Preservice Elementary Teachers Create Mathematical Mystery Object Boxes to Review and Teach Numeration, Algebra, Geometry, and Measurement

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Abstract
A study was conducted with forty-seven preservice childhood (elementary) education teachers (42 F, 5 M) enrolled in two mathematics methods classes taught by the same instructor to determine the effect of these college students making curriculum materials appropriate for upper elementary students on the preservice teachers' knowledge of numeration, algebra, geometry, and measurement. A *Mathematical Mystery Object Box* is a box containing a set of objects with corresponding clue cards. The student reads the mathematical clues addressing numeration, algebra, geometry, and measurement and attempts to locate the object that satisfies them, checking work with the picture of the correct object on the reverse side of each clue card. The study used an identical pretest/posttest design with a 20-item instrument tied to the New York State Standards for Mathematics for grades four through six. Preservice teacher scores on the pretest administered the first day of class were low (mean = 54%, standard deviation = 18%). However, without any class instruction or review, but through creating teaching materials for elementary students, the posttest scores of preservice teachers increased significantly on the posttest given nine weeks later (mean = 71%, s. d. = 14%). This indicates the amount of learning that occurs when preparing materials to teach others. Example mystery object box materials created by the preservice teachers are provided.

Introduction

Mathematics is a complex domain dependent on factual knowledge, procedural knowledge and conceptual understanding. Learning with deep comprehension is essential for transferring mathematical knowledge to new situations. Hands-on materials provide an important component of learning in a mathematical program, as they allow students to portray mathematical concepts concretely. The National Council of Teachers of Mathematics (NCTM) (2000) has identified process and content standards for school mathematics that relay the need for mathematics programs that include active engagement in challenging mathematical tasks connected to real life, that requires problem solving and reasoning, that provides opportunities for mathematical discourse, and that represents mathematical ideas in many ways. This report describes a study related to the learning by elementary education majors of mathematics concepts through participation in making teaching materials based on fourth, fifth, and sixth grade state curriculum standards for numeration, algebra, geometry, and measurement. A simple pretest - intervention - posttest design allows the effect of this project on students' knowledge to be determined.

Literature Review

Reform-Oriented Mathematics

Reform-oriented curriculum materials provide student exploration of real-world mathematical situations and discourse associated with problem-solving activities, as compared to traditional materials that focus on computation and memorization of procedures. Most elementary education majors at our institution experienced a very traditional approach to mathematics during their elementary grades. How will these preservice teachers learn to implement reform-based instruction in their future elementary classrooms? The Mathematical Sciences Education Board and National Research Council (1989, p. 65) argue, "Teachers themselves need experiences in doing mathematics - in exploring, guessing, testing, estimating, arguing, and proving... they should learn mathematics in a manner that encourages active engagement with mathematical ideas."

Battista (1999, p. 426) laments, "Traditional mathematics teaching ... is still the norm in our nation's schools. For most students, school mathematics is an endless sequence of memorizing and forgetting facts and procedures that make little sense to them." This style of teaching through lecture without multiple representations, open explorations, and discourse about ideas persists in mathematics classes at colleges and universities (Manouchehri, 1997). Ball (1990, 1997) determined that elementary education majors have weak, fragmented knowledge of mathematics, focused on facts and memorized rules or procedures. Hembree (1990) showed that elementary education majors have the highest level of mathematics anxiety of any major on university campuses. What activities can overcome these obstacles to prepare effective elementary teachers of mathematics?

Lloyd and Frykholm (2000) conducted a study in which preservice elementary teachers used current NCTM Standards-based middle-school curriculum materials to explore mathematics. They found that students who struggled the most with the materials seemed to learn the most, as they identified ways to help themselves and their future elementary students. Through these activities, college students recognized and appreciated the connection to real world contexts while enjoying the active engagement aspects of the lessons.

Alsup (2003) suggests that mathematics classrooms for preservice elementary teachers operate with a set of seven rules. The first and foremost rule defines a true problem: "A 'problem' emphasizes fundamental mathematical concepts, challenges students (is not trivial or overwhelming), elicits discussion and debate, and has no immediately apparent solution. Students must be able to understand a 'problem', be able to follow more than one path to its solution, and have the tools (cognitive and technological) to solve it" (p. 612). Alsup, in contrast to a more traditional instructor, does not assist students in finding solutions to the problems, but rather helps them reflect on inconsistencies or ramifications of their thinking. Sometimes he suggests strategies or answers factual questions. Students solving problems must convince their peers of the solution, often resulting in stimulating debate. Alsup has found this approach to nurture a rich, deep process that engages students in problem solving, reasoning, representation, communication, and connections between ideas from many contexts.

Object Boxes

Both of the above-described studies engaged students in problem solving and witnessed positive results. The current study takes another approach, also involving problem solving, in which preservice teachers learn by creating teaching materials for elementary students. This approach is similar to a study conducted in the different, but equally challenging, literacy area of phonological awareness. Rule and Lord (2002) in a study of preservice elementary teachers learning phonological awareness skills by making teaching materials (as described in Rule, 2001a & 2001b), found that learning was enhanced by dynamic involvement in peer-tutoring, construction of materials, evaluation of materials, and tutoring of elementary students.

The current study teaches mathematical concepts through the construction of an *object box*: a set of objects and corresponding cards housed in a box. Object boxes have their origin in Montessori education; Montessori (1964) first used a set of objects and corresponding letter or word cards to teach reading and writing. Rule expanded this method in the area of literacy (Rule, 2001c) and conducted studies to show their efficacy (Long & Rule, 2004; Rule, Dockstader, & Stewart, in press; Rule, Stewart & Haunold, 2005). Object boxes have also been developed to teach science vocabulary (Rule, 1999; Rule & Barrera, 1999; Rule & Barrera, 2003; Rule, Barrera, & Stewart, 2004; Rule, Young, & Fox, 2003), form and function analogies (Rule & Furletti, 2004; Rule & Rust, 2001), and social studies concepts (Gianetto & Rule, 2005). This study explores their use in mathematics.

A *Mathematical Mystery Object Box* contains objects with corresponding mathematical clues. Example clue cards created by the preservice teachers involved with this study are shown in Appendix 1 of this document. Students learn from the set of materials by choosing a clue card and reading the first mathematical clue. They then find all the objects to which this clue might be applied. The next clue is read to narrow the set of objects until one object has been chosen. Any additional clues are read to check that the correct choice has been made. Then the student turns the card over and checks his/her work by comparing the photograph of the object to the object.

In the sections below, we describe the set-up of the current study focusing on mathematics, discuss the favorable results, and draw conclusions.

Method

Forty-seven (42 F, 5 M) predominantly white preservice elementary teachers (college juniors or seniors) enrolled in a mathematics methods course at a mid-sized college in central New York State participated in the study. The Human Subjects Committee of the State University of New York at Oswego approved this study; students gave written permission for their scores and materials to be included in this publication.

The study was a simple pretest - intervention - posttest design. At the start of the semester, students took a 20-item pretest to assess their skills in upper elementary level numeration, algebra, geometry, and measurement content. Then they completed a project, which formed the intervention. The project involved the creation of a set of hands-on materials for practicing and applying mathematical knowledge. Finally, at the completion of the project nine weeks later, students took an identical posttest. The pretest/posttest assessment instrument is shown as Appendix 2.

