Version 2

What is foundational numeracy?

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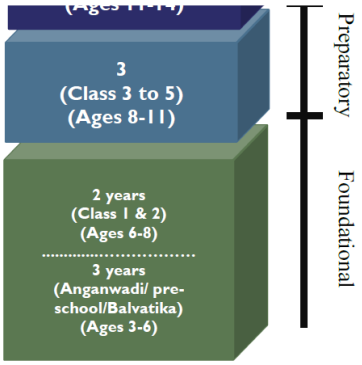
For a few decades now, educationists working with young children have been asking for a special recognition of the learning needs of young children, the children 3 to 8 years old. They have been saying that young children's educational needs cannot be met by breaking down the expectations at the end of the primary years into small parts and teaching the bits to young children. This is a building blocks approach in which children are taught to add one-digit numbers and then two-digit numbers etc. while using the same method as what they are expected to do in class 5 for larger numbers. But do young children look at numbers, in the same way as older children? There has been enough research to show that young children relate differently to numbers and need to relate differently to numbers if they have to develop their foundations. This is the reason that educationists have been asking for a different and holistic approach.

Similarly in language also a top-down approach has been taken so far by first teaching letters to children, only because the final text to be read contains letters. Here also educationists have been asking for a change in approach and to consider the process of meaning creation for young children to build foundations.

The New Education Policy, 2020 has apparently recognised in principle this long-standing demand of educationists to look at young children qualitatively differently because it has put together pre-school children and children studying in classes 1 and 2 in one educational block. This block called the Foundational years is seen as a continuum in which the `foundation of learning' is to be laid. It has also put forward that `the Foundational Stage will consist of flexible, multilevel, play/activity-based learning and curriculum and pedagogy of ECCE.' (4.2., NEP)



But the actual impact for children of NEP as far as numeracy and literacy would depend upon how the terms foundational numeracy and foundational literacy are understood. Would it be understood in the spirit of Foundational Years approach which takes into consideration the special needs of young children's learning? Or would it be torn from the context of young children's needs and seen only in the context of learning the mechanics of a procedure?

This would depend upon what sense is made of the terms foundational numeracy and literacy; How they are understood - within the text of the policy and by the many people who will direct the policy, by those who will implement it and by those who assess it. A close reading of the NEP text gives enough room to feel disquiet about the way literacy and numeracy are viewed in the text of the policy itself. [1] This indicates the challenges that are facing the very idea of Foundation Years itself.

[1] Thus for example, the NEP document (2.1.) considers the ability to perform `basic operations' with numbers as a part of foundational numeracy! This seems to indicate that the ability to do the standard digit-based algorithm is being considered being part of `foundational numeracy'. If that is the case it can have very severe negative consequences for developing foundational understanding in mathematics. Further the same paragraph refers to `addition and subtraction with Indian numerals'. The fact that numerals rather than numbers are referred to, again indicates that the standard algorithm is being referred to rather what one would consider as `foundational numeracy'.

Numeracy is popularly understood simply as the ability to recognise a number and the ability to do addition and subtraction of written numerals. There have been a lot of laments in our country about the inability of our children to do both and a lot of effort has been spent for a few decades to drill children to be able to do it. Efforts have been made for the last decade or so to change the methods from drilling to doing `activities'. *But there have been too few attempts to pause and think - to think that the reason children have difficulties may not be because of the way they are taught but because what they are expected to learn is not appropriate for them to learn.*

If such an introspection can take place, if there can be a dialogue about what is the foundational numeracy that we want to bring in and in what way it is different from the commonly held idea about numeracy, then this point in history could indeed be a turning point for the better for our children.

Therefore, we can say that today we stand at a bifurcation point as far as young children's education is concerned. And we all need to engage if the solution needs to move to produce a qualitatively different education appropriate to children's developmental needs. This itself is a good reason for an engagement by all sections of people also with the ideas about Literacy and Numeracy. This effort and dialogue can determine whether this policy will be in favour of children and their development or in opposition to it.

Therefore let us look at how we understand foundational numeracy; not as a term but as something that can be part of a qualitatively different approach to Early Years education, which is badly needed.

