

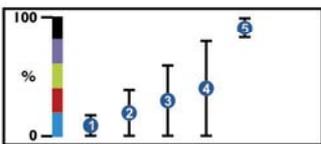
Scale Anchoring

El Working Paper Series - Issue 10

SLS 2009 Knowledge and Ability Benchmarks



Percentage of Students Reaching SLS 2009 National Benchmarks								
Subject	Percentages of Students Reaching National Benchmarks				Advanced Benchmark	High Benchmark	Intermediate Benchmark	Low Benchmark
	Language 4	[Stacked bar chart showing cumulative percentages]				10.1	26.0	55.1
Language 6	[Stacked bar chart showing cumulative percentages]				15.0	27.6	51.0	76.3
Language 8	[Stacked bar chart showing cumulative percentages]				14.2	28.0	52.1	77.4
Maths 4	[Stacked bar chart showing cumulative percentages]				6.9	21.1	47.2	73.2
Maths 6	[Stacked bar chart showing cumulative percentages]				10.5	30.0	59.2	84.3
Maths 8	[Stacked bar chart showing cumulative percentages]				16.6	32.1	58.9	82.1



Graph above shows the cumulative percentage of students reaching each benchmark.

1. Percentage of students at or above **Advanced** Benchmark.
2. Percentage of students at or above **High** Benchmark.
3. Percentage of students at or above **Intermediate** Benchmark.
4. Percentage of students at or above **Low** Benchmark.
5. Percentage of students below **Low** Benchmark.



We acknowledge the support given by the states for conducting the study.

Educational Initiatives (EI) believes that significantly improved student learning can happen only through systematic research into learning which includes assessment, as well as areas like misconception research. This working paper series will share learnings from various past and present EI projects as well as path-breaking work in these areas elsewhere in the world. Please write to us at assessment@ei-india.com for questions or comments.



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■ WHY THIS IDEA HAS LARGER RELEVANCE

Angoff (1984), writing about test scores and interpreting them, said that the test user needs to understand the meaning of the score itself and what it represents.... And, clearly, meaning is essential; for, without meaning the score itself is useless; and without a meaningful score to transmit the value of the test performance, the test ceases to be a measuring instrument and becomes merely a practise exercise for the student on a collection of items.

Most achievement studies provide a means to compare groups of students across assessment years and across multiple criteria such as different regions, types of schools, etc. Such studies normally stop at reporting student average scores or percentages of students responding with correct answers. Sometimes, the performance of individual students is described in percentile scores, i.e., relative to other students taking the test. A few others report the scaled scores of ability derived through applications of item response theory. However, all these methods do not inform about the type or level of achievement that characterise the performance of students at different levels on a scale of scores. In order to start a meaningful dialogue and bring about change in student learning, it is imperative that we start constructing meaning for the scores by describing the benchmarks of achievement in terms of what students know and are able to do.

Student Learning Study (SLS) is a benchmarking study of student learning conducted by Educational Initiatives (EI), with financial support from Google.org, USA. The study has been carried out in 48 districts in 18 states and one Union Territory of India. About 1.6 lakh students studying in classes 4, 6 and 8 in 2399 selected government schools were tested in Language and Maths through common test papers in 13 language versions.

Student Learning Study is the **first comprehensive national study** of Indian states that attempts to explain the performances in terms of **what students know and are able to do** at each of the **SLS 2009 national benchmarks of achievement** – 90th percentile (advanced), 75th percentile (high), 50th percentile (intermediate), and 25th percentile (low). As per global practices followed in international studies such as Trends in International Mathematics and Science Study (TIMSS) and Progress In Reading Literacy Study (PIRLS), the Knowledge and Ability benchmarks in Language and Maths for classes 4, 6 and 8 have been derived using the **scale anchoring** methodology.

■ WHAT IS SO SPECIAL ABOUT SCALE ANCHORING

Classroom experiences, as well as assessment results, clearly show that students perform at different levels of achievement. Students can even be grouped based on their levels of performance. Neither of these, however, provides concrete steps on what can be done to help students performing at lower levels. If we could know whether there are specific topics or concepts which students at lower levels of learning are systematically answering incorrectly, and if so, what they are, then remediation could focus on those topics. That is what Scale Anchoring provides, in an extremely scientific manner. The results clearly show which concepts or topics are understood only by students performing at higher levels and which topics are understood by other students also. Certain topics are said to 'anchor' at certain percentile levels of performance. Insights provided by the Scale Anchoring process can help us understand the way children learn, and plan scientific remediation.