To ensure that all review or learning of the specific mathematical content addressed by the pretest/posttest occurred during the intervention (the project), the instructor discussed only mathematical content from grades kindergarten through third grade during class until after the posttest. This study design allowed the investigators to determine the effect of creation of this box of objects with mathematical clues, a curriculum material suitable for upper elementary grade students, upon the learning of math content by preservice teachers.

The Project

As part of the mathematics methods course requirements, preservice teachers were asked to work with a partner to make a "Mathematical Mystery Object Box." The assignment was explained in detail the first day of class (after which the pretest was given) and students were given (as part of the course syllabus) a complete example set of clue cards showing corresponding photographs of the correct objects. The rubric by which the assignment would be scored, shown in Table 1, and a chart for organizing clues according to standards to help students and the instructor determine that all required performance indicators were used in the activity, shown in Table 2, were also provided to students in the syllabus. The assignment is explained in more detail below.

True Problem Solving

This unique assignment integrated knowledge and skills from many areas, satisfying these components of true problem solving: 1) the problem can be solved in many ways — there is more than one correct solution to the problem; 2) students must use a variety of background skills and knowledge to solve the problem; and 3) the problem is complex and requires considerable thought to solve. The first criterion is easily satisfied by the activity as students gathered different sets of objects and devised different clues for these items. Many different skill and knowledge areas came into play as students worked on the problem. Preservice teachers practiced computer technology as they created the mystery object clue cards electronically and inserted digital photographs of their objects into the file. These preservice teachers familiarized themselves with many of the curriculum standards for fourth, fifth and sixth grades as they devised clues that would satisfy the given performance indicators. They activated prior knowledge in the four content strand areas of numeration, algebra, geometry, and measurement

and were forced to seek additional information from textbooks and reference sources for terms or concepts with which they were unfamiliar. This idea of learning on one's own was an important component of the activity, designed to give the college students confidence in figuring out unfamiliar mathematical ideas on their own — something they will be faced with when they are teachers in their own classrooms. The U. S. Department of Labor, in a publication titled, *Workplace basics: The skills employers want*, recognized the ability of knowing how to learn as the most fundamental skill for the next century (Carnevale, Gainer, & Meltzer, 1988). Students also used creative thinking skills and made connections between mathematics and everyday life as they viewed the common objects from a mathematical perspective. All of these steps made the problem complex and challenging for the preservice teachers, satisfying the third criterion.

Table 1. Rubric for scoring the mathematical mystery object box project

Criteria	Yes	Borderline	No
Is the set in a plastic shoebox or other **plastic box** that is **labeled** with the title of the activity and the makers' names with **8 objects** and **8 clue cards** present?	1	½	0
Are the clue cards **neatly and durably made**? I recommend either of these methods: Method 1: Print on photo paper or other heavy paper and laminate or print on regular paper and glue using glue stick to a fade-proof cardstock (never construction paper) and laminate; Method 2: Print on photo paper or heavy paper and glue to mat board; presentation board, or railroad board. Poster board is too thin; foam board is too hard to cut neatly.	1	½	0
Have all the 32 different performance indicators been used? **Proof of this is a chart with the different clues filled in for each standard. This chart will be turned in to the instructor.**	4	3, 2, 1	0
Are the clues **mathematically correct**? Have they been applied to the objects correctly?	2	1	0
Mechanics. Neatness of cards and labeling, correctness of spelling, punctuation, alignment of words on cards, etc. Cards MUST be made in PowerPoint.	1	½	0
Did the students **hand in the printout** of the fronts and backs of clue cards?	1	½	0
TOTAL POINTS out of 10			

Implementation of the Assignment

The college students were asked to produce a set of eight objects with corresponding clue cards that addressed a given set of performance indicators from the New York State Mathematics Curriculum Standards (New York is the state in which the study took place). Preservice teachers were provided with a blank chart to help them organize their work. The chart is shown in two parts as Table 2. The chart shows eight reworded performance indicators for each content strand (numeration, algebra, geometry, and measurement) taken from the state curriculum standards for fourth, fifth or sixth grade. Each clue card contained four mathematical clues, one for each content strand, which applied to the same object. A photograph of the correct object was shown on the reverse side of each clue card.

Table 2, Part 1. Blank chart showing performance indicators from state curriculum

Number Sense and Operations Strand Performance Indicators	Write clues here- one clue for each performance indicator.	Object
4.N.1 Find an object with a printed number that can be reached by skip counting by a specified number.		
4.N.4; 5.N.3 Find an object with printed number of at least 10,000 that matches given place value description.		
4.N.8 Find an object with printed number or parts that match a given fraction (not halves, thirds, or fourths)		
4.N.16 Find an object that represents a given meaning of multiplication		
5.N.10; 5.N.11; 6.N.11; 6.N.21 Find an object with printed number or parts that matches a description using percents or decimals with inequality or equality symbols		
6.N.17; 6.N.18, 5.N.24 Find an object with printed number that matches the quotient or product of a problem involving division or multiplication by fractions or that matches the product or quotient when rounded.		
5.N.25; 6.N.27 Find an object that fits with a given estimate		
6.N.5 Find an object that fits a specified ratio or proportion		
Algebra Strand Performance Indicators	**Write clues here- one clue for each performance indicator.**	**Object**
4.A.4 Find an object with a given pattern: ABAB; ABBABB; ABCABC; etc.		
4.A.2 Find an object that satisfies an inequality statement using whole numbers, fractions, or decimals		
4.A.3 Find an object that fits value or values for an open sentence		
4.a.5 Find an object that fits a rule		
5.A.3; 6.A.3 Substitute value(s) for a variable in a algebraic expressions or equation		
5.A.6; 6.G.7 Calculate and find an object that fits a given perimeter or circumference.		
6.A.2 Find an object that matches and equation having variables with exponents such as squaring or cubing.		
6.A.5 Find an object that has the given simple proportions		

Table 2, Part 2. Blank chart showing performance indicators from state curriculum

Geometry Strand Performance Indicators	Write clues here- one clue for each performance indicator.	Object
4.G.1; 4.G.2; 4.G.6; 5.G.4 Find an object that matches a given polygon or 3D shape name (examples: octagon, pentagon, quadrilateral terms, cylinder, hemisphere, rectangular prism)		
4.G.1; 4.G.2; 4.G.6; 5.G.4 Find an object that matches a given geometric term (examples: obtuse angle, intersecting lines)		
4.G.4 Find a rectangular object with a given area in square centimeters		
5.G.8 Measure and find an object with a specified angle other than a right angle		
5.G.11 Find an object with specified symmetry (examples: mirror symmetry; specified axis of rotation; both)		
5.G.14; 6.G.7 Find an object that fits a given perimeter or circumference.		
6.G.4 Find an object with a given volume in cubic centimeters		
6.G.5 Find an object with a given radius or diameter		
Measurement Strand Performance Indicators	Write clues here- one clue for each performance indicator.	Object
4.M.4 Find an object with a given mass in grams or kilograms		
4.M.6 Find an object with a given capacity in milliliters or liters		
5.M.3 Find an object with a dimension equal to the nearest centimeter to a given measurement		
5.M.3 Find an object with a dimension equal to the nearest centimeter to a given measurement		
5.M.8 Measure and find an object with a specified angle other than a right angle		
5.M.10 Find an object that matches a personal reference for centimeters		
6.M.2 Find an object with a given capacity in ounces or cups or pints		
6.M.9 Find an object that matches a personal reference of capacity in milliliters or liters or ounces, cups or pints.		

