Games can both generate excitement among students and motivate them to participate in mathematics. Although games have been used primarily to review mathematical concepts at the middle school level, games should, and often do, have other instructional purposes. Smith and Backman (1975) argued that games should be used to develop mathematical concepts, improve perceptual abilities, and encourage problem solving and logical thinking. When teachers use mathematical games as an instructional strategy, they are giving students opportunities to actively engage with the mathematics.

As middle school teachers, we often struggled with decisions related to which games to use for which mathematical purposes. We realized that we needed to critically evaluate the appropriateness and potential effectiveness of each game to address parents’ lingering question, “Why is my child playing in math class?” We wrestled with this question and sought specific criteria to help us select games that would promote mathematical thinking and reasoning. After reflecting on students’ interactions and discussions during game play, we identified specific guiding questions to help with the selection and implementation of games. We describe one game, Product Bingo, and how it played out in one middle school classroom. We then use that game to introduce three guiding principles that can help middle school mathematics teachers as they use and reflect on implementing games in the classroom.

Incorporating math games into the classroom will help your students become motivated problem solvers.

Christa Jackson, Cynthia Taylor, and Kelley Buchheister

**PRODUCT BINGO**

**Game Directions**

Product Bingo, an activity Kathryn Chval adapted from the Math Trailblazers fourth-grade curriculum (Kathryn Chval, personal communication), introduces students to probability. Students begin play by selecting a premade game board (see fig. 1). The teacher rotates a spinner with eight sectors, labeled with the digits 2 through 9, twice. The students mark the corresponding product on their game board. The game continues until a student obtains four in a row horizontally, vertically, or diagonally, similar to the traditional game rules of bingo.

The uniqueness of this game lies within its unfairness. Students realize that some boards are designed to
make winning impossible because the products listed do not exist in the sample space resulting from the digits on the spinner. As a result of this strategic variation from the traditional design, students are engaged in a deeper level of mathematical thinking.

In the following vignettes, we highlight the dialogue that occurred among seventh-grade students as they played Product Bingo.

**Game Play**
Ms. Jabuta, a seventh-grade math teacher, introduces Product Bingo in her classroom. As her students are analyzing their board, some begin to realize that their board is unfair. As numbers are called out, students discuss what they need to obtain bingo. Katie needs a 5 and realizes that the spinner must land on a 5 and a 1. However, there is no 1 on the spinner. Katie then recognizes that she is not the only one with impossible products. She points out to another student that he will never obtain the 13 on his board because the only way to get a product of thirteen is for the spinner to land on 13 and 1, which again is impossible.

As the conversation continues about numbers that are impossible to obtain, Jimmy and Marshall propose to solve the issue by switching from a spinner to dice.

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**Fig. 1** Product Bingo rules are similar to those of regular bingo, in that boards are used, but several differences exist, particularly with regard to fair boards.

<table>
<thead>
<tr>
<th>Board 1</th>
<th>Board 2</th>
<th>Board 3</th>
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<tbody>
<tr>
<td>40 72 10 35</td>
<td>9 * 22 81</td>
<td>8 24 27 54</td>
</tr>
<tr>
<td>42 28 20 27</td>
<td>64 13 25 32</td>
<td>20 12 21 32</td>
</tr>
<tr>
<td>15 45 * 6</td>
<td>15 14 56 29</td>
<td>36 * 14 45</td>
</tr>
<tr>
<td>30 48 14 56</td>
<td>7 10 4 49</td>
<td>63 18 72 16</td>
</tr>
</tbody>
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<th>Board 4</th>
<th>Board 5</th>
<th>Board 6</th>
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<tbody>
<tr>
<td>4 45 25 81</td>
<td>30 25 45 56</td>
<td>32 29 54 30</td>
</tr>
<tr>
<td>49 56 6 32</td>
<td>18 36 6 12</td>
<td>* 24 48 12</td>
</tr>
<tr>
<td>9 64 * 10</td>
<td>9 64 42 10</td>
<td>6 64 27 10</td>
</tr>
<tr>
<td>15 8 42 48</td>
<td>6 4 83 *</td>
<td>12 18 4 31</td>
</tr>
</tbody>
</table>

