AN ANALYSIS OF EARLY MATHS SKILLS IN INTERNATIONAL SCHOOLS

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Abstract

Introduction: Cambridge Early Years Check Together (Check Together) is a computer-based adaptive assessment designed to find out what children know and can do when they enter EY2. Children in EY2 are normally between 4 and 5 years old. The assessment is carried out on a one-to-one basis with a teacher or other education professional and assesses Early Literacy and Early Maths. The assessment was carried out in Cambridge schools in Cyprus, Indonesia, India, Thailand and Vietnam. The maths section of the assessment covers understanding of shapes, numbers, measure, counting, and simple addition and subtraction.

Method: At the start of the school year in 2024, 1010 students in 33 schools and 5 countries were assessed using Check Together. The results were analysed using Rasch statistics and difficulty values for each question in the assessment were calculated. These results were then used to determine the percentage of children in each country who were able to answer each question correctly. The results from each section of the maths assessment were compared by country.

Findings: Basic maths concepts were similar for schools in Cyprus, Indonesia and Thailand, but the schools in India and Vietnam showed marked differences. Counting ability was well developed in all the samples, although number recognition varied more widely. In some of the data there was a mismatch between the numbers (shown as single, or two digits) correctly identified and counting ability. Identification of shapes, both 2D and 3D was similar across the different countries sampled.

Conclusions: Children are born with an inherent ability to understand numbers. Experiments with very young children show that they are aware of quantity. For instance, they show a reaction where a small number of items changes. Parents too, like to teach their children about early number, perhaps teaching them to count. However, when children start formal schooling, typically a wide range of ability is apparent. It is important therefore, to assess children when they start a new year in school if teachers are to plan their lessons to match the children in their class. The data from the Check Together assessment shows that children across the world respond well to mathematics as a discipline and can demonstrate basic mathematical skills such as digit identification and counting from an early age.

Keywords: Early Maths, Assessment, International education.

1 HOW CHILDREN LEARN ABOUT NUMBER

For many years, trainee teachers and other education professionals were taught the findings of Jean Piaget, an early psychologist. Piaget established ideas around what children are expected to be able to do and the age ranges associated with these milestones. Essentially, Piagetian theory stated that before the age of around seven years, children were in the pre-operational stage and not capable of logical thought [1]. This led psychologists and education professionals to believe that generally, children younger than seven had no pre-formed understanding of number and lacked the capacity to do so. More recent research [2] has proved that assumption not only to be wrong, but that very young children are able to show their numeric fluency in several different ways. Indeed, some authors [3] have shown that even five-month-old infants can display a sense of number, demonstrating surprise when they do not see the quantities they expect to see.

In order to develop an understanding of number, one of the first things children learn is the names of different numbers. In the first stages this is simply putting a name to a shape, as it is in learning letters, but unlike letter acquisition, children quickly learn that the order of the number names also has meaning. This understanding is often consolidated by the use of number lines to teach children to count. When establishing their understanding of number order, young children often exhibit one or both of two behaviours: “skip” and “flurry”. In the skip situation children will miss numbers out when counting, for instance ‘one, two, four, five’. With flurry, children will name two numbers before moving on to the next item, for instance ‘one, two, threefour, five’. When watching young children counting, teachers should

be on the lookout for these behaviours and correct them in order to ensure that the child understands the importance of the 1:1 correspondence between the item and its number name.

The ability to count is fundamental to learning about numbers and one that is established early on. One of the key skills in establishing an understanding of number is the acquisition of the principle of cardinality [4]. This is the concept that when counting, the last number reached is also the size of the set counted. This is vitally important, because until this fundamental skill is achieved, numbers effectively have no meaning other than as labels for specific shapes. Once this cardinal principle has been established though, the discipline (and more importantly, the reason) for counting is established and understanding addition and subtraction becomes a possibility.

Along with cardinality, another skill that is useful, but not essential, for children to learn is the order irrelevance principle [5]. Put simply this means the understanding that they can count a set of items in any order and the number of items in the set will be the same. Another key skill, valued by children and adults alike, is subitising [6]. Subitising is the ability to instantly see the size of a set of numbers without having to count them. The most common representation of this is on the faces of a standard gaming dice. In fact, the layout of dots on a dice (or on a domino, which uses the same layout) can act as a prompt for even larger numbers.