■ METHODOLOGY OF SCALE ANCHORING

Scale anchoring method has been used to summarize and describe student achievement at each of the SLS 2009 national benchmarks¹ – 90th percentile (advanced), 75th percentile (high), 50th percentile (intermediate), and 25th percentile (low). This meant that these points along a scale were selected as anchor points. The items that students, who scored at each anchor point, could answer correctly (with a specified probability) were then identified and grouped together. Subject-matter experts reviewed the items that "anchored" at each point and delineated the content knowledge and conceptual understandings each item represented. The item descriptions were then summarized to yield descriptions of what students scoring at the anchor points are likely to know and be able to do.

Scale anchoring is a two-part process. First, the achievement data is analysed for each scale to identify items that students scoring at each anchor point answer correctly. Second, subject matter experts examine the knowledge shown by correct responses to the anchor items, summarise students' understandings for each anchor point, and select example items to support the descriptions.

An important feature of the scale anchoring method is that it yields descriptions of the knowledge and skills of students reaching certain performance levels on a scale, and that these descriptions reflect demonstrably different accomplishments from point to point. The process entails the delineation of sets of items that students at each anchor point are very likely to answer correctly and that discriminate between performance levels. Criteria are applied to identify the items that are answered correctly by most of the students at the anchor point, but by fewer students at the next lower point.

-'Describing International Benchmarks' -TIMSS technical report 1999, page 267

¹ SLS 2009 benchmark refers to the benchmark computed using the combined data from the 18 States and IUT that participated in the study.

■ WHAT ARE 'SLS 2009 KNOWLEDGE AND ABILITY BENCHMARKS'?

SLS 2009 knowledge and ability benchmarks describe learners' performance at different points on the achievement scale. This is done following the Scale Anchoring methodology. In the scale anchoring technique, as a first step, results of all learners across the country were pooled at the low, intermediate, high and advanced percentiles, so the benchmark descriptions refer to all learners achieving that level. For example, as seen in the table below, in Maths 4 test, students scoring between 614 and 638 are grouped under the advanced benchmark.

Percentile scores and corresponding Student Ability Scores in the IRT Scale

	Percentile Score	Language 4 Scaled Score*	Language 6 Scaled Score*	Language 8 Scaled Score*	Maths 4 Scaled Score*	Maths 6 Scaled Score*	Maths 8 Scaled Score*
Low	23.0 – 27.0	402 – 410	432 – 448	424 – 439	432 – 445	426 – 439	421 – 434
Intermediate	48.0 – 52.0	492 – 508	511 – 522	500 – 510	499 – 508	496 – 506	493 – 503
High	73.0 – 77.0	575 – 587	568 – 574	566 – 578	561 – 573	561 – 574	561 – 575
Advanced	88.0 – 92.0	625 – 644	597 – 618	618 – 638	614 – 638	618 – 642	622 – 646

Note: * Student ability scores based on IRT scaling. Scores were scaled to a mean score of 500 and SD of 100 as per internationally accepted conventions.

The chart below shows what students reaching the advanced, high, intermediate and low benchmark know and are able to do in class 4 Maths across the country in government schools. 'Appendix C: SLS 2009 Benchmarks' in the Student Learning Study report provides similar benchmarks for Maths 6, 8 and language 4, 6 and 8. The report can be downloaded at <http://www.ei-india.com/research-student-learning-study/>

Advanced Benchmark (students reaching 90th percentile)

90th Percentile IRT Scaled Score: 626

Students understand the concept of place value and know that a 3 digit number can be represented in expanded notation as a sum of the number of hundreds, tens and ones in it. Students understand the concept of multiplication as repeated addition and are able to equate multiplication of 2 numbers as the number of times another number is added. Students know how to form groups of equal numbers out of a given set of an object. Students understand half represented as a fraction and know that it is one out of 2 equal parts and are able to identify the correctly shaded figure based on this. Students can visually identify simple geometrical shapes such as triangles, in a tilted orientation based on their understanding that it is a shape enclosed by 3 straight lines. Students are able to perform conversions between simple units of measurement such as millimetres and metres. Students are able to evaluate and choose the correct mathematical operation to be applied to solve a word problem which requires multiplication of 2 single digit numbers.

