UNIT 11 CHILDREN'S SPATIAL ABILITIES

Structure **Page Nos.**

11.1 INTRODUCTION

The other day a group of teachers was discussing the primary school mathematics curriculum. Some of them brought up the space in the curriculum that children need versus what they get for developing various spatial abilities. There were two views that came up in this discussion. One view was that the curriculum has very little space for helping children develop the ability to communicate spatial information and ideas and become capable of using spatial relations. To this, a teacher reacted, "But we do so much about space and geometry! How do you say that spatial abilities are neglected?"

How do you react to these two views? This unit may help you in responding. It is about the ability of children to perceive, represent and utilise space. We start this unit with thinking about the knowledge about shape and space that children at various ages already have. Though it is considerable, we discuss reasons for developing their spatial thinking further. If this is done appropriately, we can help the children to sharpen and develop many spatial ideas and abstract thinking. We also consider some tasks, activities and teaching strategies that can help children to further these skills and abilities.

Throughout this unit, we touch upon misconceptions that children have regarding shape, size and space. The reason for doing so is to make you aware of the wrong messages that can get across while you are teaching children. This could happen without your realising it, due to the strategy used. This is why we always need to interact with our learners, reflect on our assumptions about children and our teaching methods,

As you know, this course is very closely linked to the earlier one you have studied, AMT-01. You should take another look at the introduction to Block 5 and Unit 16 of AMT-01 before going further.

Objectives

After studying this unit, you should be able to

- give instances of the spatial knowledge children usually have by the age of five;
- give reasons for the need to further develop children's spatial thinking and abilities;
- suggest and try out various activities to develop children's spatial abilities.

11.2 WHAT WE KNOW ABOUT CHILDREN'S SPATIAL ABILITIES

As you must have seen from your own experience, even very young children have a great deal of spatial knowledge. They use terms like 'near', 'far', 'big', 'small' quite comfortably and sensibly. Of course, what is 'far' to a 3-year-old may become 'near' to her by the time she is six! Through interacting with the world around her, the child sharpens and develops her spatial abilities. In Blocks 1 and 2 you have seen examples of children routinely making choices between which glass to use, which place is small or big enough to hide in, which way will help them reach a high place, etc. Don't you think they have a fairly well developed system of comparing sizes? Think about this while doing the following exercises.

E1) In Blocks 1 and 2 we have given several instances of very young children exhibiting various spatial abilities. List five of these examples.

E2) Observe children engaged in activities at home. In which of these activities are they exploring spatial ideas? And which spatial ideas are they exploring?

Children have a great deal of spatial abilities. These are not easy to identify and describe. Many researchers with different perspectives have tried to understand what spatial understanding children have. One of the most important efforts in this direction came from **Jean Piaget and Inhelder**. They did a series of experiments to understand this aspect of children's minds. We shall look at some of these experiments as well as those done by others. You can think about the conclusions drawn by these different researchers, which we shall also present. Let us start with the ability of children to look at things from another person's perspective.

11.2.1 Taking Another Person's Perspective

According to Piaget, preschool children look at things entirely from their own standpoint, from their own frame of reference. In other words, they think that other people see, understand and interpret events and actions just as they do. So, for example, Piaget believed that if a child closes her eyes and cannot see something, then others in the room cannot see it either. Piaget called this quality of the child's thought **egocentrism**, that is, centred in the ego.

'Ego' is the Latin word for 'I'.

In order to show that children are egocentric, Piaget carried out the following experiment with children between four and eleven years of age.
In this experiment, a three-dimensional model of three mountains of varying heights and colours is placed on a table, surrounded by four chairs. The child is asked to walk around the table and see the mountains from each side. Then she sits on one chair and a wooden doll is placed on another chair (see Fig.1). The child is, then, given ten photographs, each showing a different view of the mountains. The child is asked to pick out the picture that shows how the mountains appear to her. Piaget found that most preschoolers could do this correctly.

In the next step of Piaget's experiment, the child is asked to pick out the picture that shows how the mountains must appear to the doll. It is here that Piaget saw differences among children. The younger children would pick up any picture. The children around five years of age would usually pick out the picture that showed their own view of the mountains, not that of the doll's. By the age of six or seven, the children would usually pick on a view of the mountains that was different from theirs, but they still couldn't choose the right picture. They seemed to be guessing, picking up one picture, then another, and then yet another. By the age of nine, all the children were consistently able to choose the right picture.

