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Maths is More than Getting the Right Answer: redressing the balance through observation

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ABSTRACT This article explains how high-stakes standardised tests are distorting primary school mathematics and failing to promote pupils' cognitive development. It argues for observation and journaling for both formative and summative assessment in order to recover an emphasis on reflective mathematical understanding and problem-solving.

In this short article, we want to explore some of the problems with the current approach to assessing mathematics at primary school and how observation of process and product may offer some solutions. First, we would like to start with a personal anecdote from one of the authors which we believe highlights the importance of changing our approach.

> I love maths. I would identify it as my favourite subject without a moment's pause and have spent the last few years not only teaching maths in a primary school but also developing and implementing a new maths curriculum at school level, and coaching teachers in effective classroom practice in mathematics. But I haven't always loved maths.
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> At primary school, I struggled with times tables. Rote learning did not work for me and, no matter how many times I repeated my tables, no matter how many times I was tested or made to recite them, they wouldn't go in. As I fell further and further behind my peers, I became convinced I couldn't 'do' maths. Like many others, I equated 'doing' maths with being able to memorise facts and quickly apply rote methods and, because this didn't come quickly to me, I assumed I just wasn't a 'maths person'.

> These negative feelings would probably have defined my relationship with the subject if it wasn't for a couple of outstanding maths teachers I encountered as I moved through the education system. These were teachers who encouraged me; teachers who taught me to find creative ways to solve problems. Those teachers showed me that there was much more to mathematics than learning (or not learning) times tables and calculation algorithms, and, bit by bit, they developed in me a real love of the subject.
>
> I went on to do Maths and Further Maths at A-level and then to study maths at St John's College, Oxford, before training as a teacher.

Unfortunately, in our test-driven culture, far too many young people have the early experience of maths described above and never recover from it. Negative perceptions of the subject, and negative self-perceptions as mathematicians, are defined early on and reinforced at every stage. While recent shifts in maths teaching, and the preamble at least of the 2014 primary maths curriculum (Little, 2016), are a welcome step towards redefining the subject, primary maths teaching is still driven by the assessment system, which has changed little and not for the better (Ofsted, 2012; Hutchings, 2015). Challenging this deep-rooted problem requires a revolution in the way we assess maths.

What's Wrong with the Current Model of Assessment?

There are numerous problems with the current model of primary maths assessment, and they have been well documented elsewhere (Boaler, 2009, 2016; Hutchings, 2015; Berry, 2016). We want to highlight four particular issues which we believe can be addressed through the use of observation:

- the overemphasis on product and the undervaluing of process;
- the reduction of complexity;
- the promotion of memory over cognition;
- process reduced to sterile procedure.

(i) The obsession with product and the undervaluing of process. This runs throughout our assessment systems. While there is a significant body of research which suggests that a focus on mathematical reasoning is directly linked with long-term success in mathematics (Boaler, 2009), our test-based model prioritises getting the right answer. It is telling, for example, that in the 2016 Key Stage 2 (KS2) tests, only one mark out of 110 was awarded for a written explanation. The other 109 marks were given for a correct numerical answer (Little, 2016). In a small minority of cases, there were marks for working, but only if the approved standardised method was used; if the final answer was correct, full marks were awarded without the requirement to show any method.

Not only does this approach conflict directly with what we know about learning, promoting fixed mindsets among high-achieving and low-achieving students alike (Dweck, 2017), it can also mask significant misconceptions. Consider, for example, what the following tells us about a child's understanding of place value and multiplication: 24 x 10 = 240. Very little, without further interrogation. For example, what rule have they applied to reach the answer? Would it work just as well for 240 x 10? What about 2.4 x 10?

Most importantly, this excessive emphasis on answers promotes an incorrect view of the importance of method among students. If they can find an answer, understanding the process is irrelevant; if they can't find an answer, their understanding of the process is equally irrelevant because they 'can't do it'.

