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Helping Children Learn Mathematics Through Multiple Intelligences and Standards for School Mathematics

Many approaches can be used when teaching mathematics to young children, and many theories and philosophies of learning address empowering children to learn mathematics. Whatever method is chosen, however, children's varied learning styles, strengths, experiences, and perspectives must be considered. To achieve that goal, it is important to recognize that not all children learn in the same way, and that children have multiple means of learning.

Multiple Intelligences

Howard Gardner's multiple intelligence theory (1983) states that children employ a variety of intelligences in learning situations. He originally proposed that children learn through seven intelligences (see Table 1).

Children might have strength in one or more intelligences, which serve as mechanisms for learning and lead to cognitive ability. Each child may use a variety of these intelligences to learn mathematics concepts and skills, not just the logical-mathematical. The activity and lesson ideas presented in this article represent experiences from which all children can benefit, regardless of the intelligences they most favor. Therefore, it is not necessary to attempt to categorize children by intelligence, but only to provide for them a multitude of learning opportunities.

Standards for School Mathematics

In April 2000, the National Council of Teachers of Mathematics (NCTM) unveiled its new *Principles and Standards for School Mathematics* (NCTM, 2000). Of the 10 standards, five are content-oriented and five are process-oriented. This article focuses on the process standards: 1) Problem Solving, 2) Reasoning and Proof, 3) Communication, 4) Connections, and 5) Representation. They serve as a framework for utilizing the multiple intelligences that children bring to mathematics learning. Each process standard is briefly described in Table 2.

The ideas presented here for mathematics lessons and activities are designed to capitalize on children's use of the seven intelligences for learning. Ideally, they will initiate development of more comprehensive classroom experiences. Most of the ideas build on common experiences during the process of teaching mathematics. The author hopes to create a structure, based on the NCTM process standards, for providing opportunities for all

Summary of Gardner's Original Multiple Intelligences

Intelligence	Description
Linguistics	**Words/Language:** the ability to use words correctly and comfortably, either orally or in writing, to express meaning
Logical-Mathematical	**Logic/Mathematics:** the ability to use numbers correctly and effectively; to think inductively or deductively; to categorize, classify, and generalize
Spatial	**Visual:** the ability to understand, interpret, and model the visual world; to represent spatial information effectively
Bodily-Kinesthetic	**Body/Physical:** the ability to use physical means to represent ideas and feelings
Musical	**Music:** the ability to understand and use musical concepts in a perceptive or technical sense; to develop an appreciation for music
Interpersonal	**People/Relationships:** the ability to relate to and understand people; to possess good social and leadership skills
Intrapersonal	**Self:** the ability to use self-understanding and self-knowledge; to monitor the self; to be self-disciplined

(Armstrong, 1994)

Table 1

Summary of the National Council of Teachers of Mathematics Process Standards (NCTM, 2000)

Standard	Description *Instructional programs should enable all students to . . .*
Problem Solving	• build new mathematical knowledge. • solve problems in mathematics and in other contexts. • apply and modify a variety of problem-solving strategies. • monitor and reflect on the problem-solving process.
Reasoning & Proof	• recognize reasoning and proof as foundations of mathematics. • make and investigate conjectures and hypotheses. • develop and assess arguments and proofs. • choose and use a variety of proof techniques.
Communication	• organize and consolidate mathematical thinking. • communicate mathematical thinking coherently and clearly. • analyze and assess the mathematical thinking of others. • use mathematical language to express ideas.
Connections	• recognize and apply connections among mathematical ideas. • understand how the idea "parts" create the "whole." • recognize and apply mathematics in other contexts and areas.
Representation	• create and use mathematical representations. • choose, apply, and translate among representations. • use representations to model and understand mathematical ideas.

(NCTM, 2000)

