
UNIT 15 DEVELOPING NUMBER SENSE

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15.1 INTRODUCTION

For many of us, the first sign that the child has some idea about numbers may be when the child begins to recite number names – what we commonly call ‘counting’. Adults are usually proud of this ability in children and like to show off the child’s new learning to all those who visit them. Many parents and teachers put a lot of stress on learning number names in the correct order. They believe that if the child recites the number names in the correct order, she knows how to count. Many even begin “teaching” mathematics to the children by making them write the numerals 1, 2, 3, and so on daily. However, while doing so, the adults often fail to understand that reciting counting numbers in the correct order does not mean that the child has learnt how to count. The child needs to develop other basic mathematical concepts such as comparison, seriation and one-to-one correspondence before she can count objects; she needs to develop number sense in order to learn to count. In this Unit, you will understand what is meant by ‘number sense’ and how we can help the child to develop this.

Objectives

After reading this Unit, you will be able to:

- explain the meaning of ‘number sense’;
- understand and discuss the processes involved in counting;
- state the meaning of the terms ‘categorization’, ‘ordering’, ‘comparing’, ‘seriating’, and ‘one-to-one correspondence’; and plan and conduct related activities with children; and
- describe how to introduce counting to children.

15.2 WHAT IS NUMBER SENSE?

Building a love for mathematics in children begins with building an understanding of numbers. ‘Number sense’ is the ability to understand, connect, and relate numbers with each other. It is a group of skills that make it possible for a person to work with numbers or solve mathematical problems mentally/orally without having to use algorithms on pen and paper. A person who has number sense can relate numbers to real-life situations; she can solve day-to-day situations requiring the use of numbers.

Number Sense is primarily concerned with counting, wholes and parts (fractions), and proportional thinking (how many times bigger or smaller a number is compared to another number). During the early years, the element of counting is what educators need to focus on and this is also the focus of this Unit.

The National Council of Teachers (USA, 1989) has identified five key components that characterize number sense – number magnitude, number meaning, number relationships, operations involving numbers, and referents for numbers and quantities. Let us see what each of these components includes by discussing what a child with the knowledge of number sense can do.

a) Number Magnitude

- The child grasps concepts like more and less, and larger and smaller.
- The child makes number comparisons (7 is greater than 4).
- The child understands the order of numbers in a list: 1st, 2nd, 3rd, etc.

b) Number Meaning

- The child understands that if the collection of things is rearranged, then the number does not change.
- The child understands that if the types of things being counted are changed (say 5 mangoes, then 5 buttons, and then 5 pens), then the number of things does not change. Number 5 is independent of the objects/items used to represent it.
- The child understands that if we’re counting something, the last digit in this number tells us how many things there are in that particular collection.

c) **Number Relationships**

- The child understands the relationship between numbers. For example, how 5 and 15 are related.
- The child knows how to compose and decompose numbers (put them together and take them apart). She can take numbers apart and put them back together in different ways — e.g. breaking the number '5' down several times (such as $5+0=5$; $4+1=5$; $3+2=5$; $2+3=5$; $1+4=5$; $0+5=5$), which helps the children learn all the ways to make five.

d) **Referents for Numbers and Quantities**

- The child understands that numbers have their symbol and quantity.
- The child understands symbols that represent quantities (7 means the same thing as seven).
- The child associates a certain number of objects with a certain number name.

e) **Operations involving Numbers**

- The child computes mentally. She can solve problems in her head instead of using paper and pencil.
- The child knows the basic $+$, $-$, \times , and \div operations and understands when to use each one of these.

15.2.1 Why is it Necessary to Develop Number Sense?

A strong foundation of number sense directly relates to a child's overall success in maths. It contributes to general intuition about numbers and lays the foundation for more advanced skills. Researchers have linked good number sense with effective mental calculation, computational estimation, judging the relative magnitude of numbers, place value concepts, and so on. Number sense helps children to understand that numbers are meaningful and, despite manipulation, their outcomes are constant and sensible. It allows them to create a healthy relationship with numbers and to be able to talk and love maths as a language.

Thus, Mathematics is impossible without number sense. Number sense plays a big role in all Maths disciplines. It is beyond just basic operations of addition, subtraction and so on; it helps children to understand how these operations are related to each other.

15.3 THE CONCEPT OF COUNTING

If you were to be asked what is counting, you are most likely to say that counting means listing the number names in order. However, is it? Let's find out!

15.3.1 Is Reciting Number Names the Same as Being Able to Count?

Consider the following example.

Example 1

Jai is a two-year-old child who has learnt to speak. One day, his father asked him, “Jai, have you eaten your food?” He nodded his head and said yes. Then, the father asked him, “How many chapattis did you eat?” He replied, “Two” and spread out the fingers of his right hand. However, the fingers he spread out were more than two. Subsequently, over a period of days, the father asked him many other questions of ‘how many’. He similarly replied to each question by saying ‘two’ and spreading out the fingers of his hand. Each time he spread out a different number of fingers.

Can we say that Jai understands the meaning of numbers? Can we say that he can count? Think about it and write your answer in the space below and examine your answer with the discussion further.

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Jai has not developed the concept of numbers and cannot count since he shows a different number of fingers each time he says the number ‘two’. However, he knows that:

- things can be counted; and
- when asked “how many”, the amount can be stated in the form of a number, (even he though cannot associate the correct number of objects with the number).

Let us take examples of two classrooms to further understand the concept of counting and how it is usually taught.

Example 2

The teacher wrote the numbers 11 to 20 on the board, and then, she told the children to write these in their copies. Then the teacher put her finger one by one on the numbers and said the names of each number aloud and the children repeated after her. After that, she told them to write the numbers 11-20 five times on their copies.

Example 3

In the class, the teacher made three groups with five children in each group and asked them to sit in a circle in their respective groups. She gave some sticks to each group and asked each child in the group to pick 10 sticks and make a bundle by tying them with a rubber band. Children began to count and picked up 10 sticks and made a bundle. Meanwhile, the teacher moved from group to group observing how children counted and helping children where it was necessary. In each group, children were talking and counting each other’s sticks.

