Multiply

Using Multiple Intelligences

Jody Kenny Willis and Aostre N. Johnson

Katie sings the multiplication facts quietly to herself. Sam tries to solve problems by tapping his pencil in rhythmic patterns. José draws pictures from his teacher's tile-array models. Alima sorts her crayons into groups to help herself find the answer. Lin checks his solutions with his neighbor. Maria uses logic to extend her knowledge of simple facts to harder ones. These children naturally express their intelligence strengths as they attempt to master their multiplication facts. Their teacher knows that children learn in different ways and seeks to consciously translate these differences into learning methods that will be meaningful. Howard Gardner's theory of multiple intelligences has significant implications for all mathematics teachers who are looking for diverse instructional methods that encourage depth of understanding by tapping students' particular inclinations. As Gardner (1991, p. 13) says, "Genuine understanding is most likely to emerge and be apparent to others . . . if people possess a number of ways of representing knowledge of a concept or skill and can move readily back and forth among these forms of knowing."

In his 1983 book *Frames of Mind: The Theory of Multiple Intelligences,* Howard Gardner proposed a revolutionary revision of our thinking about intelligence. Traditional views and testing methods emphasize a unitary intelligence capacity based on linguistic and logical-mathematical abilities. Gardner suggests that intelligence is based on multiple "frames," each consisting of unique problem-solving abilities. Gardner's eight intelligences are called *logical-mathematical, naturalistic, bodily-kinesthetic, linguistic, spatial, interpersonal, intrapersonal,* and *musical.* All people use all these intelligences in their lives, but through unique relationships between "nature and nurture," each person has a particular mix of intelligence strengths at any given time.

What does multiple-intelligence theory have to do with teaching mathematics? It allows teachers to use eight different possible approaches to mathematical learning and teaching. This multiple-instruction approach—

- results in a deeper and richer understanding of mathematical concepts through multiple representations;
- enables all students to learn mathematics successfully and enjoyably;
- allows for a variety of entry points into mathematical content;
- focuses on students' unique strengths, encouraging a celebration of diversity; and
- supports creative experimentation with mathematical ideas.

Because the idea of multiple intelligences is a theory, not a strict educational methodology, it can be applied flexibly and in diverse ways that work for particular students, teachers, and contexts (see **table 1**). Teachers' strategies may vary from establishing specific times of direct instruction using various methods to setting up multiple-intelligence centers or stations that students visit at flexible times throughout the day. Although all children will benefit from experiences with all intelligences, teachers can encourage students to "lean" on their strengths to achieve mathematical understanding.

The following application of this multiple-intelligence theory to mathematics instruction focuses on building mastery of multiplication facts

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with MI:

to Master Multiplication

as an example. The goal is for children to use their different intelligence strengths to attain initial conceptual understanding of multiplication, then to move toward developing their own thinking strategies for harder facts, gradually building mastery through practice and problem solving. Multiple-intelligence theory can be adapted to any other mathematical concept or skill.

Logical-Mathematical Intelligence

Logical-mathematical intelligence includes the five core areas of (1) classification, (2) comparison, (3) basic numerical operations, (4) inductive and deductive reasoning, and (5) hypothesis formation and testing—all basic "tools" of the mathematician. Although current classroom practices for