Table 2

Multiple Intelligences and Problem Solving

Intelligence	Problem Solving *Children can . . .*
Linguistic	• write stories as contexts for word problems; trade stories (and problems) with classmates; read stories; solve problems, discuss solutions. • record journal entries related to the problem-solving experience, and, with instruction, be able to explain their way of thinking about problems. • explain problem-solving strategies (e.g., working backward, trying a simpler problem) to each other.
Logical-Mathematical	• sort polygons into separate groups according to a rule known only by a leader; the leader only answers "yes" or "no" to the children's question as they search for the leader's rule for classifying the polygons. • gather, record, and use numerical data to solve problems. • solve problems with numbers used in various contexts (e.g., ordinal numbers, nominal numbers).
Spatial	• hypothesize about the identity of geometrical solids according to "clues" given by a leader (e.g., "It is a solid with 12 edges. What is it?"). • use drawings and diagrams as problem-solving strategies. • build physical models as tools for solving problems (e.g., use toothpicks for network problems). • create a problem-solving board game with manipulative pieces.
Bodily-Kinesthetic	• engage in simulations to demonstrate and model problem contexts. • use dramatization as a strategy for solving problems. • use bodily movement to express feelings and attitudes about problem solving.
Musical	• find and extend patterns in music (e.g., Given the scales for several measures in sequence, students should be able to determine the next measure) (NCTM, 1997). • look for patterns as a problem-solving strategy. • translate problem-solving strategies to a musical tune to help recall strategies.
Interpersonal	• write or find problems that they think can be solved by their classmates (these problems can be used for explorations). • solve problems through cooperative learning. • be leaders or guides of a problem-solving team.
Intrapersonal	• consider a set of problems to be solved and conjecture about their own abilities or confidence to solve the problems. • set goals for growth in problem solving. • reflect on and discuss reasons for performing certain actions during the problem-solving process, orally or in writing.

Table 3

Multiple Intelligences and Reasoning and Proof

Intelligence	Reasoning and Proof *Children can . . .*
Linguistic	• discuss patterns in real-world and mathematical situations. • provide written and oral justifications of their learning actions. • express their arguments in ways that make sense to others. • summarize and explain the justifications of others.
Logical-Mathematical	• develop mathematical conjectures and hypotheses. • generalize mathematical conclusions (e.g., The sum of zero and any number is that number). • be challenged to answer questions such as "Why is this true?" and "How can you prove that your answer is valid?" • explore the mathematical properties of calendars, and make conjectures about certain phenomena.
Spatial	• use paper folding or cutting to prove concepts (e.g., $1/2 = 2/4$). • build models to prove relationships between concepts (e.g., What is the relationship between the concept of square and the concept of rectangle?). • analyze objects for useful information.
Bodily-Kinesthetic	• use their bodies to reason about concepts (e.g., proportion, measurement). • act out (dramatize) in order to demonstrate their understanding and reasoning. • consider why a base 10 numeration system is common in the United States, while other cultures use a base 20 system.
Musical	• make conjectures as to whether or not patterns are infinite (e.g., compare patterns to songs that have patterned rounds that "never end"). • write a song (to a known tune, if necessary) that expresses understanding for a mathematical concept.
Interpersonal	• listen to conjectures and hypotheses presented by others and communicate accordingly. • collaborate with others to develop arguments and proofs. • compare justifications to look for common ideas. • engage in debates and discussions with classmates.
Intrapersonal	• evaluate the validity of conjecture(s) after an experiment. • be challenged to avoid making groundless hypotheses and conjectures. • use personal knowledge and previous experiences to build a basis for a conjecture.

Table 4

children to learn mathematics through those intelligences that serve the children best.

Multiple Intelligences and Problem Solving

To consider problem solving as "the central focus of the mathematics curriculum" (NCTM, 1989) evokes a multitude of heuristics, plans, methods, and strategies. The multiple intelligences theory provides a platform from which to build on learners' diverse problem-solving characteristics and strengths. An understanding of the multiple intelligences approach is critical, because problem solving involves a person participating in a task or experience for which the answer or solution is not readily known or available (Krulik & Rudnick, 1993). Hence, each child has the potential of using a unique approach when solving a problem. Consider the ideas in Table 3 for approaching mathematics through problem solving.

Multiple Intelligences and Communication

Intelligence	Communication *Children can . . .*
Linguistic	• respond to prompts for writing with, and about, mathematics and mathematics learning experiences. • read and develop stories about the mathematics they are studying. • engage in discourse about mathematics and indicate that they can correctly use mathematical terms. • explain mathematical terms to children whose first language is not English; English as Second Language students will be able to share their mathematical terms and labels with classmates.
Logical-Mathematical	• express their understanding of the magnitude of numbers and their interpretations of the uses of numbers through written and oral assignments (Explore the distance between the sun and the earth using everyday objects as arbitrary measurements: e.g., How many cars, if positioned bumper-to-bumper, would it take to reach from the sun to the earth?). • exercise critical thinking through open-ended discussions. • develop and use categories to classify written and oral mathematical information.
Spatial	• describe characteristics of two-dimensional shapes and three-dimensional objects as part of a geometry assessment. • use concept mapping to communicate their patterns of thinking. • write and verbalize descriptions of mathematical objects. • draw and use objects to convey ideas about mathematical concepts.
Bodily-Kinesthetic	• use "body language" or charades to convey a mathematical message to classmates. • use the body to answer questions or engage in an exploration (e.g., raise hand, join a specific group, move to a certain place in the room, place self in the correct position in some ordinal group—arranged by height, age, etc.).
Musical	• listen to popular children's songs to detect the mathematical concepts therein (e.g., "This Old Man"—counting song; "If You're Happy and You Know It"—pattern song). • write songs to communicate mathematical ideas to others. • listen to counting songs from other cultures and languages.
Interpersonal	• listen to others share their mathematical ideas. • share journal entries or other writings, and assist each other with developing questions for the teacher to eliminate misunderstandings. • share communicative roles in cooperative groups (e.g., recorder, reporter, etc.). • consider the validity of different mathematical points of view, as well as others' perspectives.
Intrapersonal	• review problem-solving experiences and provide reflections about their thinking during the process of solving the problems. • keep a personal journal of mathematical experiences. • explain and justify their answers. • discuss with others the thinking behind a mathematical learning experience. • describe feelings and attitudes about mathematics.