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<tr>
<th>Board 7</th>
<th>Board 8</th>
<th>Board 9</th>
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<tbody>
<tr>
<td>4 6 8 10</td>
<td>6 9 12 18</td>
<td>* 12 21 42</td>
</tr>
<tr>
<td>12 14 16 18</td>
<td>37 56 63 65</td>
<td>56 56 63 65</td>
</tr>
<tr>
<td>20 * 22 24</td>
<td>25 * 36 10</td>
<td>63 26 8 10</td>
</tr>
<tr>
<td>21 28 30 32</td>
<td>27 16 55 99</td>
<td>14 16 24 5</td>
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</tbody>
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<tr>
<th>Board 10</th>
<th>Board 11</th>
<th>Board 12</th>
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<tbody>
<tr>
<td>27 21 43 54</td>
<td>27 21 14 54</td>
<td>64 63 72 21</td>
</tr>
<tr>
<td>* 61 24 12</td>
<td>40 72 35 10</td>
<td>40 72 35 10</td>
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<tr>
<td>8 49 81 16</td>
<td>24 16 5 6</td>
<td>16 21 55 49</td>
</tr>
<tr>
<td>28 32 1 10</td>
<td>* 32 15 26</td>
<td>32 * 36 25</td>
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<tr>
<th>Board 13</th>
<th>Board 14</th>
<th>Board 15</th>
</tr>
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<tbody>
<tr>
<td>12 9 22 19</td>
<td>5 25 81 19</td>
<td>8 16 24 48</td>
</tr>
<tr>
<td>21 72 26 10</td>
<td>10 35 56 12</td>
<td>32 * 40 56</td>
</tr>
<tr>
<td>1 16 24 18</td>
<td>15 30 14 8</td>
<td>64 72 81 8</td>
</tr>
<tr>
<td>6 32 * 49</td>
<td>20 40 * 4</td>
<td>20 23 11 4</td>
</tr>
</tbody>
</table>
Jimmy: Hey, wait a minute. This is not fair! I can never get bingo! Most of the numbers on my board are like that. The only way I can get their product is by multiplying that number and 1, and that will never happen because 1 is not on the spinner. Ms. Jabuta, I want a new board!

Marshall: Hey, I know. We can use dice instead. If you roll dice, you can get a 1, then we can get our numbers.

Jimmy: Yeah! [Raises hand] Ms. Jabuta, can we play the next game with dice?

Marshall: [Pointing to 61 on the center of his board] But, wait! I can't get this number with dice because the biggest is 6 x 6. No! Jimmy! Dice isn't going to be good. We can't get the really big numbers like in the 50s and 80s and stuff.

After a few rounds, the students realize that some boards are fairer than others. This dilemma initiates subsequent mathematical discussions focusing on prime numbers, composite numbers, sample spaces, and fair and unfair games. Following a discussion of their observations, Ms. Jabuta distributes blank boards and challenges her students to fill in the boards with their numbers. The boys make a list of possible numbers to put on their boards.

Ben: I think we should do 24 too because we can get 6 x 4, 8 x 3, and . . . that's all.

After discussing numbers that are possible from the spinner, the boys realize that square numbers provide limited options.

Ben: Like 81; we can only get it one way, 9 x 9.

Oliver: And 25; there's only one way to make it, 5 x 5.

Ben: Yes, those are square numbers. I think there is only one way to get those since the spinner has no 1.

Gabe: So maybe we should put the numbers that have the most factors on our boards.

Oliver: But the factors have to be between 2 and 9.

The boys make a list of possible numbers to put on their game board. Through this analysis of what numbers to put on their game board, students as they decide where to place their numbers:

Gabe: I think we should do 24 too because we can get 6 x 4, 8 x 3, and . . . that's all.

GUIDING PRINCIPLES

As middle school teachers, we make decisions every day about which activities to use, when to use them, and for what purposes. The emphasis on mathematical content and student learning in the classroom has made the job of finding engaging and worthwhile activities essential. Every minute counts in classrooms; as a result, we are looking for fun, productive, and creative ways to increase student understanding. As illustrated through the excerpts described above, games such as Product Bingo can be used to—

• investigate mathematical ideas;
• reinforce mathematical concepts;
• engage students in mathematical thinking; and
• provide formative assessment data.

But the critical question becomes this:

How do I ensure that the games I select for my students will encourage them to participate in valuable mathematical thinking and reasoning?
From our own classroom experiences and review of existing research in mathematics education (e.g., Ernest 1986; Lach and Sakshaug 2005), we have identified three guiding principles that can help middle school mathematics teachers select games that promote a deeper understanding of mathematical ideas. Games should be—

1. grounded in mathematics;
2. self-directed and engaging; and
3. appropriate and challenging for all students.