TABLE 1

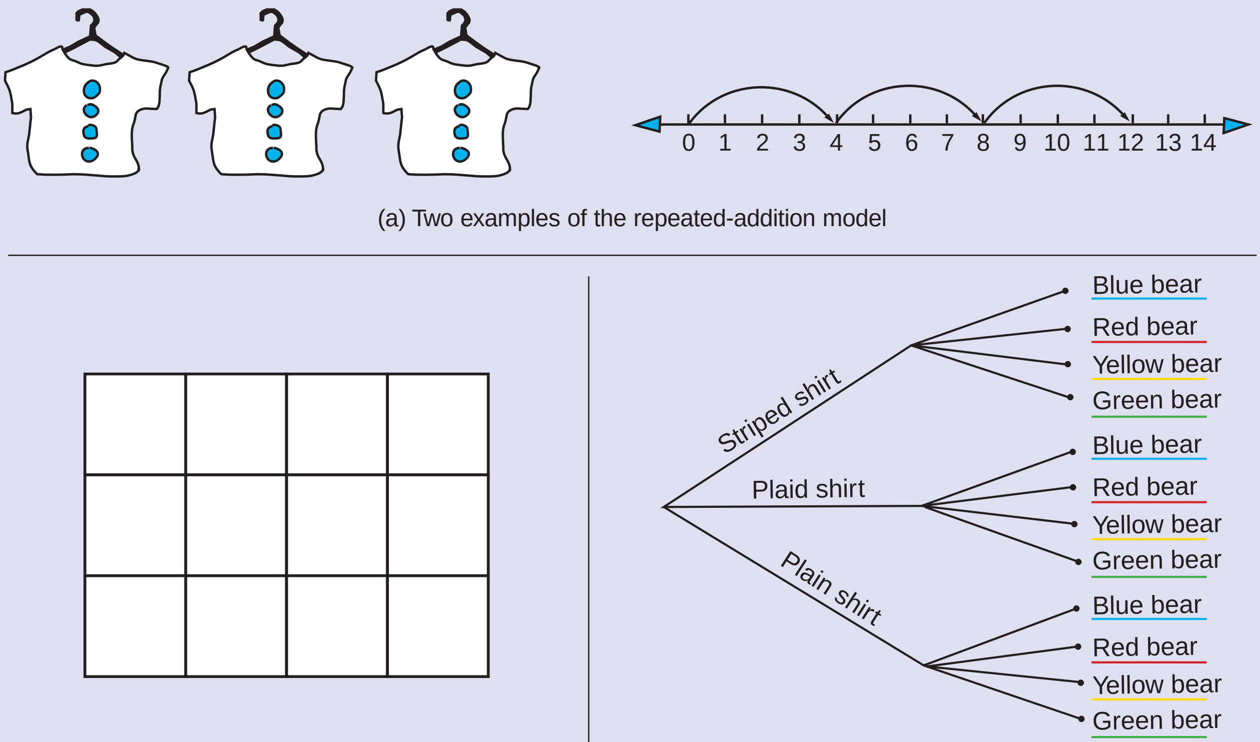
Instructional matrix for multiple intelligences in mathematics

Intelligence	Materials	Learning Activities	Teaching Strategies
Logical-mathematical	calculators manipulatives games number lines Venn diagrams	creating or solving: brain teasers problems logic puzzles equations algorithms justifying thinking	worthwhile tasks connections with previous concepts variety of representations inquiry methods
Naturalistic	natural objects models observation notebooks magnifying glasses	using nature classifying objects observing patterns	demonstrations outdoor activities naturalistic investigations
Bodily kinesthetic	manipulatives models individual children or groups	sequencing movements exploring tactile models dramatizing clapping, tapping, hopping using concrete materials	gestures dramatizations hands-on examples physical models
Linguistic	children's books textbooks audiotapes activity sheets journals	reading word problems writing mathematics stories listening to explanations talking about strategies	storytelling book corners humor and jokes questions assessment tasks lectures written or oral explanations
Spatial	computers graphs charts playing cards manipulatives dominoes bulletin boards overheads	decorating flash cards drawing diagrams creating pictures or other representations looking at illustrations	mental models visual cues; e.g., color, circles, boxes, arrows guided imagery graphic organizers concept maps or webs
Interpersonal	games shared manipulatives	working cooperatively participating in simulations interviewing others engaging in role playing sharing strategies assessing peers' work	discussions people-based problems peer tutoring group activities guest speakers
Intrapersonal	self-checking materials diaries or journals	writing in journals addressing values and attitudes reflecting on connections with students' lives conducting self-assessment	private spaces choice time empowerment
Musical	tape recorders CDs instruments	composing, performing, or listening to raps, songs, chants using musical notation creating rhythmic patterns	listening corners rhythmical activities background music

