The English Language Learners (ELL) section is divided into two topics. The first subsection provides instructional strategies that are effective with ELL students in multiples settings. The second section provides instructional strategies and mathematical descriptions using manipulatives to aid learning for ELL students.

General Strategies for ELL Students

ELL students will benefit from strategies that create a nurturing learning environment. The following table is a list of strategies to utilize when addressing their individual needs and building a classroom atmosphere conducive to ELL learning.

ELL Strategies for the Classroom Atmosphere	
Provide a warm and supportive atmosphere in which limited English speaking students can learn to communicate by speaking, listening, reading, and writing.	Create a classroom that stresses a risk-free environment for children to explore literature and added parental involvement with home-based reading.
Provide “books-in-a-bag” loan program for children to take home.	Use dialogue journals where there is no fear of being marked wrong.
Emphasize the positive aspects of cultural heritage of students.	Encourage community leaders that speak a second language to volunteer their services in the classroom.
Encourage inclusion in mixed groups to gain more experience with English.	Promote real, authentic language communication activities for the students to use in meaningful situations.
Provide opportunities for sharing of culturally rich holidays and traditions.	Allow students to use “invented spelling”.
Promote the use of bilingual teacher aides that speak a second language in the classroom.	Provide a positive and tolerant atmosphere for people of differ[illegible] beliefs.
Display pictures of famous cultural individuals who have played an important role in the United States.	Provide a bilingual/bicultural tra[illegible]tor for parental conferences.
Build self-esteem through authentic academic successes/achievements.	Make sure that strategies implemented meet the individual needs of every ELL.

The following table provides a list of instructional strategies useful when teaching students in ELL programs.

Instructional Strategies for Teaching Students in ELL Programs	
The Languages Experience Approach (LEA)-	Oral information is written down and then read by both teachers and students. Students learn how language is encoded. Oral language is put into print. The students investigate familiar language, language structures, sight vocabulary, letter-sound correlation, spelling patterns and conventions of print.
Teaching Story Structure (SS)-	Teachers help provide the students with literature they can comprehend and help the students acquire the necessary background and schemata. The teacher selects reading materials that reflect the children's cultural background. Subjects are used that are familiar and predictable. The teacher uses cueing strategies (changes in voice for various characters and changes in facial expression). Diagrams, charts of the story maps and props are also used. Wordless picture books are used as springboards for discussions of sequencing events and character development.
Process Writing	Steps: Prewriting, drafting, sharing and responding to writing, revising, editing and publishing (according to each child's individual writing level).
Substitution	The student substitutes, the pronoun, "his" or "her" instead of a person's name or the student fills in a missing word to complete a sentence. This may help students understand a word problem.
Question and Answer Drill	The student answers the teacher's questions with consistent wording and numerous repetitions.
Demonstration	The teacher models a word, sentence, or action.
Representation	The teacher uses a picture to represent a general word (ex: mother, father, etc).
Modeling	The teacher models language patterns and structure used in a natural course of classroom conversation.
Dialogue Journals	The student writes down conversation between teacher and student on any topic.
Sequencing	Students put pictures or objects in proper order.
Semantic Webbing	Students learn how to perceive relationships and integrate information and concepts within the context of a main idea or topic.

Cooperative Learning	Students work together in small heterogeneous groups or pairs with well-defined, assigned roles based on each student's strength.
Total Physical Response (TPR)	A language teaching strategy that introduces new language through a series of commands to enact an event (student responds to command with actions).
Elicitation	Structure interactions that elicit elaborate responses, as students are capable of producing.
Chunking	Use "chunks" of language in meaningful, appropriate, and playful context. (ex: pop songs and read-aloud poems).
Directed Reading/Listening/Thinking Activity (DRLTA)	Establish background, allow for oral or silent reading and study, follow-up activities, SQ3R (Survey Questions, Read Recite, Review).
Problem Solving (PS)	Students learn to restate the problem, brainstorm, look at the problem in different ways, identify models, state possible cases, determine hypotheses, and draw conclusions.
Prediction	Prediction is a basic strategy for using prior knowledge to understand text. The learner generates a hypothesis about the type, purpose, or scope of a problem to provide a framework for transacting with the text to confirm comprehension.
Brainstorming	A way to value prior knowledge experience by inviting students to associate concepts with selected topic. All contributions are accepted and recorded. Group members review/discuss the related ideas and determine how to organize and use the information.
Reciprocal Teaching	An instructional activity that takes place in the form of a dialogue between teachers and students regarding segments of text. The dialogue is structured by the use of four strategies: summarizing, question generating, clarifying and predicting. The teacher and students take turns assuming the role of teacher in leading this dialogue.
Partner Reading	Partner reading encourages the sharing of ideas. Sometimes partners take turns talking about their perceptions, questions, and insights. Partners of different ages and abilities work well together. The teacher may be a student's partner to assess individual needs and strengths.