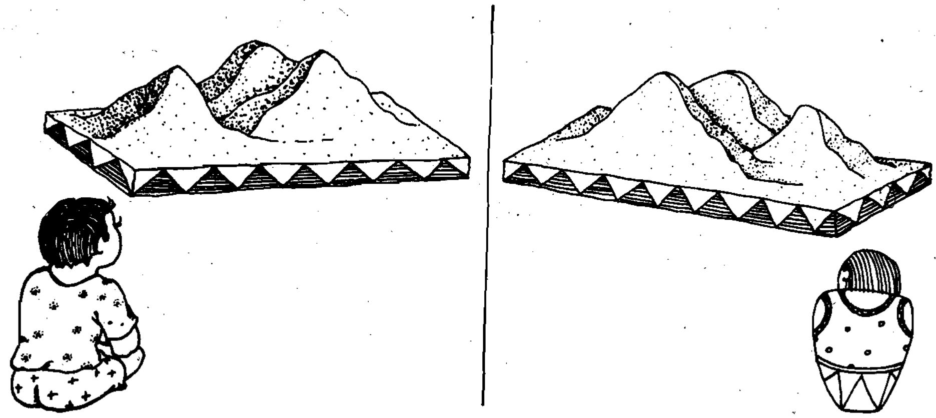


Fig. 1 : Child's perspective and doll's perspective

Based on this outcome, Piaget suggested that children below four years of age have no idea about different views, and five-year-olds assume that the doll sees the mountain as they do. He also suggested that by the time children are nine years old they are able to imagine another person's perspective, not before that.

Many researchers have questioned the precision in Piaget's experiments and the results drawn from them. They state that there are two major reasons for preschoolers being unable to give the right answer in the experiment above — firstly, it is too complicated for them; and secondly, it is far removed from their day-to-day lives. In fact, some researchers have done experiments to show that children **are capable of looking at events from another person's perspective**. These experiments have been built around situations that relate to preschoolers' real-life experiences or contexts that are meaningful to them.

For example, Martin Hughes devised a series of tasks to understand this aspect of a child's spatial reasoning . One task devised by him is as follows. He took two 'walls' intersecting to form a cross, and two small dolls, representing, respectively, a policeman and a little child. We have shown the layout in Fig.2.

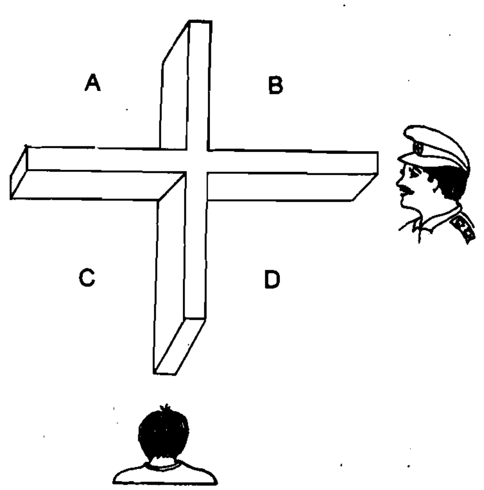


Fig. 2

In the studies which Hughes conducted, the policeman was placed initially as shown in Fig. 2. In this position, he could see the areas marked B and D, while the areas A and C were hidden from him by the wall. The child was then introduced to the task very carefully, in ways that would help her understand the situation fully and grasp what was being asked of her. First, Hughes put the doll in Section A and asked if the policeman could see the child there. The question was repeated for Sections B, C and D in turn. Next, the policeman was placed on the opposite side, facing the wall that divides A from C, and the child was asked to 'hide the doll so that the policeman can't see her'. If the child made any mistakes at these preliminary stages, her error was pointed out to her, and the question was repeated until the correct answer was given. But very few mistakes were made.

Then the actual test began. And now the task was made more complex. Another policeman was produced and the two were positioned as in Fig.3.

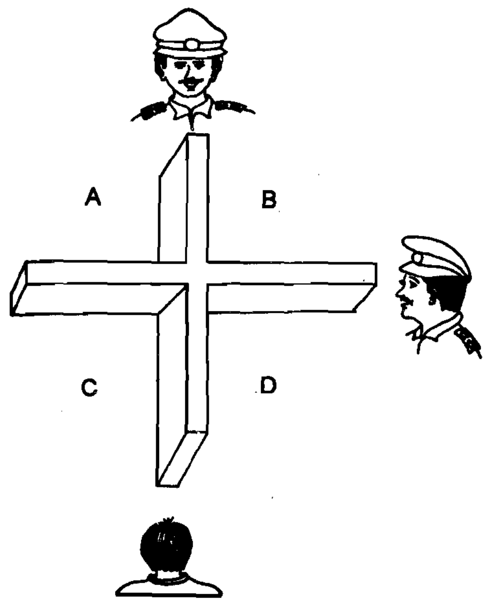


Fig. 3

The child was told to hide the doll from both policemen, a result which could only be achieved by the consideration and coordination of two different points of view. This was repeated three times, each time a different section being left as the only hiding place. **The results were dramatic**. When thirty children between the ages of three-and-a-half and five years were given this task, **90 per cent of the time their answers were correct**. So, unlike the mountain experiment, most of the children were able to do this task successfully. **The reason for this, the researchers felt, was that the children could relate to this task.**

There have been many other experiments in this area. Some of the conclusions reached agree with Piaget's findings, and some don't. What does this contradictory evidence tell us about the preschool child's ability to take another person's perspective? Think about this while trying the following exercise.