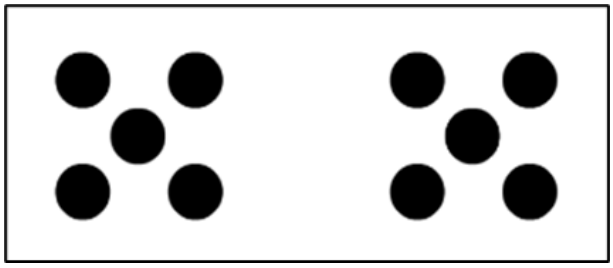

Figure 1. Simple representations of number

A child could recognise the five dot layout and another five dot layout next to it. The child does not have to count ten dots, but simply to add two numbers, five and five to arrive at the total number of dots. In some ways this is analogous to the ability to read words by their shape rather than by sounding out their individual letters.

In the previous paragraph I used the phrase “simply add” as if that was the obvious way to carry out a task, but there has a been a great deal of debate about young children’s abilities to add and subtract [7]. Most young children are introduced to addition (or subtraction) by the use of physical objects, but research [8] has shown that the use of such objects can hinder rather than help by adding a further cognitive load to the task. To the adult, the task is clear, “If I have two plastic teddy bears and put two more next to them, how many do I have altogether?”. To the child, though, the plastic teddy bears themselves may have some intrinsic interest which could cause them to lose focus on the task in hand. To the adult these are just handy objects to count, but to the child who is still trying to make sense of the world, the size, colour or orientation of the teddy bears may be just as important.

Of course, these individual skills are linked. If a child only knows the numbers up to six for instance, they would not be able to count or do simple arithmetic for numbers above six as they would not have the vocabulary to explain it.

These preliminary skills summarise the requirements of the curriculum at this level, but for the early maths student there is still much to learn. Even at this young age, some children show that they can work at a higher level, more appropriate for an older child, but as would be expected the numbers of children displaying these skills is low.

2 CHECK TOGETHER

Check Together is made up of short sections that each assess a different part of the curriculum. Taking about 20 minutes to complete, the assessment is carried out on a one-to-one basis with a teacher or teaching assistant. The assessment is computer adaptive, meaning that the questions it asks are at an appropriate level for the child being assessed. The questions are read out to the child by the software and the child responds by either pointing to the screen or answering verbally. Each question is marked by the teacher or teaching assistant. The maths assessment starts with recognition of simple shapes

and continues through various mathematical concepts finishing with some more difficult additions and subtractions. However, since the assessment is adaptive, only the children who have an exceptional knowledge of mathematics will see the final questions.

The sections chosen for analysis in this study and how they relate to the EY1 Cambridge Early Years Curriculum are shown in table 1.

Table 1. Sections of the Check Together assessment and curriculum links

Section	*How it is assessed*	*Curriculum area*
Shape Recognition	Pointing out common 2D and 3D shapes.	**1Ms.02** Talk about shapes in the environment, using everyday language when shape names are not known.
Ideas About Maths (IAM)	Using comparison words, taller shorter, larger, smaller.	**1Ms.07** Talk about length, mass and capacity in practical activities.
Number Recognition	Naming single digit, two digit and higher numbers.	**1Mn.01** Join in number rhymes and songs and refer to numbers in practical activities. **1Mn.02** Say the number names in order to at least ten.
Counting	Counting increasingly larger numbers of items.	**1Mn06** Count up to at least 5 items (objects or pictures) by saying one number name as they point to, touch or move each item, and knowing when to stop the count. **1Mn08** Recognise small numbers of objects without counting.

3 WHAT IS THE PURPOSE OF A BASELINE TEST?

Check Together is a baseline test, that is, it is a test of prior learning. What is being tested is whatever the student has learnt previously. Teachers will typically use the results of such a test to plan their lessons and to group students who have similar abilities. Since Check Together was designed to support the Cambridge Early Years curriculum, one measure of its efficacy is to compare what students know and can do against the requirements of that curriculum. Students taking Check Together will be starting in EY2 and will have experienced a year in EY1, so it is from the EY1 curriculum that we have to take our requirements.