Table 5

Multiple Intelligences and Connections

Intelligence	Connections *Children can . . .*
Linguistic	• explore and discuss relationships between mathematics and other subjects (e.g., mathematics and art). • write about relationships between mathematical concepts (e.g., addition and subtraction).
Logical-Mathematical	• explore relationships and differences between numbers (e.g., prime and composite, odd and even, etc.). • study the uses and interpretations of various numbers (e.g., How are negative numbers used in various jobs? How are numbers used in sports?). • categorize and classify numbers (e.g., real, rational, integer, etc.).
Spatial	• explore relationships between and among two-dimensional shapes. • explore relationships between and among three-dimensional objects. • explore the uses of mathematics in architecture (e.g., Why would people build round houses versus rectangular houses?)
Bodily-Kinesthetic	• explore relationships of the body (e.g., One's arm span is an indication of one's height). • investigate connections between the body and various restrictions (e.g., the maximum number of people that can ride an elevator at one time). • use body characteristics for learning about disjointed or intersecting groups.
Musical	• explore the connection between music and mathematics (e.g., both use terms like "half," "quarter," "whole"). • use musical notes to learn fractions (e.g., How many half notes equal a whole note? How many quarter notes equal a half note?). • create a mathematics musical in connection with the music program.
Interpersonal	• engage in group explorations related to studying mathematics, as it is applied in other subjects and contexts. • explain to others, coherently and clearly, the connections between mathematical concepts (e.g., the connection between circumference and diameter of a circle). • lead a peer group discussion about various mathematical connections within and outside the realm of mathematics.
Intrapersonal	• be challenged to use prior knowledge to solve problems. • explore opportunities for connections between mathematics and other subjects in their own environment (e.g., homes, neighborhoods). • consider ways in which they use mathematics outside of the classroom.

Table 6

Reasoning means using available information and prior knowledge to make sense of an idea or phenomenon. Estimating, questioning, hypothesizing, and conjecturing are some of the components of reasoning (NCTM, 1989). One of the best ways to improve children's reasoning skills is to create opportunities and situations that encourage them to use reason. In addition, children should be encouraged to justify, or "prove," their reasons and explanations relevant to a mathematical situation. They should be challenged to support or refute conclusions with well thought-out evidence and suggestions. The suggestions in Table 4 provide reasoning and proof opportunities for children with various learning styles. Many other reasoning and proof experiences can be added to this list.

Communication is a key component of an effective classroom. Oral discourse, written work, and dramatization provide opportunities for children to share with, and learn from, others. Communication also offers an opportunity for children to be part of an active community of learners, wherein each person's input is valued and respected. Table 5 includes ideas for enhancing communication in the classroom.

Making mathematical connections within mathematics, and between mathematics and other disciplines (NCTM, 1989, 2000), is important to helping children view mathematics as an applicable tool. Because children learn differently and benefit from operating within the strength of one or more intelligences, mathematical

Multiple Intelligences and Representations

Intelligence	Representations *Children can . . .*
Linguistic	• write numbers in various forms (e.g., scientific notation, fractions). • translate word problems to algebraic expressions, and vice versa. • explain their representations of mathematical ideas.
Logical-Mathematical	• work with numbers in various forms (e.g., fractions, decimals, percents). • compare representations of numbers to consider what is most effective or efficient for communicating an idea. • use technology (e.g., a computer spreadsheet) to represent and sort data.
Spatial	• develop graphs of algebraic expressions. • use diagrams, charts, pictures, and tables to solve problems. • use manipulatives and other objects to represent mathematical concepts (e.g., base 10 blocks).
Bodily-Kinesthetic	• model concepts with people (e.g., two groups of four people each has the same quantity as four groups of two people each). • model division by distributing objects to people.
Musical	• collect information on the different rhythmic patterns of music, and record the information. • use concrete objects to model music rhythms. • represent rhythms through dance patterns and drawings.
Interpersonal	• engage in discussions about different mathematical representations. • participate in group work that involves the use of various mathematical representations. • debate the applicability of various representations.
Intrapersonal	• represent mathematical ideas in meaningful ways. • make decisions about which mathematical representation works best for given situations. • organize thinking according to various representations.

