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LESSONS FOR TEACHING BOTANY: WHAT MIDDLE SCHOOL STUDENTS KNOW ABOUT PLANTS

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Abstract

Students' alternative conceptions arise out of an interconnected system of beliefs: about the nature of science, of learning, of the natural and social world. Cross-cultural perspectives on these world views are therefore essential. This study probed middle school students' conceptions about plants.

Tribal students were found to have a richer and more varied knowledge base about plants both in comparison with the textbooks at their level and urban students. While textbooks emphasized detailed structural descriptions, students focused on gross shapes, environmental features, seasonal variations, and feelings, which in turn they related to the uses of plants. Data for urban and tribal students showed that mere presence of plants in the environment did not result in students being aware of them. Everyday use and socio-cultural significance of plants played a greater role. The direct dependence of tribal cultures on forests for shelter, food and medicine, was reflected in their positive attitudes towards plants, and in their more detailed knowledge of ecological interdependencies as compared to urban students.

Introduction

School students' conceptions form an interconnected system of beliefs: about the nature of science, of school, of learning, and of the world around. Knowledge is constructed through interaction with the physical as well as the social environment. Alternative conceptions therefore need to be seen in terms of the context of learning, including the local environment and the socio-cultural background of students, and its relation to the classroom climate. This was one of the goals of the DLIPS Project - Diagnosing Learning in Primary Science, undertaken at the Homi Bhabha Centre for Science Education. The DLIPS project studied three main themes that are intimately connected with primary (grades 1 through 4 in Maharashtra State) and middle school (grades 5 through 8) science: students' ideas related to living and non-living, students' ideas about plants and the role of experiments in school science [Chunawala et al, 1996; Natarajan et al, 1996; Ramadas et al, 1996].

Students in India grow up in a variety of economic and socio-cultural backgrounds. Although in school they follow a common curriculum, research and other observational evidence suggests that the experience of schooling may actually differ for students from differing home backgrounds. Their life-styles and environmental experiences may also differ. It is possible that these factors besides the curriculum and textbooks influence students' worldviews and shape their conceptions. Our study of students' conceptions was motivated by these rather complex considerations.

Context, cognition and the study of plants

Cognition in natural and social settings has been the subject of many research studies. Implicit in these studies is the view, developed by Lave [1988], Brown and others [1988], that cognition is 'situated' - that knowledge is closely intertwined with the activity, the context, and the culture within which it is developed. This view is particularly relevant in situations where there is a wide gap between the culture of school and home. The study of botany for tribal school students in India is a case in point.

Tribals typically regard humans as part of a community of beings that include other living creatures as well as elements of the landscape. Tribals in India, many of whom live in the outskirts of forests, supplement their meagre earnings as tenant farmers/ labourers, with the sale of fuel wood, and minor forest produce like herbs and honey. *Ashramshalas*, or residential schools, are an attempt by the government to educate the tribals and integrate them with the mainstream. Lack of effective linkage between informal experiences and formal education leads to classroom learning limitations.

In rural and indigenous cultures, even children under 12 years of age participate in agriculture and collection of forest produce. Urban students on the other hand, merely use plant products in their daily lives. In schools, both tribal and urban students go though a common curriculum, in which the study of plants is an important component from grades 1 through 6.

Anthropological and ethnobotanical studies, which have documented names for plants, show that adults in rural and underdeveloped societies have names for many wild plants in their environment [Berlin et al, 1966; Tull, 1993]. Other studies [Dougherty, 1979] find that urban students have a poor knowledge of names of plants and cannot identify as many different varieties as tribal students of the same age. Hunn [1985] points out that "biological taxonomies only lexicalize a small portion of the total number of available plant and animal taxa, and what is lexicalised are the plants and animals that have some special importance to people".

Scribner and Cole [1973] see a juxtaposition of formal and informal education as a source of problem in bringing about cognitive change. Their thesis is, "... *that school represents a specialised set of educational experiences which are discontinuous from those encountered in everyday life and that it requires and promotes ways of learning and thinking which often run counter to those nurtured in practical daily activities.*"

Informal education in traditional societies is contextualised and person-oriented - each task is taught by a particular person, and the position of the person, say a family or group elder, imparting the skill is as important as the task to be learned. On the other hand, formal school education demands that children relate only to the subject matter, which is not only decontextualised, but often taught by a different teacher each year. This problem is compounded, in education of tribal children, by the schools representing a culture that has historically oppressed and maligned the indigenous people. Besides, the organization of knowledge in subjects like formal mathematics, grammar and the sciences often conflicts with the traditional ways of understanding and interpreting the world [Harris, 1992].