4 METHOD

Item level data were collected from schools in Cyprus, India, Indonesia, Thailand and Vietnam. In total there were 1010 students in 33 schools. These children all took the assessment at the beginning of the new school year in 2024 and were aged between 4 and 5 years with a mean age of 4.6 years. Check Together is a live assessment used by schools to provide them with useful information about their students. The numbers of children in each country are shown in Table 2. The children from Cyprus had the lowest average age on assessment and those from Vietnam the highest.

Table 2. School summary data

Country	*Number of schools*	*Number in sample*	*Average age at assessment*
Cyprus	2	23	4.3
India	21	817	4.5
Indonesia	3	116	4.8
Thailand	2	30	4.9
Vietnam	1	24	4.9

As may be clearly seen, the results were not evenly spread between the participating schools with the schools in India being overrepresented and the schools in Cyprus and Vietnam least represented. Such an uneven spread of results is not ideal as a basis for a comparison, but since this is a live and comparatively new assessment it does contain the results from all the children who took it in the latter part of 2024.

Sections of the assessment that would be seen by all the children taking the assessment were chosen for analysis. Since the assessment is adaptive, not all children would see the whole test. For instance, if a child showed that they knew only a limited number of digits, they would not be asked any questions that required greater mathematical knowledge such as addition or subtraction.

Rasch difficulties for each item were calculated using the R *mirt* package [9] and percentages were derived from these difficulty figures by using the R *unimirt* package, [10]. The percentages calculated indicated the percentage of children in the sample that could answer the question correctly. The resulting percentages were displayed as bar charts by country. In some cases, the results were compared with a previous study from the UK [11] that analysed over 70,000 results using similar questions.

5 RESULTS

5.1 Shape Recognition

The maths part of the assessment starts with comparatively easy questions around the naming of shapes. If the child is able to name the majority of the 2 dimensional shapes asked, they are then asked to name some common 3 dimensional shapes. Fig 2 shows the results for shape recognition broken down by country.

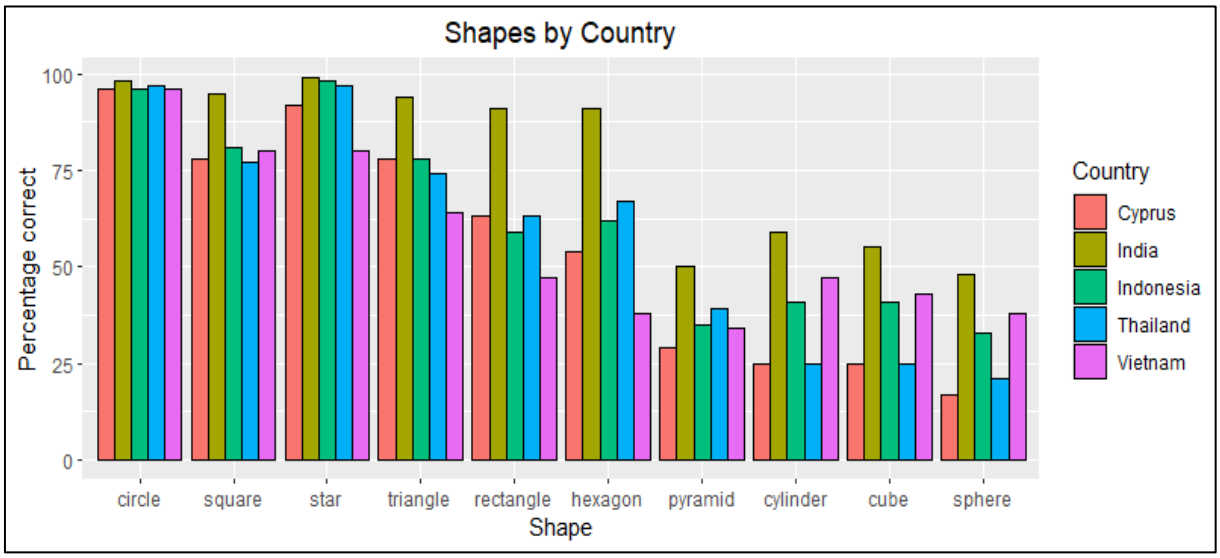

Figure 2. Shape Recognition by country

The majority of the children in each country were confident in pointing to a circle and a star, fewer were capable of recognising a square and a triangle. The children from India were consistently good at knowing all the 2D shapes in the assessment. As would be expected, far fewer children were familiar with 3 dimensional shapes, including the children from India, although they tended to have a greater knowledge than those from other countries. The children from Vietnam showed a strong skill here though.