Learning Logs	Learning logs may be used at the end of a class session, the end of the day, the end of the week, or the end of a focused study, a presentation, or a theme unit. Students reflect on what they learned and request further assistance if needed. They may include responses to a variety of content materials and concepts, or theme cycles, or they may focus on one particular lesson or idea. Students keep track of what they have learned about a particular topic in the learning log and use it for reflection and self-evaluation. Entries include summaries, insights, and questions to extend learning. Exit slips are self-evaluations that prompt students to review their learning.

Self-Evaluation for ELL Teachers
Adapted from Classroom Skills for ESOL Teacher
(Celce-Murcia, M., 2001)

Social Climate
Do I demonstrate interest in and concern for each student?
Do the students know each other by name and enjoy exchanging information?
Do I project a friendly, positive attitude in the classroom?
Are the students comfortable and relaxed with the teacher and each other?
Do the students volunteer and cooperate in carrying out group responsibility delegated by the teacher?
Do I use the physical environment to enhance language learning and social interaction?
Variety in Learning Activities
Is appropriate use of several language skills required for each lesson?
Are audio-visual aids or other supplementary materials used to enhance the lesson?
Is there appropriate variation in student grouping?
Is there appropriate variation in input?
Is there appropriate variation in pacing?
Opportunity for Student Participation
Do I delegate tasks to students whenever possible?
Do I distribute turns evenly among all students in the class?
Do I use techniques and drills that maximize student talk time and minimize teacher talk time?
Do I develop appropriate tasks for pairs and groups of students to maximize student participation and lessen teacher domination?
Do I make use of games/competitions/songs to enhance student participation?
Feedback and correction
Do I help the students to monitor their own output whenever the focus is on form or accuracy?
Do I effectively elicit self-correction of errors whenever possible?
Do I pinpoint the source of error without actually correcting the error?
Do I strike an effective balance between correcting so much that students become inhibited, and not correcting any of the errors that occur?
Instructor
Volume level: Do I maintain an appropriate volume level when speaking?
Clarity: Do I give clear instructions?

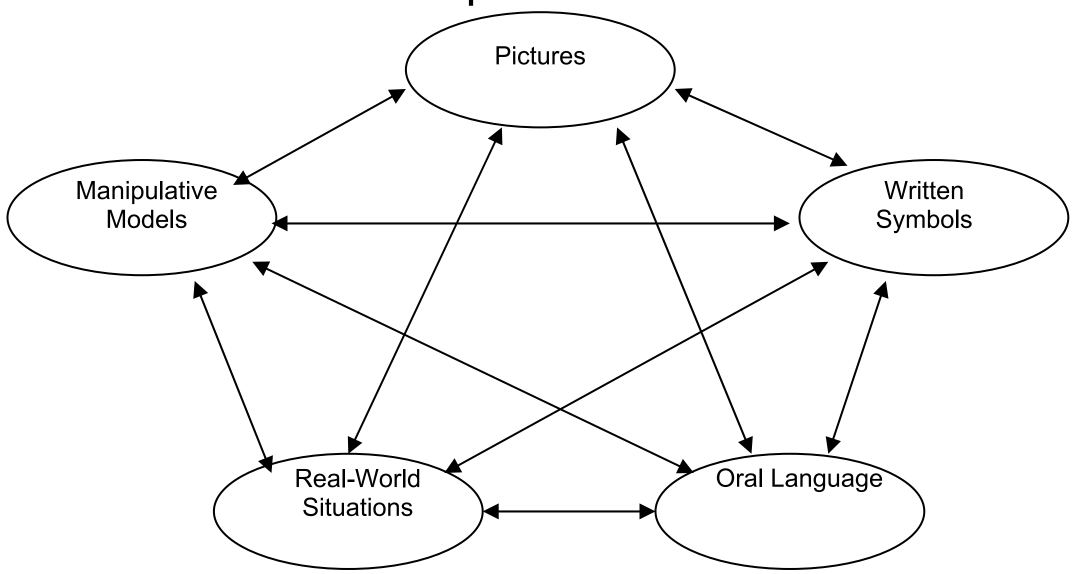
Eye Contact: Do I maintain eye contact with the students whenever talking to them or listening to them?
Legibility: Are my materials neat and legible?
Question Posing: Do I pose the question first, give thinking time, and then call on a student to respond?
Pause: Do I allow an appropriate 3-5 second pause between posing the question and calling on a student?
Wait Time: Do I give the student enough time to answer the question before facilitating a correction? Are all students given equal time to respond?
Students' physical movement: Do I provide an opportunity for appropriate physical movement during the lesson?
Teacher's mobility: Do I spend more time moving purposefully among the students than sitting or standing in one position?

