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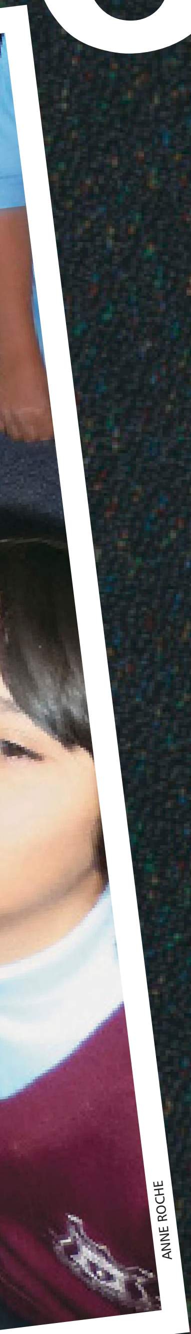

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Learn a simple game to support your students' mathematical learning across a range of content areas.

By Doug M. Clarke, Ann Downton, and Anne Roche

Considerable evidence shows that the number line is a powerful learning tool for children in elementary school. Diezmann and Lowrie (2006) noted several cognitive advantages for users, including opportunities to demonstrate the continuity aspect of numbers as well as the provision of a useful tool for representing and solving problems. By using the number line, students can observe at a glance several concepts pertaining to addition and subtraction (Kurland 1990).

The regular use of a number line also develops children's ability to form a *mental number line*. Gervasoni (2005) claimed that the capacity to form a mental number line is an important key to learning mathematics. She argued that it enables students to order numbers by quantity, locate any given number along the number line, and generate any portion of the line that may be required for problem solving. Schneider, Grabner, and Paetsch (2009) agreed, noting that a mental number line can be regarded as a domain-specific foundation on which the acquisition of more advanced mathematical concepts and procedures can be built. Clearly, extensive experience with a number line will increase the chances of students forming such mental number lines.

However, Diezmann and Lowrie (2006) found that many fifth graders were unsuccessful in using a number line effectively; they attributed this lack of success to students' inexperience with number lines. We believe that Australian students would benefit from more opportunities to work with number lines: locating numbers on them, using empty number lines to solve addition and subtraction computations (as is common in The Netherlands), and using number lines to solve particular problems. Unlike a hundred chart, which, of course, has a wide range of worthwhile uses, the number line has the advantage of more meaningfully showing the way numbers "go" in both directions as far as you like, as well as providing a way to connect whole numbers, fractions, and decimals (Gravemeijer 1994).

As part of the Contemporary Teaching and Learning of Mathematics Project with the Catholic Education Office in Melbourne, we have had the chance to try out a wide range of worthwhile activities and refine them using feedback from teachers and students. We describe an activity—for which a number line (in the form of a number roll) is a key component—that is built around the One-minute challenge game, which Ann Downton first devised. We outline the way in which the mathematics involved is potentially appropriate for grades 2–7.

Game basics

As with many games, this one has a variety of possibilities. We outline the basic game and then present a range of ways to adapt it according to content focus and student age. The relevant equipment is listed in the **sidebar** (**p. 346**).

Set the scene

We gather students in a circle and ask two volunteers to come into the middle to demonstrate the game to the class. They are given one standard six-sided number cube and a bag of about 200 grams of lima beans. Other materials can be used instead of lima beans, but beans are ideal for the game and worth the minor effort to obtain. A third student is given a one-minute timer. Once again, the effort of obtaining a large egg timer is worth the effort.

Explain the rules

We tell the pair that they will be trying to accumulate as many lima beans as they can in one minute. One student will toss the number cube repeatedly and call out each result; the other person will quickly put that number of beans aside. As the action is quickly repeated again and again, the pile of beans will grow larger and larger.

We give the volunteers a chance to practice, as we sometimes find that younger students have cumbersome ways of counting the beans, and we often must ask, "Could you do that a quicker way, without counting them one by one?"

It is often the case also that students do not subitize although they are capable of doing so (Bobis 2008, Mulligan et al. 2008, Trundley 2008). S*ubitizing* means being able to recognize the size of a collection without counting.