Students were given one class period to work on the mystery object boxes with the instructor being available to clarify directions and then asked to complete the project as homework. The due date for the project was the ninth week of classes of the semester. On the due date of the project, preservice teachers brought their object boxes to class. They were passed to other groups of students who attempted to solve the clues. This provided additional practice in the mathematical content covered by the assignment and allowed students to see how others had creatively used different objects to accomplish the objective. Students were impressed with the cleverness of other students' choices of objects and clues. Some students organized their set of objects around a holiday theme (Halloween, Christmas) or chose very attractive, trendy items. One group provided an animal-headed long-handled implement that opened the animal's mouth to pick up objects when the trigger grip was squeezed. This was a big hit with the preservice teachers and would certainly be appreciated by elementary students. An appendix shows example cards and objects (as photographs on the card backs) from the sets made by preservice teachers. After the object boxes had been rotated through the class, the posttest was given.

Results and Discussion

Analysis of Pretest and Posttest Performance

On the pretest, students scored low with a mean score of 54% overall (standard deviation of 18%). Posttest scores improved to a mean of 71% (s. d. 14%), indicating that students learned mathematical content by creating the curriculum materials. Because the instructor did not teach or review the content covered by the pretest/posttest, this learning can be attributed to the effect of completing the project.

Table 3 shows a breakdown of pretest/posttest scores on individual questions. Pretest results show that less than half of the students answered any one question correctly. Concepts that the students as a whole seemed to know best on the pretest (41-46% of students answering correctly) were: identifying an octagon and cylinder, estimating an angle measurement, and identifying the ten thousands place. On the posttest, students performed best on these questions, raising the percentage of students answering correctly to the range of 89-98%.

On the pretest, students performed most poorly on questions requiring identification of a rectangular prism, measurement in ounces, volume of a cube, producing a specified pattern, using variables in an equation, producing a palindrome, stating a rule for objects, and an inequality involving division by a fraction. Although students improved a large amount on identifying a rectangular prism and determining the volume of a cube on the posttest with 89% and 72% of students responding correctly, students made smaller gains in the other above-mentioned specific areas.

Areas in which students performed most poorly on the posttest were measurement in ounces and milliliters, supplying values for an inequality involving division by a fraction, and producing a pattern. Students may have performed poorly on the liquid measurement concepts because these are unfamiliar to traditional-age elementary education majors who are still residing and eating in residence halls and have little experience in cooking, an area in which many people gather experience with liquid measurement. Elementary education majors also take few science labs in which they measure liquids in milliliters and so lack those encounters that would support knowledge in this area.

The problem featuring an inequality involving division by a fraction was difficult for students, although they did make gains in this area. The instructor noticed that object box clues

involving division by fractions were scarce in the sets and often incorrectly solved when used. This indicates that students tend to avoid this difficult area and probably would benefit from an instructor-lead review of this concept. This was planned for the second half of the course.

Student work on patterns showed progress toward a correct response. On the pretest, many students left this item blank or merely wrote "ABBC". On the posttest, some students responded correctly, drawing, for example, these items: circle, square, square, triangle, circle, square, square, triangle, circle, square, square, and triangle. Others drew a circle, a square, another square, and a triangle (or other sequence of images), but failed to repeat the images. Therefore they did not demonstrate the understanding that a pattern repeats and were scored as incorrect.

Table 3. Pretest, Posttest and Gain Scores

Question Number	Strand	Mathematics Concept	Percent Correct		
			Pretest	Posttest	Gain
1	Geometry	Rectangular prism	11	89	78
2	Geometry	Octagon	43	89	46
3	Geometry	Cylinder	46	96	50
4	Geometry	Pentagon	37	72	35
5	Measurement	Centimeters	24	63	39
6	Measurement	Grams	28	78	50
7	Measurement	Ounces	15	39	24
8	Measurement	Milliliters	24	43	19
9	Algebra	Volume of a cube	17	72	55
10	Algebra	Perimeter of figure	20	57	37
11	Geometry	Diameter	26	78	52
12	Algebra	Draw ABBC Pattern	7	41	34
13	Geometry	Angle measurement	43	98	55
14	Geometry	Angle type	33	78	45
15	Algebra	Variables in an equation	17	74	57
16	Numeration	Palindrome	15	70	55
17	Numeration	Ten-thousands place	41	93	52
18	Algebra	Determine simple proportion	24	74	50
19	Algebra	State a rule for objects	11	65	54
20	Algebra	Inequality / division by fraction	15	46	31

Additional Learning through the Project

After the posttest, the college students were asked to tell what, other than mathematical content, they had learned from participation in the project. The responses to this question are shown in Table 4. Many students discussed how they had come to realize that everything in the world (common household objects in particular) could be viewed from a mathematical point of view. This is an important observation because it indicates the preservice teachers' awareness of the connections between mathematics and real life and will allow them to convey this perspective to their elementary students. Making mathematical connections is one of the process skill strands of the NCTM Standards (2000) and the New York State Curriculum Standards for Mathematics (University of the State of New York, 2005); in particular, a component of the

connections standard is the ability to "recognize and apply mathematics to contexts outside of mathematics" (p. 200).

Table 4. Additional concepts or skills reported by students as learned from the project

Additional Concepts/Skills Learned from Project	Number of students reporting idea
Awareness that mathematics can be found in everyday objects and everywhere	26
Learned problem solving skills	14
Practiced collaborative work skills	10
Realized the value of manipulatives	9
Learned computer technology skills	8
Learned how to get small cards laminated	7
Realized the work ethic needed for being a teacher	5
Time management is important	5
Learned more about the state standards	5
The cost of materials became clear to me	5
Using a variety of different perspectives (such as clues about objects) can help in understanding math	4
The mystery object format was motivating for children	4
Learned or practiced creativity in the project	4
The importance of making materials look appealing	4
Became familiar with area stores and services that support making materials	3

The second most frequent response was that the college students honed their problem solving skills by locating suitable objects and devising clues. Students engaged in many process skills while developing clues for mystery objects. They were able to "build new knowledge through problem solving; solve problems that arise in mathematics and other contexts; apply and adapt a variety of appropriate strategies to solve a problem, and monitor and reflect on the process of mathematical problem solving" (NCTM, 2000, p. 182). The recognition of problem solving is important because it shows that these preservice teachers realized how they learned mathematics through problem solving and were aware of the many sub-skills necessary for effective problem solving. Examples of some of the sub-skills mentioned by students are: "having patience with myself that I will get it," "creating meaningful questions," "creating clues that refer to several objects so that several clues are needed," "the thinking process of wording clues so that students will be able to search for the objects," and "creating a box for any level by tweaking the questions. "They will be much more able to involve their elementary students in the problem-solving process because of this experience. The fourth-most frequent response, a realization of the value of hands-on materials for mathematics, also supports best teaching practices in this subject area. Besides problem -solving, this project addressed other process skills; in particular, reasoning when devising or solving clues, and mathematical communication and representation when expressing ideas as clues and finding mathematical ideas shown by the objects. Although the students did not specifically record these process skills, their comments imply their presence.

Students mentioned that they had improved interpersonal skills by participating in the project. Interpersonal skills are necessary for student success. She and Fisher (2002) found an increase in students' cognitive achievement scores when students perceived their teacher as using more challenging questions, as giving more nonverbal support, and as being more understanding and friendly. Practice in negotiating a project with a classmate can help build skills necessary for success as a teacher. Some comments supporting this idea were: "It's important to have good communication when working with a group," "I learned how to work well with a partner," and "I had to compromise with my partner to come up with the best clues."

