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Self-explanation prompts explained



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Self-explanation prompts are questions that encourage students to explain their reasoning. In this article Kelly, Laura and Julie explain the benefits of using self-explanation prompts for teachers, describe how they align with the Australian Curriculum, and provide instructions for creating them.

Research shows that students benefit when they explain their mathematical reasoning (e.g., Booth et al., 2015); however, not all students will do this on their own without being prompted (Berthold, Eysink, & Renkl, 2009). Self-explanation prompts are questions posed to a student that encourage the student to explain what they have learned (Rittle-Johnson, Loehr, & Durkin, 2017). While self-explanation prompts can be used in a variety of ways in the classroom, this article will focus on the use of these prompts conjoined with worked-examples; in such cases, students are asked to study a worked-example—an example of a potential solution to a mathematics problem that is already completed—and are then prompted to explain the reasoning behind the procedure used to solve the problem (see Figure 1 for an example). These worked-examples and self-explanation prompts are presented to students in the form of a worksheet, with the expectation that students will explain the reasoning of others through their writing. This task is suggested as an alternative type of classroom activity that teachers could use rather than a string of traditional practice problems.

This article provides instructions for creating and revising your own self-explanation prompts for your students. It then describes how these prompts are aligned with the *Australian Curriculum: Mathematics* (Australian Curriculum, Assessment & Reporting Authority [ACARA], n.d.), the benefits of using self-explanation prompts paired with worked-examples, and teachers' perspectives on using this tool.

ACMNA073. Apply place value to partition, rearrange and regroup numbers to at least tens of thousands to assist calculations and solve problems.

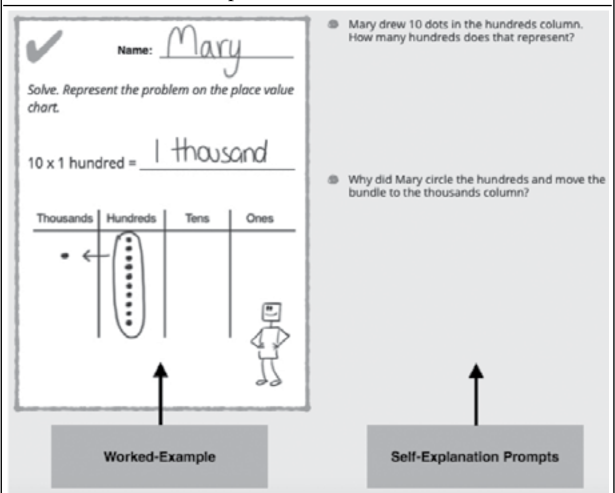


Figure 1. Self-explanation prompt paired with worked-example.

How to write self-explanation prompts for your students

The following section will lay out the steps for creating your own prompts. We will provide a few dos and don'ts with examples along the way.

Choose a target concept

The first step in creating this type of task is to determine which mathematics concept to focus on. There are three important things to keep in mind here. First, only choose one target concept. Do not try to cover too much in one item. This will only dilute the intended target. Even if a secondary target concept seems to fit very nicely, save that target for another problem. For instance, when presenting students with a word problem, it may seem logical to focus both on interpreting the word problem and on the steps used to solve it. However, both of these are very large concepts. It is better to create two items, focusing on each target separately.

Second, your target concept must be as specific as possible. For instance, rather than targeting the "interpretation of a word problem," focus on "determining which variables are important when interpreting a word problem." The more specific, the better. This will ensure that the prompts you ask your students truly address the intended concept. See Table 1 for a comparison of vague and specific targets. In Table 1, the first example vague target is "understanding place value." As you can imagine, there are a large number of misconceptions a student could hold about place value. Being more specific helps you write self-explanation prompts that align to the exact misunderstanding your student(s) hold.

Table 1. Comparison of vague and specific targets.

Vague targets	Specific targets
Understanding place value	Understanding that a digit in one place represents ten times what it represents in the place to its right
Understanding how to compare numbers	Understanding what digits to compare when the digits in the largest place have the same value
Understanding how to decompose a fraction	Understanding how to determine the correct unit fraction when decomposing a fraction
Understanding the properties of multiplication	Understanding why multiplying two numbers does not always lead to an answer that is greater than either factor

Third, targets should be conceptual in nature, rather than solely focused on the procedures used in the worked-example. While it is okay to sometimes focus on the steps to solve the problem, it is more effective to also focus on the concept behind the procedure. As you can see in Table 1, most of the specific targets focus on understanding a concept. For instance, the target, "understanding why multiplying two numbers does not always lead to an answer that is greater than either factor", is conceptual in nature. It focuses on the why. A related procedural target could be "understanding how to multiply whole numbers and fractions."

