Math Fluency: Engaging Students Through Game Play

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As we reflect upon our own experiences learning math, the instances that stand out tend to be those we spent trying to recall a math fact or attempting to remember how to perform a procedure. Oftentimes these memories do not stir up an excitement about math, but rather remind us of a struggle we faced. Gaining fluency should instead be a time in which students develop a love for math. Through game-based practice, students will learn to relish the challenge of noticing a new pattern or gaining automaticity of a learned skill. *Matika Worlds' Astronaut Run* is one way for students to gain fluency and develop a love and appreciation for mathematics.

What is fluency?

While fluency used to be known as simply the ability to quickly recall math facts, over the years the definition has grown and changed as our understanding of fluency has evolved. The mathematical community has agreed on definitions of fluency that include efficiency, accuracy, and flexibility (NCTM, 2014; NRC, 2001). No longer is it good enough for a student to just shout out the answer to 6 x 8 as they are gaining fluency, but they should also be able to explain how they got their answer. This shows considerable progress from traditional views that involved more of an emphasis on memorizing. The 2012 PISA results show that students who rely on memorization as a primary strategy are some of the lowest achieving math students (Boaler & Zoido, 2016).

According to the National Research Council's 2001 publication *Adding It Up*, procedural fluency is one of five intertwined strands of mathematical proficiency and it does not just involve the basic facts. It also includes the ability to solve computational problems and make decisions on the most efficient strategy to use for problems. Fluency works hand in hand with conceptual understanding, as students improve their efficiency the more they develop an understanding of the ideas behind the procedures (NRC, 2001).

How do students work toward fluency?

According to Baroody (2006), students move through several stages as they progress toward mastery of the basic facts. Students begin by working on counting strategies such as solving 7 + 2 by counting up "8, 9" or solving 5 x 3 by skip counting "5, 10, 15." During this first stage, students may use concrete objects such as fingers or blocks to help them in their counting. When students are able to move into the next phase, they use reasoning strategies, applying what they know to new facts. For example, they could use their knowledge of doubles facts to determine 7 + 8 as one more than the answer to 7 + 7. With multiplication, they can reason that 6 x 6 is one more six added to the answer to 6 x 5. As they become more flexible and accurate with these strategies, students move toward mastery of their facts.

What are some barriers to fluency?

While working to help students gain fluency, some teacher practices can actually serve as barriers in this process. When teachers focus on speed as an important part of fluency, this can send students the wrong message about what makes a strong math student; the emphasis on speed can distract students from the importance of understanding math deeply (Boaler, 2015). Math anxiety is another consideration while working towards fluency. It has been found that when people are stressed, working memory (which students use to recall information) is blocked (Bielock, 2011). For these reasons, in *Astronaut Run*, students are not given a timer for each fact they are looking to complete. Instead, a jet pack slowly consumes fuel, which can be earned at any point during the journey. This allows students to take time on facts that they need more time on and move faster when they are confident.

Astronaut Run, **Multiplication, Basic Facts (Grade 3)**

Another barrier to mathematical understanding and ultimately fluency occurs when teachers deal only with abstract concepts, ignoring the visual nature of mathematics. Educators and brain scientists (Boaler, Chen, Williams & Cordero,

2016) recently highlighted the importance of the connection between visual pathways in the brain as students work on mathematics tasks. Boaler, et al. (2016) make a recommendation for "mathematics teaching and learning…to become more visual—there is not a single idea or concept that cannot be illustrated or thought about visually." *Astronaut Run* aligns with this recommendation as many of the skills in the program incorporate models or pictures so that students can activate and use these visuals as they develop their skills and understanding.

Astronaut Run, Subtraction Through 20, (Grade 1)

Why is fluency important?

Fluency with both basic facts and computation are important to students' mathematical development. As stated by the National Research Council in *Adding It Up* (2001), "In the domain of number, procedural fluency is especially needed to support conceptual understanding of place value and the meanings of rational numbers. It also supports the analysis of similarities and differences between methods of calculating" (p. 121). In other words, in order for students to be successful in more difficult mathematics, procedural fluency works alongside the other strands to help students reach proficiency.