5.2 Ideas About Maths

Much of early maths involves comparisons between groups and these are explored in the Ideas About Maths section. Fig 3 shows the comparison by country.

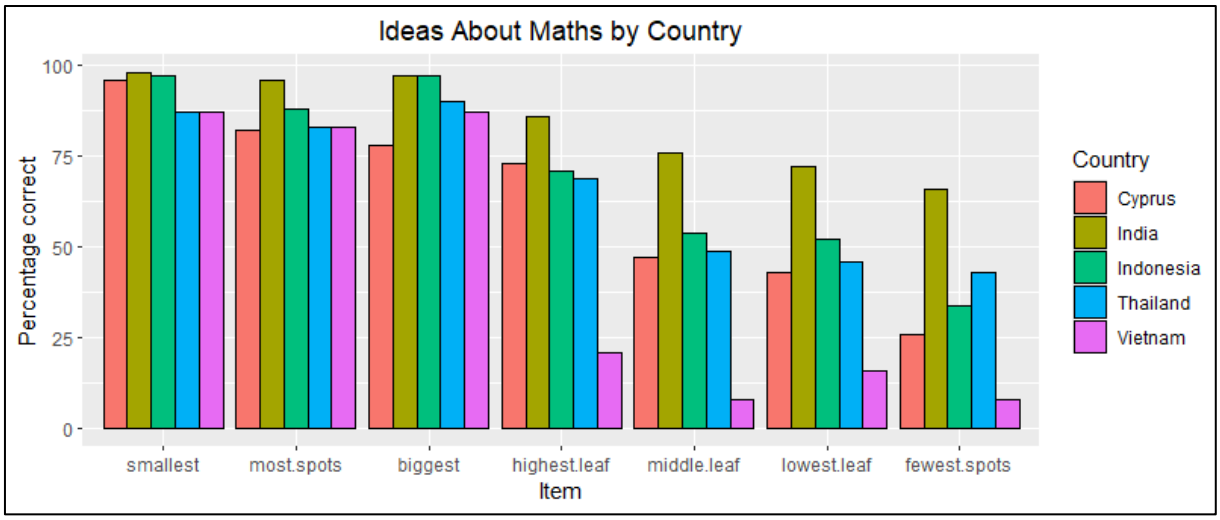

Figure 3. Ideas About Maths by country

Being able to use simple comparison words is fundamental to mathematics, but with young children whose first language is not English it can easily become a vocabulary test rather than a maths assessment. The questions related to small insects ("bugs") sitting on leaves. The majority of children in all the countries in the study could point to the bug that was the smallest, had the most spots or was the biggest. Slightly fewer could point to the bug that was on the highest leaf, but with the exception of the children from India there was less success pointing at a bug on the middle leaf, on the lowest leaf, or that had the fewest spots. This may be due to the words used, lowest, middle or fewest, being less familiar to these children.