(ii) The reduction of complexity. The second issue is the way in which standardised testing reduces complexity. This happens at every level, from the individual problem upwards. While the very nature of mathematics revolves around the study of complexity and the ability to find patterns and generalise without losing that complexity, this is difficult to assess in a format which only awards marks for correct or incorrect answers. This means that the complex and ongoing process of problem-solving is not adequately replicated in test situations, and therefore in many classrooms as we tend to teach what we know will be assessed, particularly when the tests are high stakes.

As we step back from the classroom, this reduction of complexity is repeated at a second level. In order to make comparison of children easy, their performance in a whole range of mathematical domains (already lacking descriptive quality) is reduced to a single number, usually dominated by calculation. This is repeated at a third level when these individual scores are aggregated at school level to produce (generally statistically insignificant) 'measures' of school performance. By this point, the data are almost completely meaningless, having been stripped of any useful link to children's understanding of mathematics. It is of course these data which are used to decide the future of schools and wider education policy.

(iii) The promotion of memory over cognition. The third issue is the way in which our current assessment system promotes the memorisation of facts and the application of set procedures over conceptual understanding. The lack of attention to explanation and mathematical reasoning in current assessments has already been commented on, but another clear example of this is the proposal to introduce a 'times tables' test at the end of KS2. This is not to say that multiplication facts are unimportant, or that learning them is unhelpful, but the moment you introduce a high-stakes test of something, you send a signal to teachers and pupils that this is what matters most. In this case, you send a signal about the very nature of mathematics. Introducing a high-stakes test of multiplication facts, out of the context of using and applying them or demonstrating fluency with the underlying concept of multiplication, will result in more pressure to rote-learn these facts, rather than to understand the concepts behind them and how to use them in practice. Worst of all, we send a clear signal to those who struggle to memorise facts without meaning that they will never succeed at mathematics.

(iv) Process reduced to sterile procedure. Finally, having been almost entirely stripped out of our measurement, and consequently our teaching, of primary mathematics, process re-enters in its most sterile form – as prescribed method. The replacement in 2016 of the KS2 mental maths test with a written arithmetic test in which marks are only given for working if DfE-approved methods have been used is almost beyond parody. The signal it sends to young mathematicians is clear: 'Follow approved methods and don't think for yourself because that will not be rewarded and may well lead to failure.'

How Does Assessment through Observation Help?

Assessing maths through observation of process and product allows us to reassert the importance of process. By looking not just at whether and when a student reaches a solution but crucially at how they reach that solution, observation gives us a powerful tool to assess the sophistication of children's approaches to problem-solving and identify opportunities to develop this further. An excellent example of this is given in the book *Teaching Fractions and Ratios for Understanding* (Lamon, 2005). Each chapter begins with examples of children's work, which are then analysed in terms of the child's understanding of fundamental mathematical concepts and their approach to problem-solving.

Observation allows us to capture the complexity involved in problem-solving over time. This means using descriptive, rather than numerical or tick-box, records and having a clear system for identifying and recording information about children's approaches. Clearly, this information is more useful than test data in terms of formative assessment but it can also play a key role in summative assessment – for example, as a basis for providing descriptive feedback to parents about their child's progress, or to school management about overall progress across a class.

Observation allows the teacher to focus on what is meaningful and to communicate this to students. Because it is possible to assess process rather than just outcomes, and to obtain real information about a child's conceptual understanding, rather than approximations based on right/wrong answers, assessment through observation allows us to show the student clearly that their understanding matters, not just whether they can apply a fixed algorithm and reach an answer.

Finally, assessment through observation removes the need to use 'approved' methods because interrogation of a child's method and its sophistication and suitability to the problem being approached is fundamental to what is being assessed. This allows a wide variety of methods and approaches to be compared and contrasted, and commented upon, removing the false dichotomy of 'official' (correct) and 'unofficial' (incorrect) methods.