After the bundles had been made, then the teacher asked the children to pick one more stick and asked, "10 tilli aur ek tilli kitna hua?" (How much are 10 sticks and one more stick?).

The children responded: "Gyarah" (Eleven).

Then, the teacher asked the children to make 11, 12... 20 in this manner.

Having read the above two examples, which teacher would you say is correctly teaching counting by building an engaging classroom? Why would you say so? Write your views and compare them with ours that follow:

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In both classes, the same concept was taught, but in different ways. In Example 2, the teacher is simply giving information and the children are passively taking in the information. There is no interaction among the children or between the children and the teacher. In Example 3, the teacher is a facilitator who has set up a situation so that children find out for themselves. Children are actively participating in developing their understanding. She helps the children whenever necessary. There are interactions between teachers and children and among children also. In a class that engages children, children would not be expected to sit quietly and listen to the teacher, curbing their desires to express themselves. Instead, they would be expected to be active, articulating their thoughts, and consulting each other.

Now let us understand what is essentially involved in counting!

15.3.2 What is Involved in Counting?

To understand what counting includes, let us discuss the abilities/steps involved in counting. Let us assume that there are a lot of beads of different colours and we are asked to count the purple beads, we would do so in the given manner:

Step 1: To begin with, we visually identify the beads that we have to count. We are able to do so because we know that the purple ones **match** in colour.

Step 2: Having visually identified the beads that we have to count, we separate (**group**) the purple ones from the rest, i.e., we group the beads into two sets — purple and non-purple.

Step 3: Then, we put the purple beads in a **suitable arrangement** for counting. Perhaps, we lay them out in a row, or arrange them in a circle, or put them in groups of two beads each, so that we would not leave any out or count any bead twice.

Step 4: Next, to count, we must know as many number names in the correct sequence as the number of beads, at least. Not only this, we must know them in the sequence of 1, 2, 3, 4, ... This involves the understanding that each number name denotes a quantity which is one more than the quantity denoted by the previous number name. In other words, this involves understanding the concept of **seriation**.

The child has to also learn that the number 'one' always signifies one item; the number 'two' signifies two items, and so forth. In other words, she has to learn that every number signifies a certain quantity and that this remains the same no matter what objects are being counted.

Step 5: We touch one bead (actually or mentally) as we say each name. We touch each bead only once and leave no bead untouched. This means that we pair one bead with one name. In other words, we set up a **one-to-one correspondence between number names and beads**.

Step 6: While counting, we are also **grouping** the beads into two sets –those that have been counted and those that are yet to be counted. Sometimes we push the counted beads to one side, sometimes we place our fingers over the beads we have counted so that we remember which ones have been counted; sometimes we keep track of the counted and uncounted beads mentally, using our eyes.

Step 7: As we touch the last bead, we say a certain number. Let us say that we had ten beads – so we say 'ten'. Then we say that we have ten beads. This means that a label (i.e., the number name 'ten') which we associated with the last bead has changed its role and is now used to describe all the purple beads that were counted. So the number name 'ten' has been used in two ways – first to refer to the tenth bead and second, to denote the total number of beads in the group.

Step 8: If the arrangement of the beads is changed, this does not change the count of beads. So whether the beads are laid out in a long straight line or if they are put close together in a circle, we still count the same number of beads. We can count the number of beads correctly whatever the arrangement because we can **conserve number**. Do you recall reading about the child's ability to conserve number in Unit 12, Block 3, of MCD-001?

So, we carried out **eight** different steps/processes before we could count the number of beads. But where do most of us begin when we introduce counting to children? We begin by teaching number names in a sequence without bothering to find out whether the child can match, group (also known as classifying), seriate (also known as ordering), or set up one-to-one correspondence. We are also very keen to teach the writing of numerals 1, 2, 3 and so on and we mistakenly believe that writing numerals correctly mean that the child can also count correctly. However, as you would have understood this is not so. Having taught number names and written numerals we move to the fifth step directly, ignoring Steps 1, 2, 3, and 4. We pay very little attention to the fifth step in learning counting – i.e., putting beads and number names in one-to-one correspondence. We indicate just once or twice to the child in a casual manner, that each object is touched only once in

counting, without giving the child enough time to understand or practice what this means. We assume that since we have touched each object once and said a number name on touching it, the child will see our actions and grasp this rule that each object has to be touched once in counting and that no object has to be missed. But this understanding takes time and the child needs repeated practice. We do not often provide this practice. The seventh step is the most confusing of all – using a number in two ways. However, we hardly realize how confusing it must be for the child.

So, being able to count correctly requires the foundational abilities to match, classify, seriate, set objects in one-to-one correspondence and conserve. Being able to count is necessary to learn any other operation on numbers such as addition or subtraction. All subsequent mathematics is built on the ability to count.

Therefore, children must be well-equipped with this foundational ability that supports them to count. In the subsequent Sections, we have discussed various abilities required to count in detail. You have also read about how to foster a few of these abilities in Unit 16, Block 4 of MCD-002. This discussion in this Unit will help you to recall those activities and you will also come to know of new activities.

Check Your Progress Exercise 1

- 1) Which of the following is NOT an example of number sense?
 - a) The child understands the order of numbers in the list: 1st, 2nd, 3rd, etc.
 - b) The child understands that if we are counting something, the last digit in this number tells us how many things there are in that particular collection.
 - c) The child knows the basic $+$, $-$, \times , and \div operations and understands when to use each one of these.
 - d) The child says the names of various numbers in a different order each time.
 - e) The child makes number comparisons (7 is less than 12).
- 2) Which of the following statements is NOT related to counting?
 - a) It is attaching a number name to each object.
 - b) It is finding how many objects are in a collection and separating objects that have been counted and are still to be counted.
 - c) It includes making straight lines to form numbers.
 - d) It is the ability to recite number names in the order.

15.4 DEVELOPING THE ABILITY TO CATEGORIZE

Let us first understand what categorization means through some examples.