Informal learners lack explanations for how and why they perform a task, while school learners know the words but not the referents, because they have never encountered a practical situation related to their knowledge. These arguments lead to a strong plea for making a connection between everyday life of students and the decontextualised learning in the classroom [Brown et al, 1988; Brown, 1989]. It has been recognized for over a decade now that students' understandings include non-semantic aspects, like, emotions, values, beliefs, interpretive frameworks and personal experiences [Gilbert et al, 1982], which are also deeply embedded in the physical, social and cultural settings of the students. The school, and evaluations therein, are only concerned with the formal propositional (semantic) knowledge.

The present study was motivated by the observation that tribal students are seen to be at a disadvantage in formal school in terms of performance. Their life-style, and the knowledge of plants and forests on which it has depended over the years, remains unrecognised and under-valued. By documenting students' ideas, we hope to see if a connection is possible between the situated knowledge of students, and the requirements of the curriculum.

Sample and tasks

The study was done with middle school students from generally deprived socio-economic backgrounds. The data was collected over two academic years from three residential schools, one in Mumbai city (*Urban*) and two tribal schools in rural areas (*Tribal*) of Maharashtra State. The urban school is run by a charitable organisation and has a mix of students from poor and lower middle-class families. The data analysis was largely qualitative, with testing for statistical significance where appropriate.

Both urban and tribal students belonged to grades 5 and 6, and ranged in age from 10 to 15 years. About a hundred students each in the tribal and urban groups participated in the study. The actual number of participants varied for the different tasks. The ratio of girls to boys was about 1: 2 in the urban school and 1: 4 or less in the tribal schools, reflecting a severe gender bias in schooling opportunities. The gender ratio decreased further in the higher grades. The medium of instruction was Marathi, the language of Maharashtra State. The tribal students' mother tongue was a dialect of Marathi.

Our experience has been that these students, particularly in the school situation, are not used to expressing their own ideas freely. Through the medium of classroom discussions along with a variety of written tasks, games and activities, students were encouraged to express their ideas related to a topic. Games that required the students to form teams and compete, served to open up interaction channels with the students. In one such game, played outside the classroom during early interactions, students formed teams and identified living things found on land, water, or in the air. The fact that tribal students were able to give more than 150 plant names provided the impetus to probe the students' knowledge of plants in greater depth. Several tasks were subsequently designed, of which the analysis of two tasks that focus on the aspects of situated cognition are reported here. A brief description of each task is given below.

Herbarium collection
In the 'herbarium' task, 58 urban students of grade 6 and 99 tribal students of grades 5 and 6 participated. Each student was asked to select one plant from the environs of their school or home, preferably different from that of her/his classmates, and bring a twig containing a few leaves and a flower, fruit or seed, if it had any. The students then filled out a questionnaire which asked for information about the plant selected by them: its name, the surroundings where it was found, if the plant was a vine, the support of the plant, their 'thoughts and feelings' about the plant and any stories about it that they may be aware of. They were also asked to give the colour of the flowers when fresh, and human uses of the plant and its parts.

Drawing and writing about a plant
The participants for the drawing and writing task consisted of 104 urban students from grade 6 and 108 tribal students from grades 5 and 6. The students were asked to first draw the overall shape of the plant and its features, and then to fill out its surroundings. They also drew in detail, on a separate sheet, a branch, a leaf, flower, fruit and seed, of the same plant. Unlike the herbarium task, different students could draw the same plant. After completing the drawings, every student wrote about each aspect of the plant. The writing task was complementary to the drawing task and helped in probing students' ideas about the plants beyond the limitations of the drawing task.

Results

Herbarium collection
Students collected a great variety of plants distributed over many categories. The plants chosen by the tribal and urban students differed in two ways: the total number of plants in each category, and the variety, or the number of distinct names, within each category. The salient features of the responses to the herbarium questionnaire are given in Table 1 and tribal and urban students' responses are compared below.