Using Manipulatives and ELL Strategies in Math Education

Enrique Ortiz, University of Central Florida

This second session provides examples on using manipulatives and strategies helpful to all students but especially ELL, due to the fact that concrete experiences provide ways to understand algebraic thinking concepts. This section provides strategies to help address the various modes of representation of mathematical concepts recommended by NCTM. Below is a visual representation of the various modes of representation.

Modes of Representation



The Importance of Teaching Algebra

All students should learn algebra. Algebra is one of the NCTM standards for instructional programs from Kindergarten through grade 12:

- ❖ understand patterns, relations and functions;
- ❖ represent and analyze mathematical situations and structures using algebraic symbols;
- ❖ use mathematical models to represent and understand quantitative relationships;
- ❖ analyze change in various contexts.

Two major connections that can be used as a framework are geometry and data analysis. Algebra is more than moving symbols around.

The modes of representation lend themselves to address the learning styles of students in terms of concrete representational and abstract, as well as the teaching styles of teachers within the levels of learning. The table below provides a representation of different examples addressing both teaching styles and student learning styles framed within the levels of learning.

Teacher Moves/Child's Response

Child's Response \ Teacher Moves	Concrete	Representational	Abstract	Oral
Concrete	Teacher shows concrete representation; child manipulates concrete objects	Teacher shows picture; child manipulates concrete objects	Teacher writes; child manipulates concrete objects	Teacher talks picture; child manipulates concrete objects
Representati onal	Teacher shows concrete representation; child chooses or draws picture	R —> R	A —> R	O —> R
Abstract	Teacher shows concrete representation; child writes symbols	R —> A	A —> A	O —> A
Oral	Teacher shows concrete representation; child discusses/talks	R —> O	A —> O	O —> O

Three Complementary Models of Algebra

Numerical Model: Investigate a problem first, a pattern could be analyzed using numerical methods resulting in students' hypotheses and generalizations about a given situation.

Visual Model: Through the use of graphing calculators or computers (computer languages like Logo, turtle geometry, or computer software like The Geometer's Sketchpad), the same problem might be represented in a visual mode, which can facilitate students making mathematical connections among topics in the algebra curriculum.

Abstract Model: Finally, problems can be solved symbolically using more standard algebraic procedures, promoting appreciation of the efficiency and elegance of algebraic solutions.

Some Misconceptions of Variables

- belief that letters have order:
  Thinking that $a < b$
- variables are labels for objects not number representations:
  $a \neq$ apples
  a = number of apples
- tendency to mix letters and numbers:
  $3a + 4 \neq 7a$
- tendency to ignore operations in generalizations:
  $7a \div a = 7$
  $7a — a \neq 7$
- understanding that $5a = 5 \cdot a$, or $ab = a \cdot b$.

In most cases at the elementary school level, concepts of algebra are developed informally. For example, students learn that symbols are used to construct number sentences that represent addition and subtraction.