5.3 Number Recognition

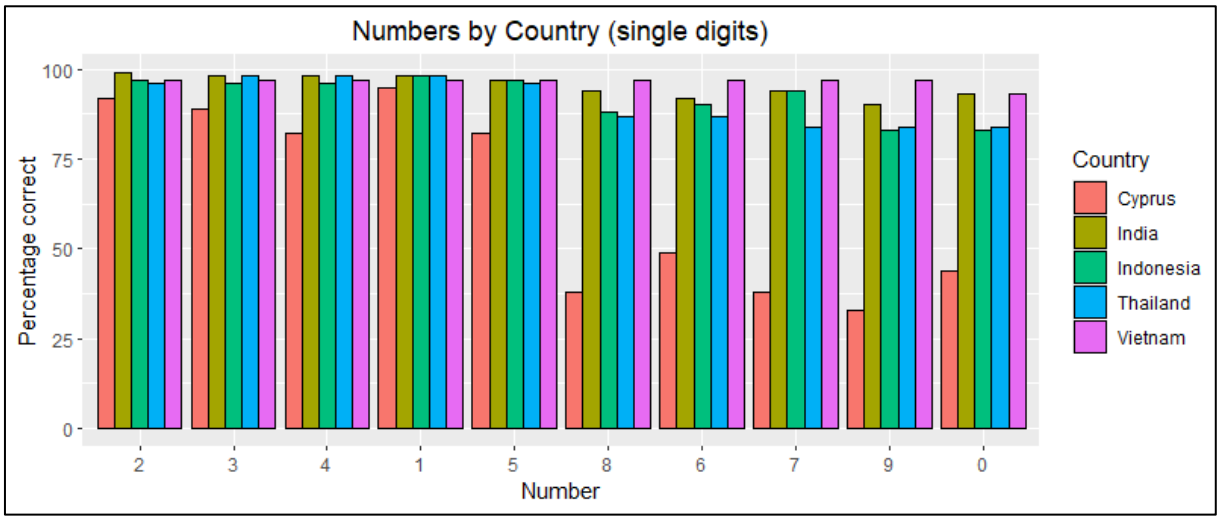

Figure 4. A comparison of first digit naming by country

The majority of children in the sample were able to recognise the numbers from 0 to 9. With the exception of the children from Cyprus who only had a strong understanding of the numbers from 1 to 5. The children from India and Vietnam were particularly strong in this area

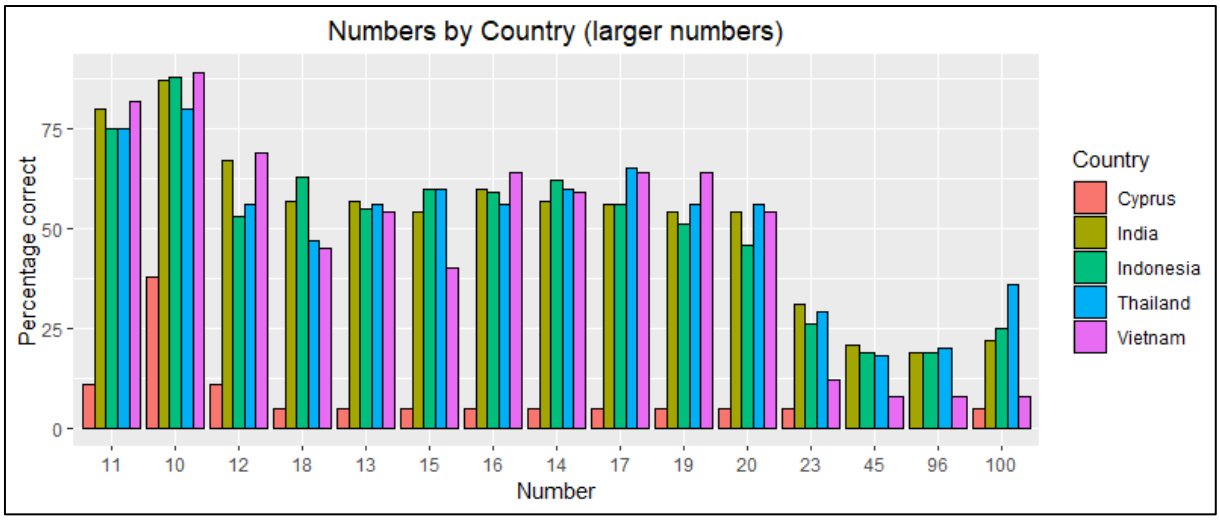

Figure 5. A comparison of two and greater digit number recognition by country

As would be expected of younger children, fewer knew the names of the numbers above 10, although the majority (around 50 to 60%) in the sample knew numbers up to 20. Only around a quarter of the children studied knew any numbers above 20 which again is not very surprising since an understanding of place value is in itself another skill to learn and relies on a strong understanding of the number values from 1 to 9.

5.4 Counting

The Check Together counting task does not use number lines or grids, but instead spreads the items to be counted across the screen. This makes the task harder for the child, but also allows the teacher observing to note the different strategies the child might use to solve the problem.