E3) Try some of the experiments you have read about as well as the following ones with young children around you.

Experiment 1 : Face the child and give her a picture. Ask her to show it to you.

Experiment 2 : Face the child and ask her to show you her fingernails.

What were the outcomes of your experiments? What conclusions about the children's egocentrism can you come to from your experiments?

E4) Why is it important for a mathematics teacher to understand to what extent her pupils are egocentric?

To conclude this section, can we say that whether or not the child is able to take another's perspective depends upon the situation? There are individual differences as well. It is not as if the preschool child is completely egocentric. She **can** consider another person's viewpoint, but she is more tied to her own view of things than is an older child.

Piaget and his colleagues also carried out some very interesting experiments to probe into another cognitive ability — the ability to conserve. We have discussed this briefly in AMT. Let us consider this some more now.

11.2.2 Conservation

'Conservation' means being able to understand that the quantity or the amount of a certain substance remains the same, even if its shape is changed or if it is transferred from one container to another, so long as nothing is added to or subtracted from it. So, for example, if I shift several 'laddus' to a large plate from a saucer, the amount of 'laddus' is the same. To us this may be obvious. But it is not so obvious to preschoolers, according to Piaget. He concluded this from the following classic experiment.

In this experiment Piaget gave preschool children a ball of clay and asked them to make another "just as big and just as heavy". Then he asked them if the amount of clay in both the balls was the same. All the children agreed that the amount was the same. Then, as they looked, he flattened one of the lumps of clay. Now the children were asked, "Is there the same amount of clay here (*pointing to the squashed lump*) as there is here (*pointing to the ball*)? Or, is there more here, or more there?" Most of the children believed that the amount of clay in the two lumps was different. In other words, they could not conserve mass.

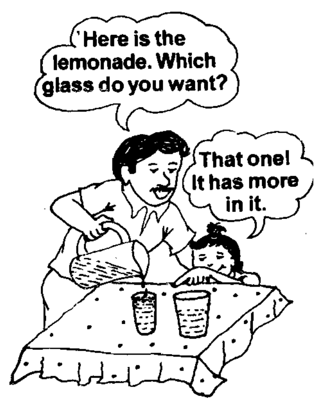


Fig. 4

In another experiment, Piaget showed preschoolers two identical glasses with water filled to the same height in both. On being asked if the amount of water in the two containers is equal, the preschoolers agreed. Then, while the children watched, the water from one glass was poured into a third glass which was wider and shorter than the other two. In this glass, as expected, the liquid rose to a lower height. Now the children were asked whether both the glasses contained the same amount of water, or if there was more in one. Most of them said that the wider glass had less in it. In conversations with them, they agreed that no water was added and none was taken away while transferring it from one glass to another. But the children still insisted that the wider glass had less water after the transference.

According to Piaget, these outcomes show that a child between 4 and 5 years of age does not conserve at all. He also concluded from his experiments that the slightly older child conserves in some situations and not in others. She is developing this concept but it is not stable as yet. He also concluded that a child between 8 and 10 years of age is able to conserve.

Interestingly, in one version of the experiment, the glass into which the water was being poured was covered from all sides so that the level of water was not visible to the preschoolers. In this case, the preschoolers did conserve. However, on making the level visible again by removing the cover after the water was poured, many of these children changed their minds and said that one glass had more water. Anything to do with 'seeing is believing'?

Other researchers have tried to replicate these experiments. They agree with Piaget's findings in several cases, but don't accept them as a general rule. These researchers have found that if the child is asked the question in situations that she is familiar with, then she consistently conserves quantity. Thus, a five-year-old child who regularly brings water and pours it into other containers would not believe that the amount of water changes when it is poured from one container to the other. However, if this child is not familiar with clay and has not dealt with it, then she is likely to not conserve in the 'clay experiment' Piaget did.

Try an exercise now.

E5) Try the following experiment done by Piaget with some children aged 4 and 5 years around you. (Do it separately with each child.)
Place two sticks of equal length in front of her, as shown in Fig. 5(a). Ask her if she thinks the sticks are equally long. Then, before her eyes, move one stick towards the right as shown in Fig.5(b). Now, again ask her whether the sticks are equal, or whether one is longer than the other.
What did the child answer? Does this agree with what Piaget found (which we have given in Sec.11.6)?

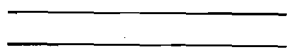


Fig.5(a)

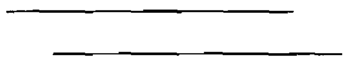


Fig.5(b)

In AMT-01 you read about some other spatial abilities that children have to some extent. Let us consider one of them now.