What and why of foundational numeracy

The term `numeracy' originally arose out of the concern that even after full school education adults did not develop a balanced education. The Crowther Report of 1959 submitted to the government in England for the education in fact of older children suggested to take measures `to save scientists from illiteracy and arts specialists from innumeracy' .[i] Later the term numeracy came to get different meanings and got debased as Mcintosh and others have explained[ii] and came to mean just the calculations. The original sense of the Crowther Report for the word numeracy is nowadays linked to the term number sense which is also a part of a growing research tradition.[iii] Independent of the words and their history the question before us is how we should understand the words `foundational numeracy', especially about what is foundational in it. This is needed because the meaning given to the term would determine the nature of the educational initiatives that would be taken.

The Foundational Years

We recognise today that young children's world is **qualitatively** different from that of ours. Young children respond to the world around them with their whole selves - a world that has not yet been divided into different domains. They look for meaning and the meaning they grasp has predominantly both emotional and perceptual aspects to it. This qualitative difference has been recognised by psychologists of different hues, including by Piaget[iv] and Vygotsky[v]. They have interpreted this period differently but have all recognised the qualitative difference in knowing the world during this period. Piaget considered this period up to 7 years as being pre-operational, in the sense that the logic of mathematics, the logic of reversibility was something that was not there at this stage for children. Vygotsky spoke about the leading role of socio-dramatic play in laying the basis for going beyond the immediately given situation. Not only psychologists, but all us who have been with young children have sensed this difference.

But this period is also a great period in which children are making big leaps in making human sense[vi] [vii], in making sense of the social meanings and purposes of the world around them. This period is not just different qualitatively but is also crucial in the sense that it determines whether the formal learning which is to follow can be built up at all. Children think and feel very much *in a situation* and so far, schooling did not recognise this.[viii]

In numeracy this understanding would involve the recognition that the formal concept of number has a long path of development going through various stages of number sense before it can meaningfully reach the abstract level. Without going through this process number would become an empty shell devoid of meaning and identified simply with numerals and numeral manipulations. Foundational numeracy can then be seen as basic number sense connected to a sense of quantity. Children need to see numbers as whole numbers before seeing them as being split into parts. At the foundational level seeing numbers as wholes involves the ability to relate numbers to each other in the range up to 100.[ix] Because of the evolutionary character of the development of conceptual understanding, it is more appropriate that we talk of mathematisation in which children are increasingly organising and structuring the world.[x]

Foundational numeracy is emergent numeracy

Foundational numeracy or basic number sense is emergent; Emerging not from perception, not from just looking but through engagement with the outside world; In fact, it is not emerging from just engagement but engagement which involves the need for communication. Engagement itself is a catch-all word and can mean different things to different people. Here we are talking about involvement and activity full of attention. When a child is attentive to something it also means that the activity has a meaning and purpose for the child. The role of actions with objects for the development of the idea of number was emphasised by Piaget [2], and the key role of communication during joint activity involving adults was pointed out by Vygotsky[3].

Let us imagine a scene. A teacher is distributing blocks to the children and asks each child how many they want.

Teacher: “How many blocks shall I give you?”

One child simply shows the five fingers of the hand and says nothing.

The teacher says, ”Ok. You want Five blocks!” And she proceeds to count one by one and gives the child five blocks. There is some conversation in which numbers are used, imperceptibly as a natural part of the environment and the activities.

[2] Piaget emphasised the active role of the child in actions with objects. His famous number conservation experiments were revealing of this idea that it is only by 8 years or so that one can say that the child has a basic idea of number. This is the time by which the child would not be misled by the perceptual characteristics and understand that number of objects would not change in a collection if you spread them out or bring them together. This made people aware that just chanting number names or recognising written numerals does not amount to having the concept of number. Later the works of Gelman and Gallistel (1978) focused on the role of counting processes in developing the idea of number and current researches are exploring the relationship between our approximate number system and exact quantity as indicated by number.

[3] Works of scholars such as Wertsch, Chaiklin, Oers, Saxe and Sfard can be consulted about the social aspects of mathematical cognition. To underline the role of communication in the process of cognition Sfard has suggested that we should be talking about commognition rather than about cognition. Cognition is often assumed to be taking place between the child and objects and neglects the role of language and communication in mediating human cognition.

Another child says, “Two!” And also shows two fingers.

The teacher says, ”Ok. I am giving you two of these green blocks.” And then goes on to say, “Shall I give you two of these red blocks also?” After counting and giving the blocks, teacher pauses for a second and says, “Shall I give you two of these yellow blocks also?”