Pair prompts with a worked-example

As mentioned above, self-explanation prompts pair well with worked-examples. You may either create a worked-example yourself or choose a piece of student work that clearly illustrates your specific target concept (see McGinn, Lange, & Booth, 2015 for information on creating your own worked-examples). While this worked-example can be completed either correctly or incorrectly, it is important that you determine whether it is better to use a correct or an incorrect example to illustrate the target concept. Often it is easier to illustrate a common mistake with an incorrect example, rather than a correct example. For instance, if you notice that students are misapplying the regrouping rule when subtracting multi-digit numbers, you may wish to write self-explanation prompts using the example in Figure 2a because it clearly illustrates this mistake. On the other hand, if you are interested in having students compare the standard algorithm to a diagram, it may be easier to use a correct worked-example, similar to Figure 2b, because it allows students to view true depictions of these strategies.

ACMNA053. Apply place value to partition, rearrange and regroup numbers to at least 10 000 to assist calculations and solve problems.

a) Incorrect worked-example. b) Correct worked-example.

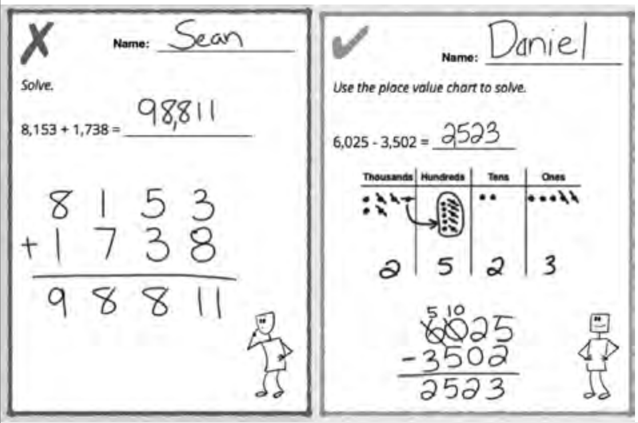


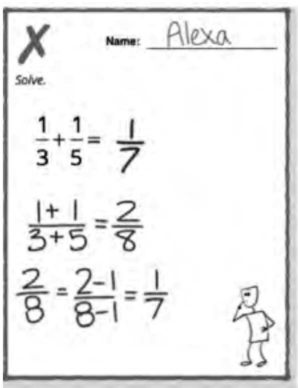
Figure 2. Correct verses incorrect examples.

Although it may seem counterintuitive to show incorrect work, incorrect examples are particularly useful because they help change the error climate of the classroom. They lessen the stigma of making mistakes in mathematics by helping students see mistakes as a learning opportunity, rather than a sign of failure. Siegler and Chen (2008) found that students learned more when they studied and reflected on a combination of correct and incorrect work than when students just studied correct work alone. When we look internationally at education practices, we see that errors are thought to be an integral part of learning in Japanese classrooms so they are discussed frequently (Stigler & Hiebert, 1999). Therefore, we encourage you to include some incorrect examples for your students to study.

If you decide to use an incorrect example, ensure that only one mistake was made. Your goal is to focus students' attention on the target concept. You do not want to distract them with other mistakes, even if they seem related. As seen in Figure 3a, Alexa made two related mistakes: she added across when adding the two fractions, and she subtracted one from the numerator and from the denominator when simplifying. While it may seem appropriate to use Figure 3a when targeting either misconception, it is less distracting for the student answering the prompt if the example only contains one of the errors, as seen in Figure 3b.

ACMNA153. Solve problems involving addition and subtraction of fractions, including those with unrelated denominations.

a) Incorrect example with two errors.



b) Incorrect example with one error.

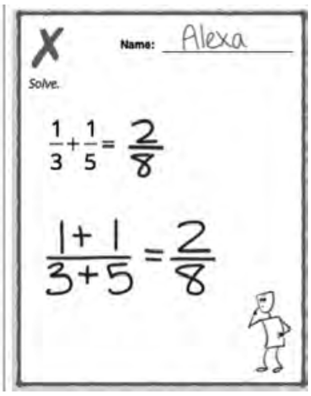


Figure 3. Incorrect example with two errors compared to incorrect example with one error.

