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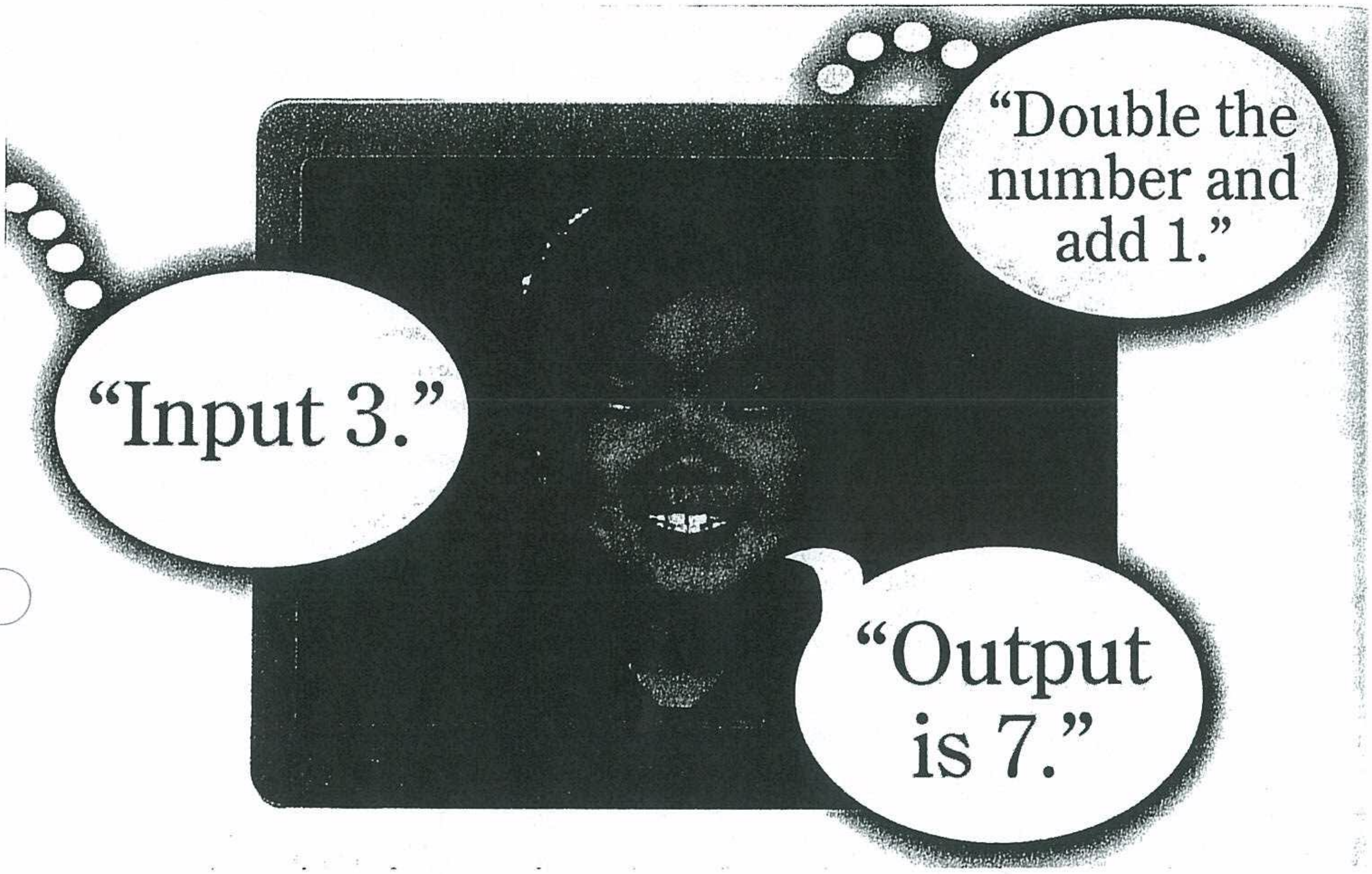
The Function Game



WHEN I began teaching in the late 1960s, we had no videotapes, commercial manipulatives, or calculators to create engaging learning activities for students. I recall spending a good part of my first year searching desperately for ways to motivate my seventh and eighth graders and help them learn mathematics. One activity that I stumbled across worked magically. I thought, "This is a gem," and I continue to cherish it today. I call it the "function game," but my students and others have called it the "input-output game," "guess my rule," or the "computer game." I understand that the game first gained prominence in the "new math" era, but it must have been around in some form much earlier. Today, the game is available on many computer systems and is popular with students and teachers. The computer versions, however, lack many dimensions of the live version.