In short, assessment through observation of process and product presents an opportunity to address key weaknesses in the current assessment system and deepen our understanding of children's mathematics.

Observation in the Primary Classroom – Is It Practical?

Observation is clearly fundamental to most teachers' ongoing formative assessment in maths, in either a formal or an informal way, but is it practical as an approach to summative assessment? In short, is it possible to implement structured approaches to observation in the primary classroom that provide opportunities to conduct comprehensive assessment of children's maths using the resources available to most teachers? In this section, we want to look briefly at three approaches, drawn from experience in our Year 5 class over the past year and developed in cooperation with other teaching colleagues. The first is the most pure approach to observation but also the most time-consuming.

Option 1 – Individual Observation

A lot of information can be gained through direct observation of a child working independently on a short problem-solving task. It is important to select an appropriate task – one that requires a student to explore their conceptual understanding and demonstrate key skills and knowledge. Jo Boaler's guidelines on developing rich mathematical tasks (Boaler, 2016, Chapter 5) proved invaluable to us in selecting/designing tasks, as did examples from Lamon (2005) and the NRICH website (nrich.maths.org). We debated and explored two main options for conducting observation: one in which the teacher was an external observer, remaining silent throughout the process so as to follow the flow of the child's thinking; and one in which the teacher acted as a problem-solving partner, using questions to probe understanding and prompt contradictions. The eventual conclusions we came to were that a level of questioning is necessary to obtain the maximum amount of useful information from the process but that the questioning itself needs to be carefully targeted, in order to avoid 'leading' the student's thinking. Our questions tended to be along the lines of seeking clarification or explanation, or prompting the use of practical or pictorial approaches ('Can you draw a picture to show me that?'). This allowed us to maximise the value of an observation without distorting the picture we were seeing too much.

Individual observation provided us with significant insight into children's mathematical thinking but was incredibly time-consuming, involving substantial investment of adult resource. It also required having appropriate alternative tasks for the rest of the class while particular children were being observed. We used this sparingly throughout the year to gain a deeper understanding of where particular children were in their thinking, using it with the entire class on only one occasion.

Option 2 – Whole-class Observation

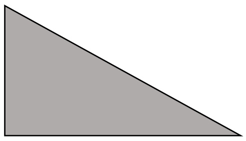
In this option, we chose a series of longer problem-solving tasks, connected by a theme, and used these as the main class work over the course of a week, in order to allow us to carry out observation of a whole class. One example of this was a week-long 'Pirate Treasure' investigation we used at the end of the first half-term of Year 5. Our term's work had focused on factors and multiples, using these to understand prime and square numbers, mental methods for multiplication and division, equivalent fractions, and addition and subtraction of fractions. At the start of the final week of term, the children 'discovered' a coded note in an envelope marked with a skull and crossbones. This was the first in a sequence of clues, each of which led to the next, and which all had to be solved to find the treasure.[1] The children worked in pairs to try to crack the code and were initially told to keep their results to themselves and their partner. Each code was designed so that, once the code itself had been broken (and key mathematical understanding demonstrated), there was still a substantial task involved in decoding the message. This allowed teaching staff to circulate, questioning individual children as they worked in pairs, but also meant that when partial answers were shared as a class through mini-plenaries to bring the group back together in order to ensure no pair was left behind, every pair had already completed the main mathematical task for the day, even if their message was only partially decoded.

Judicious selection of the order in which children were questioned each day, based on the topic of that day's code and the information we already had from the children's previous work, ensured that, through the course of the week, we had assessed every child in all the key objectives for that term's unit of maths, as well as recording a wealth of information on deeper problem-solving approaches, using a combination of observation and prior knowledge from class work. By the end of the week, we could confidently say we had our most accurate assessment data, having interrogated the children's understanding personally, rather than relying on a test. Meanwhile, the children enjoyed what they were doing so much that they didn't realise they were being assessed, and some asked us when they would have to do an assessment week like the other classes!