There was a greater variety in tribal students' responses: majority of their choices (>70%) were evenly distributed over fruit trees, flowering trees and garden plants. They also gave a significantly greater number of fruit (z=2.46) and flowering (z=3.34) trees. There was a greater variety of flowering trees (z=2.51) as well. Tribal students chose many trees, which have a social and religious significance (socially significant trees). The tribal students in this study are dependent on a wide variety of plants. Thus, it is not surprising that they selected a large variety of plants from several categories.

Table 1: Number (No.) and variety (Var.) of plants in the herbarium task

Category	Tribal		Urban	
	No.	Var.	No.	Var.
Fruit trees	27	16	7	4
Flowering trees	25	16	4	3
Garden Plants	21	15	24	12

Veg. Plants	7	5	13	8
Grass/Water plants	4	4	2	2
Other socially significant plants	15	10	8	2
Total	99	66	58	31

Forty percent of all plants chosen by urban students were common garden plants, significantly greater in number (z=2.63) and variety (z=2.09) than the garden plants given by tribal students. They also chose a larger number of vegetable plants (22%) than did tribal students (7%), whose choices were different.

Several of the trees found in the tribal environs are also found near the school of the urban students in this study. Yet the urban students chose only a few fruit trees, the fruits of which they like to eat! Their choices in the garden variety were dominated by the plants that they use in their everyday lives. Complementarily, although a large variety of vegetable (and garden) plants are found around the *Ashramshalas*, tribal students chose them less frequently than did urban students. In the urban students' case, all 'useful' plants may not be found in their surroundings, while in the case of tribal students, the mere presence of a variety of plants in the forest has traditionally led to their use in the everyday life of their community.

Tribal students often expressed positive feelings about the plants they had chosen, in addition to their uses. It appeared that students' feelings were often linked to the uses of plants, as food, medicine or fuel. At other times they described the flowers as beautiful and 'gladdening'. Both urban and tribal students' responses had only a few structural descriptions like, "*chini gulab* leaves stand erect". This is in contrast to textbooks that abound in structural descriptions and underplay feelings.

It appears likely that, in the herbarium collection task, more than the availability of a variety of plants in the environment, the perceived dependence on the plant, and its everyday relevance, influenced students' choices. Their perceptions of use and 'feelings' about the plants were also an important factor that influenced the variety and number of herbarium samples.

One might expect that four years of formal schooling with similar textbooks would have a certain homogenising influence on urban and tribal students. This was not found to be so. Tribal students brought herbarium samples of many plants that did not appear in the textbooks, largely in the categories of fruit, flowering and socially significant trees. About two thirds of the plant samples brought by the tribal students, and about half those brought by urban students, were different from those given in the text. Textbooks, on the other hand, cite a large number of trees and plants of several categories, possibly in an effort to cater to a majority of rural and urban students.

Drawing and writing about a plant

This activity was meant to probe students' observations about a plant of their choice: the overall shape of the plant or tree, the details of its parts like, leaf, flower, fruit and seed, the surroundings in which the plant may be found, and any other ideas about the plant that they would want to write about. The activity had two distinct parts: drawing, followed by writing.

Choice of plants - number and variety

The predominant categories of plants chosen by the students were analysed on the same lines as in the herbarium collection activity. In this case too, each student drew only one plant. The salient differences in number and variety of plants chosen by tribal and urban students for this task are discussed below. The total number of plants in each category (No.) and the number of distinct names in each (Var.) are given in Table 2.

Table 2: Number (No.) and variety (Var.) of plants in drawing and writing task

Category	Tribal		Urban	
	No.	Var.	No.	Var.
Fruit trees	60	13	67	7
Flowering trees	18	8	0	0
Garden Plants	14	5	32	11
Veg. Plants	1	1	0	0
Grass/Water plants	0	0	1	1
Other socially significant plants	15	6	4	3
Total	108	33	104	22

There was less overall variety in the plants chosen by both tribal and urban students in this task than in the herbarium task, probably because variety was not insisted upon. The nature of this task required the students to visualise the plant and draw it. Their observations, ability to visualise and draw, and a tendency to copy from neighbouring students, may all have reduced the variety of plants in students' responses to this task.