11.2.3 Finding Relationships

In Unit 5, AMT-01, we have spent quite some time on ways of developing children's abilities to sort and match. Note that sorting (or classifying) is looking for some common property and gathering together things that have the property. Matching, on the other hand, is putting together identical things.

To study how far children have the ability to classify, Piaget gave them various objects and asked them to put together those things that 'go together'. In one particular experiment, the children were given cutouts of rectangles, triangles and quadrants of circles of three different colours — red, blue and yellow — and were asked to put the similar things together. Most two and three-year-olds made a design or a picture with these different shapes — picking them up randomly and arranging them in a line or in a circle or to make structures like a house, etc. They did not notice the shape or the colour of the cutouts and did not categorise them on these bases. From this outcome, Piaget concluded that younger preschoolers cannot classify.

However, Piaget found that preschoolers between four and six years of age sort and group objects more systematically. Now they begin to use shape and colour to group the cutouts. But the criterion for classification does not remain stable or consistent. By **a consistent criterion** we mean, for example, that if a class of rectangles is created, then it should include all the rectangles, and should include only rectangles. But what happens in this age group is that the child begins to classify using shape as the criterion and so goes ahead to put all the rectangles together. But, while doing so, she suddenly notices the colour of the rectangle she has just placed and changes the criterion of classification to colour, thereby putting quadrants and triangles of the same colour next to the last rectangle. After arranging some cutouts on the basis of one colour, the criterion changes to another one of colour or shape. So, each subset of the child ends up as an assortment since the criterion for classification changes so often. According to Piaget, this shows that preschoolers are learning to classify objects. But, while they put them side by side, they get distracted by their other properties. In other words, **these preschoolers are dominated by their perceptions while classifying.**

According to Piaget, most children around six years of age are able to decide upon a criterion and are able to maintain it throughout the classification. If they choose colour as the basis, then they will put all the cutouts of the same colour together, whether they be rectangles or triangles. Piaget also concluded that a more highly developed classification is achieved by the child when she enters the concrete-operational period. Here the child is able to classify on the basis of both shape and colour. So, for example, the child first divides the cutouts on the basis of shape. Then, since within each shape there are cutouts of different colours, she subdivides the class of rectangles into subclasses of rectangles of different colours.

As with other Piagetian experiments, here too other researchers don't agree with all his conclusions. One researcher gave some 3-year-old children picture cutouts of animals, food and furniture. She also gave them a puppet and told the children that the puppet liked food. These children were able to put all the pictures the puppet would like in one container. Apart from this, they were also able to put together all the furniture pictures when asked to do so. According to this researcher, **if the context and category is clear and meaningful** to even a young child, **she can sort** pictures.

In fact, don't we see young children classifying at some level all the time? They separate vegetables and fruits, they put red beads on one side and blue ones on the other, they can separate balls from other toys, big balls from small balls, and marbles of different sizes and types. Think about this while trying the following exercise.

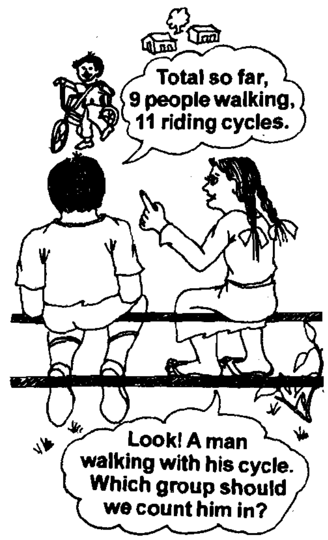


Fig.6

E6) "If three-year-olds are given a familiar simple criterion for grouping, they can do the task. Older children (say, 4 or 5 years of age) can even find a basis for classifying, but they get confused and need help if the set of objects could be classified according to more than one criterion." What evidence can you give in support of these findings by several researchers?

Another kind of 'finding relationships between objects' is the ability to arrange them in an increasing or decreasing order related to some common property they have like size, length, weight, etc. We call such an ordering a **seriation**, and have discussed it in Sec. 5.3.2. of AMT-01.

The question is : Can preschoolers seriate? To test this, Piaget used ten sticks of differing lengths and asked children to put them in the correct order of size. Most of them were able to put two or three sticks in the correct order, after which errors came in. He concluded that preschoolers are generally not able to do this task. He also found that children could seriate correctly and consistently only after they entered the concrete-operational stage.

However, recent research which has been carried out, making simple modifications in Piaget's method, **has given different results**. In experiments using four sticks instead of ten it was found that most three and four-year-olds could put the sticks in the correct order and could insert new sticks in the correct place. This means that **preschoolers can seriate** to a certain extent.

There are several other spatial abilities that young children **do** have. Try the following exercise to find another.

E7) Are pre-schoolers able to match, that is, from a set of objects identify the identical objects? Give reasons for your answer.