Option 3 – Journaling

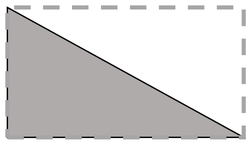
Aware of the time and adult resource implications of assessing through observation, we wanted to experiment with an approach that came as close as we could to observation with the minimum, or at least most efficient, use of adult resource. This we found in journaling, an approach we developed throughout the year and which was a good fit with our school's adoption of a version of the 'mastery' approach to maths teaching (NCETM, 2014). We encouraged children to express their mathematical reasoning through regularly annotating their work with explanations of their thinking. To begin with, this was often forced and in response to direct questions or sentence starters given by the teacher. As the children became more familiar with the process, they began to spontaneously contribute their thinking in written form as part of answering questions and solving problems. On a number of occasions, it was this journaling that uncovered key misconceptions that would have gone undiscovered by assessment based on their answers and working alone. An example of this is shown in Figure 1.

Formula for the Area of a Triangle — Child A



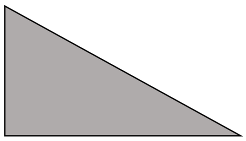
This may look like a triangle but it's not; it's a rectangle but half is invisible and, because it is invisible, it is only half the rectangle.

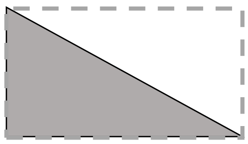
Can you explain why it is a rectangle?



Formula for the Area of a Triangle — Child B

If you want to find the area of a triangle, you first need to multiply the height by the base. That base of the triangle is the long side of the triangle at the bottom. The height is the short side of the triangle that is the tallest. Once you calculate the length of the base and the height of the triangle, you need to multiply the two numbers. Now imagine a rectangle with the same dimensions. The picture shown below shows that the triangle is half of a rectangle with the same dimensions. The product that you got when you multiplied the height by the base is 2 times the area of the triangle. To get the area of the triangle, you need to half that number.





An excellent explanation. Is the base always "the long side"?

Figure 1.

From their prior work, Child A and Child B both seemed to have a secure grasp of calculating area for both rectangles and triangles, getting every question right. It was only when they set out to explain their answers that the difference in understanding became clear. If the learning process had stopped with answers, how likely is it that Child A would retain a secure understanding of how to calculate the area of a triangle? Too often, we hear teachers lamenting that children seem to retain little of what they learn from year to year. This seems unsurprising when what appears to be understanding can actually be built on key misconceptions. After the conversation that followed this lesson, we can guarantee Child A has a secure understanding of how to calculate the area of a triangle and why it works! Similarly, from the numerical answers in Figure 2 alone, we might have had concerns about Child B's understanding of area. The written explanation makes clear this is simply a calculation error.