High Benchmark (students reaching 75th percentile)

75th Percentile IRT Scaled Score: 568

Students are able to write the number names for 2 digit numbers when their numeral forms are given. Students know the value of single digit whole numbers and are able to identify the greater and lesser numbers. Students are able to identify and count different objects separately and can compare their quantity. Students can perform subtraction of a smaller 2 digit whole number from a larger 2 digit whole number that ends in zero, placed vertically and involving borrowing. Students are able to identify a 3 digit number that is less than another 3 digit number when the difference is given. Students know the arithmetic operation of division and are able to perform simple division of a two digit number that ends in a zero, by a 1 digit number. Students understand parts of a whole and can visually identify equal parts. Students understand the sign of equality and the concept of equations. They are also able to apply simple arithmetic operations in solving equations.

Intermediate Benchmark (students reaching 50th percentile)

50th Percentile IRT Scaled Score: 504

Students are able to write the numeral form of 3 digit numbers when their number names are given. Students can recognise missing numbers in an ascending sequence of 2 digit numbers greater than 20. Students can perform multiplication of a 2 digit number with a 1 digit number, not involving carry over. Students understand the concept of half as a number divided by 2, for example they know that in a group of same objects, 3 out of 6 is half the number of that object. Students are able to recognize patterns in sequences involving shapes. Students are able to apply subtraction operations appropriately and successively in word problems. They are able to represent 'nothing' that remains after the subtractions as a 'zero'. Students are able to apply the appropriate mathematical operation in word problems involving day-to-day life situations such as finding the age of a person from that of another person when the difference is known.

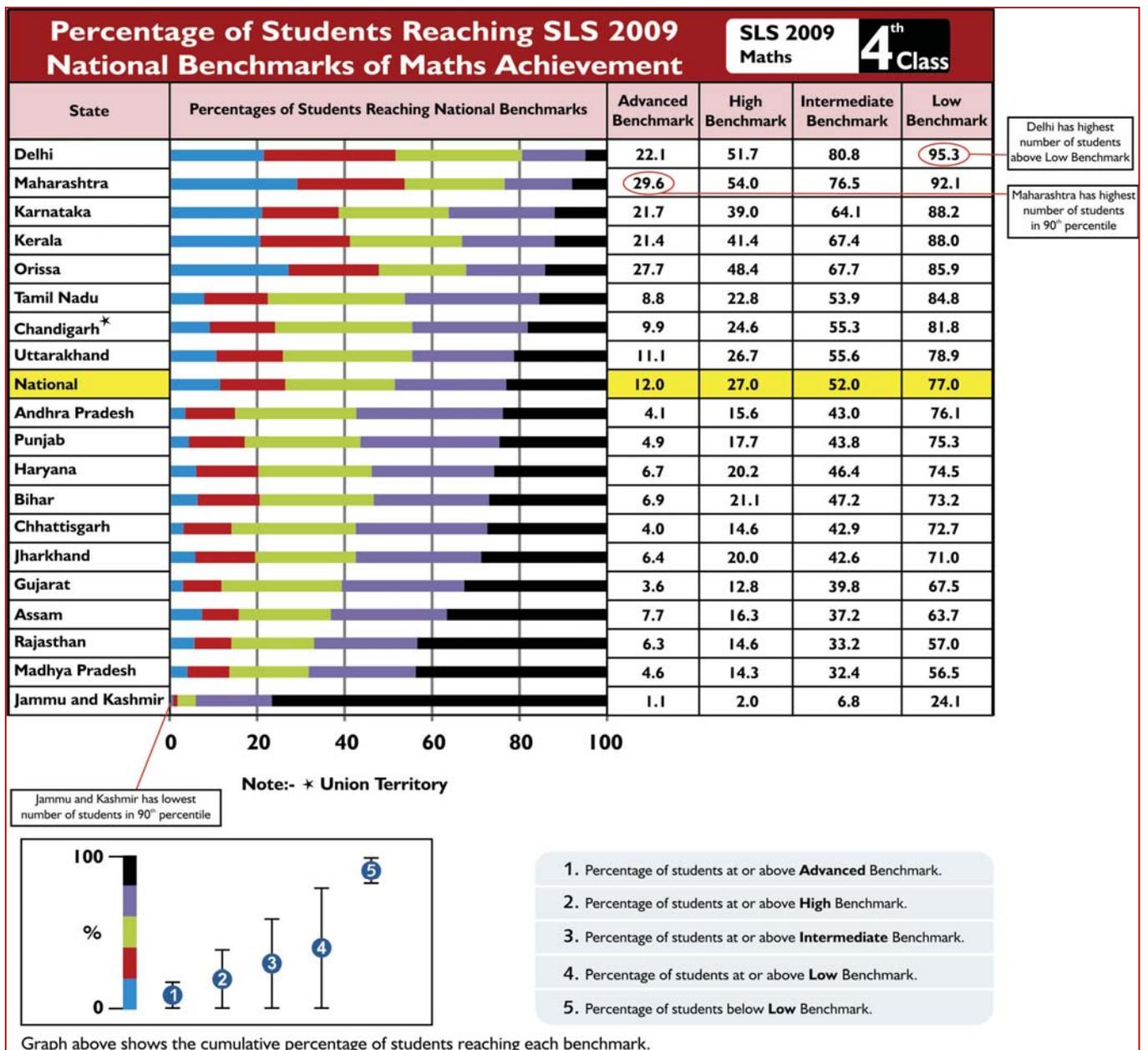
Low Benchmark (students reaching 25th percentile)