Conceptions of Algebra and Uses of Variables

The concept of variable has multiple uses and should not be reduced to just one conception of algebra. As teachers, we need to make sure we include the different uses of variables involving different cognitive levels (concrete, pictorial and abstract). The table presented below, adapted form Usiskin (1988), presents four different conceptions of algebra:

Conception of Algebra	Use of Variable	Examples
Generalized arithmetic	Pattern generalizers (translate, generalize)	Properties, spreadsheets, relationship among numbers, arithmetic generalizations: $a \cdot b = b \cdot a$
Means to solve certain problems	Unknowns, constants (solve, simplify)	Placeholder for an unknown, find the solution of an equation: $3n + 5 = 40$
Study of relationships	Arguments, parameters (relate, graph)	Domain value of a function, number on which other numbers depend, find the pattern, the values vary, relationship among quantities: $A = LW$
Structure	Arbitrary marks on paper (manipulate, justify)	Factor $3x^2 + 4a - 132a^2$ (without having to go back to specific numbers)

Conception I: Algebra as Generalized Arithmetic

In this conception, variables are used as pattern generalizers, and no unknowns are involved. For example, you can tell students, "You can multiply two numbers in either order, and the answer is the same," but you can write "For any number's a and b, $a \cdot b = b \cdot a$" (Usiskin, 1997). As Usiskin indicated in his article, "the specific instance $6 \cdot 12 = 12 \cdot 6$ looks more the algebra and does not look like the verbal description." In another example, which one is easier, "The product of any number and zero is zero" or " For all n, $n \cdot 0 = 0$"? The algebraic version is superior to the description in words.

You are doing algebra when you discuss generalizations such as "Add 0 to a number, and the answer is that number. Add a number to itself, and the result is the same as two times the number." Using the language of algebra, these are $0 + n = n$, $t + t = 2t$, respectively.

For this conception of algebra, a strong development in arithmetic is very important. Work with the meaning of the operations, proper use of manipulative materials (for example snap cubes and two-color counters), and proper use of symbols. Use story problems and role playing to help understanding of concepts and make generalizations.

Conception II: Algebra as a Study of Procedures for Solving Certain Kinds of Problems

This conception is used when a word problem is translated into an equation and the equation is solved (Usiskin, 1997):

> What number, when added to 3, gives 7?
> Fill in the blank: 3 + ___ = 7
> Put a number in the square to make this sentence true: 3 + □ = 7
> Find the ?: 3 + ? = 7
> Solve: 3 + *x* = 7

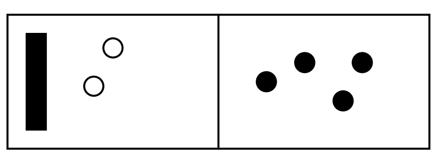
The unknown above is represented by the word, or by the blank, or a square, or a question mark, or the letter *x*, some argue that only the last example is algebra. Conventionally, we use a letter to represent an unknown. Another example is the following:

> When 4 is added to 2 times a certain number, the sum is 10. Find the number (Usiskin, 1988).

The above problem may translated into the language of algebra: $2x + 4 = 10$. This will be the solution under conception I. However, for conception II, we need to solve for the variable and find an answer. Using arithmetic, you need to subtract 4 and divide by 2. These are the inverse operations of the one represented in the algebraic equation.

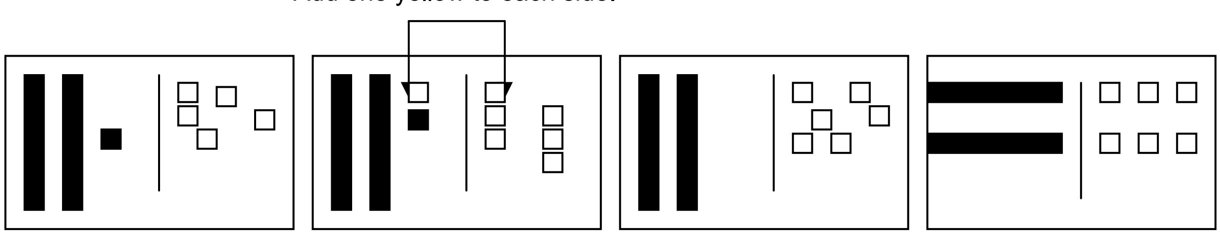
Algebra Tiles

Algebra tiles can be used to solve equations. Red pieces equal positive values, and yellow green and blue pieces negative values. The number represented by the objects to the left line is the same as the number represented by the objects to the right side of the line. One black (red) chip cancels one white (yellow) chip and vice versa. The box below shows *x* — 2 = 4.