Source: Adapted from a model by Armstrong (1994, p. 52)

FIGURE 1

Three models for multiplication showing the fact 3 × 4



(a) Two examples of the repeated-addition model

(b) Array model

(c) Combination model

teaching mathematics frequently focus on rote answers, research encourages children to explore various representations for different multiplicative situations and to investigate the relationships among these models to obtain a deeper mathematical understanding of the operations (Kaput 1989; Kouba and Franklin 1995; Isaacs and Carroll 1999).

Logical-mathematical intelligence allows children to develop an understanding of the three models for multiplication illustrated in **figure 1** and to apply this knowledge to real-life situations. Teachers usually introduce facts using repeated addition with manipulatives, such as buttons, candies, or Cuisenaire rods. Other possibilities include using number lines or a calculator's repeated-addition function by pressing + 4 + 4 + 4. The array model, which relates to area, can be illustrated with color tiles, geoboards, pegboards, and graph paper. The combination, or Cartesian-product, model of multiplication requires each member of a group for one number to be paired with each member of a group for the second number. For example, four bears of different colors can be paired with three different T-shirts in twelve possible combinations in a tree diagram.

Effective use of logical-mathematical intelligence would enable children to conceptualize multiplication's relationship to other operations, namely, as repeated addition and as the inverse of division. This intelligence also underlies the development and articulation of thinking strategies. For instance, students can work from known facts to reason about multiplication problems: "If $10 \times 7 = 70$, then $9 \times 7 = 70 - 7 = 63$," or "If $3 \times 7 = 21$, then 6×7 would be double that, or 42." Such strategies not only encourage problem-solving skills but also are faster than more immature counting methods and help children learn facts in relation to other facts, not as isolated bits of information.

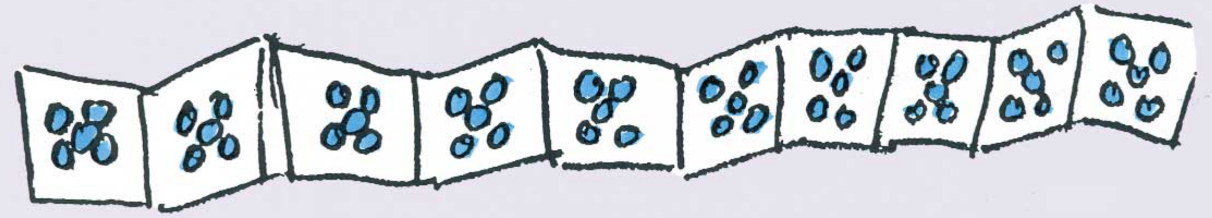
The role of logical-mathematical intelligence in acquiring mathematical skills and concepts is obvious, yet the seven other intelligences also make significant contributions as children select their own unique strategies to move from initial investigations, through increasingly sophisticated levels of understanding, to mastery.

Naturalistic Intelligence

Naturalistic intelligence includes the ability to relate to the natural world with clarity and sensitivity; to recognize and classify living things, natural objects, and patterns; and to use the information gained productively. Ecological and environmental perspectives are grounded in this type of intelli-