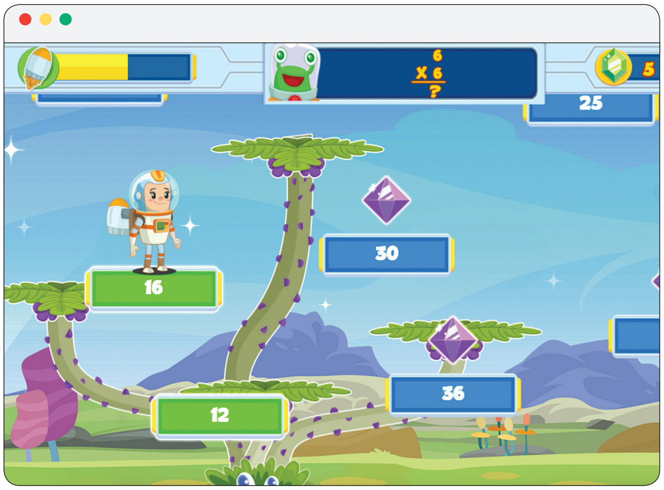
In the past, fluency has been seen as a strand of mathematical proficiency that runs counter to conceptual understanding. Rather than considering it a one-or-the-other situation, in recent years, it has widely been agreed that the two support one another (Hiebert et al., 1997; NRC, 2001). One such case is when students develop procedures on their own, they are using their understanding to support the development of fluency (Hiebert et al., 1997). Meanwhile, they can use strong fluency skills to make understanding of complicated topics less cumbersome (NRC, 2001). For example, students may find that computing division of decimals, such as 40 divided by 0.8, is initially easier when using the algorithm and paper. However, as they build fluency by playing *Astronaut Run*, students will begin to notice patterns that allow them to make more efficient calculations, resulting in a deeper understanding of the nuances of dividing decimal numbers.

What are some strategies to support fluency?

"The role of practice in mathematics, as in sports or music, is to be able to execute procedures automatically without conscious thought" (NRC, 2001). Therefore, a large part of building fluency involves incorporating practice into students' work. Practice can take the form of worksheets, games, tasks, or any number of ideas that are only limited by the creativity of a teacher. Teachers should, however, be sure that students have been exposed to conceptual strategies before offering them opportunities to practice, since "practice prior to development of efficient methods is simply a waste of precious instruction time" (Newton, 2016, p. 25). The development of skills in *Astronaut Run* is gradual and comprehensive, allowing students and teachers to pinpoint the specific skill that students are ready to practice. Therefore, although one student is practicing subtraction of a 2-digit number from a 3-digit number, another student might only be ready to subtract a 1-digit number from a 2-digit number. The game allows students opportunities to practice in the appropriate areas.

Technology offers several benefits for students as they practice while working toward fluency. Van de Walle (2014) suggests technology as a tool for teachers to use for practice of math facts, as it allows students quick feedback on their answers and an opportunity to self-monitor. The immediate feedback helps students fix and adjust their mistakes, rather than continue practicing with incorrect answers. When a student finds the answer to 17 - 9 as 7, *Astronaut Run* gives the student feedback that this answer is wrong. This quick feedback allows the student to reconsider his or her approach and try again, instead of continuing to practice incorrectly, which could happen if the student were simply completing a worksheet independently.

Another format for practice is in workstations or centers. Dr. Nikki Newton (2016) recognizes math workstations as an opportunity for students to self-monitor. Elementary students should be continuously working toward knowing their facts, with an understanding of which they know fluently and which they still need to work on. Perhaps a student is excellent at remembering facts that can be determined with skip counting (x3, x5, etc.), but is struggling to recall facts with larger numbers (x7, x8, etc.). As this student works on groups of math facts, he or she can use games at workstations to practice. For upper elementary students, the opportunity



Astronaut Run, Multiplication, Basic Facts (Grade 5) to practice fluency of fraction skills is invaluable. When students subtract fractions with unlike denominators, they may initially forget to find a common denominator. However, the quick feedback would allow students to realize that their approach was incorrect, and reconsider their methods of calculation. Games like *Astronaut Run* give students a chance to monitor their strengths and identify areas and specific facts or skills that they still need to work on.

A final strength of *Astronaut Run* is the large breadth of skills with which students can practice and progress toward fluency. From recall of math facts to calculations with fractions and decimals, students have a wide range of opportunities to practice specific mathematical skills, receive feedback, and adjust their thinking while working toward fluency. During this development, students gain confidence in their abilities with the ultimate goal of deepening their appreciation and love for mathematics.

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Dr. Scillieri is an educator from New Jersey where she has been a classroom teacher, team leader, mathematics coach, and mathematics supervisor. These roles have afforded her the opportunity to develop mathematics curriculum, present in local and state professional conferences, serve on a state mathematics committee, and share her love of math with teachers, students, and parents. She received her doctorate in Educational Leadership from the College of St. Elizabeth in Morristown, after dissertation research in the area of elementary mathematics. Her current research interests are in the areas of mathematical proficiency at the elementary level as well as the mindsets of parents, teachers and students toward mathematics.

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