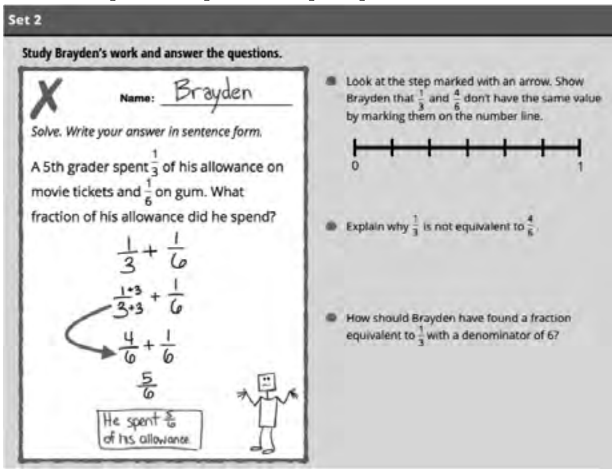
Writing prompts

At this point, you have chosen your target concept and worked-example. Finally, it is time to write the self-explanation prompts. There are three things to keep in mind when writing your prompts. First, write one to three questions that are aligned to your specific target concept. These prompts should scaffold students towards understanding that target. For instance, the target mistake in Figure 4a is "adding the same value to both the numerator and denominator in order to find an equivalent fraction." The goal of the first self-explanation prompt is to allow students to visually see that the two fractions are not equivalent, the goal of the second prompt is to allow students to explain why they are not equivalent, finally in the third prompt students are asked to correct the mistake.All three prompts scaffold students' understanding of the target mistake.

Second, your prompts should not solely focus on the procedure used to solve the problem, but also include conceptual prompts. The ultimate goal is for students to understand the why behind the procedure used to solve the problem. For instance, in Figure 4b, the

ACMNA126. Solve problems involving addition and subtraction of fractions with the same or related denominators.

a) Conceptual and procedural prompts.



b) Procedural prompts.

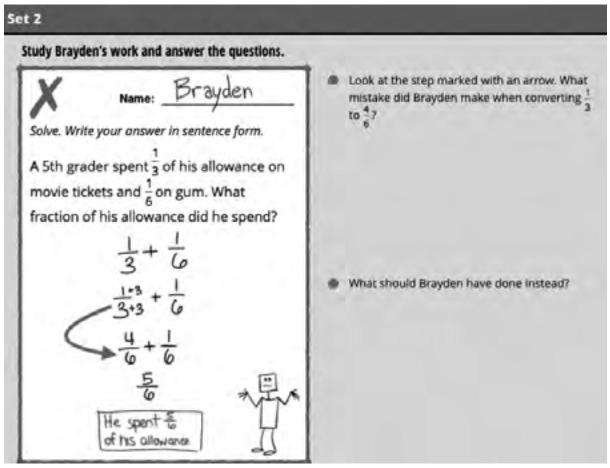


Figure 4. Conceptual and procedural prompts verses only procedural prompts.

self-explanation prompts allow the student to identify the mistake and then correct it. These prompts are procedural in nature. This item does not help the student understand why the procedure is incorrect. Alternatively, the prompts in Figure 4a help the student understand why $\frac{1}{3}$ and $\frac{4}{6}$ are not equivalent; they focused on the concept behind the procedure.

Finally, using arrows helps draw students' attention to specific features of the worked-example; it directs students to the specific part of the example that the self-explanation prompt refers to. For instance, in Figure 4 the curved arrow is used to show that Brayden converted $\frac{1}{3}$ into $\frac{4}{6}$. In the first self-explanation prompt, students are asked to look at the step marked with an arrow and show that, in fact, $\frac{1}{3}$ is not equivalent to $\frac{4}{6}$.

Revision process

Writing your own self-explanation prompts is not a one-step process. Review is always needed, even after you have used the prompts with your students.

When reviewing, take a look at your students' answers to make sure that they are answering the prompts the way you intended. For instance, in Figure 1, the intended answer to the second self-explanation prompt was "because 10 hundreds is equal to 1 thousand." However, many of our students wrote, "because she can." In the future, we may update this prompt to ensure that students provide the intended response. We may ask "Why could Mary circle the hundreds and move the bundle to the thousands column?"

It is also helpful to ask other teachers, mathematics specialists, or coaches to review the prompts. While you may think that the self-explanation prompt is targeting a specific concept, instead you may actually be asking an ambiguous question that could be improved. While working with others, you can brain-storm ways to revise the wording of the self-explanation prompt. If you are still not satisfied with the wording, sometimes stepping away from the problem and coming back to it later will help. Finally, always make sure that you check back with your original target concept. It is very easy to lose sight of the original target as the item evolves. Make sure that your prompts still target the intended concept as edits are made.

Alignment with the Australian Curriculum

Self-explanation prompts help teachers integrate the general capabilities, specifically the Critical and Creative Thinking capability (ACARA, n.d.), into their classrooms. This content descriptor calls for students to "develop the capability in critical and creative thinking as they learn to generate and evaluate knowledge, clarify concepts and ideas, seek possibilities, consider alternatives and solve problems" (ACARA, n.d.). While an argument could be made for the alignment of multiple critical and creative thinking elements, self-explanation prompts most easily integrate the elements of "reflecting on thinking and processes" and "analyzing, synthesizing and evaluating reasoning and procedures." Within these elements students are asked to "reflect on, adjust and explain their thinking and identify the thinking behind choices, strategies and actions taken." They are also asked to "analyze, synthesize and evaluate the reasoning and procedures used to find solutions" (ACARA, n.d.). Quality self-explanation prompts ask students to explain the reasoning behind a concept or procedure. When used to combat misconceptions, students are often asked to explain why certain procedures are not valid. In both of these instances, students are required to formalize and communicate their reasoning on topics they may not have otherwise considered.