FIGURE 2

Paper-folding task for the facts for 5

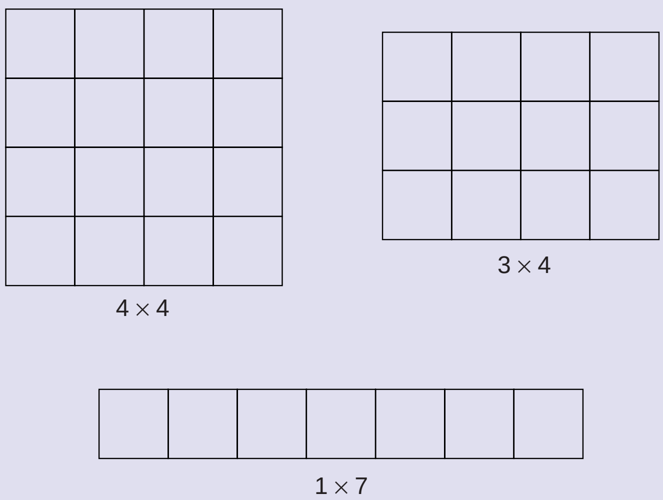


gence and use mathematical concepts in their theories and methods. Students who have a particular ecological strength show a strong interest in the natural sciences and in the outdoors.

Children's first examples of groups of objects emerge from the "natural" world around them. For example, a baby notices the five fingers on each of her two hands and the two eyes of her father. Initial informal multiplication experiences spring appropriately from nature. For example, how many eyes do the four people in a family have? How many noses, ears, hands, or fingers do they have? All mathematics curricula connected with this intelligence use as many natural objects and as much time in nature as possible. These curricula provide unique opportunities to encourage a sense of wonder at the extraordinary mathematical patterns found in the natural world—in plants, pets, insects, birds, shells, zoo animals, and the children themselves. Biological classification systems allow students to work in authentic ways on subtle and complex organization and numbering. *Sea Squares* (Hulme 1991) is an example of an effective picture book for multiplication ideas. The book uses illustrations of natural creatures to pose multiplication questions, such as how many arms are found on four starfish or how many legs on six pelicans. Teachers and students can create their own problems and examples using number patterns in nature.

FIGURE 3

Visual models of square facts, rectangular facts, and prime numbers



Bodily-Kinesthetic Intelligence

Children with strong bodily-kinesthetic intelligence use their bodies in highly differentiated ways to develop and express concepts. They may naturally tap out facts with their fingers, trace facts with their fingers on other body parts, or manipulate various physical objects to represent different facts. Instructional approaches that use a variety of manipulatives allow for the expression of both visual and bodily-kinesthetic intelligences. Even adult mathematicians might use this intelligence as they build models in their scholarly pursuits. Einstein described his theorizing as more "visual and motor" or "muscular" than linguistic (Einstein 1952, p. 43).

Teachers who wish to help students acquire multiplication facts using bodily-kinesthetic intelligence may have groups of students dramatize facts by asking them to act out various problems. For example, teachers could introduce the concept of multiplication by physically arranging students into three basketball teams with five players each. Students can also do "multiplication exercises" by hopping, jumping, or clapping to various facts. The fact 3 × 4 might be four jumps—rest—four jumps—rest—four jumps. "How many jumps in all?" Children can create kinesthetic patterns as they count to the number 40, stamping on multiples of 4 and clapping on every number in between. Tracing facts in sand, doing finger painting, or writing facts in glue and decorating the numbers are other possible bodily-kinesthetic activities. Using the picture book *Knots on a Counting Rope* (Martin and Archambault 1990) as a model, children can create ropes that represent different facts by knotting strings or by stringing beads.

Linguistic Intelligence

Linguistic intelligence encompasses a wide range of language skills, from sensitivity to the meanings of specific terms to the ability to use language in a variety of contexts. The NCTM recognizes the importance of language in its *Curriculum and Evaluation Standards for School Mathematics* (1989), which state that "representing, discussing, reading, writing, and listening to mathematics are a vital part of learning and using mathematics" (p. 26). Most teachers require children to listen and read during their mathematics lessons; in recent years, many teachers have begun to initiate more opportunities for children to speak and write about their experiences.