So far we have discussed a variety of abilities that some preschoolers have, and some seem not to have. We have also seen that these abilities are very highly developed in situations that the child relates to and finds meaningful, and may not show up in other situations. Let us now try and understand why these and other spatial abilities need to be developed further.

11.3 WHY DEVELOP CHILDREN'S SPATIAL ABILITIES

We have seen that children do have various spatial abilities, some more developed and some less. These abilities are developed through the children's interaction with the world around them. However, this learning shows up in certain situations and not in others, as we have seen. Their ability to abstract these ideas and use them in unfamiliar non-contextual and specially designed confusing situations is limited. Do these abilities need to be developed further?

Let us consider, for instance, the ability discussed in 11.2.1. This is an important ability for at least two reasons — firstly, it helps children to become capable of dealing with abstract ideas and visualising various possible arrangements; secondly, it helps to build social interactions. To understand the second reason, think about what would happen if people don't consider the perspective of others. How would they be able to have a meaningful discussion if they aren't able to understand other people's viewpoints?

Fig. 7

Now let us consider the ability to conserve. Why do preschoolers respond to the Piagetian tasks in the way they do? What prevents them from realising that the amount of clay, the quantity of water and the length of the stick remain the same? The reasons may be many. There is, however, a pattern in them. According to Piaget, one of the reasons is that **preschoolers cannot reverse their thinking, i.e.,** they cannot mentally retrace their steps. For the child to conserve, she has to mentally pour the water back into the original glass, or make the flattened piece of clay into a ball, or place the two sticks as they were. In other words, she has to think back on what happened. But she is not able to do so. If she could, she would have probably understood that the low height of the water in the short glass is compensated for by its greater width. This **reversibility of thinking** is crucial for conservation. According to Piaget, it comes when the child enters the next stage of development, i.e., the concrete-operational period.

Another reason why preschool children do not conserve in the experiments discussed is because they have a tendency 'to centre'. **Centering** is one of the characteristics of a child in the pre-operational stage (see Unit 2, AMT-01). This means that at a particular time the child pays attention to, and focusses on, a single and striking feature of an object or an event, and neglects all the others. She finds it difficult to look at different aspects of the experience simultaneously. So, for example, in the experiment with water, the preschooler will either concentrate on the width of the two glasses and say that the wider one has more water "because it is wide", or else she will concentrate on the height of the water and say that the one in which the water rises to a greater height has more of it. What the child cannot do is to consider both the height and width together and reason out the comparative effect.

Apart from the two reasons mentioned above, the analysis of these children is dominated by what they see. Because of this, they don't realise that, for example, the flattened lump of clay contains the same amount of clay as before. They think it is less because this is how they see it.

So, given these reasons, what would you say is the need for helping children to develop their ability to conserve? There is a need for the child to become capable of using abstract ideas and relationships in the context of space. She needs to learn to de-centre in her analysis and be able to go through what she has seen by reconstructing it in her mind step-by-step (reversibility of thought). It is also important for the child to conserve because in many real-life situations, particularly in sharing complex and abstract ideas, it is crucial. In a sense the principle of conservation is one of the foundations of logical reasoning. All measurements involving length, area, and so on are based on conservation.

Try this exercise to see how far you have grasped what you have just read.

E8) How is the ability to conserve necessary for
- i) being able to measure length?
- ii) sharing complex and abstract ideas?
- iii) developing logical reasoning?

Let us now look at what is involved in the ability to classify. It requires being able to pick up a quality that is common between all the objects that are being sorted even though they appear different. Classification requires the child to discriminate, reason, analyse and select. A child who can classify realises that there is more than one way of grouping objects. So, if we help the child develop this logical ability, several abilities are being developed simultaneously.

You can analyse the ability to seriate in the same way, which is what the following exercise is about.

E9) Why do we need to help children develop the ability to seriate?

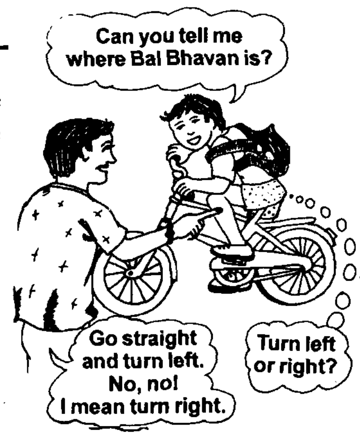


Fig. 8 : Is left right?

There are several other space-related problems that children face, and continue to face as they grow older, unless they can be helped to deal with them. For example, people are fairly comfortable using 'above' and 'below'. But is the situation the same for 'left' and 'right'? The obvious thing that comes to our mind is that we make far more errors using 'left' and 'right' than we make regarding 'up' and 'down'. While giving instructions to somebody, particularly if the vehicle is moving, don't many of us often end up saying 'left' when we should have said 'right'? Or, we end up pointing by the hand saying "this side, this side" instead. Because of this, while giving truck/bus drivers instructions for reversing and turning, the terms used are 'driver side' and 'conductor side' rather than 'left' and 'right'.