GROUNDING IN MATHEMATICS

Games should provide opportunities for students to discuss mathematics at a high level of cognitive demand and challenge misconceptions. Mathematics should be fundamental to the game. For example, the structure of Product Bingo stimulates discussions of prime numbers, sample space, theoretical and experimental probability, likely and unlikely events, and fairness. Moreover, during play students are engaged in a number of the NCTM Process Standards (NCTM 2000) including Reasoning and Proof, Communication, and Problem Solving. Similarly, students are engaged in several of the Standards for Mathematical Practice (CCSSI 2010), including making sense of problems and persevering in solving them, reasoning abstractly and quantitatively, constructing viable arguments, and critiquing the reasoning of others.

For example, Gabriel, Katie, and Jimmy debated the possible products in the game. During their conversations, they began to make sense of prime numbers as they engaged in quantitative reasoning and persevered in solving the problem by justifying why certain results were not possible. Additionally, as the students worked in collaborative groups to design a winning board, they constructed viable arguments and critiqued the reasoning of others to provide support for their choice of a number and where to place it on the game board. For instance, in Ben, Oliver, Damion, and Gabe’s group, the boys began to make sense of the relationship between the number of factors and the greater probability of spinning that product as they reflected on the thoughts and dialogue of one another.

SELF-DIRECTED AND ENGAGING

Self-directed games involve minimal teacher direction. There should be no need for the teacher to stop in the middle of the game to instruct. Instead, the structure and format of the game should encourage students to continue with play and initiate mathematical discussions on their own. For example, Marshall and Jimmy engaged in rich mathematical discourse as they analyzed their boards in light of the potential for winning. In their conversation, they challenged each other’s ideas and generated questions that the class could investigate. Kennedy (1999) and Martinie (2005) found that when students are engaged in playing games, they improve their participation and ability to communicate mathematically.

APPROPRIATE AND CHALLENGING FOR ALL

All middle school students can play Product Bingo because it has the potential to address various mathematical concepts. It also provides multiple entry points to engage students. In the following dialogue, four students (i.e., Lane, gifted; Jessie, identified with specific learning disabilities in both reading and math; and Oscar and Stevie, identified as on grade level; names are pseudonyms) collaborated to determine the most strategic location for their numbers to increase their odds in winning. In addition, Oscar and Jessie debated on whether to place numbers with the most factors in the corners, reasoning that the corners could help them win in more ways.

Jessie: So we should put 36 and 24 in the corners?
Lane: Yes, and we should also put 18 in the corner because we can get 6 × 3 and 9 × 2.
Stevie: Can we put 16 in the corner?
Lane: No, it’s a square number, so there’s less ways.
Oscar: You can get 8 × 2, and you can get 4 × 4.
Stevie: Can you count 8 × 2 and 2 × 8?
Jessie: It’s the same. You get 16 both ways.
Lane: So 16 has three ways, but 24 and 36 and 18 have four ways.

After discussing the four ways, the group continued to debate the characteristics of square numbers and concluded that “odd square numbers you can get one way, but even square numbers you can get three ways.” Each student eagerly participated in the conversation by posing questions or brainstorming ideas. Bay and Ragan (2000) discovered that students had less anxiety when making mathematical arguments in front of their peers. Moreover, van Oers (1996) argued that “all mathematical learning should take place in the context of a socio-cultural activity in which the pupils want to participate and in which they are able to participate given their actual abilities” (p. 104). In the previous episode, the students discussed mathematical topics such as factors and square numbers, as well as problem solving and organizational strategies. The rich discussion that resulted from constructing their ideal game board provided all students with an opportunity to learn.

The game of Product Bingo has multiple possibilities to address various mathematical concepts and mathematical practices. Fifth- and
sixth-grade teachers can emphasize factorization and help students who are struggling with basic facts; sixth- and seventh-grade teachers can explore sample space and prime numbers; and seventh-, eighth-, and ninth-grade teachers can use the game to investigate theoretical and experimental probability. Product Bingo can provide opportunities for rich mathematical discussions that further students’ mathematical understanding.

GAMES AND THE STANDARDS
Principles and Standards for School Mathematics argues that students’ learning of mathematical concepts is deepened if they are allowed to socially interact with their peers (NCTM 2000). Social activities, such as game play, can motivate students to do more mathematics. If games are thoughtfully selected and implemented, they provide opportunities for students to deepen their mathematical understanding.

As we analyze how to select games to use in the middle school classroom, we consider the reflection questions in figure 2. These questions will assist teachers who want to use math games as an instructional tool. Using games can enhance teaching and learning by providing opportunities to build mathematical language and communication and promote higher-order thinking and reasoning related to specific mathematical concepts.

BIBLIOGRAPHY


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