All children should be exposed to a wide variety of worthwhile verbal tasks as they encounter the idea of multiplication and learn their facts. The teacher may offer a persuasive verbal introduction to the exciting uses of multiplication in the world, from the kitchen to the workplace. Children can also tell or write their own multiplication stories. Many children's books, such as *Anno's Multiplying Jar* (Anno 1983) and *One Hundred Hungry Ants* (Pinczes 1993), relate to multiplication either directly or indirectly. Although the text in books may use a verbal-linguistic approach to pose problems or offer explanations, the pictures in these books will also engage students who prefer visual models.

Oral recitations of facts may be beneficial for some students. The facts for 2 and 5 tend to be easy for children who have been introduced to skip counting at earlier ages. Children can use language to communicate the results of multiplication tasks, to explain the reasoning behind their problem solving, to comprehend other children's thinking strategies, and to assess their progress by explaining to their teacher, parent, or another student the facts that they know well and those that they need to practice.

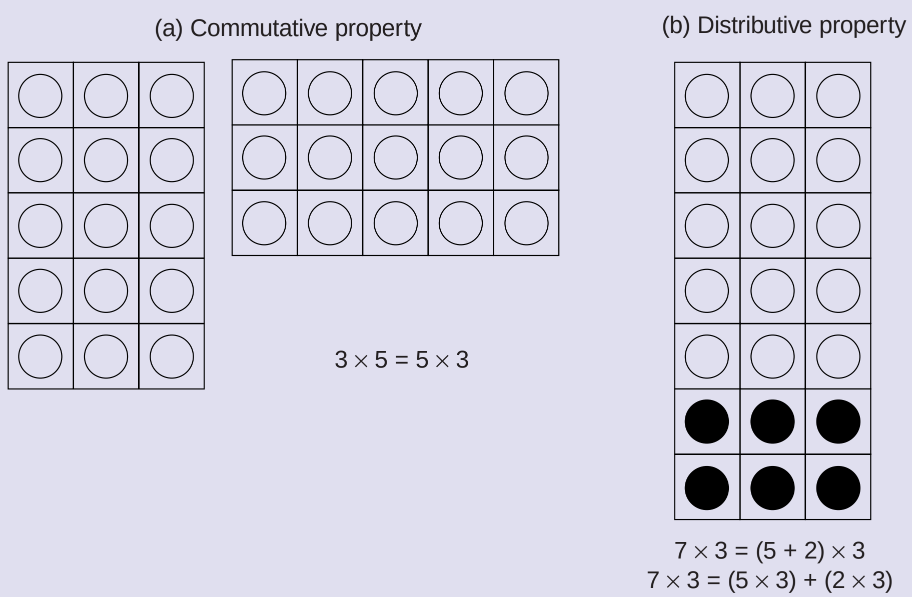
Spatial Intelligence

Children who have strong spatial intelligence are able to perceive the visual world accurately, create images in their minds in the absence of physical stimuli, and produce effective two-and three-dimensional representations. Many adult mathematicians rely heavily on this intelligence as they theorize and represent their findings.

Visual models enhance memory by creating images that the mind stores for subsequent reference. Many picture books contain excellent prospects for teachers to develop spatial intelligence in students. For instance, in the book *Madeline* (Bemelmans 1939), the picture of six girls in each of two straight lines presents an interesting chance to explore whether the girls could be grouped in other ways, such as in three lines of four. Flash cards can be decorated by using different colors or pictures or by writing difficult facts in creative ways, such as in "fat" numerals. Students

FIGURE 4

The commutative and distributive properties of multiplication



could create an advertisement for a multiplication fact, draw a fact picture, or create a bulletin board that illustrates the doubles facts. Children can also work with models, such as an egg carton for 2×6 or a spider's legs for 2×4. A paper-folding task could depict the repeated-addition model as each segment unfolds. **Figure 2** shows such a task for the facts for the number 5.