Preservice teachers indicated they had increased their knowledge in the area of computer technology. Many mentioned learning how to insert digital photographs into a file and to attach files to an email message for collaborating with partners. One of the six principles for school mathematics (NCTM, 200, p. 11) is technology: "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning." So many exciting teaching materials can be made with computer technology. The cards produced for this project are just one small example.

There were other concepts learned that were mentioned by fewer students, but these ideas were nonetheless important. Several students discussed the high work ethic necessary for being a teacher, time management issues and the cost of hands-on materials. A teacher's life is challenging; Ingersoll (2002) found that as many as 46% of new teachers leave the profession during their first five years of teaching. Nieto (2003) suggests that good urban teachers who stay, even under difficult and demanding circumstances, stay because they love, believe in, and respect their students, imagining possibilities for them. This is true commitment. Cochran-Smith (2004) notes that the subject of teacher retention is complex, and teachers need school conditions where they are successful and supported, working with others in professional learning communities with leadership opportunities. A successful teacher will need personal communication skills as mentioned above, coupled with a strong work ethic, time management and organizational skills, in addition to best teaching practices, and content area knowledge.

Ideas related to motivation formed another group of comments about learning. Some preservice teachers expressed the realization that a novel activity like the Mathematical Mystery Object Box provides an effective approach to mathematics with a new perspective that motivates students: "Making math fun can help children learn;" "Children would enjoy this more than working out of a math book;" "Using different math skills for one object can help students see how objects can show different math concepts;" and "These different techniques have helped me better understand the math topics." Several college students appreciated creative materials and approaches. Others noted the importance of making materials that were beautiful or appealing to children, an idea supported by Rule, Sobierajski, and Schell's study (2005) showing improved mathematical performance of fourth graders using materials they perceived as beautiful and motivating.

Conclusion

The project described in this report was successful in teaching preservice teachers mathematical content related to numeration, algebra, geometry, and measurement. These elementary education majors made large gains from pretest to posttest that can be attributed to participation in the project. Students noticed connections between mathematics and their everyday lives, practiced important problem-solving skills, addressed other process skills such as

mathematical reasoning, communication, and representation, and added to their computer technology skills, while enjoying a creative and novel approach to learning mathematical content. Although not all students mastered all the concepts, a significant amount of learning took place. The writers suggest that projects such as the one described here can help students learn independently through a problem-solving process.

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Appendix 1. Example clue cards for Mathematical Mystery Object Boxes.

	Mathematical Clues for Mystery Object
Number Sense/ Operations	The object is divided into 8 equal parts which could be used to show 2 x 4 or 4 x 2.
Algebra	If you square the number of sections and add 11 you get the number printed on the object: $s^2 + 11 = n$.
Geometry	The object has a series of 45 degree angles around it.
Measurement	The circumference of the object is about 15 little finger widths or 15 cm.

Mystery Object
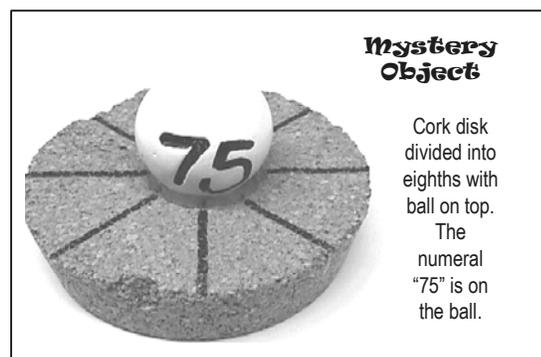
Cork disk divided into eighths with ball on top. The numeral "75" is on the ball.

	Mathematical Clues for Mystery Object
Number Sense/ Operations	Find an object that represents the fraction 6/18.
Algebra	The object has a pattern of ABAB.
Geometry	Find an object that has a perimeter of 25 cm.
Measurement	Find an object with one dimension the same length as your pointer finger, about 8 cm.

Mystery Object

Row of dominoes taped together with wide, clear tape.

The number "7575" is depicted with the dots or pips.
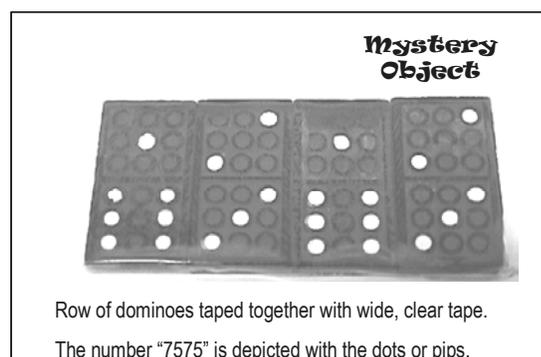
	Mathematical Clues for Mystery Object
Number Sense/ Operations	The object has a '4' in the ten-thousands place.
Algebra	The object's number follows the rule of a palindrome. The number is the same forwards and backwards.
Geometry	A rectangular part of this object has a perimeter of 30 cm.
Measurement	The diagonal measurement of a rectangular part of this object is 10.5 cm.

Mystery Object

A hand of cards showing the numeral "945,549".

	Mathematical Clues for Mystery Object
Number Sense/ Operations	Find an object that has a number printed on it that can be reached by skip counting by 5's.
Algebra	Find an object with a printed number, n, that satisfies the equation $5^2 = n$.
Geometry	Find an object with an area of 18 cm^2 on the top side.
Measurement	Find an object with a mass of 26.4 grams.

Mystery Object

Two blocks glued together with the numeral "25" shown.
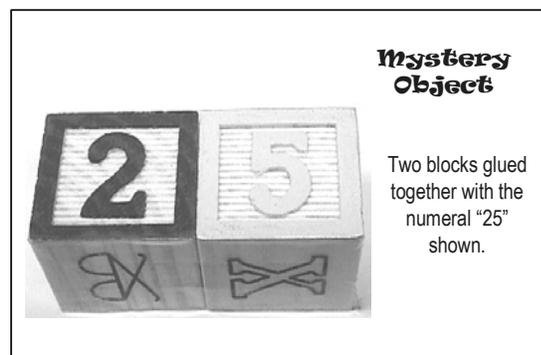
Mathematical Clues for Mystery Object

|	
Number Sense/ Operations	The height to width ratio, when rounded, is 16:4.
Algebra	The length of the object is < 20 cm.
Geometry	This object displays mirror symmetry.
Measurement	This object is 16.4 cm in length, which is equal to twice the length of a standard credit card.
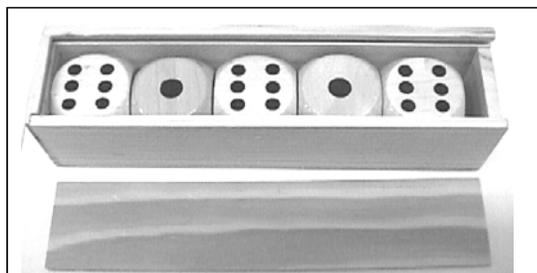
Mystery Object — Box of dice showing the number "61,616"

Mathematical Clues for Mystery Object

Number Sense/ Operations	This object displays the ratio of 6:6.
Algebra	This object has a pattern of ABAB.
Geometry	This object has a diameter of approximately 12 cm.
Measurement	This object has a circumference of twice the size of your wrist, about 36 cm.
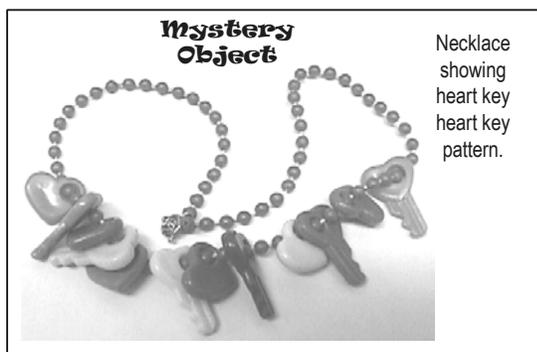
Mystery Object — Necklace showing heart key heart key pattern.