Some questions that emerge from what you have just read are :

? Should we only use categories and words the child knows? Or, is there a need to extend her vocabulary and her criteria for classifying?

As children's spatial abilities are developed, their logical abilities get sharpened. This development also involves using terms in a precise manner. In ordinary usage we often use terms imprecisely, which may not matter in the usual day-to-day situations. But such usage reduces the categories we refer to and reduces our ability to perceive differences in many things. For example, we call a ball as well as a bangle round. The context makes it clear as to which 'round' we are talking about. In usual situations children may not find any problem with this understanding and use of the concept. However, what happens when we want to abstract the concept of round as in a ball and the concept of 'round' as in a bangle? The two categories have some common properties, but the differences in properties is substantial. We need to help the child become capable of greater abstractions using the spatial knowledge she already has.

Try an exercise now.

E10) Piaget and Inhelder, while describing the process through which a child tries to make sense of her environment, say that this process functions at two levels. The first level is the **perceptual level** — learning about objects through direct contact with them. This process begins from birth and the knowledge is gradually constructed. The second level is the **representational level**, which also includes the ability to evoke an object in its absence.

Based on these few lines that you have read, write down which abilities of a child are developed when moving from the perceptual to the representational level. The portion on representation in Unit 6 may be of use to you here.

Let us now see how we can help children develop the various spatial abilities we have been discussing. We have suggested some tasks at various points in AMT-01. Please take a look at them before going further.

11.4 WHAT WE CAN DO WITH CHILDREN

To start with, let us consider what we are already doing with children. As we have observed earlier, children learn a lot about space in dealing with different tasks at home. Apart from these experiences, the school curriculum exposes them to geometry. But what is the geometry that is taught? Does this school geometry help a child see and understand various properties of the objects around her? If it did, we wouldn't see the kinds of problems we have spoken about in AMT-01. Think about this while trying the following exercise.

E11) Why is it that many Class 4, and older, children say that a square is not a rectangle? How can we change the way we teach geometry so that such misconceptions don't arise?

To see how we can develop children's understanding of geometry, let us try and understand what we mean by geometry. Would you agree with the following perception of Earnest Choat, an educationist?

Geometry is the beginning of mathematics for the young child since geometry is none other than the study of spatial relationships. It is the means of viewing a situation mathematically to provide one or more ways of gaining understanding. Almost every object has some geometric property, and stimulated by his experiences, a young child has an innate curiosity about geometry. Shapes, size and position are entities for him to explore, manipulate and control, and the means whereby he organises his environment, so that geometry becomes the ***natural way for developing intuition, creativity, enquiry, and the ability to solve problems.***

We need to look at these 'natural ways' to understand the kind of tasks we should give children for developing various spatial abilities. For instance, many real-life situations require children to have a notion of size. They need to answer questions like : Can I pour all the milk into the jug? Can my books be fitted into a box? Is this piece of cloth enough for making me a shirt? Is this pole long enough to reach the top branch? etc. They try and find the answers by comparing objects, or trying with various objects. With multiple experiences they abstract concepts related to length, area, volume and capacity. But this abstraction is limited to the class of objects they come across. This is where the school curriculum is expected to help — by giving them experiences that would help them generalise the concepts. We can help them by providing them with opportunities to experiment with their own body movements, for occupying space in various ways, to arrange or represent objects in the context of space, etc. Think about what kind of opportunities you can design while doing the following exercise. Before doing it please take a quick look at the points made in Unit 7.

E12) What are the kinds of experiences that you would provide children of Classes 1 and 2 with to help them explore space and practise their abilities to represent and organise space? Would you give children of Classes 3 and 4 similar opportunities? Give reasons for your answer.

Let us now consider examples of tasks that can develop the abilities that we have discussed in Section 11.2. In any of these, or other, tasks that the children do, there is a need to give the child enough opportunity to analyse the experience and talk about it. For instance, in a task related to developing the ability of conservation, any opportunity of talking to a child about whether one container can hold a larger quantity should not be missed.

TASK 1 (for conservation) : You could give the child a glass of water and an empty glass of a different shape. She should pour water from one to the other after being asked to anticipate whether all the liquid will fit into the other glass or not. She could also be shown a jar full of water and be asked to estimate how many small glasses can be filled by the water in the jar.

TASK 2 (size and capacity) : You could ask the children to repeatedly carry out activities in which they are required to compare containers and then ask them to articulate why they think that one container is bigger. This would help them abstract the reason for considering a container to be smaller or larger.

Talking to children about different types of containers in their homes and what they are used for may be useful too. You could ask them to talk about why a certain container is more useful for keeping sugar and another container is used for keeping water, or why is it that a container similar in size to the container for wheat and rice is not used for storing salt. Through such articulation, experience and observation the children would gradually understand that the shape of a container and the dimensions of its sides decide the quantity it contains.