There was a greater variety of plants in the drawings of tribal students than in urban students' drawings. Most students (60%) drew fruit trees, with a greater variety in tribal students' drawings (T=13,U=7). Garden plants figured less in tribal students' drawings, both in number (z=3.8) and variety (T=5,U=11).

Urban students largely drew either fruit trees or garden plants, and no flowering trees or vegetable plants. The fruit trees were mostly the three stereotypical ones; *coconut* palm, tamarind and *mango*. *Coconut* palm is often perceived to be easy to draw and is part of all typical 'rural scenes' in books. The sour tamarind fruit is inexpensively available with roadside vendors in urban areas and is a favourite with children. The *mango* is a summer treat. Interestingly, no tribal student drew a tamarind tree.

Textbooks cite names of several plants, but give few pictures of specific plants or trees with notable exceptions of a *hibiscus* plant and a rose plant. Some nondescript trees not attributable to a particular variety are drawn in the textbooks as part of scenery. There are also pictures of fruits, vegetables, a few flowers, leaves and roots as independent structures.

Only about half the varieties of plants drawn by tribal students and about two-thirds the varieties drawn by urban students were the same as plants mentioned in textbooks. Most of the socially significant trees drawn by the tribal students were different from textbook ones. Urban students drew all the garden plant varieties drawn by tribal students, some mentioned in the textbooks and not drawn by tribal students, and more.

Students' drawings thus may indicate many things: their observations of plants around them, picture books, their ability to visualise these plants in the classroom, and their ability to draw. They collectively drew a large variety of plants from memory. Clearly, in this task, as in the herbarium task, textbooks have had marginal influence. Hence, students' drawings can be analysed for patterns that could reveal their ideas about plants.

Students' drawings

In a study of emotional and cognitive developmental features in the drawings of young children, Jacqueline Goodnow [Goodnow, 1977] states that, "No drawing is an automatic print-out of some perceptual world ... What is seen or intended must be translated into the action of drawing, and we need to understand fully the nature of translation and the nature of action".

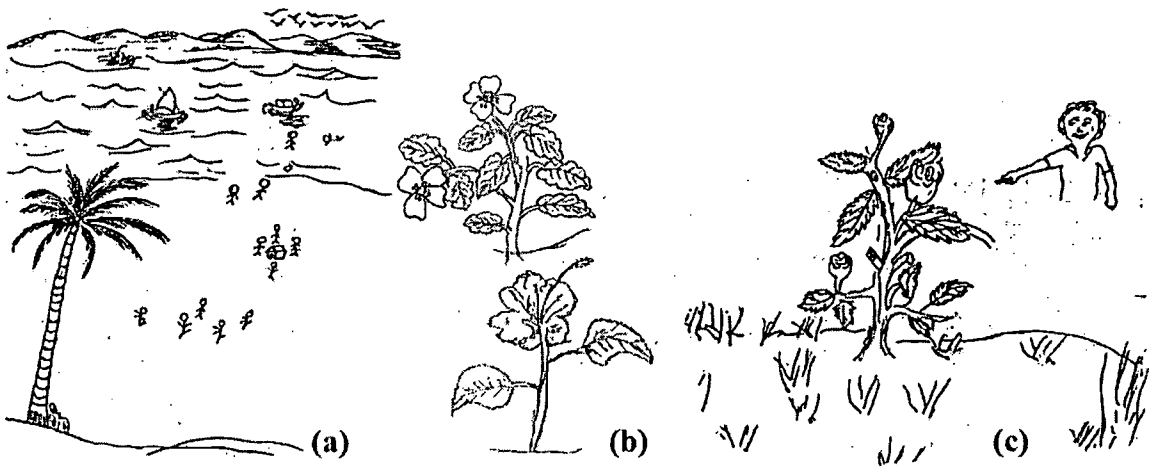
The following analysis focuses not on cognitive development, but on 10-15 year old students' observations and knowledge about plants. In particular, we look for evidence for realism, and attention to details of structure. The analysis starts from the premise that students' drawings of plants are their translation of what they see and 'think' about plants, and hence provide clues to their understanding of plants. Certain features of the drawings indicate possible lacunae in the teaching of botany in classrooms. The nature of these features, or 'patterns' in them, may help us understand what needs to be addressed if school botany is to form a useful scientific basis for the students to understand their environment. The salient features of the drawings of urban and tribal students fall in the categories of cases of accuracy in urban and tribal students' drawings, kinds of inaccuracies, like gross inaccuracies, wrongly directed venation and exaggerated proportions, and ecological features and realism. These are discussed below.

