

Beyond quick answers

Encouraging a problem-solving mindset in assessments

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In this edition of Assessment News, Charles Darr uses a case study from the National Monitoring Study of Student Achievement (NMSSA) to highlight how students can benefit from activating deliberate thinking in assessments. The key message underscores the value of using assessment information to generate insights that inform better teaching and learning.

Have a go at this problem.

A bat and ball together cost \$1.10. The bat costs one dollar more than the ball. How much does the ball cost?

Many people say that the ball costs ten cents and the bat, a dollar. That's the intuitive answer—it comes quickly, and it feels right. However, when you do the maths, the intuitive answer doesn't stack up. The ball should cost five cents and the bat, one dollar and five cents.

Shane Frederick, an American psychologist, included the bat and ball problem in a three-question test he called the Cognitive Reflection Test (Frederick, 2005). The other two problems also invited quick intuitive—but incorrect—responses. When the test was used at a range of American universities including Harvard, MIT, and Princeton, Frederick found that many of the students were quick to settle on the intuitive answers rather than do the relatively simple mathematics that would have led to the correct solutions.

In this edition of Assessment News, we look at how encouraging students to activate themselves as problem solvers could lead to deeper engagement and more success in assessment tasks. We start with a quick look at why people are often satisfied with an intuitive

answer when further thinking could be merited.

System 1 and System 2 thinking

Psychologists sometimes use the terms *System 1* and *System 2* to describe two different modes of thinking. The kind of thinking associated with intuitive thought is categorised as System 1. This kind of thinking is unconscious and fast. It also feels relatively effortless. System 2 thinking, on the other hand, is conscious, slow, and deliberate. System 2 requires effort and is tiring. People will often avoid System 2 because of the effort it takes. Nobel prize-winner, Daniel Kahneman (2011), notes that people often resist the cognitive strain that accompanies System 2 thinking, when a System 1 solution is readily available. Both systems, however, are important, and each can complement the other. People can use System 2 thinking to reflect and check on their initial System 1 response.

Thinking in assessments

It is reasonable to assume that students use a mixture of System 1 and System 2 thinking when doing assessments. Knowing how and when to activate a System 2 thought process while doing an assessment

task would be a useful skill for a student to have.

The team involved in the 2022 National Monitoring Study of Student Achievement (NMSSA) considered this recently when they assessed students' ability to answer questions involving fractions.

One of the tasks the NMSSA team developed concerned a problem that had been used in several previous national monitoring studies at Year 8.

$$\frac{1}{2} + \frac{1}{4} =$$

Over the years, many students had struggled to answer this question correctly. In NMSSA's 2018 assessment, for instance, only 32% of Year 8 students in the nationally representative sample responded with the correct answer ($\frac{3}{4}$). Given the relatively simple fractions that are involved and the age of the students, the NMSSA developers believed the students could do better.

Like the bat and ball problem, the $\frac{1}{2} + \frac{1}{4}$ problem suggests an intuitive answer— $\frac{2}{6}$. Students can get to $\frac{2}{6}$ by simply adding the top and bottom parts of each fraction (the numerators and denominators). Many of the Year 8 students who had answered incorrectly in past assessments had written $\frac{2}{6}$ as their answer. The team wondered whether students would reconsider their answer if they were asked to reflect further and hence engage their System 2 thinking.

The student interview

In 2022, the NMSSA team designed a three-stage interview to explore how students answered the problem.

The interviews were carried out by the teacher assessors who visited the schools in the study and involved a portion of the total number of students in the Year 8 sample. About 340 students were interviewed.

In the first part of the interview, students were presented with the fraction problem written on a card. They were given paper and pen and encouraged to write or draw anything that might help them solve it.

Thirty-nine percent of the students answered the problem correctly at this stage. These students explained how they had got their answer and then moved onto a different problem. The students who answered incorrectly went on to Parts 2 and 3 of the interviews.

In the second part, the students were asked to read the problem out loud. This was done to check that they were able to recognise the symbols in the equation. If they showed any hesitancy, they were supported to read the problem. A small number of students adjusted their response at this stage to the correct answer.

In the third part of the interview, the students who were still unable to answer correctly were given the

problem again. This time it was presented orally within a simple context:

You have half a pizza and a friend gives you another quarter of a pizza. How much pizza do you have altogether?

At this point, a further 59 students were able to recognise that $\frac{3}{4}$ was the correct answer. This meant that, in total, about 61% of the students had been able to answer the question correctly, much more than the 39% who got it right at the beginning.

The results of the NMSSA interview suggest that many Year 8 students do have the understandings necessary to deal with $\frac{1}{2} + \frac{1}{4}$. For many, however, this will require knowing how to activate themselves as problem solvers and use some System 2 thinking. This includes reflecting on the meaning of the equation and the reasonableness of their response. Thinking about what the problem could mean in a context is one way of doing this.

What next?

The insights generated through the interview can be used to suggest some teaching responses. One of these involves considering what teachers can do to encourage and model problem solving behaviours. George Pólya, a Hungarian mathematician, described a systematic approach to problem solving that can be helpful here (Pólya, 1945). Pólya identified four main steps that are outlined below in Table 1.

TABLE 1: PÓLYA'S APPROACH TO PROBLEM SOLVING

Step	Description
Understand the problem	Take some time to understand what the problem is about. Restate it in your own words and draw pictures to represent it.
Plan	Think of a strategy or strategies that could be useful. Some strategies include: looking for a pattern making a list or table working backward breaking the problem into simpler parts using symmetry considering extreme cases solving a similar problem.
Carry out the plan	Apply the method and be systematic. Check as you go.
Look back	Review your work. Is the answer consistent with the original problem? Can the answer be generalised?

A "critical mathematics" perspective can be added to Pólya's approach, especially when the problem involves applying mathematics to a real-world problem. Critical

mathematics encourages learners to consider the broader social, political, and cultural implications involved in using mathematics to solve problems. Integrating this perspective as part of a problem-solving process means that learners are encouraged to see mathematics not just as a set of abstract ideas, but as a powerful tool that influences how people interact with and perceive the world around them.

To finish

When we take time to examine why questions can be difficult for students and to interpret what their responses might mean, assessment becomes a stimulus for learning. The insights that are generated can result in feedback to students and changes in the way teaching occurs. As teachers also engage their System 2 thinking about students' assessment results, it allows for better understanding, more flexible thinking, and, ultimately, better learning. Understanding that humans are drawn to quick, intuitive responses invites us to consider how we can encourage students to slow down and take on a problem-solving perspective, especially when in assessment contexts. Pólya's approach and the perspective critical mathematics brings to problem solving provide some starting points for how we might encourage a productive balance of System 1 and System 2 thinking in the classroom, and in assessment.


Notes

NMSSA has developed several resources for teachers that build on insights garnered from student responses to NMSSA assessment tasks. The most recent involve insights around mathematics and health and physical education. These include further information about the fractions task described in this article and can be found at <https://nmssa.otago.ac.nz/reports-and-resources>

This year, the NMSSA study has been replaced by a new curriculum insights and progress study. A major focus of the study is to use national progress and achievement data to generate insights that support teachers and schools.

References

- Frederick, S. (2005). Cognitive reflection and decision making. *Journal of Economic Perspectives*, 19(4), 25–42.
- Kahneman, D. (2011). *Thinking fast and slow*. Straus and Giroux.
- Pólya, G. (1945). *How to solve it: A new aspect of mathematical method*. Princeton University Press.

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