness. And it proves sensible and justifiable only after hard work within the discourse and only after obeying its implicit rules. I assert that a specific view, called an as-if attitude can be of much support for accepting mathematical discourse. (Dorfler, 2000).*

This *as-if* attitude reflects an epistemological stance regarding quality and existence of mathematical objects (Dorfler, 2000). Mathematical objects like any abstract concept are discursive objects that come into existence exclusively by and within the discourse. A number of *as-if* assumptions underlie these discursive acts that play a role in the development of mathematical understanding among children. These *as-if* assumptions develop a kind of *as-if* attitude among the children, which could be of much support for accepting mathematical discourse and carrying out the discursive acts in a legitimate manner. While elaborating on the experiential basis of further mathematical learning, Dorfler (2000) introduces the theoretical notions of protocols and prototypes, both of which serve as a means of supporting children's induction into mathematical discourse. He assumes that the inter-discursive resources that generate at the level of mind as a result of complex interaction among *as-if* attitude, protocols and prototypes support all kinds of mathematical learning. He defines protocol as a cognitive process in which one reconstructs the stages, phases and results of a prior activity while interpreting a symbolic record of that activity. Here the protocol is not the symbolic record but rather a particular way of interpreting the record. The present approach extends Bloor's (1976) observation that physical reality constitutes the ultimate metaphor with which we generally think to include socio-political realities. In other words, the geo-political realities provide the metaphors with which we think and interpret mathematical objects.

The discourse perspective suggested here challenges the more traditional psychological approaches that treat mathematics as a cognitive activity, and focus more on internal conceptual developments. It also serves the vital purpose of bringing people's daily routine discourses to the centre of the study of mathematical cognitions. By doing so, the culturally and socially constituted activities and settings of everyday life and their economic and political structures and their cyclical routines form the basis of studying mathematical thinking.

From this theoretical perspective, the present paper examines the relationship between cultural practices, *as-if* assumptions and the willingness to engage in a mathematical discourse and mathematical meaning-making process. Cultural practices include dominant values, norms and ethics at the societal level and prototypes and protocols at the cognitive level. The study takes a cultural psychological perspective that assumes the everyday activities of Saoras help them to develop certain kinds of *as-if* attitudes which would help Saora children and adults negotiate and arrive at mathematical meaning. The paper also examines cultural factors that allow or inhibit Saoras from indulging in mathematical discourses.

ABOUT THE STUDY

This article reports on an ethnographic study of Saoras (a tribe from Orissa) engaged in activities such as shopping in weekly markets, folk games and the classroom activities were sampled from two villages (Saralapadara and Saranga villages from Gajapati District of Orissa, India) and studied in detail. The discourses among participants were recorded and analyzed to examine how and what makes Saoras engage in mathematical discourses, the as-if assumptions that lurk beneath these discursive acts, how the Saoras talk about these assumptions, and how they arrive at a particular meaning. Reflections are also made on the nature of discursive recourses that may generate at the level of mind as a result of interaction among these as-if assumptions, the mathematical protocols that generate from the specific nature of the discussions and the available prototypes. Before discussing the case studies, a brief account of the socio-cultural milieu of Saoras is presented.

Social Milieu of the Saoras

Saoras inhabit the forested regions of the Gajapati district of Orissa (India). The total Saora population of Gajapati district is 216,043 (47.88% of the total district population) out of which 106,733 are males and 109,310 are females (1991 Census). They live in small, thatched houses made of stone or earthen, mud-plastered walls with low ceilings, timbered doorframes and exotic wall paintings on outside walls Some villages are situated as far as 25/30 km. away from the pucca (built) road. The two villages surveyed in this study did not have schools; the children attended primary school in neighboring villages. No one in these two villages had completed high school. The Saora men and women wear scanty cloth which they have woven... The Saora women use ornaments of silver to decorate their ear, nose, wrist and ankle, as well as tattoos. The Saora mainly depend on terrace and shifting cultivation for their livelihood. There is almost no concept of division of labour. Every family engages in all kinds of economic activities from house construction to working in *Bagada (paddy field)*, to making agricultural tools, knitting cloths, and/or taking care of pets.