Drawings of big trees by tribal students had the correct overall shape. Shape of leaves, leaf arrangement on branches, and position and shape of fruits were mostly correct for different kinds of trees.

About 40% urban students drew the *coconut* palm and most drew it correctly: ribbed trunk, location and shape of leaves and fruits. Besides, these trees were shown, curving artistically, in very picturesque surroundings, by a stream or river, with a boat in the stream. A typical drawing is given in Fig.1(a).

Several urban students drew leaves of common garden plants, like the *hibiscus* in Fig.1(b) or rose in Fig.1(c) accurately and in great detail - relative size, position, serrated leaf margins, and thorns at the nodes. In urban areas, potted plants around the house, courtyard or even on balconies and their everyday use for decoration and worship afford students an opportunity for close observation of such plants. Some features, like the *hibiscus* flowers in Fig.1(b), were exaggerated. This plant has been drawn in textbooks, and the one in grade 6 textbook is a small-sized plant with rather large flowers.

Figure 1: Drawings by urban students: (a) *Coconut* palm showing scenic surroundings, (b) *Hibiscus* plant and (c) Rose plant.

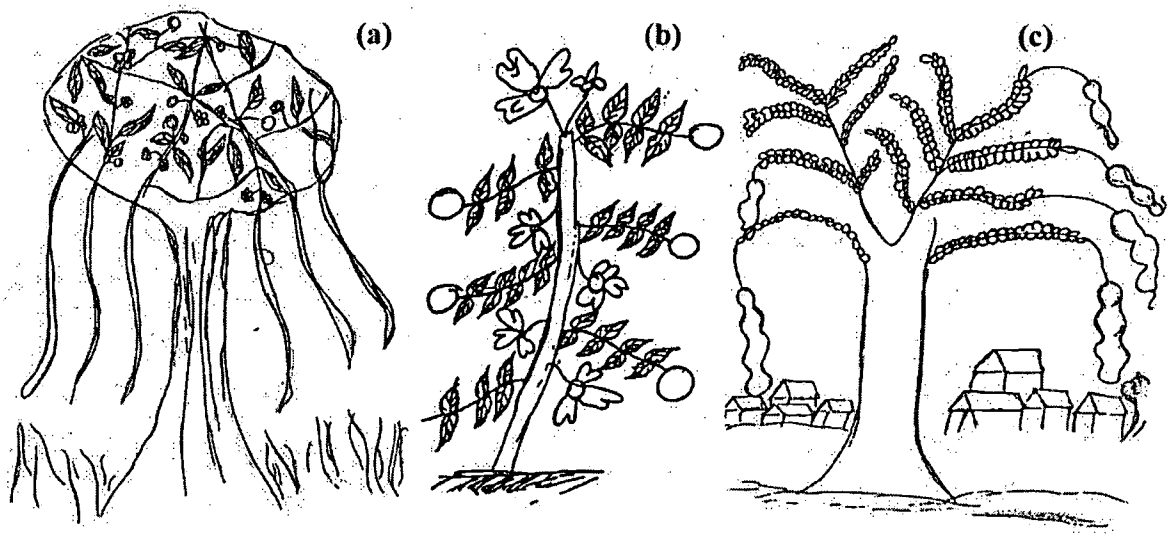


There were several kinds of inaccuracies in the drawings, which could serve as teaching learning opportunities. An urban sixth grader inaccurately drew prominent adventitious roots on the *peepul* tree (Ficus religiosa) (Fig.2(a)), which belongs to the generic class of trees characterised by adventitious roots. The student in this case may have overemphasised the roots, or made an observational error. The round fruits were attached to the branch by a stalk, rather than growing directly on the branch. The leaves were oblong instead of the well-known shape of a heart with an elongated and pointed apex. The drawing had stereotypical flowers, also at the end of stalks.