15.4.1 What is Meant by Categorization?

‘Categorization’ (or classifying or grouping or sorting, as it is also called) means putting objects together based on a common property. As children get more and more experiences in grouping objects, they develop the concepts of “alike”, “different” and “belongingness”. The ability to pinpoint categories to be used for classification and name them, the complexity of the categories chosen, and the consistency in using them improves as the child grows. This is so because as the child gains more information, her logical thinking and ability to see relationships improve.

Do not confuse categorization with matching – the latter involves identifying and putting together those objects which are identical. We must recognize that categorization is not equivalent to matching objects. In a matching task, the objects must be alike in all respects; in categorization activities, the objects placed in a group may be somewhat different from each other but have the common property that is the basis of categorization. For example, lemon and guava are very different in terms of colour, size, taste, and texture and cannot be matched at all but both are spherical and hence would be members of that category.

However, once children can match, they are ready for sorting or categorisation activities. Sorting tasks arise in play and everyday activities as children are asked to put the doll’s clothes in one bag and the doll’s ornaments in another; as they put the unclean plates in one tub and the clean ones in another; and as they separate square paper cut-outs and triangle paper cut-outs. Categorization into two or more groups requires the ability to observe and be aware of the properties of objects and then identify the criterion/criteria that one wants to use for creating the categories. We will say that a child has learnt to categorize, only when she can decide the criterion/criteria for categorization and hold that criterion criteria throughout the activity.

During preschool and early primary grades, these early experiences can be extended. Before you read about some play activities to foster the ability to classify, consider the following situation and answer the questions that follow.

Situation 1

Four-year-old Vivek attends a preschool centre. The preschool teacher gave him cut-outs of triangles and rectangles of two different colours — red and blue. Thus, there were red triangles and red rectangles, and blue triangles and blue rectangles. The educator asked him to “put similar things together”. She had expected that the child would make four groups — red triangles, red rectangles, blue triangles, and blue rectangles. Vivek, however, did not make such groups. He began by selecting a blue triangle. Then he

picked up another triangle which was red in colour and placed it next to the first one. Then he picked up a red rectangle and placed it next to the red triangle. Then he created the second group where he placed a blue rectangle, followed by a red rectangle, and finally a red triangle. At this point, he stopped.

On another occasion at home, Vivek's mother was busy separating two pulses that got mixed — Green gram and Bengal gram. To finish the task sooner and also to manage Vivek, his mother asked him to help her. Vivek joined her eagerly and correctly separated the pulses into two piles.

It is quite clear that Vivek could not do the categorisation task set up by the educator but he could classify in the situation at home.

- 1) Why could Vivek not classify in the first situation but could classify in the second situation?

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- 2) Considering both the situations together, would you say that Vivek can classify? Give reasons for your answer.

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Compare your answers with the discussion that follows.

One reason why Vivek could not classify in the first situation is that it is a difficult activity for the child.

The first activity requires the child to keep two criteria in mind while classifying — shape and colour; while in the second activity, the child needs to only keep the colour of the pulses in mind while separating them. The former is a relatively difficult task for four-year-old Vivek. In the first task, Vivek began by using shape as the criterion for categorisation. Then his attention shifted to colour. Thus he picked up a red rectangle and placed it next to the red triangle. Thus, his basis for categorisation changed from one piece to the next. This is not a true categorisation. One should be able to decide upon the criterion for categorisation and maintain it throughout the activity.

Another reason why Vivek could not classify in the first situation is that the first one seems an artificial task. The second situation is more meaningful for the child and he is familiar with it. It makes sense to the child.

In response to the second question, we can say that Vivek is developing the ability to classify. He can classify when the situation is simple. This ability will develop fully and completely during middle childhood years (i.e., during concrete-operational stage – 7 to 12 years).

15.4.2 Principles to Keep in Mind When Planning Categorisation Activities

- Begin the categorization activities where objects differ on one criterion only and where the criterion for categorization is a physical property of the objects – such as size, shape, or colour.
- Introduce these activities in situations and ways that are meaningful for the child.
- Gradually, the categorisation tasks can be made more complex by involving sorting by two criteria. Of course, younger preschoolers will not be able to do this, while many older preschoolers may be able to. Do not force them if they find it difficult.
- Use a variety of materials for categorization activities — cloth pieces that differ in texture, twigs that differ in size, books that differ in thickness, and pebbles that differ in weight.
- Talk to children about the categorization activity: “Why have you made the groups like this?”, “What is common between these objects that you have placed together?” This is necessary for two reasons — talking about what they have done helps children to clarify their thoughts and you come to know how far they have grasped the concept.

15.4.3 Specific Activities to Foster the Ability to Categorize

With these aspects in mind, **let us now broadly list the categorization activities in terms of the level of increasing difficulty.** We begin with the simpler ones and go on to the more difficult ones.

- Initially, give children material to classify in any way they like. Ask them about the groups they have made and why they have made these groups. For example, make available a variety of vegetables of different colours, sizes, and shapes and ask children to sort them into groups. Let children evolve their criteria for categorization and group them in any way they like. Once they complete the activity, talk to them about the criteria they have evolved by asking them questions like: “Why are these together?”, “Why not put this here?”

Or you may give them a collection of flowers and invite children to classify these on any basis that they like — colour, shape, or smell. Once they have sorted, ask them their basis for categorization. Do not label their categorizations as ‘correct’ or ‘incorrect’. This can de-motivate the child. They are at the stage of developing concepts, so their categorizations may not correspond to adult criteria. This does not matter. What is important is that they are thinking.

- As you ask children to make categories on the basis of some specific criterion/ criteria, explain what has to be done. For example, when children finish playing with blocks and are putting these away, ask them to put blocks of a particular colour together — For example, say “put together all the blocks of red colour”.

To take another example, give children buttons that vary only in terms of colour or shape, or size. Ask them to put similar buttons together. If children find it difficult to carry out the activity based on this general instruction, be more specific and ask them to “put all the round ones together” and so on.

Another activity can be as follows: Collect leaves of three different shapes and show the children the three different leaf shapes. Tell them to form three groups based on shape. You can say, “Put together all the leaves that are long” or “Put together the leaves that look alike”.