Benefits of self-explanation prompts

Self-explanation prompts improve students' conceptual and procedural knowledge. Self-explanation prompts improve students' conceptual knowledge by focusing their attention on important mathematics concepts, like base-ten and place value principles, while fixing or enhancing existing knowledge (McEldoon, Durkin, & Rittle-Johnson, 2013). In addition, when students are asked to explain their existing knowledge, students often realize that they do not understand the concept as well as they thought (Thompson & Chappell, 2007). Self-explanation prompts encourage students to integrate new knowledge with what they already know; this practice helps students make this new knowledge explicit (Chi, 2000; Roy & Chi, 2005).

Many researchers have documented mathematics procedural knowledge gains through the use of self-explanation prompts, especially increased procedural transfer, which is the transfer of knowledge to new contexts or problems (Rittle-Johnson, 2006). Students can also develop new procedures with the help of these prompts (Lombrozo, 2006; Rittle-Johnson, 2006). For instance, self-explanation prompts can introduce more efficient procedures, such as using mental mathematics and place value rather than the standard algorithm to solve.

Teacher perspectives

While empirical research has shown the benefits of using self-explanation prompts in the classroom, it is always important to hear what teachers have to say about their experiences using this tool with their students. During a focus group, we asked a few teachers to explain how they use self-explanation prompts with worked-examples in their classroom and the benefits they find in using them.

According to several teachers, self-explanation prompts provide students with a chance to engage with the content in a meaningful way where they are asked to make sense of a particular concept. This engagement allows the student to reflect on what they actually know, and whether their knowledge is complete or whether it might be inadequate. One teacher describes how self-explaining benefits her students during their mathematics lessons, "I think when you ask them to tell me how or why you solved that problem, they then realize where it goes off track or why this step doesn't actually make sense."

Teachers also note that having students self-explain mathematics is not always natural at the beginning of the school year, but students improve their explanation abilities over time with the use of self-explanation prompts and as self-explanation becomes a more regular classroom practice. Teachers note that it is sometimes helpful to scaffold students' self-explanations more at the beginning of the school year. Self-explanation prompts can be designed to include this type of scaffolding, so that in the beginning of the school year students are being asked to explain very specific aspects of a problem and at the end of the school year the prompts are more open ended. Prompts can also be scaffolded to meet the language needs of ELL students. Self-explanation prompts can be designed and worded to meet the specific language needs of particular students.

Additionally, having students share their responses to the self-explanation prompts with others provides a useful learning moment not only for the student, but for the teacher as well. As explained by another teacher, "sometimes kids will come up with interesting ways to think about a problem, so the self-explanation prompts will help us see how the student is thinking."

Summary of instructions

This article provided a detailed set of instructions for creating and revising your own self-explanation prompts for your students. We also described how self-explanation prompts integrate the Australian Curriculum's Critical and Creative Thinking capability into the classroom, the benefits of using these prompts, and teachers' perspectives on using this tool. As a review, below is a consolidated list of these instructions.

- First, choose a concept to focus on. Choose one target concept for each item. Write a specific, rather than a vague, target that is conceptual in nature.
- Second, choose a worked-example that clearly illustrates the specific target. This example can be completed either correctly or incorrectly. When using an incorrect example, be sure to choose an example that contains only one mistake.
- Third, write one to three self-explanation prompts that are aligned to your specific target. These questions should scaffold students towards understanding the concept. Avoid simply asking students to identify the mistake and then correct it. Your prompts should not only focus on the procedure used to solve the problem, but also include conceptual questions. Finally, use arrows to draw students' attention to distinct features of the worked-example.
- Last but not least, constantly revise self-explanation prompts. Check student answers to make sure that they understand your questions. Ask other teachers, mathematics specialists, or coaches to review the prompts. Also, take a step back and review the prompts later with fresh eyes. Finally, always make sure that your prompts still target the intended concept as edits are made.

Self-explanation prompts can improve students' understanding of both conceptual and procedural mathematics concepts (McEldoon et al., 2013). Teachers have found that the use of self-explanation prompts also provides a window into what their students are currently thinking, making it easier to detect misconceptions. In summary, the use of self-explanation prompts can help teachers to improve their students' conceptual understanding of mathematics content while also giving them practice thinking critically and articulating their understanding.

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