Table 7

connections can help children view mathematics from different perspectives. Table 6 offers some insight into how connections can be addressed for the multiple intelligences that children bring into the classroom. Children also need to gain a perspective of mathematics as a body of knowledge that is related to other subjects in multiple ways. Curriculum integration is one tool for making these connections explicit.

Mathematical knowledge and information can be represented in a variety of ways. How children perceive, interpret, and create these representations is an important issue. For example, children benefit from being able to use various representations for solving problems, engaging in projects and discussions, and exploring the world of numbers. Some mathematical information is easier to understand and work with in one representation than in another. Consider the multiplication of mixed numbers, for example. It is easier to multiply mixed numbers when they are represented as improper fractions than it is to leave them as mixed numbers.

As children learn mathematics, they should be encouraged to use and create representations that not only make sense to them, but also are efficient means of completing a mathematics task. Table 7 offers some insight into activities that might help children learn about mathematical representations. When considering the ideas presented in the table, think of the many representations of a mathematical concept that are available and how these representations might be useful to children.

The author hopes that this article will initiate dialogue among teachers regarding the multiple intelligences children use for learning mathematics (and other subjects), and the relationship between those intelligences and the new NCTM standards for school mathematics. By paying attention to children's varying abilities, interests, and intelligences, we will enhance the quality of mathematics curriculum and instruction. Teachers may want to consider the different ways in which a mathematics concept, skill, or procedure might be approached in light of the different multiple intelli-

Overlapping of Gardner's Multiple Intelligences and NCTM Process Standards

	Problem-Solving	Reasoning & Proof	Communication	Connection	Representation
Linguistic	• Write stories as context for word problems. • Write about problem-solving.	• Express arguments in ways that make sense to others. • Refute/support a mathematics idea.	• Respond to prompts for writing with/about mathematics. • Define terms.	• Write about relationships between mathematical concepts.	• Translate word problems to algebraic expressions and vice versa.
Logical-Mathematical	• Gather, record, and use numerical data to solve problems. • Calculate to solve problems.	• Generalize mathematical conclusions. • Provide non-examples.	• Develop and use categories to classify written and oral mathematical information.	• Categorize and classify numbers. • Explore the use of numbers in other disciplines.	• Use technology to represent and sort data. • Represent numbers in various ways.
Spatial	• Use drawings and diagrams as problem-solving strategies. • Explain a drawn solution.	• Use paper folding and cutting to prove concepts.	• Describe characteristics of two-dimensional shapes and three-dimensional objects.	• Explore the uses of mathematics in architecture. • Describe classroom and school.	• Use diagrams, charts, pictures, and tables to solve problems.
Bodily-Kinesthetic	• Use dramatization as a strategy for problem-solving.	• Use parts of the body to reason about concepts (e.g., proportion).	• Use body language or charades to convey a mathematical message.	• Investigate connections between body and various restrictions in the world.	• Model division by distribution of objects to people.
Musical	• Translate problem-solving strategies to a musical tune to help recall strategies.	• Compare patterns to songs that have patterned rounds that "never end."	• Listen to counting songs in other cultures and languages.	• Create a mathematics musical in connection with the music program.	• Use objects to model music rhythms. • Explore the sound of concrete objects.
Interpersonal	• Solve problems through cooperative learning. • Lead a problem-solving excursion.	• Collaborate with others to develop arguments and proofs.	• Share communicative roles in cooperative groups.	• Lead peers in discussions about mathematical connections.	• Debate the applicability of various representations.
Intrapersonal	• Set goals for growth in problem-solving. • Monitor problem-solving process.	• Use personal and previous knowledge to build a basis for a conjecture.	• Describe feelings & attitudes about mathematics. • Think aloud.	• Consider ways in which mathematics is used in own life.	• Organize thinking according to various representations. • Use different representations.

Table 8

gences, while also acknowledging that many of these approaches and multiple intelligences overlap.

Considering how the NCTM 2000 standards overlap with Gardner's multiple intelligences is helpful when developing accessible mathematics curriculum, instruction, and assessment. Table 8 provides an example of how the standards and multiple intelligences can be used together to create meaningful and challenging mathematics experiences for all types of students. Several of the activities presented in Tables 3-7 show the strength of the relationship between the standards and the intelligences. A thorough exploration of the related possibilities can lead to successful and rewarding mathematics teaching and learning experiences in the classroom.

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