- Asking children to make categories based on function or a class like vegetables or fruits is more complex. This is because the criteria on the basis of which children have to classify is not immediately visible since it is not a physical characteristic. Examples of such activities could be the following:
 - a) “Put together all the things you would see on a farm.”
 - b) “Find from this pile all the things a carpenter would use.”
- Make available items of clothing to be sorted based on function, such as clothes that help in keeping warm, and clothes that keep you cool. Initially, you may have to show the children how to do the activity.
- Put together some objects in a group based on some common property. Show this to the children and ask them what in their opinion is common to these objects grouped together. This is more complex than all the former activities.
- Categorization activities taking two criteria into account are difficult for younger preschoolers as explained in the earlier example of how Vivek classified the cut-outs. In such activities, there is more than one way of categorization. In Vivek’s example, one would get four groups — red triangles, red rectangles, blue triangles and blue rectangles. However, categorisation based on one criterion is also correct. In such a case, when children have made groups based on one attribute, either colour or shape, draw their attention to the fact that each group can be further subdivided. The important point in categorisation activities is that the child should be able to maintain the criterion for categorisation throughout the activity.
- Many older preschoolers can classify based on two criteria. The interesting point is that many of them will first classify based on one criterion and then further sub-classify each of the two groups into two groups each based on the second criterion.
- When children have had many experiences with concrete objects you can organize categorisation activities that involve pictorial representation. For example, draw an apple, a banana, an orange, an onion, a brinjal, and a radish and ask the children to connect the objects that belong to a specific category with a line – say connect all the fruits or vegetables or utensils, etc.

- The next step is to create categories at the verbal level. For example, while they are enjoying a meal, ask them to identify foods that taste sweet, sour, or salty.
- Always ask the children the reason why they have created a particular category and try to understand their reasoning. The idea is not to make a judgment whether or not the child's categories are correct, but to understand the child's thought process.

15.5 DEVELOPING THE ABILITY TO COMPARE AND SERIATE

15.5.1 What is Meant by Comparing, Ordering and Seriating?

Comparing involves only two objects. It involves establishing a relation between two objects based on some specific attribute such as colour, texture, weight, size, or any other.

Children can compare before they can seriate. Children of preschool age make comparisons naturally in many day-to-day situations. They often say sentences such as: "I have more juice", "This bed is bigger", "My pencil is bigger", and "My bag is heavier." While doing so, they also begin using comparative terms like 'bigger-smaller', 'taller-shorter', 'heavier-lighter'.

In general terms, arranging objects in some defined way can be called **ordering**. One of the forms of ordering is seriation. **Seriation** involves arranging three or more things in an increasing or decreasing gradation of size, colour, or any other attribute so that there is a sequence from the first to the last. For instance, you can arrange a collection of five stones based on their weight, the heaviest comes first and then the second heaviest, and so on until the lightest stone is placed at the last position. This implies that seriation is a sequence that is based on a specific common property of the objects.

Objects can be seriated by arranging them in increasing or decreasing order of any of their quality such as length (smallest, larger, largest); thickness (thin, thicker, thickest).

At the simplest level, seriation involves putting three objects in a series – smooth, smoother, and smoothest. For a child with two siblings, the first seriation experience could be identifying the eldest, the middle one, and the youngest child.

Many day-to-day situations will arise when children will need to deal with more than two things at the same time – for example, when they are asked to pick the smallest plate from a collection of plates of different sizes when they have to choose the biggest piece of cake out of many pieces. In this way, they begin to develop the ability to seriate, and adults can further help them see that comparative terms like 'big and small', 'bigger and smaller', 'long and short', etc. are not adequate and thus, strengthen their vocabulary.

Can you think of other day-to-day situations that promote understanding of seriation?

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The ability to seriate develops with age. Initially, a child may have difficulty in seriating even three objects. What happens is that while seriating, children place the first object (let us say, a stick) and then they compare the length of the second stick with reference to the first one. But while placing the third stick, they tend to refer only to the second stick, instead of looking at the total arrangement. The child must perceive the third stick in relation to both the first and the second — that it is longer than the first but shorter than the second, and, therefore, must come in between them. But the child perceives each subsequent stick only in relation to the last stick that has been put in the sequence, and, therefore, does not get a uniform gradation.

When children can seriate three objects, then they can gradually seriate four, five and more objects.

15.5.2 Principles to Keep in Mind When Planning Comparison and Seriation Activities

In the following points, we have described the principles for planning comparison and seriation activities in terms of levels of increasing difficulty.

- Begin by asking children to compare two objects based on any physical characteristic such as size, colour, and weight by asking them which is longer, lighter in colour, or heavier.
- The simplest seriating activity is asking children to copy a pattern. For example, make a row of pebbles that increase in size and ask children to make a similar row using pebbles from a heap.
- A higher level of difficulty involves asking children to continue a pattern. For example, in the above case, ask the children to extend the row of pebbles you have made. The question to be answered in ordering activities is “What comes next?”
- The next level of difficulty involves asking children to arrange a few objects based on some attribute such as colour, length, width (thickness), or weight such that there is a uniform gradation. Initially, you may need to prompt by asking questions such as: “Which is the smallest?”, “Which is longest?”, and explain how to do the task. When children have put objects in a series incorrectly, you will need to help them see their mistake by asking questions like: “Is A (pointing to the object) thinner than C (pointing to the object)?” or “This one looks bigger, should it not come here?”

- Begin by giving children three objects to seriate and then gradually increase the number. Seriating more than five objects may be difficult for preschoolers.
- If children arrange objects in the wrong order, then ask them questions that will help them review their arrangement. You may ask them questions such as:
“Is this object smaller than this?”
“This seems bigger, why don’t we put it here?”
“Does it fit better here?”
- They can also benefit by carrying out seriation in groups as talking to each other and looking at each other’s work helps improve understanding.
- **When carrying out seriation activities, you will use words like ‘last’, ‘first’, ‘in between’, ‘before’, ‘after’, ‘next’, ‘bigger than’, ‘longer than’, ‘smaller than’, ‘biggest’ and ‘smallest’, ‘longest’ and ‘shortest’.** This will help the children to consolidate these concepts in their minds as they use these repeatedly.