Mathematical Clues for Mystery Object

Number Sense/ Operations	This object shows an array; a way of representing multiplication.
Algebra	$5n = 2p$: where n = printed number and p = number of appendages with a black dot on the end of them.
Geometry	This object shows mirror symmetry.
Measurement	The mass of the object < 5 g or 0.005 kg.
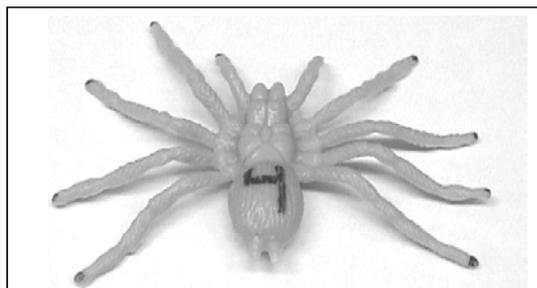
Mystery Object — Eight-legged spider with "4" on abdomen.

Mathematical Clues for Mystery Object

Number Sense/ Operations	3/24 of the contents of this object are orange.
Algebra	The perimeter of the front panel of the object is 37 cm.
Geometry	The object is a rectangular prism.
Measurement	If the object were made of plastic and hollow, its capacity would be 264 ml.
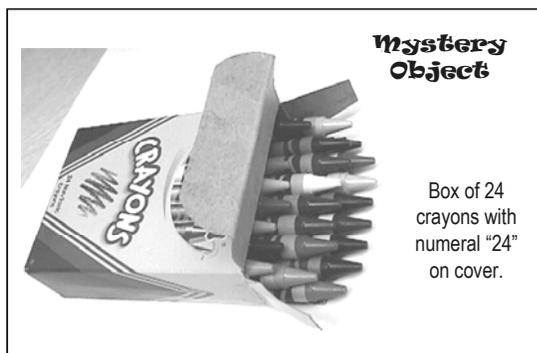
Mystery Object — Box of 24 crayons with numeral "24" on cover.

Mathematical Clues for Mystery Object

Number Sense/ Operations	Two-tenths of the teeth on this object are blackened.
Algebra	This object is twice as high as it is wide resulting in a height to width ratio of 2:1.
Geometry	The volume of this object is 750 cm^3.
Measurement	The capacity of this object is approximately one pint, two cups, or sixteen ounces.

Mystery Object — Skull cup.

Mathematical Clues for Mystery Object

Number Sense/ Operations	20% of 60 is greater than or equal to the printed number.
Algebra	If you square the number of people, p, and multiply by 3, you get the printed number, n. $3p^2 = n$.
Geometry	The perimeter of this object is about 21 cm.
Measurement	The mass of the object > 15 g.

Mystery Object — Characters showing the numeral "12".

Mathematical Clues for Mystery Object

Number Sense/ Operations	This will hold at least 100 marbles, but no more than 300. 200 is a good estimate.
Algebra	N x 25 = p, where n is the number of colored stripes on this object and p is the printed number.
Geometry	The distance around the outside edges of this object's decorated lid is approximately 16 inches.
Measurement	The largest diagonal is approximately 27 cm.

Mystery Object — Snowman box with "250" printed on it.

Mathematical Clues for Mystery Object

Number Sense/ Operations	The number of rounded sides is the cross product of 2 sides with 6 colors.
Algebra	The number on this object satisfies the sentence: $296 > n > 136$.
Geometry	This object is spherical with pentagons printed on it.
Measurement	The height when rounded to the nearest whole centimeter is 9 cm.

Mystery Object — Fabric ball with twelve pentagon-shaped sides and "219" printed on it.

Mathematical Clues for Mystery Object

Number Sense/ Operations	The printed number on this object can be reached by skip counting by 10's, as one would count dimes.
Algebra	$456 > n > 200$, where n = the printed number.
Geometry	There are two intersecting lines in the middle of this object.
Measurement	This object has the capacity to hold 525 ml.
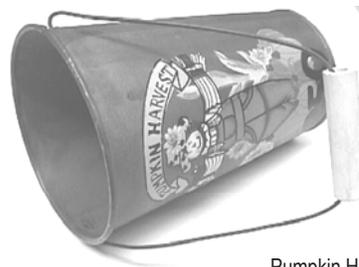
Mystery Object

Pumpkin Harvest bucket with "250" printed on it.

Mathematical Clues for Mystery Object

Number Sense/ Operations	20% of 10,025 is greater than or equal to the printed number.
Algebra	The circumference of the object is about 9 cm.
Geometry	The radius of the object is about 1.5 cm.
Measurement	The capacity of this object is about 1 ounce.

Mystery Object

Goblet showing the numeral "2005."

Mathematical Clues for Mystery Object

Number Sense/ Operations	The number printed on the object has a '3' in the ten thousands place.
Algebra	If you square the number of buttons and add 9034140, you get the printed number, n: $b^2 + 9034140 = n$.
Geometry	The object can create an obtuse angle when opened.
Measurement	The width of the object is about 1.25 cm, which is close to the thickness of a deck of cards.

Mystery Object

Toy phone showing the number "9,034,284"

Mathematical Clues for Mystery Object

Number Sense/ Operations	The identity property in multiplication is demonstrated by this object when used with the number four.
Algebra	$2 \times 1 < n < 10 \times 2$.
Geometry	The measure of the marked angle on this object is 50 degrees.
Measurement	The mass of this object is approximately 20 grams.
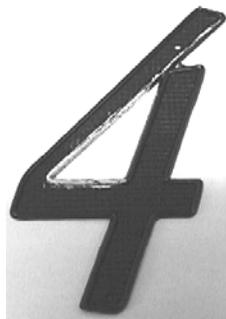
Mystery Object

Metal numeral "4".

Mathematical Clues for Mystery Object

|	
Number Sense/ Operations	The smallest increment shown on the customary side is 1/16.
Algebra	This object shows a smallest fraction of 1/16 and the largest whole number is 60.
Geometry	This object has a circumference of 14.13 cm.
Measurement	A dimension of this object is ½ inch.

Mystery Object

Measuring tape showing increments of 1/16 of an inch.
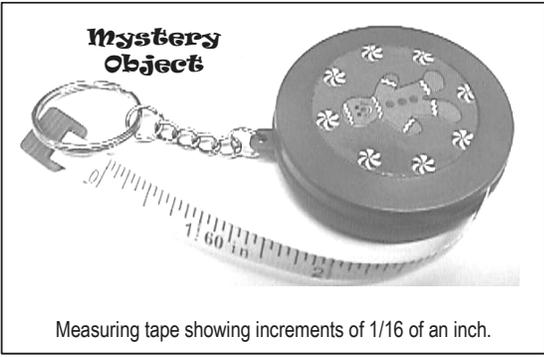
Mathematical Clues for Mystery Object

Number Sense/ Operations	This may be used t demonstrate probability because it shows several different numbers.
Algebra	Summing the symbols for digits on this object results in 21.
Geometry	The surface area of this object is 37.5 cm^2.
Measurement	The mass of this object is 0.02 kg.