25th Percentile IRT Scaled Score: 439

Students write the numeral form of 2 digit numbers when their number names are given. Students know 2 digit numbers less than 20 and can identify a number that is missing from a sequence of consecutive numbers. Students complete the missing numbers in a descending sequence of 2 digit numbers less than 20. Students know the arithmetic operations of addition and subtraction and are able to carry them out for 1 digit numbers, placed vertically. Students do addition of two 2 digit numbers, placed vertically and involving carry over. Students do subtraction of 1 digit numbers from 2 digit numbers, placed vertically and not involving borrowing. Students know the arithmetic operation of multiplication and are able to perform the same for 1 digit numbers, placed horizontally. Students identify similarities and differences visually, between different 2D shapes. Students understand fractional quantities such as half written in a word form as one out of 2 parts and apply them practically in their daily context. Students read time from a traditional analog clock. Students are familiar with the traditional currency denominations and can perform simple addition of the same. Students can read the price tags of objects whose values are represented by 3 digit numbers, to find the one which costs the least. Students understand word problems based on counting the number of objects present in loose and in bundles of ten.

HOW DIFFERENT STATES ACHIEVE THE SLS 2009 NATIONAL BENCHMARKS

The graph below describes how different states performed in respect of reaching the SLS 2009 National Benchmarks of achievement for class 4 Maths. The states are sorted / arranged in the rank order of performance at the low benchmark level i.e., sorted based on the percentage of students at or above 25th percentile in each state. The section of each bar that is coloured black indicates the number of students who fail to reach the low benchmark. While the graph is arranged to draw particular attention to the percentage of students failing to reach even the low benchmark, it also conveys information about the intermediate, high and advanced learners.



The graph shows that the profile of performance of each state varied widely. Jammu and Kashmir, Madhya Pradesh and Rajasthan have the maximum number of students who fail to reach the low benchmark, as could be seen from the extent of the black coloured section of their bars. Maharashtra has the maximum number of students (29.6%) reaching the Advanced Benchmark and also has fewer students failing to reach the low benchmark (i.e., 92.1% are above low benchmark); Jammu and Kashmir, Gujarat, Chhattisgarh and Andhra Pradesh have a negligible number of students (1.1%, 3.6%, 4.0% and 4.1% respectively) in the Advanced Benchmark. At the national level 33.0% of students are below the low benchmark and about 12.0% of students reach the advanced benchmark. 'Appendix C: SLS 2009 Benchmarks' in the Student Learning Study report provides similar benchmark graphs for Maths 6, 8 and language 4, 6 and 8.

An Example of What Students Reaching Low Benchmark in Maths Class 4 Knows and Are Able To Do

Class 4 Maths

Write the number that comes between:
18, _____, 20

Students reaching the low benchmark know 2 digit numbers less than 20 and are able to identify a number that is missing from a sequence of consecutive numbers.