Seriation activities help the children to be aware of transitivity – i.e., if A is greater than B, and B is greater than C, then A would be greater than C.

- Once the child can perceive this, she will be able to make seriations in both directions – in increasing and decreasing order. Conversations with children about big and small can be carried to different sets where an object that is large in one group is small in another. For example, the tallest child in the preschool section is not among the tallest in the common assembly with the primary section.

15.5.3 Specific Activities to Foster the Ability to Compare and Seriate

Keeping the above principles in mind, the following are some examples of play activities that can be devised to foster the ability to compare and seriate.

Activities for Comparison

- You can create many situations in preschool when children are asked to compare objects based on different attributes. Ask children which block is heavy and which is light, which twig is long and which is short, which colour is dark and which is light, whose voice is shrill and whose is hoarse.
- Comparison activities also help children to understand one-to-one correspondence. You know that this ability is basic to counting. The following activity, involving the comparison of quantities helps the child to understand one-to-one correspondence. Take some pebbles (or any other material) and divide these into two groups with four and six pebbles each. Ask children to say which group has more pebbles. For a child who cannot count, this involves setting objects in one set into one-to-one correspondence with objects in the other set and seeing in which group (set) the pebbles are left over. Such activities strengthen the concepts of more than, less than, how many, and the same.

Activities for Seriation / Ordering

- Give children containers or rings of different sizes and ask them to fit them into each other so 'that none remain'. This can happen only when the containers or rings are fitted by pulling according to size.
- Ask children to stack play material according to size, with the big ones first, then the smaller ones, and then the smallest ones on the top.
- Ask children to arrange sticks or leaves according to increasing or decreasing size.
- Seal different amounts of pebbles in tin boxes and ask children to shake them and then arrange the boxes according to the sound they produce – from the least sound to the most sound.

Think of some more play activities that involve seriation and write these in the space below.

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Check Your Progress Exercise 2

- 1) What is the difference between matching and categorization activities?
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- 2) Why is it important that the task you set up for categorization initially has one striking criteria only?
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15.6 DEVELOPING THE ABILITY TO SET UP ONE-TO-ONE CORRESPONDENCE

15.6.1 What is Meant by One-To-One Correspondence?

To understand what is meant by one-to-one correspondence, imagine that you have some slates and pencils. You have to check if there is one pencil for every slate. Similarly, if you have plates and spoons, cups and saucers, you would need to check if each plate will have a spoon or if each cup will have a saucer. Can you do this if you cannot count?

Yes, it can be done by placing one spoon on one plate. This will tell you if there is a plate without a spoon or if there is an extra spoon. In other words, you have set spoons and plates in one-to-one correspondence.

Preschool children can also do one-to-one correspondence by pairing or associating each slate with a pencil, a cup with a saucer, a plate with a spoon, and so on. This means they place slates and pencils in one-to-one correspondence with each other. This, they can do before they learn to count.

When you are counting objects, you are putting up the objects and the number name in one-to-one correspondence. You would notice that when young children count, they are not able to come up with a consistent number. They give a different number each time they count. As adults, we also often end up having to recount objects multiple times, as the counts do not match. In all these situations, either we leave out an object while counting or count some objects multiple times, or do both, which leads to a different count each time. Preschool children sometimes continue reciting number names even after each pebble has been counted. As you would realize from your own experience of counting, when we count we must ensure that:

- An item has to be included in the count only once
- Nothing has to be left un-included
- Only one number is spoken while including an object

The inclusion of the objects in the set as 'having been counted' can be marked by physically shifting their position to the set of objects already counted (for example, putting the counted objects in the box and letting the uncounted remain where they are) or by just touching these to identify that the object has been counted.

As we gain experience in counting and develop a greater ability to hold visuals in our mind, we do not need to physically shift objects to make the categories of 'counted' and 'uncounted' objects - we can first keep track of counted and not counted objects by looking at them and keeping a track mentally. However, for young children, particularly when they are beginning to count, it is important to either physically shift the counted object to a different location or at least touch it to fix the inclusion in their minds. This will help them to understand that they have to set up the objects and the number names in one-to-one correspondence. It will also help them to set up this correspondence.

Children's daily experiences also provide some opportunities for them to set up things in one-to-one correspondence. While making teams, they divide by choosing one partner at a time for each team and in this way end up with equal numbers in both teams; they share and distribute things so that each one gets an equal amount, and so on. They are engaging in one-to-one correspondence without realizing that they are doing so. This they may not do consciously though.

Setting up one-to-one correspondence helps children to understand the meaning of 'many' and 'more than', 'less than', and 'as many as', 'none' and 'all'.

Visual Comparison of Arrangements

Children as young as three can understand the difference between 'many sweets' and 'few sweets', particularly when the difference between them is large. If you set up two piles of stones, one of which is a much bigger heap than the other, then children will be able to point to the one that has more stones.

Interestingly, some research about children's visual understanding of one-to-one correspondence has shown that preschool children can visually compare two small piles of objects when they have been arranged in such a way that the objects of one set correspond with the other. In the following picture, in the first arrangement, the children correctly recognize that Group B has more objects than Group A because the objects are arranged in one-to-one correspondence. However, when the two sets of objects are not arranged correspondingly, then the children make mistakes. In the second arrangement, the number of objects in Group C is less than in Group D but the arrangement is spread out and it occupies more space. The objects in the second group are more but the arrangement is compact (close together). The children concentrate on the visual appearance of the group and conclude that the objects in group C are more. At this stage, children cannot conserve numbers and follow one-to-one correspondence to make judgments of more and less, which sometimes come out incorrect.

First Arrangement	0	0	0	0	0		Group A
	0	0	0	0	0	0	Group B
Second Arrangement	0	0	0	0	0		Group C
	0	0	0	0	0		Group D

Therefore, it is important to give children tasks that help them engage with one-to-one correspondence as this would develop their ability to count and also help them slowly develop their visual acumen in estimating the number in groups.