The Saoras speak Saora language which has no writing system of its own. The from the Oriya language that belongs to Indo-Aryan language family. The principal feature of this language is the existence of semi-consonants in perfectly articulated and distinct manner (Elwin, 1955). The copious use of prefixes, infixes and suffixes and the use of dual case in addition to the singular and the plural makes it resemble least with the Oriya language spoken by the non-tribal Oriya speaking people. The primary social contact group for the Saoras in this region is Oriyas belonging to the Hindu caste hierarchy. According to Elwin (1955), the Saora language is remarkably pure, containing very few Oriya or Telugu words (another not so dominant social contact group in the vicinity). He observed that although the great majority of Saora in their dispersion across the country have lost their own language and now speak that of their neighbors, the hill Saoras in Orissa have preserved their ancient tongue and very few of them speak any other. However, in recent times, Saoras from road side villages have some contact and exposure to the Oriya language.

The Saora Number System

The Saora have their own number system though they do not have symbols for it. They use the numbers like 'zero' and have the concept of infinite numbers. Saoras have thirteen basic numbers i.e. from zero to twelve. These are *ariba* (0), *abay* (1), *bagu* (2), *yagi* (3), *unji* (4), *Malay* (5), *turu* (6), *gulji* (7), *tanji* (8), *tinji* (9), *galji* (10), *galmuai* (11), *migal* (12). The creation of numbers from thirteen to nineteen is done using the rule of combination where twelve is taken as the basic unit. For example thirteen is formed by combining twelve with one i.e. *migalbay [(migal (12) + abay (1)]* and fourteen is formed by combining twelve with two i.e. *migalbagu [(migal (12) +bagu (2)]* and so on up to nineteen. After nineteen the basic unit becomes twenty or *kudi* (20) for higher values. And here again the numbers from 1-10 are also used along with *kudi* (20) to count multiples of twenty and also the numbers between them. For example, twenty means one *kudi* (20), forty means two *kudi* (20 +20) and fifty mean two *kudi* (20) and one ten.

The Saora use large numbers like one thousand, ten thousand and hundred thousand etc. They know that 10 hundreds make one thousand. Hence they call one thousand as *galhji sha* or *madi*. The Saoras use madi (1000) as another basic unit to count bigger numbers with the help of basic numbers from 1 to 12. The next higher unit is called *puti* (20,000). The higher numbers are counted as a multiple of *puti.*

Mathematics is found in various forms ranging from a notional knowledge to some formal articulations in almost all the activities that the Saoras engage in. They have notional knowledge of complex mathematical operations like addition, arithmetic and geometric progression, functions, probabilities, and forecasting (Panda, 2004). The Saora nomenclature for addition is ***'mai mai'*** and for subtraction is ***'tab tab'***. Principles of additions are used to do subtraction and multiplication.

THE USE OF MATHEMATICAL CONCEPTS IN DIFFERENT DAILY LIFE ACTIVITIES

The use of mathematical concepts in different daily life activities was explored through ethnographic studies in the two villages noted earlier. Some specific observations drawn from the ethnographic study are discussed here from the theoretical perspective presented earlier. These observations were based on interactions of the researcher with adults and children in various settings. The researcher has limited understanding of Saora and, hence, a Saora interpreter was used. The conversations have been translated into English by the researcher. Only relevant excerpts of the longer conversations have been reproduced.

Case 1

In the weekly market place, Sunemi S. (SS), a 55 year old illiterate female from Parisala village was selling rice in the weekly market. Presented below are the conversations between the researcher(R) and Sunemi S.

R: If the cost of 1 kg rice is Rs.2/- then what will be the cost of 2 kg. rice?

SS: No, No, Babu (Sir), where from we will get rice at the rate of Rs.2/- per kg. when we do not have Below Poverty Line Card. We are paying four rupees per kilogram.

R: If the cost of 1 kg rice is Rs.4/-, what would be the cost of 2 kilogram of rice?

SS: Rs.*baakudi* (40) for *Galji (*10) kgs and therefore Rs. *Tanji* (8) for *Baagu* (2) kg".

R: What will be the cost of ½ kg rice if the cost per kilogram is Rs.8/-.

SS: In that case the price will be too high to purchase. I will die of starvation.

Case 2

Sitara M. (SM), 50 years old male member from Saralapadara village had three cocks to sell in the weekly market. He demanded fifty-five rupees for each cock.

R: Hello! We want to buy all the three cocks. What will be the cost of these three together?

SM: (After a long pause) "I can't do the calculation, because I generally sell one cock to one person".

R: But we want to buy all 3 cocks.

SM: O.K.… (thinks for sometime, engaging in mental arithmetic) it becomes malaykudi yakudimalay (165/-). Baakudigaljimalay, Bakudigaljimalay, Baakudigaljimalay (fifty five, again fifty five and another fifty five). Baakudigalji, Baakudigalji and Baakudigalji Malaykudi bakudigalji (fifty, fifty hundred and again fifty, hundred fifty). Then malay, malay au malay mai mai, migal yagi (five, five and five makes it fifteen). Together they make malaykudi yakudimalay (hundred sixty five).

