UNIVERSITY OF LEEDS

असर ASER
Evidence for Action

UCL
Institute of Education

Continuity, Discontinuity and Progression in India's Early Years Mathematics Curriculum

Key findings from the study *Pathways to Numeracy in Rural India: Policies, Patterns and Perceptions*

Introduction

India's 2020 National Education Policy (NEP 2020) calls for a 'foundational' stage of education for children aged 3-8 (GoI 2020). This structure aligns with international research underlining the importance of building strong foundations for learning by ensuring continuity and integration across the preschool and early primary years, a key period in young children's development. Specifically with regard to mathematics, global research shows that mathematics achievement in primary school grades and beyond is strongly related to children's acquisition of pre-numeracy and early numeracy skills before they even enter school (eg. Desoete et al. 2009, Jordan et al. 2007).

A new curriculum spanning the proposed foundational stage is currently under development. The need for a revised curriculum is underlined by the available national evidence on children's mathematics learning. It shows that large proportions of children begin to fall behind from the very first year of formal schooling, suggesting that their early preparation to handle formal mathematics content is insufficient. Once they have fallen behind, children have few opportunities to catch up (Kaul et al. 2017, ASER Centre 2020).

This evidence also suggests the converse: children with emergent and early numeracy skills have a significant advantage at the primary stage.

The Pathways to Numeracy study examines continuity and coherence within and across the existing national frameworks for early mathematics content, as well as workbooks and textbooks currently used in Government schools in the States of Assam, Telangana and Rajasthan. The analysis focuses on:

- Learning domains and expected learning outcomes for early mathematics in national curricular frameworks for age 3-6, which collectively span the preschool years as well as Std I of primary school.
- The degree of alignment between national frameworks and State curricular materials for preschool and the first primary-school grade (Std I); and
- The extent to which a continuum of learning opportunities for early mathematics is visible across preschool years as well as from preschool to primary school.

Approach and Methodology

A comparative analysis of national curricular frameworks was conducted alongside learning materials (workbooks and textbooks) from three major and geographically diverse States: Assam, Rajasthan and Telangana. The analysis focuses on the topics related to mathematics presented for children to learn in these materials.

The analysis of national frameworks is based on two key National Council of Educational Research and Training (NCERT) publications:

- The Preschool Curriculum (NCERT 2019) sets out key concepts and skills to be taught, processes to be used, and expected outcomes for each of the three prescribed years of pre-primary education.
- Learning Outcomes at Elementary Stage (NCERT 2017), developed two years earlier, sets out the content that children are expected to master for each of Grades 1-8, separately for each subject.

The State-level analysis focused on government-issued workbooks (for pre-primary years) and mathematics textbooks (for Std I) mandated by each State. Because of different norms for age of entry to Std I, Assam and Rajasthan each have separate pre-primary workbooks for age 3, 4, and 5; whereas Telangana has these materials only for age 3 and 4. In total, across these three States, we examined 11 books for pre-primary and Std I, all published within the last five years.

In order to accurately reflect the content of these materials, our analytical framework was developed from the materials themselves, working back and forth between the State-level learning materials and the national-level policy documents (Table 1). While the first two domains in this framework contain topics that are usually included in pre-primary curricula as cognitive and pre-numeracy skills and concepts, the third and fourth domains include topics that typically span both pre-primary and primary curricula.

Table 1: Maths topics in pre-primary workbooks and Std I textbooks in three States, by domain

Domain	Topics
Concept and Identification	Objects and Things Colours Five Senses Missing Parts
Pattern and Seriation	Pattern Seriation Classification Functional Association
Spatial Thinking and Measurement	Shapes Location-Position Maze Measurement
Number concepts and Arithmetic	Quantity Comparison Counting Number Recognition Number Sequence Number Operations Money

National curricular expectations

This analysis reveals that the pre-primary (NCERT, 2019) and elementary (NCERT, 2017) frameworks show substantial discontinuities in learning expectations for children across the envisaged foundational stage. A review of the nationally prescribed learning outcomes for preschool and Std I in these two documents reveals that there are gaps and inconsistencies rather than a clear progression of topics between the two stages (Table 2). [1]

Table 2: Early mathematics topics and learning outcomes in preschool and Std I

Topic	Learning outcome specified?	
	In pre-school (one or more years)	In Std I
Number concepts	✓	✓
Pattern	✓	✓
Measurement	✓	✓
Shape	✓	✓
Seriation	✓	
Classification	✓	
Functional association	✓	
Concept Identification	✓	
Colour	✓	
Data Handling		✓

Several domains that are key to children's early numeracy acquisition are addressed only at the preschool stage. Their absence in the Std I learning outcome specifications suggests that children are expected to have acquired these skills prior to entering primary school. This assumption is not supported by data on children's learning.