The above example also helps us to recognize that when children and adults look at a situation, they do not focus on the same aspects. In dialogues and tasks with children, this has to be kept in mind. Children's perceptions gradually acquire aspects that seem natural and obvious to us as adults.

As a teacher, you can strengthen children's understanding of one-to-one correspondence by discussing children's experiences and encouraging them to talk about them. Also, you will need to set up activities where children put up objects in one-to-one correspondence so that children get repeated opportunities to practice. Engaging with repeated experiences helps in strengthening their understanding.

15.6.2 Principles and Specific Activities to Foster the Ability for One-to-One Correspondence

Can you think of some activities to strengthen an understanding of one-to-one correspondence?

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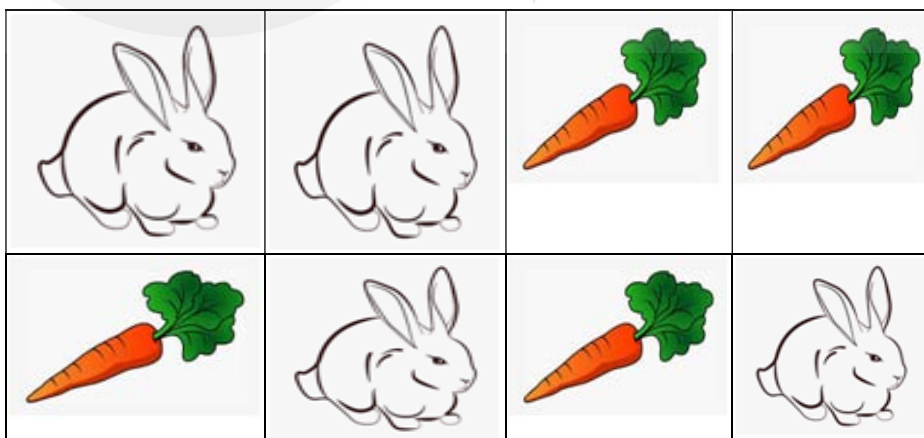
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Given below are some activities that will support the development of one-to-one correspondence in children.

- a) Begin with activities where the number of objects in the two groups is equal and no object is left unmatched. Through such activities, children develop the idea of ‘as many as’, ‘none’, ‘same’, and ‘equal’. Some examples of activities are the following:
- Keep some bowls in front of the children. Give them some spoons and ask them to keep one spoon in each bowl.
 - Lay out a row of pebbles and ask the child to make another row with as many pebbles.
 - Lay out leaves on the ground and then ask them to place a pebble on each leaf.
- b) Once children have many experiences of such activities with actual objects, you can devise activities using pictorial representation.
- Ask the child to connect a carrot with a rabbit by drawing a line.



During the activities, ask children questions like: “Are there as many carrots as the number of rabbits?”, “Are there more rabbits or more carrots?”

- Make a picture on the blackboard or a piece of paper in which there are some children and the same number of kites. Now ask children

to join every kite with a child. Such activities will help the child to visually understand what is involved in one-to-one correspondence.

- c) Once children begin to understand 'as many as', create situations where there may also be more objects in one group as compared to the other. This will lead to an understanding of 'more than', and 'less than'. The situations described above can be easily adapted to lead to an understanding of 'more than' and 'fewer than'.
- Take some pebbles (or any other material) and divide these into two groups with four and six pebbles each. Ask children to say which group has more pebbles. For a child who cannot count, this involves setting pebbles in one group into one-to-one correspondence with pebbles in the other group and seeing in which group the pebbles are left over.
 - Give the child more spoons than the number of children in her group. Ask her to give one spoon to each child. When she does that ask her questions like, "Are there as many spoons as the number of children?", "Are there more children or more spoons?". Similarly, you can ask, "Are there more kites, or are there more children?", "Are there as many kites as the number of children?"

15.7 COUNTING AND READING NUMERALS

Many experiences in categorization, seriating, and setting up objects in one-to-one correspondence are the base from which the ability to count and other numerical abilities will develop. However, many of us do not focus on developing their abilities and instead make the child memorize number names, expect her to recite them in the correct order and when she does so, we believe that this means she can count. But as explained earlier, reciting number names, hurrying up, and introducing counting before the child has had the chance to explore the above-mentioned emergent mathematical concepts, may confuse the child.

As mentioned earlier, if a child remembers and recites the names of numbers in the correct order does not guarantee that she will also be able to count things correctly. Even children in the age group of four to five-year-olds may easily recite number names up to 20 or more, but may not be able to count and pick up five objects correctly.

Similarly, if a child can write some numerals such as 2 or 4, it does not mean that the child has understood what the written number '2' signifies.

15.7.1 How to Introduce Counting?

The following steps explain how to develop the child's ability to count.

- Most of us while introducing number names and teaching how to count, do so in the absence of real objects. We present number names to children in a sequence, expecting that children learn them in order and understand what they mean. But to many children, this may not make sense, as we have said repeatedly in this Unit. It would be helpful to introduce **counting using objects**.

- When learning how to count, children need to understand that each successive number is one more in quantity than the previous one. **However, the typical way in which we introduce numbers creates confusion, instead of helping the child understand this.** Most of us begin in the following manner:

Often when counting objects for the child, we move from one object to the next, saying “one, two, three”, and so on as we touch each object. The child, on seeing the adult touching these items, which in all other respects look alike, and saying a different word for each one, may conclude that ‘one’, ‘two’, and ‘three’ are names of these objects. We do not explain to the child that we called the second object ‘two’ because we assumed that we are now referring to a collection of two objects — the object that we touched earlier and the one we are touching now. We understand this and we expect the children to follow this by themselves, without our explanation to them. In fact, we do not even realize that the child may be confused. **This confusion can be easily avoided if you introduce counting in the following way:**

As you begin counting, touch the first object and say: “This is one leaf” and take it to another side. Then, take the second one, move it towards the first one, and say — “This is one more. So now there are two. One and one more make two” and continue in this way. In this way, it becomes clear that the number name refers not to a particular object but to the size of the group of objects that we have kept to one side. Such a method helps the child to know that there is a sequencing of number names and that the subsequent number is one more than the previous one. As you move the counted objects a little away from the uncounted objects, it makes it clear to the child what has been counted and what remains to be counted.