I have used this game throughout my career with junior and senior high school students and, more recently, with preservice and in-service teachers. I find it to be flexible, engaging, and effective in teaching many essential mathematics concepts. Every time I use it, I continue to marvel at its power and potential. I will demonstrate how it works and share ideas for using it to teach lots of mathematics.

The rules are simple. One person is the "computer" and thinks of a rule, for example, "double the number and add 1." Classmates give "input" values, and the "computer" gives the corresponding output for each. These output values are recorded one at a time on a table as shown in figures 1–9. The object of the game is to guess the rule. When playing with a whole class, we do not went to spoil the fun quickly, so I tell the students that if they know the rule, they should not say it aloud but just tell the "computer" that they know it. Then the

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"computer" gives an input value and the player must give the output If the answer is correct, it will be recorded in the table and play continues. When it becomes clear that most students know the rule, one player is allowed to state it Another student is then chosen to be the next "computer."

Benefits of the Game

The game has many benefits. Because it it predicated on a "secret rule," students are intrigued and motivated to play. Because it is simple and requires no materials, it can be played at any time, for example, as a warm-up or brief closing activity or as part of the development of a lesson. More important, the game uses lots of mathematics. Even to determine simple rules, students must use mental mathematics. Clearly, it requires problem solving that can be very challenging, as shown subsequently. Playing also promotes many opportunities for communication. Moreover. as its name suggests. it is a function game and develops key ideas of algebra: variable, expression, function, and modeling. Let us see how some of these concepts are fostered.

Figures 1–9 show several games in action. Before reading on, try to guess the rules.

Discourse about Equivalent Expressions

One of the major recommendations of the NCTM's *Professional Standards for Teaching Mathematics* (1991) is for teachers to promote discourse in mathematics classes. This game definitely affords opportunities for class discussions. For example, when I use the rule in figure 1, I ask students to state it in as many different ways as they can. Some of their responses follow:

- "Double the number and take away two."
- "Take twice the number, then minus two."
- "Multiply by two, subtract two."

This activity gives us an opportunity to recognize that mathematical operations can be expressed in many equivalent ways, which leads to one of the major benefits of the game: the natural and meaningful introduction of variables. Among the multiple expressions of this rule that students may suggest—or can be shown—is $2n - 2$, where n represents any number. This expression illustrates the efficiency of using symbols and, when coupled with the earlier discussion of different expressions, shows how the language of algebra can generalize arithmetic.

Another expression that sometimes surfaces for the data in figure 1 is "take one less than the number, then double it." If this answer is not suggested by a student, I will say, "I once had someone tell it to me like this...." As with the other rules, we discuss it to see if it works. Depending on where students are in their work with variables, this discussion can serve as an excellent entree to explore the equivalence of $2n - 2$ and $(n - 1)2$ or $2(n - 1)$. Figure 2 shows another example in which two seemingly different rules work: multiply the number by the next number or square the number and add it to itself, which algebraically is $n(n + 1)$, or $n^2 + n$. These and similar examples are opportunities for introducing the concept of the distributive property in rewriting algebraic expressions.

Figure 3 is also interesting. Some students see it as "what you need to add to get ten," whereas others see it as "ten minus the number." I call it "the tens complement." Each new type of rule enlarges the students' repertoire of ideas with which to challenge their classmates in future games.

Number Theory and Number Sense

Number theory, an important topic in middle school mathematics, can be developed nicely through this game. For example, figure 4 shows a rule that sorts multi-

Input	Output
7	12
12	22
4	6
8	14
3	4

Fig. 1

Input	Output
5	30
8	72
11	132
0	0
2	6

Fig. 2

Input	Output
2	8
5	5
12	−2
6	4
20	−10

Fig. 3

Input	Output
7	0
12	1
4	0
8	0
3	1
9	1

Fig. 4

Input	Output
5	0
8	3
11	1
0	0
2	2
9	4

Fig. 5

Input	Output
2	1
5	1
12	0
6	0
20	0
11	1

Fig. 6

Input	Output
2	1
5	2
12	3
6	2
20	4
36	6

Fig. 7

Input	Output
7	11
12	13
4	5
8	11
3	5
9	11

Fig. 8

Input	Output
5	4
8	4
11	4
0	4
2	4
9	4

Fig. 9