When the volunteers are ready to start, the timekeeper uses a loud voice to announce the start and finish of one minute.

Estimate and count

Once the minute has elapsed, each student estimates separately and guesses out loud how many beans have been set aside in one minute. We have noticed that teachers and students alike usually underestimate the quantity at this stage. The person who rolled the number cube the first time now counts the beans to find the actual total. Typical scores at this demonstration stage seem to vary from about 40–60 beans in grade 2 to around 60–90 in grades 4–7. The volunteer pair is asked to record the actual number in large digits on a card. Depending on the grade level and the counting expertise of the children, some teachers will make the decision to ask the second child to check the count, with the pair then resolving any disagreements about the total.

Reveal the number roll

With a dramatic flourish, we then reveal our number roll, carefully unrolling it so that the numbers get larger as more of the roll is revealed. We invite the class to predict the highest number at the end of the roll—students' answers are both revealing and surprising.

If the number roll has negative numbers (down to –10), which we recommend, they are best kept hidden at this stage. Reveal only

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After one minute, students set aside their beans, make an estimate, count the beans, record the total on a card, and peg the card to the number roll.

0–120 or so, depending on the size of the classroom and the available space. Give students a red peg (or clip), for instance, and invite them to use it to attach their card to the number roll, alongside but not covering the equivalent number on the roll.

We then point out that this is now the "school record" for the one-minute challenge. Clarke also uses the occasion to point out that he and his daughter Sandy hold the "world record" of 195 beans for the game. At the same time, he confesses to the group that there are probably not a lot of people around the world taking on the challenge. We have found that students from grade 4 and up are particularly interested in the possibility that they may break the world record. It also gives us a chance to talk about the need for careful protocols to be followed during record-breaking attempts, such as starting and finishing when told and resisting any temptation to bend the rules.

At this stage, we tell students that they will get to play the game twice: Each person will have a chance to roll the numbers, call the numbers, and pull aside the beans.

Let's play!

Students are invited to find a partner and a quiet spot on the floor or at a table. Each pair receives a number cube, a bag of beans, two blank cards, and a red peg. The pair decides which role each of them will take in the first round, and they practice for a few minutes. When everyone is ready, the signal to go is given. After one minute, when told to stop, students carefully set aside the collection of beans they have separated from the original pile. As before, both students make an estimate, and then the roller of the number cube counts the beans. The total is recorded on one of their cards, and the card is pegged—with a red peg—to the number roll. We find it helpful to ask young children to verbalize the number as they peg it.

It is possible to have a discussion about the results so far, but our experience has been that students are keen to move to the second round, so we go through the same routine with the roles reversed. This time, students receive a blue peg to use to record their second total. Once again, the process is to estimate, count, record, and peg.

Preparing to play the game

To play this game, you will need the following equipment:

- **A number roll** labeled from –10 to about 200. You might use the material that protects wooden dining tables—the kind with the soft, fluffy backing. A good size to use is a roll 10 m long and 10 cm wide, with 5 cm for each number. Alternatively, create the roll from long strips of paper, such as adding machine tape.
- **A timer**—preferably a large, one-minute timer
- **1 bag** of lima beans per pair (200 g is appropriate)
- **1 number cube** per pair (standard six-sided)
- **1 red** peg or clip per pair
- **1 blue** peg or clip per pair
- **2 cards** per pair (small, about 5 cm × 5 cm)

Look at the data

By now, we have two pegs from each pair. Student pairs sit beside the number roll. After some general questions about the kinds of totals that they have recorded, we challenge them to find the *difference* between their two scores. We do not focus on improvement, as the roles have been reversed and only some will have improved from the first to second turn. Our purpose is two-fold:

1. Many students in grades 2–4 are unclear on the mathematical notion of *difference* (Clarke 2003), and this is a chance to revisit the concept.
2. We are interested in the various mental strategies for calculating difference.