Mystery Object

A die.
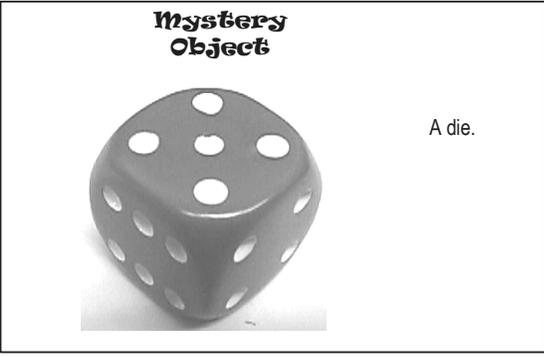
Mathematical Clues for Mystery Object

Number Sense/ Operations	3/6 of this pattern is yellow.
Algebra	This object has an ABAB pattern.
Geometry	If you fold this object you will see the edges line up perfectly, showing mirror symmetry.
Measurement	This object has numerous acute and obtuse angles.

Mystery Object

Repeated shapes
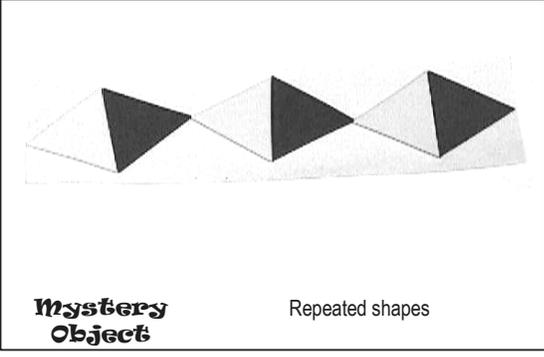
Mathematical Clues for Mystery Object

Number Sense/ Operations	This object has a height of about 1.5 cm.
Algebra	The circumference of this object is about 19 cm.
Geometry	The diameter of this object is about 6 cm.
Measurement	This object has a capacity of 50 ml.

Mystery Object

Container of butterfly spangles.

Mathematical Clues for Mystery Object

Number Sense/ Operations	33280 x ¼ is this number.
Algebra	This object is twice as long as it is wide. The length to width ratio is therefore 2:1.
Geometry	This object has a cylindrical shape.
Measurement	This object is about 5 cm long.

Mystery Object

Peep-hole from a door with the number 8320 printed on it.

Mathematical Clues for Mystery Object

Number Sense/ Operations	Take 20 and divide 1/5. The answer to this equation is found on the object.
Algebra	The perimeter of this object is 62 cm.
Geometry	The measurements 15.5 cm x 5 cm x 15.5 cm equal the object's volume in cubic cm.
Measurement	The object is 15.5 cm wide, which is about the same size of a mechanical pencil.

Mystery Object

Jigsaw puzzle box with "100" printed on it.

Mathematical Clues for Mystery Object

Number Sense/ Operations	26862 x ½ equals the number printed on the object.
Algebra	The number on the object follows this rule: it is a palindrome. A palindrome has the same digits forward and backward.
Geometry	The object has an angle that is approximately 45 degrees.
Measurement	The object has an obtuse angle of 135 degrees.
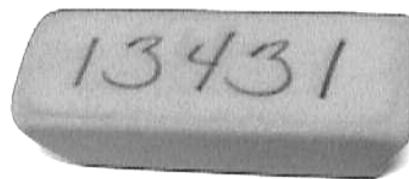
Mystery Object

Pink eraser with the numeral "13,431."

Mathematical Clues for Mystery Object

Number Sense/ Operations	The number printed on this object has a four in the hundreds place.
Algebra	The number printed on this object, n, fits in this sentence: 24380> n > 12145.
Geometry	The object contains spheres.
Measurement	The capacity of the box in which the object rests is 38 milliliters.

Mystery Object

Box of five balls with the numeral. "17,438" written on them.

Mathematical Clues for Mystery Object

|	
Number Sense/ Operations	The colored parts on this object form an array, a way to represent multiplication.
Algebra	The proportion of red to white parts is 1:1.
Geometry	The object is a quadrilateral with four right angles and it contains acute isosceles triangles.
Measurement	The spaces between the colored parts of the object contain an angle that measures approximately 15º.

Mystery Object

Game board.
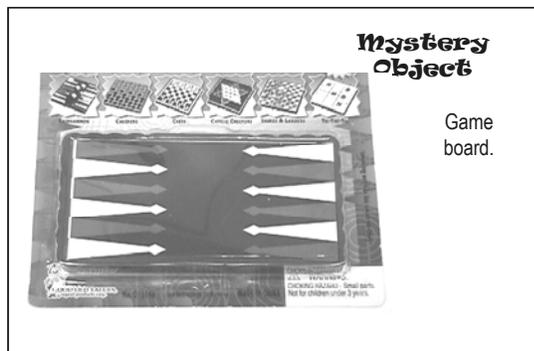
Mathematical Clues for Mystery Object

Number Sense/ Operations	This object has a 2 in the ten-thousands place.
Algebra	This object's dimensions form the proportion 1: 1.5 : 0. 2
Geometry	This object is a rectangular prism.
Measurement	The object is approximately 7 by 10.5 cm.

Mystery Object

Cassette tape
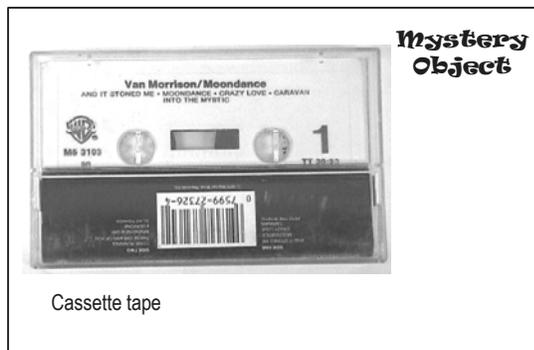
Mathematical Clues for Mystery Object

Number Sense/ Operations	The height to width ratio is approximately 12 : 8.
Algebra	The height of the object is > 10cm
Geometry	This object has an area of 96 square centimeters on its largest face.
Measurement	The object is 12 cm. in length, which is close to the length of an index card.

Mystery Object   Sponge
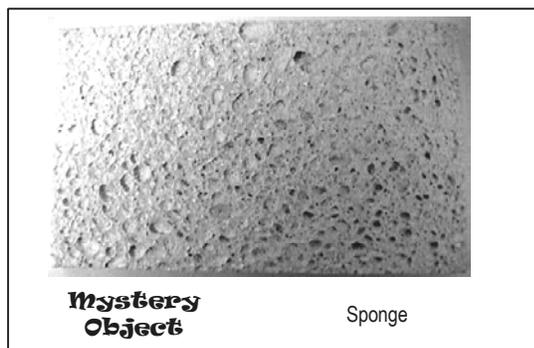
Mathematical Clues for Mystery Object

Number Sense/ Operations	This object has an "8" in the ten-thousands place.
Algebra	The number follows this rule: It is a palindrome. A palindrome has the same digits forwards and backwards.
Geometry	The middle number of the object has an acute angle of 70º.
Measurement	The object is approximately 15 cm long.