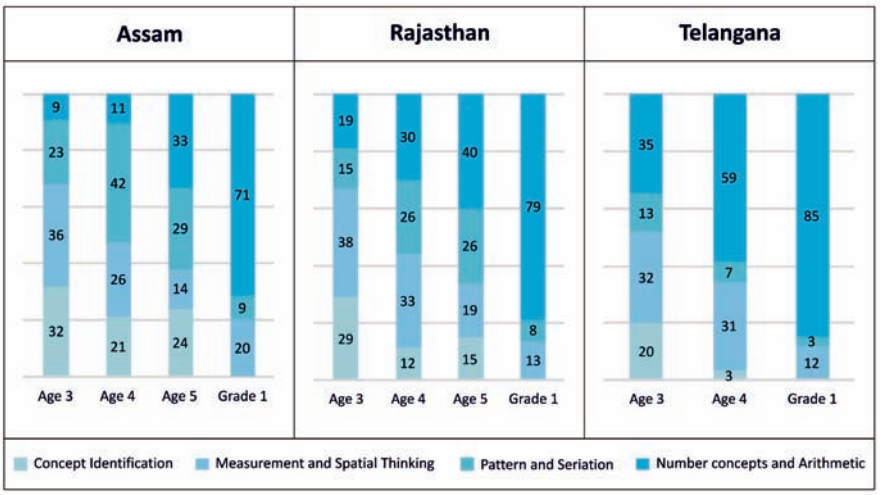
Given that preschool education is not compulsory and is not covered under India's Right to Education Act, the focus on numbers in the Std I curriculum, together with the lack of attention to key pre-numeracy and cognitive domains once children begin formal school, may help to explain why children begin to fall far behind official curriculum expectations as soon as they enter school. (Kaul et al. 2017)

[1] 'Vidya Pravesh', a 3-month play-based school preparation module for Std I students released in 2022, aims to bridge these gaps. See https://ncert.nic.in/pdf/vidyapravesh.pdf

Approaches to early numeracy across States

The three States covered in this study treat early mathematics topics and domains differently in each preschool year and in Std I (Figure 1).

Figure 1: Distribution of different early numeracy and mathematics domains in preschool and Std I learning materials across sampled States (%)



Differences are observed with respect to the amount of exposure given to a given topic and domain, as well as to the pace at which new topics are introduced, which in turn influence the scope for revisiting topics that were introduced earlier. For example,

- In both Assam and Rajasthan, at age 3 and 4, activities for children focus largely on non-number related topics and domains such as concept identification, spatial thinking, measurement, pattern, and seriation. In Telangana, on the other hand, workbooks for these years focus more on the number domain, along with topics related to spatial thinking and measurement.
- For the number concept and arithmetic domain, the jump between the last year of preschool and Std I is huge in all States. Compared to the books for the last year of preschool, Std I maths textbooks leap from 7 to 75 pages of content in Assam, from 19 to 82 pages in Rajasthan, and from 55 to 114 pages in Telangana.
- In consequence, there is far less attention to concept identification, pattern, seriation, and other topics and domains in early mathematics, with 71% of the Std I maths textbook chapters in Assam, 79% in Rajasthan and 85% in Telangana covering number and arithmetic related topics.
- Workbooks in different States cover similar topics differently. For example, within the number domain, the workbook for age 3 in Assam only introduces quantity comparisons; the workbook in Rajasthan introduces quantity comparisons and counting up to 5; and Telangana goes even further, introducing quantity comparisons, counting, as well as number recognition of numbers 1 to 3. Similar variations are visible in other domains as well.

Once formal schooling begins, fewer differences are visible across States. The Std I maths textbooks in all three States focus heavily on number concepts and arithmetic, with far less attention to other dimensions of early numeracy (see also Table 3 below).