Case 3

Munia (M), a student from Class Ⅶ was asked to solve a textbook problem.

R: If/suppose a train runs at a uniform rate of 40 km. per hour, how much time it will take to cover a distance of 50 kms.

(M): (After a pause)—How can a train or any body run at a uniform speed.

Another almost similar question was asked to Sumari G. (SG) from the same class.

R: If two trains are running at a speed of 40 kms per hour in opposite direction and the length of each train is 200 meters, how much time the trains will take to cross each other.

SG: (Prompt answer) The trains will have head on collision and will break.

Analysis

It may be noted here that "SS almost ignored the *'if'* aspect of the above mentioned mathematical problems, so also both school children. To SS, these questions were irrelevant because they had nothing to do with the actual price of rice in the locality. Similarly, both the children from class Ⅶ did not attend to the *'if'* aspect of both the questions and therefore did not participate further in the mathematical discourse. SM, on the other hand, after sufficient coaxing supplied the correct answer, but there was initial resistance to indulge in such a mathematical discourse. These case studies suggest that the Saoras both value and judge mathematical propositions from a reality perspective; the hypothetical mathematical problems made little sense to them (Panda, 2004). This was further substantiated by interviews conducted with children. Saora school children took more interest in mathematical problems that depicted actual local events/facts rather than abstract problems. If it was a hypothetical question completely divorced from reality, the Saoras showed little interest in indulging in related mathematical discourses and to stretch their imagination to arrive at a mathematical solution. This confirmed our assumption that the physical and social realities constitute the ultimate metaphor with which the children and adults in this culture think and act. So strong is the reality orientation that the Saora children and adults raise moral questions when the mathematical problems assume violations of social norms. For example, given the following question, three Saora children reacted to the moral assumptions rather than to the mathematical problem.

> "A man named Raghu bought 100 kgs of rice at the rate of Rs4/- per kg. He mixed 5 kgs of stones with the rice and sold them at the same rate of Rs.4 a kg. How much of profit Raghu made at the end?"

The initial reaction of these Saora children was—"why should anyone mix stones in rice? They should be punished by the village Mukhia (village head)". However, two non-tribal Oriya children and one Saora child did attend to the mathematical problem going along with the "if" assumption therein. When the same question was asked of Saora adults, their first reaction was that such a man should be driven out of the village. None showed any interest in treating it as a hypothetical mathematical question. Non-tribal children and adults did not raise such a value question as they treated it as a hypothetical mathematical problem. This makes it evident that cultural values and norms play an important role in determining the willingness among children to participate in a mathematical discourse. Clearly, mathematics does not mean the same to everyone.

Case 4

In the Saranga Ashram School (a Tribal residential school located in the Saranga block of Rayagada district, Orissa), students were taught probabilities, permutation and combination more formally in Class VIII. Five textbook questions were given to 28 Saora and 7 Oriya students present on that day in order to assess their understanding of the concept of probability. The test showed that 24 of the Saora students and 5 of the Oriya students failed to exhibit adequate understanding of probabilities. The next day, the whole class was asked to play a game[1] common among the children in Saora villages.

Folk Game

The class was divided into 7 groups of four children each. The game was played on a square drawn on earth by tossing four tamarind seeds. One side of the tamarind seeds was polished white and the other side was kept black. Four players participated in the game each having three tamarind seeds on the board. The game involved throwing the four seeds to earn points depending on how many seeds have white or black surface up

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[1] The game was documented while it was played by the Saora children in their communities in the afternoon. Most of the children from the Saora villages were well conversant with the rules of the game.

when they landed on the ground. The points were required for forward movement of the three pieces towards home. The player who managed to send all the three tamarind seeds first to the home was the winner. But the interesting part of this game was tossing of 4 tamarind seeds that involved a complex process of calculation based on the notion of probability. A Saora student (Ananga R,) explained the probability-based calculation as follow:

> "If you toss all the four tamarind seeds, five combinations are possible—4 coming white, 3 whites and 1 black, 2 whites and 2 blacks, 1 white and 3 blacks or, 4 blacks. If there are four whites, the person who tossed will get total 8 points (two points for each white tamarind seeds). If there are three whites and one black, then three points will be recorded (one point each for three whites and no point for the black). Again if the toss turns out to be three blacks and one white, only 1 point for the white will be counted. And if there are four blacks the tossed will get 4 points."

