Mastering Fact Fluency: Are They Game?

Take-home binders and daily math talks help a second-grade class ease through Baroody's (2006) stages.

By Connie J. Godfrey and Jamalee Stone

Jackie: *Do you have a two?*
Sarah: *Go Fish.*
Jackie: *I drew a four. I know five plus five is ten. If you take one from a five and give it to another five, you would have four and six; and four plus six is ten. I have a six right here, so I have a pair. Your turn.*

Second-grade students are playing the game Tens Go Fish to practice their addition and subtraction fluency. Jackie uses a compensation strategy to derive the missing part of a combination of ten. While she and Sarah focus on combinations of ten, other students in the classroom play games to master fluency of their "working number," the number for which they are working to attain automaticity.

Baseline fluency assessments

One method used in my district to assess fact fluency and determine individual working numbers is a *hiding* assessment based on the work of Richardson (2002). Students are first assessed on their knowledge of number combinations of five as follows: The teacher lays out five cubes for the student to see, then covers a portion of them. She then asks the student to tell her how many cubes are hiding by looking at the number of cubes in front of the child. If students can fluently (using a quick, noncounting strategy) tell the teacher how many cubes are hidden for each possible combination, the number of cubes increases to ten, because the make-ten strategy is important in building fluency for number facts greater than ten. After the student masters combinations of ten, he or she is then assessed on the numbers six, seven, eight, and nine, accordingly. This series of assessments continues to progress until the student reaches the point where fluency breaks down and he or she is no longer able to demonstrate mastery, thus establishing a baseline. This baseline is the "working number" for which students begin to play games to develop fluency for that particular set of combinations until they are ready to resume the assessment.

Next, the student is asked to compute unknown parts to the same sequence of numbers without the benefit of

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seeing cubes. For instance, the student is asked, "If you had ten cubes and you gave me four of them, how many cubes would be leftover?" Posing questions in this manner during a hiding assessment encourages students to see the relationships between addition and subtraction facts and allows them to build knowledge of traditionally taught "fact families."

A baseline hiding assessment is administered to every student during the first days of the new school year. After practicing combinations of their working number, the student or I may initiate a new assessment. Ideally, a hiding assessment is administered to each student at least every two weeks until he or she reaches mastery of all basic facts to ten.

Is everyone game?

Playing math games is an integral part of the inquiry-based mathematics curriculum used in my school district. During the past several years, I have learned how powerful math games can be in helping students achieve automaticity in basic addition and related subtraction facts if both teachers and students use them purposefully. Having students engage in discourse is crucial to effectively using games as learning tools.

According to the National Council of Teachers of Mathematics (NCTM 2000), developing a solid mathematical foundation is essential for every child in prekindergarten through second grade. This grounding must include a strong number sense as well as computational fluency in basic addition and related subtraction facts where both addends are less than ten. The Common Core State Standards for Mathematics document (CCSSI 2010) suggests that first-grade students be fluent in all combinations to ten. Second graders must use mental strategies to fluently add and subtract within twenty. By the end of second grade, students should know all sums of two one-digit numbers from memory. If math games are played purposefully, with discourse and a goal of fact mastery in mind, they can help children build number sense, fact fluency, and confidence in their mathematical abilities.

On the basis of my own pedagogical knowledge, research I have examined, and personal experiences as a mathematics teacher, I believe that children gain automaticity along with number sense when they are given time and opportunities to explore number relationships. Manipulatives, repeated practice with real-life problems, invented strategies, and encouragement to communicate their thinking to others can assist children in building their own understanding and increase their number sense. Math games offer children the chance to engage in these activities.

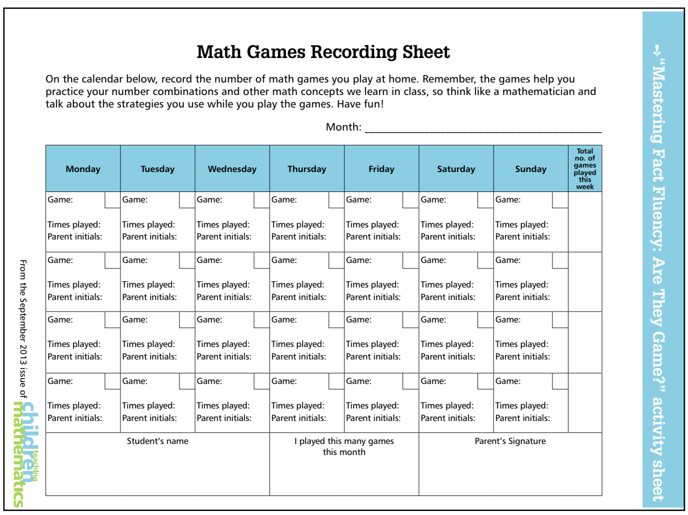
Do take-home binders help?

When I first began using game binders, I sent games as homework once per week after students had been introduced to a game and had received an opportunity to play it in class. Although classroom time was dedicated to allowing students to explain their thinking and share strategies they had used to solve problems, little emphasis was placed on communicating the strategies when students played the games at home. With this method, I found that students were neither mastering the facts nor developing a deep understanding of number relationships to the extent I had anticipated.