Table 3: Std I textbook content in relation to topics covered at the preschool stage, by State

Domain	Topic	Assam	Rajasthan	Telangana
Numbers	Quantity Comparison	Missing	Revision	Missing
	Counting	Revision	Revision	Revision
	Number Recognition	Revision	Revision	Revision
	Number Operations	New	New	Continuation
	Money	New	New	New
Pattern and Seriation	Classification	Missing	Missing	Missing
	Functional Association	Missing	Missing	Missing
	Pattern	Continuation	Continuation	Missing
	Seriation	Revision	Revision	Continuation
Measurement and Spatial thinking	Measurement	Gap	Gap	Continuation
	Position Location	Gap	Revision	Revision
	Shapes	Continuation	Missing	Revision
	Maze	Missing	Missing	Missing
Concept Identification	Concept Identification	Missing	Missing	Missing

Revision: The topic in the Std I textbook begins by revisiting concepts covered in the year immediately preceding Std I.

Continuation: The topic in the Std I textbook does not revise previous content, but builds on content covered at the preschool stage, i.e. it presumes learners have acquired adequate familiarity with the topic.

Gap: The topic is addressed in the Std I textbook after a gap of one or more years, indicating some exposure at the preschool stage but not in the year immediately preceding Std I.

Missing: The topic is not addressed in the Std I textbook, but is addressed at the preschool stage.

New: The topic in the Std I textbook is not introduced in any preschool year.

This analysis suggests that:

- Although the materials reviewed here form only a part of the learning and teaching process, they evidence considerable variation in how States approach early numeracy teaching and learning. Differences are observed in relation to: the age at which topics are introduced; how topics progress across years, both within the preschool stage as well as at the point of transition to primary school; and the pacing of topics, which in turn shape the available opportunities for revision and recap.
- States have different ways of envisioning the best approach to building early mathematics skills among preschool children, but there is broad consensus that formal mathematics should be the focus as soon as children enter primary school.
- By Std I, the focus on numbers and formal mathematics is clear. But prior to this point, children's level of preparation for this transition is uneven across the country, even among those children who are able to enrol in preschool for the nationally prescribed three years. States vary in terms of ensuring that there is scope to revisit or reinforce key pre-numeracy concepts and mathematical skills when children enter primary school.

Alignment of State-level materials with national Learning Outcomes

A comparison across States for each domain and topic covered in early mathematics shows that while most learning outcomes for the topics of numbers, shapes, and functional association are fully addressed in preschool, many learning outcomes for other topics are either not addressed or are partially addressed. There are also examples of content that goes beyond the level of difficulty specified in the national framework, raising concerns about including content that is not age appropriate, and the effects of doing so on children's foundational mathematical understanding and its later development.

This analysis shows that:

- *State workbooks and textbooks do not always incorporate the learning outcomes specified in the national framework.* For example, the specification of early numeracy outcomes for Std I requires that children be able to 'estimate and measure short lengths using non-uniform units like a finger, hand span, length of a forearm etc.' While Std I maths textbooks in Assam and Telangana contain activities designed to achieve this outcome, the textbook in Rajasthan does not. There are also instances where the learning outcomes are clearly specified but are not fully covered in the books. For example, preschool learning outcomes for age 4 specify that children should be able to classify objects on the basis of two categories, but both the Assam and Rajasthan workbooks for this age only cover classification on the basis of one category and the topic is missing altogether in the Telangana workbook. There are many other examples.
- *State workbooks and textbooks sometimes introduce content that is more difficult than the level specified in the national Learning Outcomes framework.* For example, the topic of Location-Position within Spatial Thinking is not mentioned in the NCERT preschool curricular outcomes (NCERT 2019) but is covered explicitly in preschool workbooks in all three States. Similarly, while the topic of one-to-one correspondence in the number domain mentions numbers up to 5, workbooks in Telangana and Assam cover this topic for numbers up to 9 and 10 respectively, which is higher than the national curriculum expectation.
- *The specification of learning outcomes in the national framework is, on occasion, overly generic, inviting varying interpretations.* For example, under 'measurement', the NCERT preschool learning outcomes include 'concept formation of distance, measurement, size, length, weight, height, time, etc.' for preschool ages 3-6. Absent greater specificity regarding what children should understand at (for example) age 3 versus age 6, State workbooks vary in how they interpret this outcome. Similarly, for the topic of shapes, while the national document only specifies one outcome, 'identification of shapes', for all three preschool years, the workbooks in the focal States show considerable variation in the types of shapes covered at different stages.