The children were grouped to discuss the rules of the game. The Saora and Oriya students who played the game were aware of all the possibilities of outcome of the tossed tamarind seeds. . But there was a fierce debate regarding the correct point distribution. The Oriya students argued for equal point distribution to white (one point for white) and black (0 point for black side) despite the combination in which they occur. Thus the debate was over the underlying rationale for point allocation. The Saora and Oriya students finally agreed the point distribution rules in the manner that it is done in the Saora community, i.e. the black sides of the seeds get points only when all the four tossed seeds turn black, otherwise no point is recorded. The white side of the seeds gets one point each except when all the four tossed seeds turn white. In the later case, each seed gets two points. Interestingly both the groups also discussed that the weighting of each side was to be calculated according to the frequency of occurrence. Rarer the chance of occurrence of a particular combination, higher is the weighted score. In addition, white carries more weight than black.

Many students did not process the information in formal mathematical terms such as (4W+0B), (3W+1B), (2W+2B), (1W+3B) and (0W+4B), but, at a notional level they were aware of the distribution pattern. Though only four students clearly could spell out that there were five possibilities, others played the game perfectly well without explicitly articulating this.

Analysis

In this game, a number of *as-if* assumptions such as, "different events can be assigned different weightings; rare occurrences carrying higher value or weight" are necessary for understanding the concept of probabilities. When the researcher asked students to give examples from their daily life about the relative values of rare things, objects or events, one Saora child, Jhumuki, replied that "—my father said if he buys more dress for me, I will not value them". Another student replied that "—because no body is a matriculate in my village, my mother says if I pass school final I will be the most important person. Everybody will regard me". The third child said that "I love Kheeri (a sweet made of rice, milk and sugar), because it is made only in festivals". It is clear from these that such discursive elements must have developed a relational prototype of chances of occurrence of events/objects and their relative values.

It can be noted that the teacher failed to develop this understanding of probabilities among children despite working repeatedly through textbook problems, whereas one folk game made the children indulge willingly in the activity and discussion of various aspects of the concept of probability. A number of factors were found to be operating simultaneously which reinforced the meaning of probability. These are the *as-if* assumptions that underlie each rule of the game and few supportive protocols mentioned by the students. The inter discursive exchanges between these *as-if* assumptions and the protocols provided necessary cognitive mechanisms to process these information and arrive at a meaning.

Strictly speaking, the game is not a protocol for understanding the concept of probability. Instead, the protocol is a particular way of interpreting and talking about how the game should be played and how the points should be distributed. It is reasonable to believe that there could be a complex communication among the *as-if* discourses underlying this game and few supportive prototypes available in the environments and the protocols (examples of rare things and events in life and the relative importance of these events). Here the meaning of the probability (probable occurrence of things or events and their relative values) did not come from outside. The discourse itself created its meaning. In other words, this game could not have served as an intra-discursive source of mathematical meaning for concepts like probabilities and relative weighting system unless students developed these ways of interpreting it or participated willingly in the practice invented or developed by the community.

CONCLUSION

These case studies make two points. First, mathematics is a special form of discourse in a culture. Second, children learn mathematics by willingly indulging in these discursive acts. Different aspects of the Saora culture—their world view, values and norms, economic engagement, topography etc. —provide the context within which the relevant prototypes and protocols are formed and are accessible by members of the community. The *'if'* assumptions underlying mathematical acts/objects were validated against these prototypes and protocols. The interactions among these three aspects, i.e. the *as-if* assumptions, protocols and prototypes—which are both cognitive and cultural—generate the discursive resources that support mathematics learning. The case studies discussed above clearly indicate that the Saoras value and judge mathematical propositions from a reality perspective. Hypothetical mathematical problems, divorced from reality, make little sense to them. So robust is the reality orientation and reluctance for *'if'* assumption, that the Saora children raise moral questions when mathematical problems violate the social norms and ethics and show less interest in mathematical problems *per se*. The complex communication between the *as-if* assumptions underlying each of the mathematical activities, the culturally accessible prototypes and protocols that support the mathematical thinking influence profoundly the meaning-making processes. In the present study, when Saoras perceived incongruence between *as-if* assumptions and cultural values, they showed less interest in continuing with the discourses. It can, therefore, be reasonably argued that conventions of mathematical discourse and mathematics learning go much beyond a cognitive understanding and they need to be accepted as legitimate cultural processes. Understanding of mathematical cognitions is incomplete without consideration of cultural practices.

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