- **When you have introduced some numbers in this way, give children repeated experiences with these numbers.** Give them opportunities to encounter ‘two’ in different situations — two people, two sticks, two pencils, and two balls. Some of us, when teaching children how to count, always use the same material again and again — pebbles, buttons, or sticks. But this restricts children’s experience and prevents them from generalizing that ‘two’ refers to the collection of *any* two objects. In fact, they might develop a notion that you had no intention of fostering — that number names and pebbles (if you have been using pebbles for counting) go together and that nothing else except pebbles can be ‘one’, ‘two’, or ‘three’.
- There is another aspect you need to remember when introducing numbers. When using pebbles or beads for teaching counting, most of us tend to arrange them in a similar pattern each time for a particular number name. For example, to represent ‘2’ we usually arrange the pebbles as • •; to show ‘3’ we lay them out as •••; for ‘4’ as •••• and so on. Here the child may begin to think that it is something about the arrangement of objects that is called ‘two’, ‘three’, ‘four’, and so on. **This confusion can be avoided if we keep the smaller numbers, i.e.**

numbers smaller than 10, in different patterns. Thus when showing three objects you can, on one occasion, put them in a row, on another as a triangle.

- **Introduce a few numbers at a time.** This gives the child enough time to understand what they mean by manipulating different materials, which will lead to more permanent learning and avoid confusion later on.
- **The script in numbers should be introduced after the children have had considerable exposure to counting using concrete objects.** However, most of us do quite the opposite — we introduce a number name by writing its script on the board or the notebook. For an adult, the script is a very convenient way of handling numbers. It is easier to write '4' on the board rather than show children four objects. But a hurry with introducing script limits the child's experience with concrete objects; children may begin to think that 'two' has something to do with the shape of the written symbol '2' instead of understanding that symbol is just an arbitrary way of denoting 'two-ness'. Not until the children seem to have some concept of numbers should the script be introduced and then the reason for introducing the script should be explained — that the script is a convenient way of dealing with large numbers; that we do not need to collect nine objects, for example, when we talk of 'nine'. It is easier to write it as '9'.

15.7.2 Specific Activities to Develop the Ability to Count

Given below are some specific activities to foster children's ability to count (in other words, to develop number sense):

➤ **Activity 1: Bol Bhai Kitne: Tell me how many? (Grade 1)**

Objective: Familiarization with numbers (initial level)

Nature of activity: Game

Materials required: None

Nature of participation: The whole class

Description: The children stand in a large circle. (They could be slowly moving around in the circle, clapping.) The teacher then calls out:

Bolo bhai kitne?

To which the children reply:

Aap bolo jitney.

The teacher now calls out a number, say, 5. The children now form groups of 5. Children who fail to do so are "out". The process can now be repeated with the teacher calling out a different number.

When done in Grade 3 and 4, the teacher can draw attention to the number of children left out and the number of groups formed and its relation to the number of children playing. This is an introduction to division, quotient, and remainder.

➤ **Activity 2: Familiarity with numerals (Grade 1)**

Objective: Associating number with the quantity it represents

Nature of activity: Finding a numeral card corresponding to the number of spots on a domino.

Materials required: Dominoes, numeral cards.

Nature of participation: Individual/ small groups

Description: Each child is given a domino as shown in the picture:



In front of the teacher, there is a pile of cards with numerals. The child has to hunt in the pile and locate the card representing the total number of dots on the domino.

This can also be played as a game in small groups. Two teams play. At “go”, each team gives the other a domino. The team that can locate the corresponding numeral first wins.

➤ **Activity 3: Celebrating Number (Grade 1)**

Objective: Encourage exploration of a number’s properties.

Materials required: Chart paper, colouring materials, glue, pictures, etc.

Nature of participation: Individual, groups as well as whole class.

Description: A day is spent in celebration of a particular number: say, a day of ‘four’. Preparations can be made in advance by asking the children to collect objects or pictures that have some “fourness” in them: a picture of a car with four wheels, for example, or a twig with four leaves on it. On the appointed day these materials are brought to class. The children can work individually or in groups, as they make posters, drawings, poems, stories, etc. in the class, around the number four. In the end, all materials made are displayed/recited in front of the class.

➤ **Activity 4: Matching Cards (Grade 1)**

Objective: Familiarity with numerals; linking numerals with pictorial representation

Nature of activity: Game

Materials required: A set of cards with pictorial representations (pictures, dots) and a set of numeral cards

Nature of participation: Individual

Description: The two sets of cards are placed in two heaps. Each child picks out a picture card and then has to find from the other heap the corresponding numeral card.

➤ **Activity 5: Riddle-me-Riddle (Grade 1)**

Objective: Seriation of numbers.

Nature of activity: Riddles involving numbers.

Materials required: None.

Nature of participation: The whole class, divided into two groups.

Description: As a preparatory activity the teacher asks the children riddles in which the answer is a number. For example:

- I am one less than two and one more than zero. Who am I?
- You add me to five, I make it six. You add me to two, I make it three. Who am I?
- I am two less than two, and three less than three. Who am I?

Once the children have played at answering such riddles, the teacher encourages them to make up their own. Then the class is divided into two groups. A child from one group gets up to ask a riddle she has made up about a number, and the other side attempts to answer it. The other group then takes its turn. Scores can be kept on the blackboard. Poorly made riddles can be corrected by the whole class (probably some children in each team will be able to spot poor riddles.)

No written work is required unless done at a later stage when children can write.

Extensions/ possibilities:

- Children could be additionally asked to write the numeral they have guessed. Additional points could be given for getting this right.
- This could be played with larger numbers, and also with more arithmetic operations.
- Played in the form of “five questions - that is, a child thinks of a number and the other team must guess the number by asking only 5 questions about it”.