Another urban sixth grader drew a *guava* tree, with flowers growing on stalks from the main trunk, whereas round fruits - rather than the actual pear-shaped ones - were shown growing at twig terminals Fig.2(b). The

student did not make any connection between the flower, the fruit, and the seed, the flowers were oversized, and the fruits were smaller than the flower.

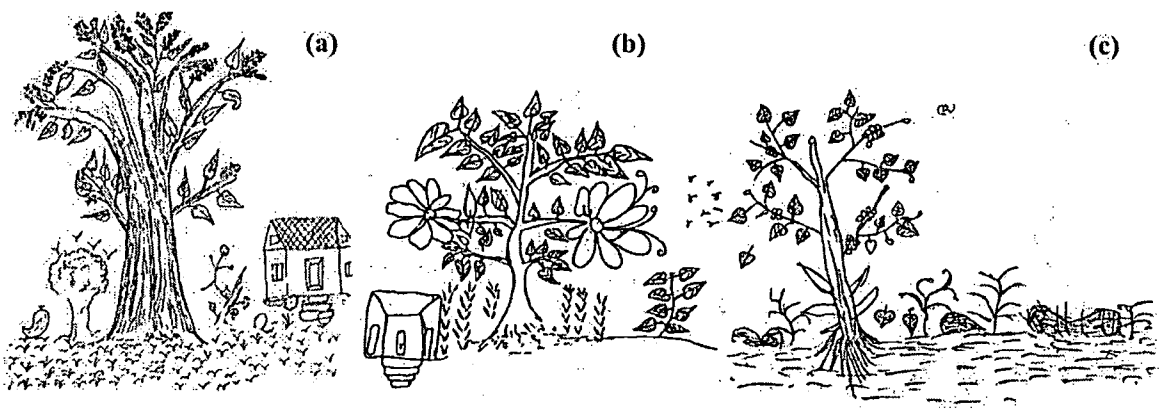
Figure 2: (a) *Peepul*, (b) *guava* and (c) *tamarind* trees by urban students.



There were many instances of students, both tribal and urban, drawing some parts of plants in exaggerated proportions (Fig.1(b), Fig.2.(a and b)). Fruits were prominent on every drawing of *mango* tree as in Fig.3(a). A *tamarind* tree (Fig.2(c)), drawn by an urban sixth grader showed large fruits and leaves. Placed in the foreground of the picture, the tree was large, 'having compound leaves, long and slender with 10-20 pairs of nearly stalkless leaflets' [Bole and Vaghani, 1986]. Juxtaposed with this accuracy of drawing were fruits placed incorrectly at the tip of leaves, correct in shape but highly exaggerated in size. The beautiful red flower of the *hibiscus* plant and the sour fruit of the *tamarind* tree happen to be favourites, especially with children. The size of these features may be an indication of the relative importance of these parts of the plant.

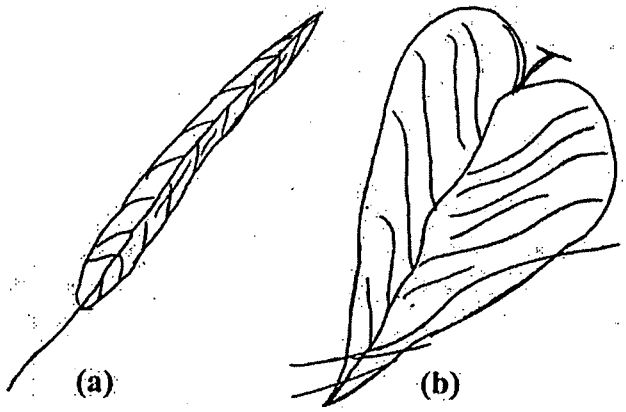
The drawing of a *bhendi* tree (Thespesia pupulnea) (Fig.3(b)) by a sixth grade tribal student was another striking example, where the flowers of the tree were incorrect in shape and were oversized. The sapling next to the tree, and the root structure near the ground indicated that it was a large tree. The leaves were of appropriate shape, but with opposite venation. In the herbarium task, students who chose this tree mentioned that they liked the tree for the attractive yellow flowers that changed to purple when about to wither. Thus the students did perceive the flowers as the most prominent part of this tree, and possibly attempted to depict that in their drawings.

Figure 3: (a) *Mango*, (b) *Bhendi* and (c) *Fig* trees by tribal students.