Mystery Object

Plastic numerals showing "80,708"
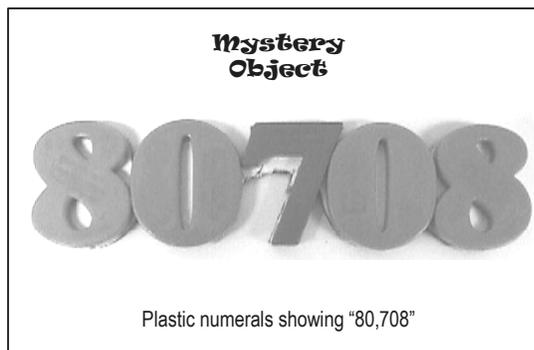
Mathematical Clues for Mystery Object

Number Sense/Operations	20 x ½ = n, the number printed on the object.
Algebra	This object has a perimeter of 38 cm.
Geometry	This object is a square prism.
Measurement	This object has a straight angle on it.

Mystery Object

Computer disk box with "10" printed on it to signify 10 disks. There is a straight angle on the front of the box.

Mathematical Clues for Mystery Object

Number Sense/Operations	7 out of 15 of the alphabet letters are vowels.
Algebra	The number printed on this object fits in the sentence 2521 > n > 952.
Geometry	Volume is approximately 25 cm³.
Measurement	Air capacity of this item is approximately 25 ml.

Mystery Object

Toy police badge with numerals:

"1082".

Mathematical Clues for Mystery Object

Number Sense/Operations	Printed number can be reached by skip-counting by 2's or 20's.
Algebra	4p² = n, where p = number of points and n = printed number.
Geometry	The object has the form of a triangle.
Measurement	The thickness of the object is approximately 1 cm.

Mystery Object

Set of toy bowling pins with "400" printed on them.
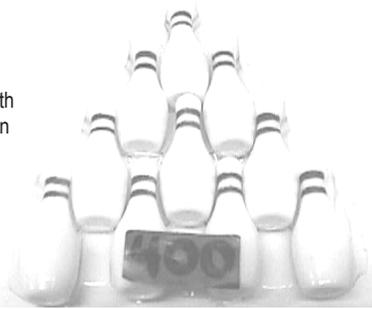
Mathematical Clues for Mystery Object

Number Sense/Operations	The object has a number on it that can be reached by skip counting by two's six times.
Algebra	The largest number printed on this object fits this statement 10 < ? < 14.
Geometry	This object has two intersecting lines printed on it.
Measurement	The weight of this object is approximately one ounce.

Mystery Object

Clock

Mathematical Clues for Mystery Object

Number Sense/ Operations	The ratio of the length to the width of this object is 17 : 11.
Algebra	The length times the width, 8.5 x 5.5, equals 46.75 square centimeters of area.
Geometry	The perimeter of this object is 28 cm.
Measurement	The width of this object is equal to about 5 cm.

Mystery Object

Gift card with numeral: 4,482,440,540,200,744

Mathematical Clues for Mystery Object

Number Sense/ Operations	The object is a 3-D array showing 5x5x5.
Algebra	The object is as high as it is wide.
Geometry	The object is composed of 125 parts.
Measurement	The object has a height of 9 centimeters, which is close to the height of a playing card.
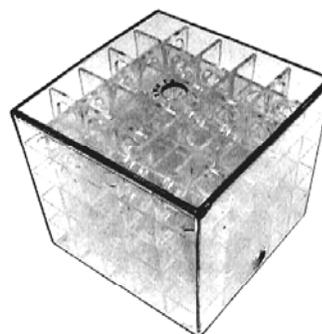
Mystery Object

Transparent plastic cube with internal maze pathways.

Mathematical Clues for Mystery Object

Number Sense/ Operations	There are multiple "zeros" on this object.
Algebra	N = number of circles. 43 – N = 39.
Geometry	This object has four 360° angles.
Measurement	This object weights less than one ounce.
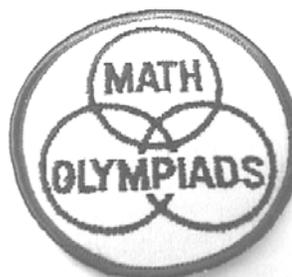
Mystery Object

Embroidered fabric patch.

Mathematical Clues for Mystery Object

Number Sense/ Operations	There is a 2 : 3 ratio of black sections to yellow sections.
Algebra	The object has a pattern of ABAB
Geometry	The radius of one of the ends of this object is approximately 2.25 cm.
Measurement	The weight of this object is .45 kilograms.

Mystery Object

Fabric-covered barbell exercise weight.

Mathematical Clues for Mystery Object

Number Sense/ Operations	The number on this object can be reached by skip-counting by 2, 3, or 4.
Algebra	The number printed on this object, n, satisfies the equation: $(12 \times 2) < n < (12 \times 4)$.
Geometry	The volume of this object is approximately 54 cm^3.
Measurement	The length of the longest side is about the size of a pen cap, or 6 cm.

Mystery Object

ABC Blocks with the numeral "36" showing.
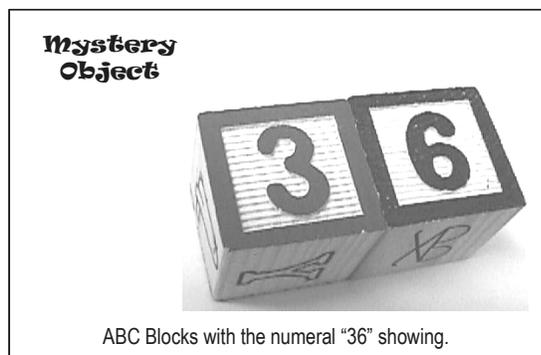
Mathematical Clues for Mystery Object

Number Sense/ Operations	3/8 of this object is one color, and 5/8 of this object is another color.
Algebra	Circumference of this object is approximately 5 inches, or 12.5 mm.
Geometry	3.14(6.25)(6.25) = Circumference.
Measurement	The diameter is 140 millimeters.

Mystery Object

Miniature soccer ball.
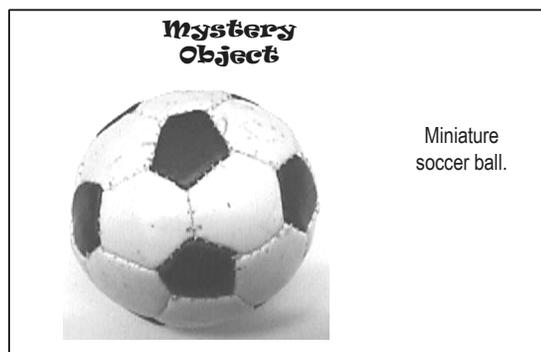
Mathematical Clues for Mystery Object

Number Sense/ Operations	This object has more than 15 and less than 35 parts: 25 is a good estimate.
Algebra	The circumference of the object is <21 centimeters.
Geometry	The circumference is approximately 19 centimeters.
Measurement	The capacity of the object is 25 millimeters.

Mystery Object

Beaded bracelet.

Mathematical Clues for Mystery Object

Number Sense/ Operations	Find the object where 25086 x ½ = n, with n being a number on the object.
Algebra	Find the object with number, n, that fits into this sentence: 12,758 > n > 2,543.
Geometry	Find the object with volume of about 17 cubic centimeters.
Measurement	Find the object with length approximately the same size as a crayon, about 12 cm.

Mystery Object

Set of dice glued together to form "12,543."
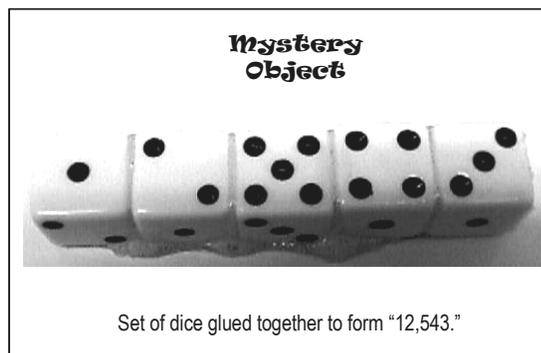
Mathematical Clues for Mystery Object

Number Sense/ Operations	The length of this object is 7 inches.
Algebra	If n = 4.5, then the length of this object in centimeters is 4n.
Geometry	This object has mirror symmetry
Measurement	This object is about 18 cm long.