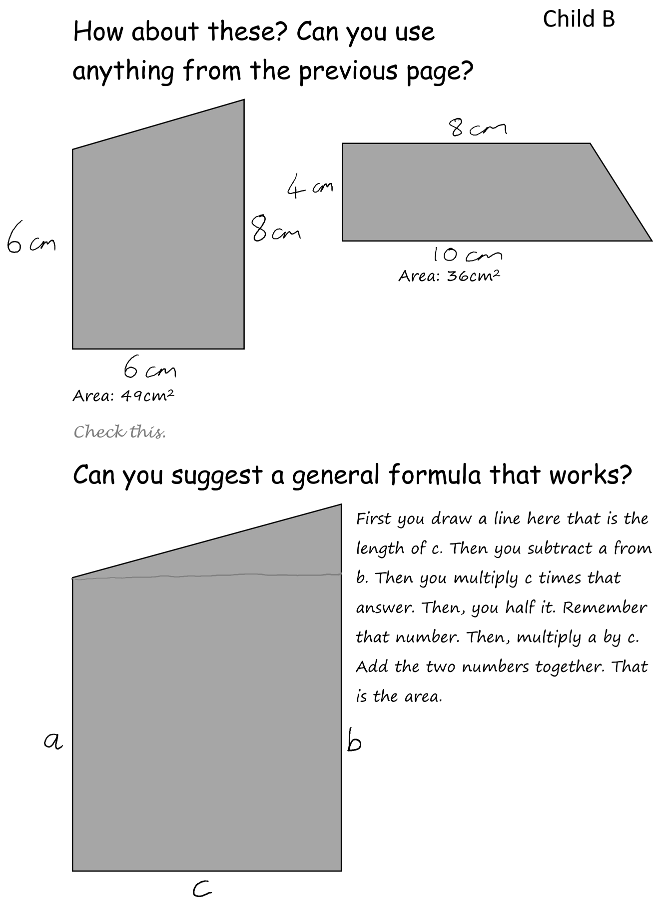


Figure 2.

In addition, the process of journaling allowed the children to see their understanding and grasp of a concept develop over time, giving them increased confidence and helping to build a 'growth mindset', where they believe that their ability in maths can 'change and grow through application and experience' (Dweck, 2017). This was reinforced through a classroom approach that encouraged children to see themselves grow through trying and retrying things, getting further each time; a classroom approach where mistakes mean learning opportunities rather than failure.

Overall, we found journaling to be an invaluable tool in assessing maths through 'observation' (at one step removed) on an ongoing basis throughout the year. It also contributed significantly to the children's ability to explain their reasoning verbally and in writing.

Conclusions

Our experience is that assessment through observation of process and product offers a practical and reliable way of obtaining meaningful assessment information about children's mathematics for both formative and summative purposes. In doing so, it addresses some serious weaknesses of an assessment system based on standardised testing. The system that worked in our class was based on ongoing journaling in combination with assessment weeks using whole-class observation tasks, to produce secure assessment data for the whole class. This was then supplemented by detailed interrogation of individual children's understanding, as necessary on a case-by-case basis, through individual observation using well-chosen tasks and carefully structured questioning.

An independent review of primary assessment is long overdue. It is clear that our current model of assessment, based entirely on standardised testing, is completely inadequate to the task of supporting our children's learning. While observation has its limitations (and resource implications in terms of time and adult availability are key to this), it provides a much more secure basis on which to build our approach to assessing children. This is not to claim there is no role for written tests, whether through a test bank which teachers can use as they see the need or through occasional sample monitoring of teacher assessment, but testing must not continue to dominate learning in maths as it does now. It is time to redress the balance.

Note

[1] A selection of these materials is available at http://www.uniting4education.org/search/label/Maths%20Teaching

References

Berry, J. (Ed.) (2016) *The Mismeasurement of Learning: how tests are damaging children and primary education*. London: NUT.

Boaler, J. (2009) *The Elephant in the Classroom: helping children learn and love maths*. London: Souvenir Press.

Boaler, J. (2016) *Mathematical Mindsets: unleashing students' potential through creative math, inspiring messages and innovative teaching*. San Francisco: Jossey-Bass.

Dweck, C. (2017) *Mindset: changing the way you think to fulfil your potential.* London: Robinson.

Hutchings, M. (2015) *Exam Factories? The Impact of Accountability Measures on Children and Young People.* London: NUT.

Lamon, S.J. (2005) *Teaching Fractions and Ratios for Understanding: essential content knowledge and instructional strategies for teachers.* Mahwah, NJ: Lawrence Erlbaum Associates.

Little, G. (2016) Mathematics: conceptual understanding or counting by the rules? In J. Berry (Ed.) *The Mismeasurement of Learning: how tests are damaging children and primary education.* London: NUT.

National Centre for Excellence in the Teaching of Mathematics (NCETM) (2014) *Mastery Approaches to Mathematics and the New Primary Curriculum.* London: NCETM.

Ofsted (2012) *Mathematics: made to measure.* Manchester: Ofsted.

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