Students drew the leaf shape and leaf margins more accurately than other parts. One of the striking features of students' drawings was the venation of the leaves. While more urban students drew the veins in the right direction (z=3.0), many drawings of tribal students indicated veins in the opposite direction. This is illustrated in the two different leaves drawn by fifth grade tribal students Fig.4: an elongated (lanceolate) one of *biti* (Thevetia nerlifolia) plant and a heart-shaped leaf of the *bhendi* tree. It is amazing how correct they could be about the overall shape of the leaf, and yet draw all the veins in the opposite direction! While drawing a bunch of leaves, for example on a branch of a tree, there was often utter confusion about the direction of veins.

Figure 4: Leaves drawn by two tribal students (grade 5): (a) elongated leaf of *biti* plant and (b) heart-shaped leaf of *bhendi* tree..



The confused venation could have arisen either because of lack of observation of details, perceived irrelevance of the venation in making gross identification of plants, or perhaps a difficulty in drawing oppositely oriented diagonal lines [Olson, 1970]. The latter possibility was ruled out when they reproduced accurate venations when asked to collect a leaf and draw it. Hence, one may argue that the confusion may originate in a lack of attention to the details of venation.

Ecological features and realism were largely evident in tribal students' drawings, although urban students' drawings of *coconut* trees in scenic surroundings would also fall in this category. Many tribal students drew large trees with saplings of the same variety growing nearby (Fig.3(a and b)). Fig.3(a), showed a realistic shape of the tree, inflorescence and fruit. The *mango* fruit was shown as a prominent part of the tree, as well as of the whole scene, for example, a *mango* on the ground with a child running to get it.

In the drawing of a *fig* tree in Fig.3(c), roots were shown above ground, saplings around the tree, and logs of wood strewn around. The fruits were attached in clusters to the main branches. The leaf shape was distinct and correct. The drawing clearly indicated that it was the season for shedding of leaves. A few leaves were floating to the ground from the large tree, while the saplings were already bare. But the fruit, indicated separately, though of the correct shape, was incorrectly positioned on the branch, and a lone seed was drawn inside the fruit.

The science textbook for grade 6 describes many parts of plants in great detail, including apex, veins, margins and stalk of leaf, and style, stamen, stigma and pollen in flowers. Detailed descriptions of the parts of a stem, leaf, and flower, are given, but the book says little about how all these are connected to each other. There are very few pictures of the whole plant or tree. All the factual knowledge about parts of a plant is usually taught within the classroom, with neither field trips nor collection of plants for demonstration in the classroom. The facts are then rote learned in the confines of students' homes. Given these circumstances, one is left to explain how the students got it so right.

Tribal people have had intimate links with the trees in their environs. They have thus evolved ways to distinguish between the different trees in their daily lives, using the visual criteria of shape, size and distribution of leaves,

besides smell, texture and other non-visual criteria. These are often used implicitly rather than in an explicit manner in identifying trees. The tribal students probably 'know' these by 'situated learning'. This was evident from the discussions with them during the game on identifying living things in their surroundings. Tribal students also expressed this knowledge in their drawings.

Urban students relate to plants in their daily life through watering their garden plants, picking flowers of garden plants and throwing stones to drop edible fruits from road-side trees. Most students also know and use many parts of the *coconut* tree. The distinct shape of the *coconut* palm is most familiar to the urban students of Mumbai.

In the drawing task the use of a plant and plant products in everyday life, and interactions with the plant, seemed to decide the plant chosen and the accuracy of drawing. Since textbooks had very few drawings of whole plants, they did not help students in responding to this task. That may also explain why the students did not give the details that the textbooks give, unless they were details of familiar plants, like garden plants for urban students. There is apparently a wide gap between students' spontaneous ideas about plants - which were varied and rich in ecological content - and the knowledge in the textbooks.

Students' writing about plants

The students were asked to describe the plant they had drawn, including its overall shape, its surroundings, its trunk, branches, leaves, flowers, fruits and seeds. They had to describe characteristics like colour, smell, texture (feeling to touch), periods of flowering and fruiting, and whether the plant shed its leaves. They were also asked to write about the uses of the plant and its role in the environment. Students may have used some of the relevant expressions from their textbooks.