TASK 3 (taking another's perspective) : The ability to look at things from the perspective of others gradually develops. Many factors related to general social development help in developing this. Giving children a task of the following kind may also be useful.

Ask the children to visualise how things would appear if they were looking at the room from the ceiling. Or ask them to describe (or draw) how their homes would appear to, say, an ant on the ground.

The idea is to give children exercises of visualising another point of view. Again, it is important here to **give children an opportunity to talk about and articulate their understanding.** You need to raise questions that sharpen their visualisation and articulation, and make them realise that their view is not the only one.

TASK 4 (classification abilities) : The very young child can be given a set of objects which differ obviously only in one property, for instance, a set of pencils and beads. She can be asked to 'put together the similar things', and explain the reason for forming the categories she does.

At a higher level of difficulty, you could give her a set of objects which differ obviously with respect to two properties, for example, large and small blue and white buttons. Ask her to sort these buttons out. See whether the criterion for sorting is consistent. Help the child, through a dialogue, to recognise the need for this consistency and to become capable of realising the underlying inconsistency, if any.

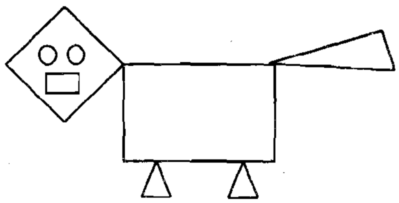
TASK 5 (seriation) : The research regarding seriation suggests that while children are able to compare the lengths of sticks, they are not able to keep a consistent standard for comparison. Consider the following task for developing the required ability.

You could ask the children to build things which require using specifically sized sticks in increasing order. You could ask questions that would require them to notice that a stick which is longer than another stick is also longer than a stick which is shorter than the second one.

You could also ask children to stand in line on the basis of their heights, from shortest to tallest. Ask them questions about who is taller, or if a child is shifted four places from where she is standing, would it cause any problem in the arrangement according to height. They could then articulate the reason for thinking whether it will or won't create a problem.

In all these tasks, the basic point is that we need to talk to the child and get her to talk about what she is experiencing. Through this dialogue, you could develop her vocabulary too. For developing mathematical language and precision in using it, the following activity may also be useful.

TASK 6 (spatial language) : Divide the class into groups of 3 or 4. Then one of them in each group can draw a picture with rectangles, squares, triangles, circles, etc. For example, she could draw a picture as shown below, and place it so that her groupmates don't see it.



Then she can give directions to the other children so that they can replicate her picture. But the instructions should be given without moving her hands or using phrases like "it is the head", or "the tail", or similar descriptions. She can use instructions that describe the geometrical shapes used and the relative position of the shapes. Ensure that the children do not copy from each other and are able to listen to the instructions carefully and clearly.

Compare the pictures drawn by the other children with the original picture, once the directions are over. Let the children see each other's final pictures and discuss questions like : Does the picture that has been drawn look the same? In what way are the pictures different?

After this interaction you can repeat the exercise with new pictures. See whether the instructions are being given more carefully. Can you get them to represent the pictures exactly and reduce variations between what they have drawn?

There are many other spatial problems children have. Think about them while doing the following exercises.

E13) Design some activities t help children get over the confusion with 'left' and 'right'.

E14) What task (or tasks) would you give children to abstract the word 'round' and realise that it means two different things?

Let us now take a quick look at what we have covered in this unit.

11.5 SUMMARY

In this unit we have discussed the following points.

1) We have considered several experiments that have been done by Piaget and others to gauge the spatial abilities of preschoolers. The conclusions reached by many present-day researchers is that children show very highly developed spatial abilities in situations that they are familiar with.

2) We have spelt out several reasons for developing children's spatial abilities further.

3) We have given examples of activities that can further children's spatial thinking.

11.6 COMMENTS ON EXERCISES

E1) For example, we have mentioned an instance of a child deciding on which particular route to take for going over a drain, and making a choice based on some reasons. Look for other such examples.

E2) One can learn a lot from watching children. Their play is often based on the desire to sharpen their capabilities. If you watch children engaged in activities at home you would find that they are always attempting to do new things. In our earlier blocks also we have suggested ways in which you can observe children and learn from them. Here, you have to pick the activities in which they are exploring spatial ideas. For example, if they are playing 'house-house', they may be arranging the kitchen, the bedroom, etc. In the process, they may be placing things and organising the space around in different ways. In a conversation, they may be talking about placing things carefully and at appropriate places. Mention the specific ideas you think they are exploring in their games, etc.

E3) Try these experiments with a number of children of different ages. Ensure that they do not share the experiments with each other. Keep in mind the ages of children while recording their responses. While interacting with them, try to keep your expression bland and carefully note the process of the child presenting to you what you have requested her to show.