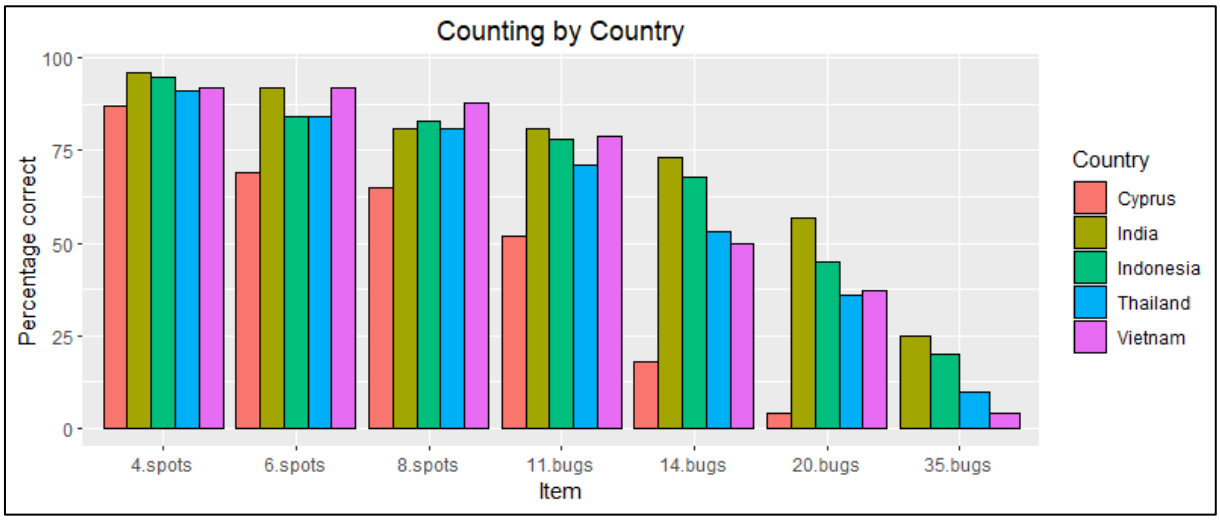

Figure 6. Counting items by country

The ability to count items up to 8 was very strong amongst all the children in the study. Counting numbers of items using two digit numbers tails off in all groups as the children need to bring together their understanding of number, the cardinal principle and the discipline of mentally keeping track of all the things they have counted so far. They also need the vocabulary in order to name these larger numbers. The children from Cyprus show the greatest drop off in this area, but they also showed the least confidence in naming numbers above 10. However, the sample of children from this country is also small compared with the rest of the data. Interestingly, the drop off is not nearly so great with the children from Vietnam and Thailand whose sample size is similar to that of the children from Cyprus, but that may be because they do show a much stronger knowledge of the numbers above 10.

6 CONCLUSIONS

These results do not support Piagetian ideas that children of this age are not capable of understanding number. As the data presented clearly show, young children do know a lot about maths and mathematical concepts when they start in EY2. The majority can recognise the first nine numbers and can count small groups of objects. They generally have good shape recognition skills and are developing their knowledge of 3 dimensional shapes too. This is significant as there is a big difference between recognising 3 dimensional shapes in toys and models and their representation on a 2 dimensional computer screen.

A comparison of the results from this sample with that from a previous analysis of similar questions in a UK sample [11] shows that age plays a large part in the development of mathematical and other learning. In the UK sample, the children were, on average, three to six months younger and their results showed that generally across the sections, age is of major importance. Around two-thirds of children from the UK sample could point to a circle, a star and a triangle when asked and over half the children could recognise the digits 1 to 9. Just over half of the children could count up to 8. In contrast, fewer than one-fifth of children could read simple 3 letter words (p1).

In the UK sample, children may have attended a nursery or similar, or nothing at all. Some of these situations will not have been academically based and the children may not have been encouraged to learn the number names or to count. The way the Cambridge Early Years curriculum is organised means that the children in this sample will also have attended an EY1 class. Since the EY1 class also follows the Cambridge Early Years curriculum those children could be receiving a better start as long as their maturity is such that they can make the most of that opportunity.

The information that the Check Together assessment provides is really valuable information for the teachers of these children. For example, instead of preparing general lessons about number recognition they can target their teaching far more precisely to areas of need for that group of children. However, the data is also limited. It is clear, for instance, that the group of children from Cyprus have a good knowledge of numbers up to 5, but this then drops off with numbers above 5 and which also has an effect on their ability to count. The children from Cyprus are also the youngest in the group, and one of the smallest samples. The groups from the other countries, on the other hand, have a good knowledge of numbers up to 20, but less so with numbers of greater value. This is true, but the numbers of pupils are also very large in comparison. However, regardless of sample size, teachers will find this information extremely valuable. For instance, using this information would allow teachers to group children with similar abilities and target teaching to their needs.

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