And in the end the teacher says to the second child,” Ah! Now you have **so many** blocks! Shall we count and see how many?”

In this process the teacher is adjusting to the responses of children and her estimate of what is appropriate for children. There is no direct teaching. The numbers are used to communicate about the quantities involved and language mediates the interaction between the teacher and the child.

Slowly numbers start developing meaning for the child.

Later when the teacher asks, ”What a nice long mala you have made for Gudiya!”, the child glows happily. Teacher says, “Shall we see how many beads there are!” The teacher and the child count together, with the teacher taking up the counting as the voice of the child starts to fade away.

This basic number sense that develops is emergent; emerging from different types of counting activities. It goes through various stages; first cardinality or the sense that the last counted number refers to the quantity of the full collection and not just the object that was last pointed at.

Slowly based on this the child develops a sense of which number is bigger and later also which number is smaller. There is a journey through which the child needs to go through without being directly taught.

The bifurcation point

If children are taught what are glibly called as basic number operations, without having had the opportunity to develop strong number sense, then there would be many consequences. One would be, that they will do the algorithms mechanically without developing any sense for the arithmetic they are learning and go on to develop a fear of mathematics.

While the idea of foundations is very important it can be effectively implemented only if all the people concerned understand what it means – this is particularly so for the policy-makers and administrators but also for teachers.

We need a wider discussion about what foundations mean in mathematics. If the popular idea of what is mathematics is not opened up, the idea of foundations would lead only to pushing downward the existing curriculum even in truncated forms and children being told to do calculations which only make sense from an adult’s point of view.

People at large sense that there is something wrong with mathematics education. But they think that the problem is with them that they have developed a fear of mathematics. We need to have widespread dialogue and reflection on what mathematics means, to go beyond the current reduction of mathematics to the so-called basic operations.

An education to face the challenges of today

Numbers get their meaning from a context. If children get the opportunity to solve context problems or problems rooted in their environment then they develop better understanding of mathematics. Let us plan for children to solve word problems or context problems before they are taught the standard algorithm. This will be the kind of mathematics that will help children to face the challenges that the Foundation document talked about.

The understanding that the focus on the standard algorithm execution is not the mathematics needed for today's world is being realised in many countries across the world. For example, the recent PISA2021 Mathematics Framework of OECD (Programme for International Student Assessment) has put forward that, children should learn to reason mathematically `in conjunction with a small set of fundamental mathematical concepts that support this reasoning and which themselves *are not necessarily taught explicitly* but are made manifest and reinforced throughout a student's learning experiences. This equips students with a conceptual framework through which to address the quantitative dimensions of life in the 21st.century.' (emphasis added. p 4) [xi]
Children today have calculators in their hands. They need not become calculators like some people had to in the nineteenth century. They need to become people who can pose new problems to solve in order to face today's challenges, whether of climate change or of increasing inequalities. They need to learn to think quantitatively and not just numerically, to think relationally and not just procedurally. That can happen only if the true foundations of mathematics can be laid for our children by considering what foundational years mean.

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[i] In 1959 the Crowther report coined the word with a much wider meaning. It argued that `Numeracy has come to be an indispensable tool to the understanding and mastery of all phenomena, and not only of those in the relatively close field of the traditional natural sciences. The way in which we think, marshal our evidence and formulate our arguments in every field today is influenced by techniques first applied in science. The educated man, therefore, needs to be numerate. (The Crowther Report (1959) Report of the Central Advisory Council for Education (England) 254/485) www.educationengland.org.uk/documents/crowther/crowther1959-1.html

[ii] However, the meaning of numeracy `became debased to mean only an ability to cope with the basic mathematical demands of everyday life … As these demands were not closely re-examined, it again, to most, implied the same range of skills as did arithmetic' and the view of `mathematics as facts, rules and formulas' Mcintosh, A.; Reys, B.J. & Reys, R.E. (1992). A Proposed Framework for Examining Basic Number Sense. *For the Learning of Mathematics*, **12**,3.

[iii] Crowther Report and the starting of the numeracy initiatives in England took place before organised research in Mathematics education started internationally. The first International Congress on Mathematics Education (ICME) was held only in 1969 and The International Group for the Psychology of Mathematics Education (PME) was established later, in 1976. These efforts have brought out deeper understanding about the pedagogic processes in mathematics education.