■ USE OF BENCHMARK INFORMATION FOR POLICY

Educational reform is a complex process and requires a focussed and consistent approach to bring about change. Often the various stakeholders are unable to decide where to prioritise their time and resources for lack of availability of data. For example, **a policy maker deciding about the training required for teacher education, may need information on which subjects and concepts need the most attention.** The policy maker would like to know if training needs to be provided for all concepts or if there a way in which the concepts requiring the most attention for a state/district can be identified and targeted. Let us see a few cases of how the information can be used.

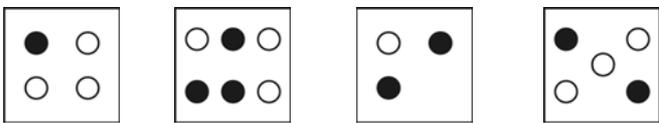
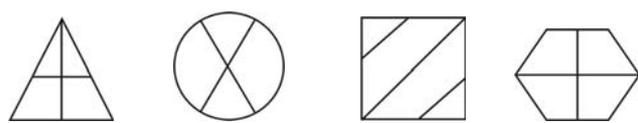
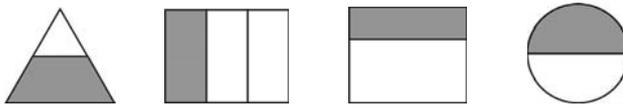
CASE 1: For example, as seen in the class 4 Maths benchmark graph given in the previous section, while 56.5% in Madhya Pradesh reach the low benchmark, the remaining 43.5% are not acquiring the knowledge and skills specified by the low benchmark. The state has to therefore ensure that the teacher training programmes enable and equip the teachers to target the below low benchmark performers to get them into the learning fold.

CASE 2: Similarly, using the graph above, Tamil Nadu may find that in comparison with Orissa it has almost similar number of students who have crossed the low benchmark (Orissa – 85.9%, Tamil Nadu – 84.8%); however, it has a low number of students in the Advanced Benchmark in comparison to Orissa (Orissa – 27.7%, Tamil Nadu – 8.8%). Tamil Nadu may then decide to target improving the number of students reaching the advanced benchmark. The state education officers as a result may focus their training and curricular efforts on bringing the ‘High’ benchmark students (students not reaching the advanced benchmark) to the advanced benchmark level by providing additional learning support for the concepts that form the advanced benchmarks.

Thus **at the policy level, knowing the benchmarks and what percentage of students reach these benchmarks allows decision makers to set their goals on specific target areas for improvement rather than spread their attention wide and lose focus.**

■ DETECTION OF LEARNING PATTERNS

Scale anchoring detects learning patterns by providing information on how students at different ability levels are able to achieve questions of progressive difficulty in a topic. For example, all the questions below that anchored at the different ability levels of Class 4 – Advanced, High, Intermediate and Low - explore the concept of a fraction as understood by students. **It is interesting to note that while the low scoring students (25th and 50th percentile) are able to understand a fractional half as one out of two OR its equivalents (3 out of 6), they have difficulty in understanding equality of parts and do not know that all the parts have to be equal.** The learning patterns detected by the benchmarks show a clear progression in the difficulty faced by students in the topic, providing scope for remediation at the curricular and pedagogy level.

Class-4 Maths		Concept of a Fraction
Low Benchmark (25 th Percentile)	If a watermelon weighs 10 kg, how much will half the watermelon weigh? _____	Students understand fractional quantities such as half written in a word form as one out of 2 parts and apply them practically in their daily context.
Intermediate Benchmark (50 th Percentile)	In which figure are one-half of the dots black? Tick (✓) the answer.  A. B. C. D.	Students understand the concept of half as a number divided by 2 , for example, in a group of same objects, they know that 3 out of 6 is half the number of that object.
High Benchmark (75 th Percentile)	Which figure is divided into four EQUAL parts? Tick (✓) the answer.  A. B. C. D.	Students understand parts of a whole and can visually identify equal parts.
Advanced Benchmark (90 th Percentile)	Which figure is $\frac{1}{2}$ shaded? Tick (✓) the answer.  A. B. C. D.	Students understand half represented as a fraction and understand it as one out of 2 equal parts and are able to identify the correctly shaded figure based on this.

■ UNDERSTANDING LEARNING ACROSS CLASSES

Improving learning is a complex exercise and requires coordinated efforts between the curriculum, pedagogy, training and inputs from assessment. The assessments should be used to inform the curriculum and pedagogy, and changes are to be made accordingly in how the concepts are being taught in class or addressed effectively through textbooks which provide a scaffolding to address the learning gaps. These aid large-scale systemic changes in how well children learn.