In my quest to help students create the strong foundation that I believed knowing their number facts would provide, I changed the game binder routine. I began by sending a letter home to parents and guardians (see the **online appendix**), explaining the importance of fact fluency and asking for their help in playing math games and discussing strategies with their child. I then sent the game binders home, asking students to keep track of the number of games they played each week. Students kept a blank monthly calendar (see **fig. 1**) in the front pocket of their binder so they could easily tally the number of games played on particular days. I had them return the binders and calendars every Monday so I could add new games if necessary and monitor how many games each student had played. Every week, I tallied the total number of games that all students had played and created a graph to display in the classroom. This routine piqued students' interest; the number of games played increased significantly. Students greatly anticipated the results as the graph was posted on a weekly basis. I also found, however, that students who played the most games during the week were usually those who already had a solid understanding of number relationships and were already at, or very near, the proficient mark. I questioned whether the new system was working.

FIGURE 1

Using a recording sheet, parents help keep track of math games that students play at home. (See the **online appendix** for a full-size reproducible page.)



Math Games Recording Sheet

On the calendar below, record the number of math games you play at home. Remember, the games help you practice your number combinations and other math concepts we learn in class, so think like a mathematician and talk about the strategies you use while you play the games. Have fun!

Month: ____________________

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total no. of games played this week
Game: Times played: Parent initials:	Game: Times played: Parent initials:	Game: Times played: Parent initials:	Game: Times played: Parent initials:	Game: Times played: Parent initials:	Game: Times played: Parent initials:	Game: Times played: Parent initials:	
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Student's name			I played this many games this month		Parent's Signature		

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"Mastering Fact Fluency: Are They Game?" activity sheet

Are they talking about strategies?

Because I wondered if students remembered to notice and discuss the strategies they used, we engaged in several math (number) talks and played whole-group games during which I modeled these behaviors. For math talks, I used small blocks of time, separate from our daily math lesson, to engage students in focused problem solving and to offer additional opportunities to learn new strategies from peers. With children gathered on the carpet, I introduced a problem and allowed time for everyone to solve it. If necessary, as students shared their strategies, I would notate them on a small whiteboard for a visual representation. Our short, fast-paced math talks ensured student engagement. I gave only a few problems; the focus was on student discourse. A ten-minute math talk might include a conversation such as the following:

Teacher: If Noah went to the store with seven dollars and found a shirt that cost eleven dollars, how much more money would he need before he

could buy the shirt? Put your thumb on your chin when you know how much money he still needs. [*Allow students some think time and begin after noticing that most children are ready.*] Turn to a neighbor and tell them how much more money Noah will need to save. [*Choose two or three students to explain their thinking to the class.*]
Meg: Well, I know that seven plus three is ten, and ten plus one is eleven, so you would need four more dollars to buy the shirt.
Tyler: I knew right away the answer was four. In my mind, I said, "Seven plus what equals eleven?" and I knew it was four.

Meg is clearly in Baroody's (2006) second phase (see the **sidebar** below), whereas Tyler has reached the automaticity of phase three and is ready for more challenging games.

Do you model desirable behaviors?

To help the class understand the phases, I modeled behaviors at each level and encouraged students to be cognizant of their journey through each phase. For instance, during a math talk, I would solve a problem by counting on and then explain the process as being a phase-one strategy. Next, I would solve a problem using a relationship such as "near doubles" and name the process as a phase-two strategy. Finally, I would model a phase-three strategy, demonstrating automaticity. After I had modeled a process, we would discuss the strategy and share examples. I allowed more time in class to play games with partners, and I encouraged class members to become aware of the strategy and discuss it with a teammate. I prompted students to begin game time by playing with their working number and then switching to a lower number to maintain fluency. Students could play with a partner whose working number was different from theirs and alternate the number used for the games. Because of the variety of games being played each session, I was able to keep working numbers between me and individual students, preventing anyone from feeling discouraged by their progress. If I noticed a particular student struggling to make progress, I would play a game with him or her to give encouragement and model appropriate discourse. Students were instructed to follow the same norms with their opponents at home.

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Game play facilitates students' development of automaticity in basic fact combinations.

I soon began to see the rich math talk that I had hoped for, and I realized the power of being a reflective teacher. I was learning as much about effective learning environments as my students were learning about number facts.

Can students self-adjust?

Although the game binder included games from our curriculum that focused on other concepts as well, I carefully chose fact fluency games that would allow students to adjust the procedure to match their individual working number. For instance, Tens Go Fish is a card game that is played like the traditional Go Fish game, with the exception of pairs being two cards with a sum of

Is fact fluency developmental?