Spatial intelligence also fosters deeper understanding as children solve problems and represent solutions. Children can explore the shapes that are formed as they create "boxes," or array models, using colored tiles. They will see that many numbers yield several rectangular shapes, whereas prime numbers yield only one row of tiles (see **fig. 3**). Teachers should guide the process by asking, "Do the multiplication facts that you have modeled always form rectangles? Why are some facts called *square facts*?" The commutative property can be demonstrated by rotating the tile models, and the distributive property can be shown by splitting an array, as shown in **figure 4.**

In an era that promotes collaboration, make sure not to neglect students who prefer to work alone

Another spatial activity that gives practice and involves problem solving is to have children color multiples of a number on a hundred chart and look for patterns. Children can do this activity for multiples of 2 through 9 and compare the patterns that are formed. If this activity is done on transparencies, the children can discover common multiples by placing one sheet on top of another (see **fig. 5**).

Interpersonal Intelligence

Interpersonal intelligence encompasses understanding and communicating sensitively with other people. It consists of the ability to notice and make distinctions about people's moods, temperaments, motivations, and intentions—and to make relevant decisions based on this knowledge. Children who are adept in interpersonal intelligence may thrive on collaborative problem solving, but compelling reasons exist to cultivate this form of intelligence in all students. Nurturing students' social and emotional skills now should produce members of society who are more caring and cooperative in the future. In the world of adult mathematicians, scholarship and work are increasingly communal, rather than individualistic, enterprises.

Obviously, learning methods designed to enhance interpersonal intelligence focus on cooperation among students. Even when students work individually on problems and assignments, they can be asked to justify their methods and results with one another. Partners can work on shared multiplication problem solving or assess each other's work. Peer tutoring allows students who have more advanced mathematics skills to assist those whose skills are not so advanced, resulting in improvement for both. Children can collaborate in short- or long-term mathematics groups.

Real-world multiplication problems can be constructed using familiar people and situations. Students and teachers might invent multiplication examples that reflect their interpersonal interests. For example, Alima could make up a problem involving the amount of candy collected as she and her best friends trick-or-treat on Halloween. Students can also interview adults in various professions about how they use multiplication skills on the job.

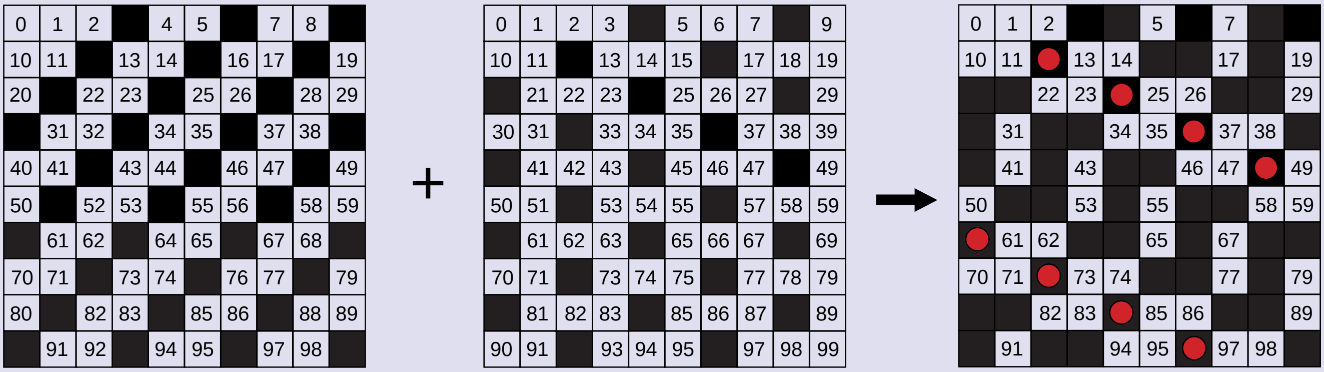
Intrapersonal Intelligence

Intrapersonal intelligence is the ability to understand oneself—to recognize one's own feelings, set goals, and make relevant decisions. In an era that promotes collaboration, we must also make sure that we do not neglect the students who prefer to work alone. Intrapersonal intelligence thrives on quiet spaces and personally challenging problems, as well as time for in-depth explorations. All students benefit from learning to deepen their knowledge of themselves, their introspection, and their ability to develop appropriate personal strategies.