Benchmark information provides insights into which concepts are not attained by students even a few years after they have been introduced to them. It is natural to expect that while a concept is difficult for a class 4 student, it will become comparatively easy to a class 6 student and much easier to a class 8 student. In such cases, one would see a question repeated across classes to anchor say at 90th percentile in class 4, then at 75th percentile at class 6 and at 50th percentile in class 8. However, **benchmarking reveals that certain concepts which are difficult and not achievable except by the brightest students in a lower class continue to remain difficult in the higher classes too, indicating that these will largely remain in the future adult population too unless remedied.**

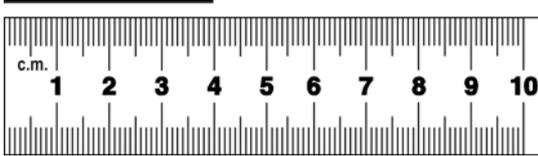
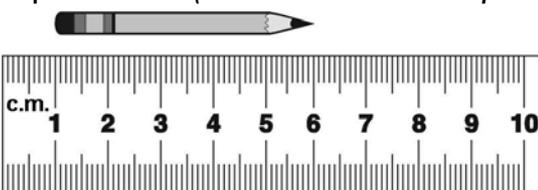
For example, the concept of multiplication below remains achievable only by the students at the 90th percentile in both classes 4 and 6, revealing that the concept has not become easier at class 6 as one would expect.

Class 4, 6 Maths		Concept of Multiplication
Advanced Benchmark (90 th Percentile)	Fill in the appropriate number in the box. $3 \times \square = 3 + 3 + 3 + 3$	Students understand the concept of multiplication as repeated addition and are able to equate multiplication of 2 numbers as the number of times another number is added.

Similarly in language, in class 6 and 8, writing a few meaningful sentences correctly seems to be most difficult and is achieved only by the students who reach the high or advanced benchmark.

Class 6, 8 Language		Writing
High Benchmark (75 th Percentile) (Class 6 Question)	Write 3 sentences about yourself. <hr/> <hr/> <hr/>	Students are able to write 3 meaningful sentences appropriate to the context. Students are able to construct these sentences applying rules of grammar correctly.
High Benchmark (75 th Percentile) (Class 8 Question)	Write 3 sentences about your favourite game. <hr/> <hr/> <hr/>	

Benchmarking also reveals that some concepts although expected to be achieved in class 4, are achieved only by the brightest students in class 8. For example, the question below on measurement was asked in the class 4, 6 as well as class 8 Maths paper, but was achieved only by students reaching the advanced benchmark in class 8.

Class 8 Maths		Measurement of Length
Advanced Benchmark (90 th Percentile)	 <p>The length of the line in the figure above is 4 cm. How long is the pencil shown in the picture below? (Use the ruler shown in the picture.)</p>  <p>_____ cm.</p>	Students understand information presented visually and are able to calculate distance by observing the starting and the ending points and calculating the units of distance travelled between the 2 points. Students can apply their knowledge of measurement to find out the length of a pencil's image using the image of a scale.

Information as above provides clear pointers for focus in textbooks and classrooms to ensure that students learn well.

■ USING BENCHMARK ITEMS IN CLASSROOM

The SLS 2009 report has released benchmark sample questions for Low, Intermediate, High and Advanced Benchmarks in language and Maths for classes 4, 6 and 8. These sample questions are given to show representations of what students in these ability levels are able to achieve.

A teacher can administer or include the sample questions that are released for the different benchmarks in her class tests. This will enable the teacher to check if the students in her class are reaching that benchmark or not.

The sample questions that anchor at different levels in language and Maths for classes 4, 6 and 8 are given in 'Appendix C: SLS 2009 Benchmarks' in the Student Learning Study report. An example is shown below.

SLS 2009 High National Benchmark (582) of Language Achievement - Example Item

An Item That Students Reaching the High National Benchmark Are Likely to Answer Correctly*

Competency: Reads short text of 5-6 sentences that describes daily activity, routine context, simple description, simple story independently and comprehends stated facts

Description: Understanding stories that are read out and answering questions that require drawing straightforward inferences from explicit information

To answer this item correctly, students need to connect the two events the laying of eggs and the baby crocodiles coming out of the eggs. While three months are explicitly mentioned, in connection with hatching, it is only implicitly connected to the laying of eggs.