The younger child will usually present the picture to you in such a way that the picture faces her. Similarly, the nails face her. This is because of egocentrism.

E4) If children are egocentric and each child has a viewpoint, then the viewpoint of each child has to be kept in mind in all classroom transactions. It is not possible to merely talk in terms of ideas as they are in the minds of the teacher. Continue this analysis, and think of other reasons why it is important for a mathematics teacher to understand the egocentrism as well as its nature in her pupils.

E5) Piaget found that after moving a stick, preschoolers generally say that one stick is longer than the other. Most of them feel that the top one is longer. Older children state that both sticks are of equal length, no matter where they are moved.

As mentioned, the experiment has to be done with individual children carefully and the observations made appropriately. Try to avoid giving a hint to children. Wherever necessary ask for reasons for their answers.

E6) You must have seen the children engaged in different tasks at home. You can also set up classification tasks and observe children doing them. While they are doing these tasks, you could talk to them and find out why they are classifying objects in the manner that they are. Try observing them working in groups as well as individually. Look for situations where there may be more than one criteria involved. Do your observations match findings presented in the unit?

You may also remember earlier incidents and give examples which explain this ability of children at different ages.

E7) This exercise has two components. One is an actual tryout with some preschoolers. In this you could give them a collection of objects and ask them to pair and pick up those which are identical. See whether they are able to do so, and follow the process with them. You could also give them a collection of objects of which several are somewhat similar and a few are absolutely identical. See whether the children are able to match the identical objects.

The second component of this exercise is to think of your earlier experiences in which preschoolers can or can't match.

E8) What does measurement of length require? You have to place one object against another and see which is longer. Or, if you are using a scale, you need to see what part of the scale matches with the length of the object, and then use this to compare with another object in the same manner. The only way this system of comparison can work is if by shifting the scale, its length does not change. If it changes (as it does for a non-conserver), then there is no way you could use the scale for measuring the scale length.

Similarly, to share complex and abstract ideas, you require a common understanding of the context. Now take a child who does not conserve. Then she would not recognise that when the water in the glass is poured into a bucket, it does not decrease in amount. Consequently, she may not be able to understand why some vessel is made bigger than another.

Think about other reasons why the ability to conserve is necessary for children when they share complex and abstract ideas.

Conservation is one of the cornerstones of the system of logical reasoning and looking for relationships between concepts. The ability to conserve allows you, for instance, to understand why if A and B have the same capacity, and B and C have the same capacity, then so do A and C.

E9) Seriation is necessary for comparison of lengths and for measurement. There are many other principles that relate to seriation and help in abstraction. For example, 'if A is bigger than B and B is bigger than C, then A is bigger than C' is an abstraction that will develop out of the ability to seriate.

E10) It is obvious that the ability to evoke an object requires both the image as well as the thought of the object. There is a transition from the perception of the object to mental representation which is accompanied by translation from tactile information to visual information. What is suggested here is that gradually the child acquires the ability to derive a mental image of, say, a ball even without the ball being in front of her. She is slowly able to reconstruct the geometrical shape of the ball in its absence and may also be able to put balls of different types in the same category.

Tactile information means that which is obtained by touching and playing with the object.

This process can be analysed and compared with the descriptions in AMT-01 where we talked about the fact that mathematical ideas move from the concrete to the abstract.

E11) The problems arise because we just give the child definitions and certain fixed examples. This is a problem on two counts. One is how we have tried to build these definitions for children. The second is the need to have the child not just look at the examples of different kinds but also to explore the non-examples.

What are the other reasons for these problems to arise? What can be done to change the process so that these misconceptions do not arise in the mind of the child?

E12) Based on whatever has been said in Blocks 1 and 2 and here, think about what should be done to help children develop abilities to represent and organise space. For example, do you think asking them to draw some pictures would help? Would getting them to talk about whatever they have drawn help? What could be the other possible activities that would help children towards this aim?

What are the differences in the reactions to your activities from the different age groups?

E13) You could get them to play games that would have them quickly turn left or right, or to run in certain directions as asked.

You could give older children instructions for reaching a place, and ask them to reach that place following the route prescribed in the description. This they have to do as quickly as they can. These descriptions could have terms like 'turn left', 'walk some (specific number) of steps and then turn right', etc.

Children could be divided into teams of two and be given a map of the school on which different routes are drawn. One in each team has to read these routes and communicate them to their friend, who would have to follow their instruction. The team which communicates correctly and reaches the marked spot in the shortest time would win.

E14) For children to recognise the meaning of 'round' we can ensure that they are allowed to explore objects that roll and objects that do not. Then, they can see which objects roll regardless of their position. It is from such exploration that they will discover and talk about the fact that spherical round objects roll from any part and others do not. We can also guide older children to discover further properties — for instance, that spherical objects have infinitely many axes of symmetry.