[iv] Piaget showed with unambiguous evidence that young children did not see the world with the same eyes – they seemed to be more affected by immediate perceptual considerations. They could therefore pour the same water into a taller glass and say, "Now it is more!" It was true that very young children did not conserve number, or length etc. Piaget also argued that children can truly understand concepts only when they are able to think relationally, to think in reversible terms – to say that "if I pour the water back into the first glass, the level is the same, so the water is the same." Or to say that `no water has been added or taken away, so the amount of water is the same'. He considered that this ability, the ability to do these operations or reversible actions mentally would emerge only 7 or 8 years. He concluded that children's ability to think logically and to be able to deal with numbers as we understand them develop after a period in which children get the time to act in the world – to explore the world by joining, by separating, by grouping, by ordering and so on to make sense of the world through actions.

[v] Sfard, A. (2001). Cognition as Communication: Rethinking Learning-by-Talking Through Multi-Faceted Analysis of Students' Mathematical Interactions

[vi] Margaret Donaldson and her colleagues showed that young children are able to correlate things when they the questions are posed in a human context involving people and their concerns.

[vii] An interesting research which brought home this point poignantly was that of Tom Hudson who asked 7 years old children the same question in two different formats while showing similar pictures.
A. Here are some birds and here are some worms. How many more birds than worms are there?
B. Here are some birds and here are some worms. How many birds won't get a worm?

All the children answered the second question correctly while only 64 % answered the first question correctly. [viii] For example, schooling did not recognise the tremendous importance of pretend-play and how it needs to be supported by teachers. During pretend-play children of this age in fact are making a major step towards abstraction. When a child takes a stick and rides it as a horse as Vygotsky said, the child is making a big step in going beyond the characteristics of the immediate situation and ascribing new meanings. Play is also a process through which children are learning self-regulation. In this they behave as per the rules of the play and act according to the character being played rather than the immediate instinctive response. There is today increasing recognition of the crucial importance of giving children of foundation years the opportunity for pretend play in which children together plan and decide how they are going to play. See Bodrova, E., Germeroth, C. & Leong, D.J. (2013). Play and self -regulation. *American Journal of Play*. Vol 6 (1). 111-123.

[ix] **Building on from emergent numeracy to further develop number sense**

Even after building basic number sense children can be considered to go through three more stages before they can with comfort and understanding start understanding place-value and do digit-based operations with numbers meaningfully. We need to see this as the development of three strands rather than as discrete stages. In all these numbers are seen closely related to quantity and not as digits.

1. **Basic Number Sense** - Ability to compare numbers by seeing numbers as a whole - extending to 20, to 100 and beyond

Ability to say which is more and which is less, by seeing numbers as a whole (29 is less than 31 not because the child looks at the tens place and one's place and analyses it, but simply because the child `knows'. This can be seen to be supported by a concept-image which the child has developed through many meaningful counting experiences) This also extends to adding numbers by counting ahead.

2. **Additive number sense** - ability to add numbers by splitting numbers. (for eg. Adding 46 and 25, by thinking 40 and 20 is 60; 6 and 5 is 11; and 60 and 11 is 71. The child does this with full sense of what she is doing without having to count on the fingers). Additive number sense builds on basic number sense

3. **Multiplicative number sense** – the ability to see a number as a larger unit and also at the same time as being made up of ones. For example, when 14 people have to be given 6 pooris each, to be able to think that 10 people will need 60 pooris and 6 people will need 24 pooris and therefore 84 pooris are required. In this case 6 is being seen as a unit which is getting replicated. This is the conceptual basis for dealing with both multiplication and division meaningfully although we might consider them as two different `operations'. This ability to mentally calculate needs to precede the use of the algorithm. This gets built up through a process starting with the ability to double and can be learnt without directly being taught, but through problem-solving. This type of thinking should lay the basis for understanding place value.

[x] The experience of Jodo Gyan with thousands of children in very different contexts across the last twenty years has shown that when children develop good number sense and then learn the formal digit-based algorithm, they not only enjoy the mathematics they are learning but also develop conceptual understanding as well as the ability to do the algorithm with understanding.

[1.] Usha Menon has been a member of various expert committees of NCERT, MHRD & NCTE including in the ones for Foundational Numeracy. In 1998 she started the social enterprise Jodo Gyan which works in maths education.