The learning continuum for early years mathematics

The NEP 2020's ideation of a 'foundational' stage, encompassing three preschool years and the first two grades of primary school, is an important first step in the provision of a continuum of learning for young children in India. A new curriculum for this first stage of education can remove some existing barriers to continuity in early mathematics content across this stage. This analysis shows that:

- Intended pre-mathematics and early mathematics learning outcomes specified at national level for the years and grades covered by the foundational stage are not always clearly defined, nor do they consistently build upwards from the envisaged abilities of the youngest children.
- States vary considerably in the extent to which they follow national guidelines and the ways in which these are interpreted, sometimes exceeding the national framework and at other times failing to address all of the content specified.
- The range of topics in key learning domains for mathematics is differentially addressed and does not ensure that all learners are exposed to the full range of skills and knowledge needed to establish firm foundations in mathematical thinking and problem-solving.
- Regardless of the diverse ways in which State materials differ from national frameworks and also from each other, in all three States included in this study, large gaps are visible between the content transacted in preschool years and the learning expectations for Std I of primary school. A focus on formal mathematics teaching takes place abruptly, as soon as children enter primary school.

Conclusions and recommendations

International evidence on early mathematics learning shows that development of cognitive skills and pre-number concepts such as non-symbolic quantity, patterning and spatial skills, and measurement is predictive of later mathematical achievement. Recent evidence from India, both from large-scale measurements of early learning across the country (ASER Centre 2020) as well as from longitudinal research that tracked children's early learning over a five-year period (Kaul et al. 2017) substantiate these findings.

However, translating these general principles into a set of clear, specific set of materials and activities for children at each age and in each grade is not a simple task. Guidelines in terms of approach, planning, and suggestive activities are available in several documents, including those forming the basis for the current analysis. Additional frameworks include MWCD's National Early Childhood Care and Education Curriculum Framework (2014), Save the Children's Emergent Literacy and Math toolkit (2016), and most recently UNICEF's Guidelines for the Design and Implementation of Early Learning Programmes (2019). These frameworks differ in terms of detail but broadly agree on principles and practices to be followed in early years classrooms.

Incorporating these conceptual ideas into a set of age and grade specific curricula for the new foundational stage of education proposed by the NEP 2020 requires three key general principles to be followed:

- First, curricular design should map onto a set of clearly specified learning and teaching expectations that fully and coherently reflect the proposed continuum, beginning from the abilities of the youngest children and building upwards.
- Second, learning and teaching materials (workbooks at the pre-primary stage and textbooks from primary school onwards) should map coherently and consistently onto this curricular framework.
- Third, these design principles should be contextualised to reflect the enormous diversity in children's age and home background (including linguistic differences). Further, at present, many children do not attend pre-primary grades for the envisaged three years. This implies building in opportunities for frequent review and revisiting of topics in different ways, rather than establishing a linear pathway through the content to be covered.

Acknowledgements

The research team for the Pathways to Numeracy study comprised Prof. Caroline Dyer (University of Leeds, UK); Dr Suman Bhattacharjea, Purnima Ramanujan, and Aashna Khurana (ASER Centre, India); and Dr Ben Alcott (University College London, UK). The study is funded by the UK's Economic and Social Research Council under its GCRF NGO Secondary Data Analysis 2019 programme (https://esrc.ukri.org/research/our-research/secondary-data-analysis-initiative/) (# ES/T010479/1).

References

ASER Centre (2020). Annual Status of Education Report (Rural) 2019 'Early Years'. New Delhi: ASER Centre.

Desoete, A., Stock, P., Schepens, A., Baeyens, D., & Roeyers, H. (2009). Classification, seriation, and counting in grades 1, 2, and 3 as two-year longitudinal predictors for low achieving in numerical facility and arithmetical achievement. Journal of Psychoeducational Assessment, 27(3), 252-264.

Government of India. (2020). National Education Policy. New Delhi: Government of India.

Jordan, N. C., Kaplan, D., Locuniak, M. N., & Ramineni, C. (2007). Predicting first-Std math achievement from developmental number sense trajectories. Learning Disabilities Research & Practice, 22(1), 36-46.

Kaul, V., Bhattacharjea, S., Chaudhary, A. B., Ramanujan, P., Banerji, M., & Nanda, M. (2017). The India Early Childhood Education Impact Study. New Delhi: UNICEF.

National Council for Educational Research and Training (2019). The Preschool Curriculum. New Delhi: NCERT.

National Council of Educational Research and Training (2017). Learning outcomes at the Elementary Stage. New Delhi: NCERT.