This intelligence has significant implications for the mathematics curriculum. A curriculum designed to facilitate a metacognitive perspective will emphasize personalized experimentation with diverse and meaningful problems. The teacher can introduce multiplication to students as a "big idea" that has extraordinary possibilities for relating to real and imaginary events in their lives. She can show how multiplication is used to address issues of concern to students, such as caring for pets or saving endangered species. Students should be encouraged to set goals for themselves on many levels, such as using their choice of intelligences to memorize multiplication facts, creating their own personally relevant multiplication problems to solve, and finding or communicating unique solutions to teacher-posed problems. Students can also assess their own mastery of facts, asking them-

FIGURE 5

Patterns of multiples on a hundred chart using the facts for 3 and 4 and a combination of the two fact patterns



Multiples of 3 + Multiples of 4 → Combination pattern

selves, "Which facts do I know well; which ones do I need to practice?" Finally, students can keep ongoing mathematics journals in which they record their multiplication goals, activities, and self-assessments, as well as their attitudes.

Musical Intelligence

Pitch, rhythm, tonal quality, and emotional expression are all aspects of musical intelligence. The underlying rhythmical patterns of music are founded in mathematics, and the musical notation system is based on fractions and numerical patterns. Gardner (1983) notes that many composers have been sensitive to mathematical patterns and that many mathematicians and scientists are attracted to music.

In learning multiplication, students can use rhythmic groupings of sound to represent problems and solutions. These activities can be either kinesthetic, involving hopping or clapping, as mentioned earlier, or tonal, using the voice or musical instruments. Many adults have learned the alphabet through singing, and multiplication facts can likewise be remembered through music. Although some children may be able to compose their own tunes as they sing their multiplication tables, adapting the facts to a familiar tune may be easier for many children. The familiar song "Row, Row, Row Your Boat" could be adapted to "Two and two are four. Four and four are eight. Eight and eight are sixteen. Other facts we'll state." Students could compose and perform similar verses. Some students may prefer chants or raps. Learning the facts for 7 are often difficult for children. The rap shown in **figure 6** serves as an example of a device that might be created to help children remember the facts for 7.

FIGURE 6

The facts for 7 put to song

Let's rap our facts quickly,
Then mathematicians are what we'll be.
For 0×7 here's a tip:
0 times a number equals zip.
1×7 is easy to remember;
1 times anything is just the number.
Doubles facts are easily seen.
Two 7s always equal 14.
3×7 gives 21.
Keep rapping our facts until we're done.
We love math and really can't wait
To state four 7s is 28.
Five 7s gives 35 real quick,
But seven 5s is 35, too! Neat trick!
Six 7s is double three 7s, 21,
So 6×7 is 42—such fun!
Keep on rapping; we're doing just fine.
7×7 equals 49.
56 answers 8×7.
Knowing our facts takes us to heaven.
Ten 7s is 70.
So nine 7s, one less, equals 63.
Mathematicians—that's what we are.
We can rap our facts both near and far!

Conclusion

According to Gardner's theory, children are intelligent in multiple ways and have unique combinations of intelligence strengths. All these intelligences can be used throughout the mathematics curriculum. Rather than treat multiplication as memorization of facts or rote computation of irrelevant equations, multiple-intelligence theory enables students to understand it as an exciting,

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relevant way of symbolizing a significant property of the world around them. When teachers encourage the use of diverse intelligence strengths in multiplication, they allow students to increase their capacities to learn facts by heart, conceptualize the meaning of multiplication, develop thinking strategies, solve problems, and engage intensively and creatively in mathematics. As they do so, students have the opportunity to discover and celebrate their own, and one another's, unique abilities.

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