We invite some pairs to share the two scores and the methods of calculating difference. Several issues usually arise, depending on grade level, which we now discuss for the hypothetical pair of scores 68 and 83:

1. Some students are able to work out the difference only by counting along a number line. They therefore jump 15 spots and conclude that the difference is 15, or sometimes 14 or 16, depending on their method.
2. Some students are encumbered by their knowledge of the *written* subtraction algorithm, which they find quite difficult to use for a *mental* calculation. These students attempt to trade as needed in their head, or they occasionally subtract the smaller digit from the larger in each case and get 25 as their answer. In our minds, this is further evidence of the need to delay teaching formal written algorithms until children can mentally add and subtract two-digit numbers (Clarke 2005).
3. Other students use desirable jump-type strategies, sometimes jumping from 68 to 78, and then 5 more; or from 68 to 78 to 80 to 83, or something similar. We then discuss these strategies and hope that most students understand them.

As an opportunity to practice these jump-type strategies, we invite the group to consider the difference between the highest and lowest scores over the two rounds. This may be too difficult for younger students. To emphasize appropriate jumps, we sometimes offer a bead string, set up with multiples of ten in different colors. As an example, when we find the difference between 46 and 55, the children can see the way in which we move from, say, 46 to 50, and then to 55.

Other possibilities

Depending on the teacher's instructional focus for the day, students in grades 4–7 can discuss statistical notions, such as *range* (the difference between the highest and lowest scores); *mode* (the most common score or scores); *mean* (the average score); and *median* (the middle score when the scores are in order from smallest to largest—as they are in this case). In finding the median score, a helpful image is for two students to move in, one card at a time, from the two extreme scores, until they physically "meet" at the median. Give students in grades 6 and 7 the chance to talk about how changing one score at the extremes can affect the mean but will make no difference to the median if it changes from, say, 108 to 186 or from 47 to 16.

We sometimes take this opportunity to explore negative numbers. One way to do so is to ask students, "What is seven minus five?" ("Easy!") and then, "What is five minus seven?" Answers to the second question typically vary (2, 5, 0, 7, and –2). The number roll provides a way of representing this subtraction easily by jumping along the number line, and it is a nice exposure to negative numbers for the students.

This is an example of the number line as a *tool for representational transfer* (Diezmann and Lowrie 2006).

Teachers of children as young as kindergarten age have indicated that their students can also participate in the basic game, as they are unlikely to accumulate many beans in a minute—given probable difficulties with subitizing quickly both the face of the number cube and small stacks of beans—and would therefore be dealing with smaller numbers.

Advantages

We believe that this game offers the following features:

- **Fun** to play—almost all students find it so.
- **Challenging**—The chance to break the school and the world records are highly motivational, particularly to students in middle and upper elementary school.
- **Shows** students the power of a number line as a representational tool for considering quantity, relative size, addition and subtraction, as well as negative numbers.

What to look for

So much observation potential exists for classroom teachers as students play this game. For example, how quickly do young children subitize the numbers on the number cube or subitize a collection of beans without needing to count them one by one? How reasonable are the children's estimates? How do they go about estimating? Do their estimates improve from the first to the second attempt?

Does the child who has to count the exact total use appropriate skip-counting methods or simply count one by one? Our experience during one-to-one assessment interviews in the Early Numeracy Research Project (Clarke, Clarke, and Cheeseman 2006) was that many children were

Offer a bead string, set up with multiples of ten in different colors, so that children can see how to move along the number line.

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able to skip count but did not choose to do so in some counting situations.

How easily do the children find their number on the number roll? (Do they go straight to the decade, or do they begin at the number 1? Do they have trouble with reversals, such as 46 and 64?) How many students are able to easily find the difference between their two scores, and what strategies do they use to find the difference? Are students able to apply helpful strategies that they hear from other students? Does the physical image of the number roll help students in their developing understanding of range and measures of central tendency (mean, median, and mode)?

In the weeks and months following the use of the number roll, the teacher may also wish to observe the extent to which the tool has supported students' creation of mental number lines for use in other contexts. We invite other teachers to try the activity. Send information on how the activity proceeds and any adaption you make to meet your students' needs to **tcm@nctm.org**, with "reader's exchange" in the subject line.

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We gratefully acknowledge the support of Diane Blake, principal of Sacred Heart Primary School (St. Albans) and her staff and students for their assistance in developing the ideas contained in this article in their classrooms.

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