SLS 2009
Language

4th
Class

State	% Correct	
Delhi	75.2	▲
Kerala	71.8	▲
Maharashtra	70.2	▲
Orissa	69.2	▲
Karnataka	66.2	▲
Tamil Nadu	62.5	▲
Chandigarh *	58.2	▲
Punjab	57.5	▲
Uttarakhand	57.2	▲
National	56.6	
Bihar	55.0	▼
Andhra Pradesh	51.9	▼
Assam	51.3	▼
Chhattisgarh	49.8	▼
Gujarat	48.2	▼
Jharkhand	47.5	▼
Haryana	46.9	▼
Rajasthan	41.1	▼
Madhya Pradesh	38.5	▼
Jammu and Kashmir	21.8	▼

EXCERPT

Crocodiles lay their eggs and cover them with sand. After three months the baby crocodiles are ready to come out of the eggs.

When do the baby crocodiles come out of the eggs?

A. one month after the eggs are laid

B. two months after the eggs are laid

C. three months after the eggs are laid ✓

D. four months after the eggs are laid.

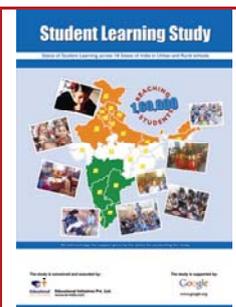
▲ State average higher than national average.

▼ State average lower than national average.

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We are an educational research organization that focuses on learning research through assessments. EI has been started by a group of IIM Ahmedabad alumni with first-hand experience of setting up and running educational institutions. It has been formed with a mission to work towards qualitative improvement in India's educational system and our vision is "A world where children everywhere are 'Learning with Understanding'".

PROJECTS OF EI:

Andhra Pradesh Randomised Evaluation Study (2004 onwards): Done in partnership with Harvard University, Azim Premji Foundation, World Bank and the Government of Andhra Pradesh, this is a longitudinal study across 8-9 years and covers currently 100,000 elementary school kids and measures the impact of various inputs (e.g., block grants, additional teachers) with outcome-based teacher incentives.

Assessment of Student Learning in Sarva Shiksha Abhiyan – RGSM, Chhattisgarh (2008 onwards): The test was developed in Hindi and administered to approximately 3 lakh students in about 1900 schools in 16 districts in Chhattisgarh states. The tests have already been conducted for students of class 3 to 8 for Language and Maths and the report submitted to RGSM.

Municipal School Benchmarking Study (2004-2007): Supported by ICICI Bank, this study assessed learning in 35,000 municipal school students from class 2, 4 and 6 across the 6 biggest towns in five states- Gujarat, Andhra Pradesh, Rajasthan, Chhattisgarh and Uttarakhand.

UNICEF Learning Assessment Study for Quality Education (2005-2006): assessed mathematics and language acquisition among primary school children in the UNICEF quality package schools in 13 states of India. The tests were standardised across 9 languages and involved very intricate development cycle involving language experts from all over India.

Teacher Needs Assessment (2008 onwards): is a census study that has been initiated by the Royal Education Council, Government of Bhutan. In this project all teachers of Bhutan are assessed for their general ability, competence in subject knowledge and pedagogical practices.

Bhutan Annual Status Student Learning Study (2008-2009): This study was done in partnership with Royal Education Council and Ministry of Education Bhutan. Nearly 34000 students in classes 4, 6 and 8 are tested for learning in Language, Maths and Science in 424 schools.

EI'S PRODUCTS AND LEARNING SOLUTIONS:

ASSET: is an objective-type, multiple-choice test for students of Classes 3 to 10. It is a scientifically designed, skill based assessment developed in India for Indian schools. It assesses students' level of proficiency in the skills and concepts underlying the school syllabus and provides them feedback about their strengths and weaknesses. Know more about ASSET at www.ei-india.com

Mindspark: is a computer based self-learning programme that helps the child improve her skills. It allows each student to follow a learning path that is based on her need. Mindspark is currently available for Maths for classes 1-10 in English version. Mindspark can be accessed at www.mindspark.in.

Rural Mindspark: Hindi version is currently available on demand for some Maths modules. Contact EI to know more about other language versions and modules.

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