A common theory embodies the belief that through repeated practice using such rote memorization methods as flash cards and timed tests, children will be able to eventually recall basic facts from their long-term memories (Henry and Brown 2008). However, Baroody (2006) sees fact fluency as developmental and describes three phases that children typically progress through when mastering basic facts:

1. Counting strategies—including object or verbal counting to derive an answer
2. Reasoning strategies—using known facts and relationships to solve an unknown combination
3. Mastery—achieving automaticity in basic fact combinations

ten rather than exact matches. By adding or removing some cards, the game can be adapted to My Working Number Go Fish. Turn Over Ten, also called Turn Over My Working Number, is similar to a memory game. Cards are spread out facedown, and players alternate turning over two cards and looking for the desired sum.

Once a student became fluent in all numbers to ten, I would add games that allowed them to practice all combinations, including those to twenty. For War of the Cards, players place number cards in a stack, facedown. Players take turns drawing two cards and discussing how they derived the sum. The player with the highest sum gets all four cards, and the player with the most cards at the end of the deck is deemed the winner.

I wanted simple ways for students to be able to practice facts even when they lacked a game partner or had a hectic evening running between sports practice and other recreational activities. Dice can be used multiple ways and have the added benefit of being small. Requiring little workspace, they can essentially be used almost anywhere. For lower working numbers, I suggested rolling two dice and deriving the sum or difference. Students who were ready to practice higher facts were shown how to roll one die (or add the results of rolling two dice) and then deduct that sum from twenty. I also encouraged students to find their own ways to use dice as tools for fact mastery.

Are cyber games fun?

A plethora of math game resources exist online. Detailed directions to Tens Go Fish, Turn Over Ten, and many others can be found on several online sites by typing *math games* or the name of a game followed by *math game* (i.e., Tens Go Fish Math Game) into a search engine. Numerous sites have interactive games that children can play on a computer. Some of my favorite games are How Many under the Shell, found at http://illuminations.nctm.org, and Math Lines at www.coolmath-games.com.

When I changed the game binder routine, five of twenty-four students in my class were proficient in basic facts. By the end of the year, nineteen students were either proficient or advanced according to our district guidelines. Although five students did not reach proficiency, each made remarkable gains on the hiding assessment. They may not have played the most games each week, but these students engaged in discussions about the strategies they used to compute problems and made valuable gains in their fact fluency.

In summary: Do small changes make any difference?

NCTM (2000) states the necessity for children in prekindergarten through second grade to develop a solid mathematical foundation. Number sense and computational fluency are integral components of this foundation. I want to help my students understand number relationships, obtain mathematical confidence, and achieve automaticity in basic fact calculations. In previous years, I had found that students could memorize basic facts, but I had also noticed that they lacked the relational thinking and number sense required to transfer that knowledge to higher-

→ reflect and discuss

"Mastering Fact Fluency: Are They Game?"

Reflective teaching is a process of self-observation and self-evaluation. It means looking at your classroom practice, thinking about what you do and why you do it, and then evaluating whether it works. By collecting information about what goes on in our classrooms, and then analyzing and evaluating this information, we identify and explore our own practices and underlying beliefs.

The following questions related to "Mastering Fact Fluency: Are They Game?" by Connie Godfrey and Jamalee Stone are suggested prompts to aid you in reflecting on the article and on how the authors' ideas might benefit your own classroom practice. You are encouraged to reflect on the article independently as well as discuss it with your colleagues.

- How often and in what ways do you communicate with your students' parents and guardians?
- What can you do to convince your students and their parents and guardians that it is worth their time and effort to play math games on a regular basis?
- As a classroom teacher, how can you foster students' beliefs that they are mathematicians?

You are invited to tell us how you used Reflect and Discuss as part of your professional development. The Editorial Panel appreciates the interest and values the views of those who take the time to send us their comments. Letters may be submitted to Teaching Children Mathematics *at* **tcm@nctm.org**. *Please include "Readers Exchange" in the subject line. Because of space limitations, letters and rejoinders from authors beyond the 250-word limit may be subject to abridgment. Letters are also edited for style and content.*

level problems. To help increase their skills, I made several small changes that yielded large gains. We held several math talks, and I shared with my students Baroody's (2006) three phases that lead to fact mastery. I scheduled additional classroom time for students to engage in meaningful tasks that often included math games, and I allowed them to keep their game binders at home for additional practice throughout the week. I encouraged parents to join in by playing the games and engaging in strategy discussions with their child, and I posted a graph in our classroom showing the cumulative number of games played each week.

I found that I had to remind my students—and myself—about the importance of noticing and discussing strategies while playing games. For example, if students became accustomed to counting and did not attempt to use relational thinking, their computational fluency did not increase as they relied on counting to solve problems; they did not attempt strategies that are more efficient. However, when students focused on higher-level thinking strategies and discussed them with a partner, their fluency and number sense increased.

Perhaps the greatest learning that took place in the classroom was my own. I had always emphasized the importance of sharing one's thinking during curriculum math lessons, but I seldom put as much emphasis on it when practicing computational fluency with math games. I learned to be deliberate when introducing new games and discussing fact mastery. Making minor changes to the way I assigned games and emphasizing discussion on noticing and sharing strategies during game time netted the increased number sense I had hoped for in my students.

Common Core Connections

K.OA.5	1.OA.4
1.OA.3	1.OA.6
	2.OA.2

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