Urban students, who gave too few items to be analyzed in any detail, mostly gave gross structure and functional features, and little else. In general, most tribal students wrote much more about the plant they had chosen to draw than did an average urban student. The description of plants given by the students was analyzed in the light of some aspects that are commonly found in the textbooks, and others that the task specified.

Textbooks give many plants as examples while discussing variety in leaves, root, stem, the general structure of plants or functions of plants and their parts. They abound in definitions, classifications and statements of cause and effect. Textbooks also describe processes like germination of seeds and give procedures for growing plants. There are a few nonvisual descriptions and do not have descriptions of a single plant on the lines requested of the students. They are devoid of affective statements or imagery and metaphor, especially in grades higher than the fourth. Time references, like, fall of leaves or flowering seasons are absent in textbooks.

The predominant feature in the writings of students was description of gross structure, such as colour and size of tree trunk, stem, leaf, flower, and fruit. Students' writings closely modelled the textbooks in four aspects - gross structure and gross anthropocentric functions, details, and process descriptions. Tribal students gave several uses, most of which were human uses, of the plants and their parts.

Students rarely referred to the subparts other than *cotyledons*, although there are many references in the textbooks to stamens, style, margins of leaves, etc. Students described processes more often than procedures, and most cases pertained to germination of seed and plant growth. This is not surprising, since textbooks deal with this in some detail, and even suggest that students try the activity of germinating some common seeds. Some of the teachers claimed to have done this in the classroom, and some students too mentioned that they had done it.

There were a large number of instances where students referred to seasonal variations in plants. Most tribal students wrote about time of flowering, when leaves were shed, and when they sprouted anew. Some students wrote a few sentences about the surroundings in which the plant was to be found and described them with feelings. The students' writings were relatively high on feelings and references to seasons in contrast to textbooks. Students did not make many classificatory or cause-effect statements, nor did they give definitions or

procedures in their writings. In this task, students gave a few instances of nonvisual descriptions (a tree trunk is strong), or imagery (umbrella shaped, half-moon, like a chicken egg). These descriptions as well as environmental details and gross function are rare in both students' writings and in textbooks.

Conclusions

The study of students' ideas about plants was done in the context of a science curriculum, which is sometimes excessively formal in its approach particularly when seen against students' spontaneous conceptions. The study found a mismatch between textbook science and students' conceptions. Nevertheless, the conceptions held by students did show some internal coherence and also consistency within groups of students.

Students' ideas about plants were seen to be influenced by physical and social settings and by textbooks. Mere presence of plants in the environment did not result in students being aware of them. Everyday use of, and interactions with, plants and plant products had a greater influence on students' ideas about plants.

There was a wide gap between students' spontaneous ideas about plants - which were varied and rich in ecological content - and the knowledge in the textbooks. Tribal students incorporated in their drawings of plants, many features that reflected their understanding of ecology. Tribal students' keen observations were further evidenced in the many instances they gave of seasonal features. In contrast to textbooks, students gave few detailed structural descriptions, focusing rather on gross shapes. Tribal students drew realistic pictures of a large variety of forest trees, often correct in placement of leaves, fruits and flowers. They frequently expressed their feelings towards plants and related their feelings about individual trees to their uses, unlike textbooks, which tend to underplay feelings. The uses, which the students gave, compared well with those cited in advanced botany textbooks.

Textbooks however depict very few whole plants or trees, and do not incorporate affective or ecological features in the pictures. Classroom intervention is necessary here. The study of botany can become meaningful to students only if ecological features, seasonal variations and affective factors are woven into classroom teaching through appropriate activities and interactions that highlight the relevance of this knowledge in everyday living.

Because of the widely different ecosystems that the country is endowed with, it may not be possible for textbooks to cover all available varieties of trees. Nevertheless, the tropical forests of the *Sahyadri* range, which are home to the tribal students in this study, is an important and geographically prominent ecosystem of the country and has been discussed in the geography textbook of grade 6. Yet, the connection with biology is unlikely to be made, since teachers rarely go beyond the textbooks, and different subjects are often handled by different teachers. It is unfortunate that there is scant attempt, either in the textbooks or in the classrooms, to address this gap between students' awareness of their surroundings and the formal knowledge of botany required of them.

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