➤ **Activity 6: Largest, Smallest (Grade 2)**

Objective: Comparison of two-digit numbers, consolidating the concept of place value

Nature of activity: Game

Materials required: Pair of dice, scrabble-style scoreboard

Nature of participation: 3 – 4 players

Description: The players throw the pair of dice turn by turn. Each time, the player has a choice regarding how to arrange the readings on the two dice. Say she gets 4 or 6, then she is free to take it as 46 or as 64. The number she decides upon is her score for that round, and is added to her previous score by recording on a scrabble-style score board, or by using paper and pencil. After a fixed number of rounds (say, 3) the scores are compared, and the player with the highest total wins. The players will all ultimately realize that it is best to have the tens digit larger every time to ensure the highest possible score.

➤ **Activity 7: Month Chart (Grade 2)**

Objective: Practice counting and addition/subtraction etc.

Nature of activity: To create and maintain a chart in which each child's month of birth is entered.

Materials required: Chart paper, matchboxes, pencils, adhesive.

Nature of participation: The whole class

Description: Twelve columns are made on the chart paper, one for each month of the year. Each child brings an empty matchbox, which is pasted in the column corresponding to the child's month of birth. After the chart is complete, there is a collective conversation in which the teacher asks questions like:

- Are there more birthdays in May than in June?
- How many have their birthdays in March?
- How many children were born during Jan or March?

15.8 SOME GENERAL PRINCIPLES FOR EFFECTIVE TEACHING - LEARNING

- Encourage children to talk and discuss as they are doing an activity. Ask them questions, and encourage discussions over the questions. This will help them to think about the reason behind their problem-solving techniques and their thinking will grow.
- Conduct as many activities as possible while explaining a particular concept.
- Use different kinds of materials while conducting an activity. This way, a particular material does not get associated with the concept explained. The children learn to generalize.
- If children make errors, do not get worried or scold them. Errors are a window to the child's mind and their greatest purpose is to help the teacher know the stage of the child's thinking.
- Use language that children can understand. Often, children are not able to carry out an activity as they have not understood the instructions, even though they have the maturity to understand the concept.
- Use the spiral approach in teaching. Introduce a new concept but continue revisiting earlier concepts. Refer to Bruner's theory in Unit 16, Block 4, MCD-001, for details on the spiral curriculum. You will understand that for effective learning, there should be plenty of revising of earlier principles. Concepts should be re-introduced in different contexts at regular intervals so that children who could not catch on in the first instance have an opportunity later on, and those who caught it have a chance to revisit it in a different context and consolidate it. While teaching, take care that there should be plenty of opportunities to return to simpler earlier concepts and operations, and also opportunities to attempt concepts judged to be at a higher level. For instance, while teaching counting to children, you have to first provide exercises related

to seriation, categorization, one-to-one correspondence, and then counting objects. Thereafter, you can introduce the related number. However, it is not that when children are introduced to counting, you will not carry out seriation, and categorization activities. These must also be done side by side to strengthen children's concepts regarding these.

- Similarly, one should use the principle of simple to complex while introducing new concepts to young children. Introduce new ideas, concepts, and operations at a slower rate in preschool and early primary grades. This means you have to provide plenty of opportunities for children to master concepts, first through the use of real objects and then through pictures. Also, activities related to the new concept have to be simple first and then gradually you can enhance the level of difficulty and complexity of the activity. For instance, for teaching counting, you can first give a few objects to count. Later on, gradually you can increase the number of objects to count. Similarly, you can show first pictures of a few objects to count, and then gradually you can increase the number of pictures of objects to count. New concepts however can be taught at a comparatively increasing pace in later classes.

Check Your Progress Exercise 3

- 1) Why should you use different types of materials while teaching counting?

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- 2) While learning to count, often children do not understand that each successive number is one more than the previous one. Give a technique/strategy to avoid such a situation.

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15.9 SUMMING UP

The child needs to develop four abilities before she can learn to count and develop a concept of numbers:

- Arranging objects in an order
- Categorization or Categorisation
- Setting up a one-to-one correspondence between the objects and saying one number name for one object
- Using a number name to refer to the collection of the entire set of objects

These abilities and the concepts inherent in these abilities that are required for a child to be able to count are called emergent mathematical concepts.

Categorization means putting objects together based on a common property. Categorization activities can be simple or difficult depending upon:

- whether your instruction for the Categorisation task is general or specific;
- the criterion /property that you have selected for Categorisation;
- the number of properties you have identified for the Categorisation task and
- the context of the Categorisation task.

If the task of arranging three or more objects in an order is done keeping in mind the decreasing or increasing gradation of a particular property of the objects so that there is a sequence from the first to last then it is called seriation. Comparing involves establishing a relation between the two objects based on a specific attribute (property) such as colour, texture, shape, weight, size, or any other.

Children's daily experiences provide many opportunities for them to set up things in one-to-one correspondence. Through one-to-one correspondence, children understand the meaning of 'many' and 'more than', 'less than', and 'as many as'. Therefore, activities one-to-one correspondence should be carried out with children before and while they are formally taught counting.

Introduce a few numbers at a time and give the child enough time to understand what they mean by manipulating different materials. The script in numbers should be introduced after the children have had considerable exposure to counting using concrete objects.

15.10 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

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- 2) c

Check Your Progress Exercise 2

- 1) While in matching activities the objects to be matched must be alike in all respects, in categorization activities the objects placed in a group are different from each other but have some property/properties in common.
- 2) The preschooler is likely to mix the criteria for categorization initially because it is difficult for the preschool child to remember in her mind, throughout the activity, the criterion on the basis of which she is sorting. Thus she would not be able to classify correctly. Hence, the important point in categorization activities is that the child should be able to maintain the criterion for categorization throughout the activity.

Check Your Progress Exercise 3

- 1) This way, a particular material does not get associated with the concept explained. The children learn to generalize.
- 2) The teacher may make use of the concrete materials and show the given arrangement to the children and name each row to make them understand that each successive number is one greater than the previous one.

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