Mystery Object

Hand trowel for gardening.

Mathematical Clues for Mystery Object

Number Sense/ Operations	Find the object that has more than 15 parts.
Algebra	Find a multi-colored object with 11/20 of the item being a solid color.
Geometry	Find the object whose parts are spheres.
Measurement	Find an object with a capacity of 20 ounces.

Mystery Object

Bag of bouncing balls.

Mathematical Clues for Mystery Object

Number Sense/ Operations	The printed number on this object can be reached by skip counting by 10's.
Algebra	Multiply the number of letters (L) by 6 and then subtract the number of cartoon characters (C) and you get the printed number (N); (6L)-C = N
Geometry	The circumference of the top of this object is about 19 cm.
Measurement	The capacity of this object is 12 fluid ounces.
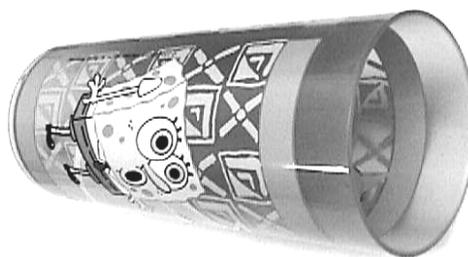
Mystery Object

Cartoon character cup.

Mathematical Clues for Mystery Object

Number Sense/ Operations	The fraction on this object is equal to 0.125.
Algebra	The number printed on this object fits in the sentence: 1/2 > n > 1/10.
Geometry	The object has a 3-D shape in it called a cylinder.
Measurement	The object is capable of holding 32 ml.

Mystery Object
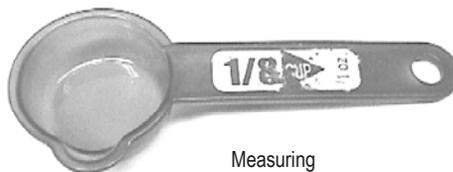
Measuring spoon for 1/8 cup or one ounce.

Mathematical Clues for Mystery Object

|	
Number Sense/ Operations	The object has more than 20 and less than 100 pieces: 80 is a good estimate.
Algebra	The height of this object is > 2 cm.
Geometry	Ignoring color, this object has mirror symmetry.
Measurement	Mass of object is > 50 grams.

Mystery Object

Necklace set.

Mathematical Clues for Mystery Object

Number Sense/ Operations	This object shows an array; a way of representing multiplication.
Algebra	3(x) = 12, where x = length in cm.
Geometry	The area of the object is approximately 160 cm².
Measurement	One dimension is approximately 20 cm.

Mystery Object

Set of stickers.
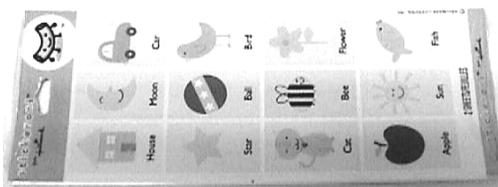
Mathematical Clues for Mystery Object

Number Sense/ Operations	3562 x 1/2 = the number printed on this object.
Algebra	The object's height is about twice its width.
Geometry	This object has an acute angle at the top which is equal to about 50 degrees.
Measurement	The base of this object is about 4 ½ cm wide.

Mystery Object

Tree-shaped car air freshener showing "1381."
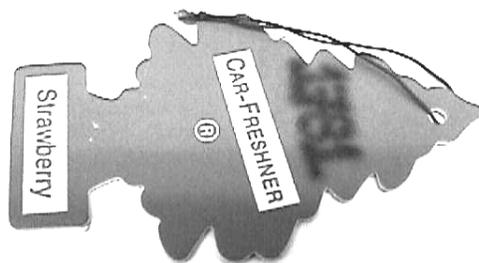
Mathematical Clues for Mystery Object

|	
Number Sense/ Operations	The number of sunrays divided by the number of large jewels is equivalent to 8/2.
Algebra	The number of small jewels on the object, j, can be related to the number of large gems on the object, g, by this equation: 4j = 10g
Geometry	Part of this object shows a design that has rotational symmetry of four.
Measurement	The length of the object is about 10 cm., the width of a piece of bread.

Sun-catcher decoration with suction cup.

Mystery Object
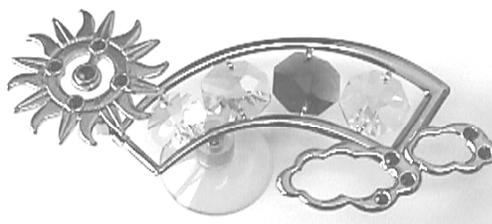
Appendix 2. Pretest/Posttest Assessment Instrument
Identify each figure below by writing its most specific correct geometric name below it

1.	2.	3.	4.

5. Circle the best estimate the length of this line to the nearest **centimeter**:	1 cm.	2 cm.	5 cm.	10 cm.

6. Find and circle the item that generally weighs about 400-500 **grams**.	A cow	An adult woman	A can of beans	A postage stamp	A plastic spoon

7. How many **ounces** are in pint of milk? _____

8. Suppose the round plastic bottle cap shown full size to the right is filled with water. Approximately many **milliliters** of water would it hold? Circle the closest answer.	
8 ml 0.8 ml 80 ml. 800 ml.	
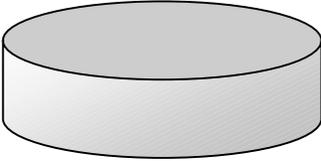
9. What is the **volume** of a cube that is 2 inches on a side?	

10. What is the **perimeter** of this figure if each little square is one square inch?	
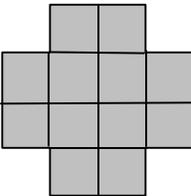
| 11. Draw a figure and label its diameter.	12. Draw a pattern that is ABBC

13. Circle the angle measurement closest to the measure of this angle.

180 degrees	80 degrees	35 degrees	65 degrees	140 degrees	45 degrees

14. What is this type of angle called?
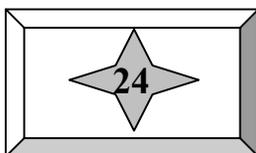
15. A box has a star and "24" on it. Write an algebraic equation that uses the number of points on the star (p) and the number 24 (n).

24

16. In the space below, give one example of a **palindrome**.

17. Circle the number that has a "5" in the **ten-thousands** place.

| 52, 800, 000	5, 000,930	3, 050, 000	6598.004	569,700.97

18. Here is a rectangle with sides as marked.
Circle the **simple proportion** that best describes the rectangle.

21

9
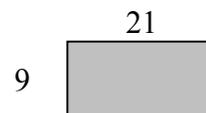
½	189	18:9	3:7	9:21	18:42

19. State a simple rule that these objects follow.

8   4   6
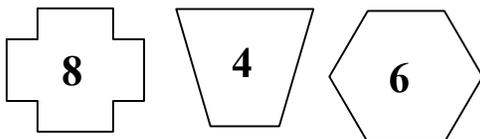
20. Find **two different answers** that will make this statement true.

$$80 \div \frac{1}{4} < \underline{\hspace{3cm}}$$