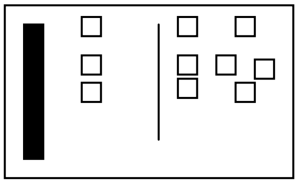
The model below shows 2*x* + 1 = -5. Find the value of x.

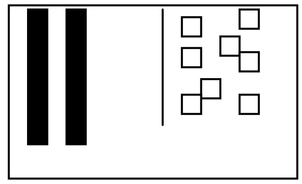
Add one yellow to each side.

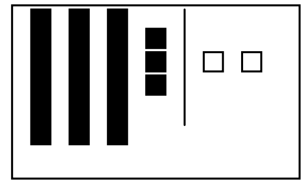


So, x is the same as 3.

Use the algebra tiles to find what x represents in terms of the color chips.

1. 

2. 

3. 

Hands-on equations

Hands-on equations may be used as well to solve this equation. For more information on these materials visit the following website: http://www.borenson.com/. See an example on the following website: http://www.borenson.com/html/sample.html.

Variable as a placeholder

Variable as a placeholder is another use within this conception of algebra. Usiskin (1997) gives the following examples:

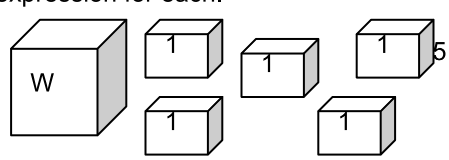
> "Monopoly or other board games in which the following kind of direction is given: 'Roll the dice. Whatever number you get, move forward twice that number of spaces.' In algebraic language it means 'If you roll d on the dice, then move forward 2d'."
>
> "Spreadsheets use algebra. Take the number in one cell of an array, subtract it from a number in a different cell, and put the difference in another cell. As in the dice situation, we do not need to know what number we have to understand the directions. If the number in the first cell is *x* and the number in the second cell is *y*, the number in the third cell is *y* – *x*."

Any time we play a game involving the idea to pick a number, add 3 to it, subtract 5, and so on, we are verbally doing algebra. We are thinking about any number and dealing with it.

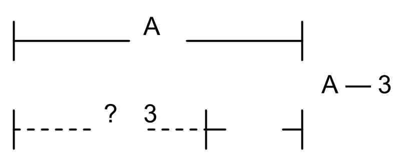
Other Sample Activities

1. Draw a picture and write an algebraic expression for each.

   a. weight of a box plus five



   b. three years less than a certain age



2. Each letter represents one of the following numbers 12, 18, or 21. Tell what each letter represents (use the calculator).

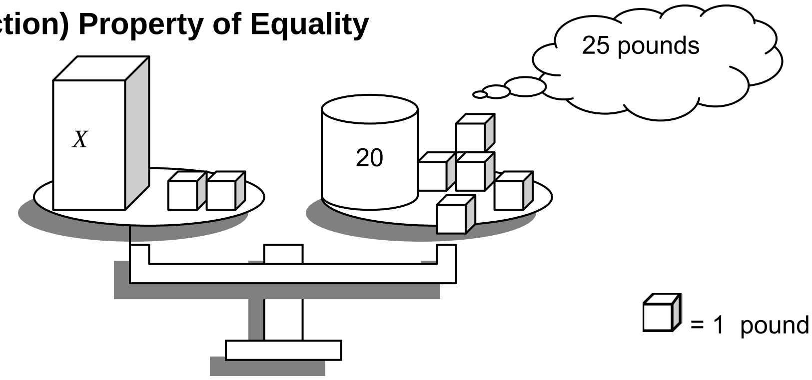
   a. P • (Q — R) = 162 b. (2 • G) — (H + I) = 12

3. Meaning of an Equation

a. Which of the statements are true? Choose an appropriate calculation method to help you decide.

1) $(6 + 14) \cdot 7 = 6 + (14 \cdot 7)$
2) $3.1 \cdot 2.4 = 10.7 - 3.26$
3) $78 \cdot 37 = (78 \cdot 7)(78 \cdot 30)$
4) $587 \cdot 0 \cdot 963 = 2874 + 5 - 2879$

Addition (Subtraction) Property of Equality

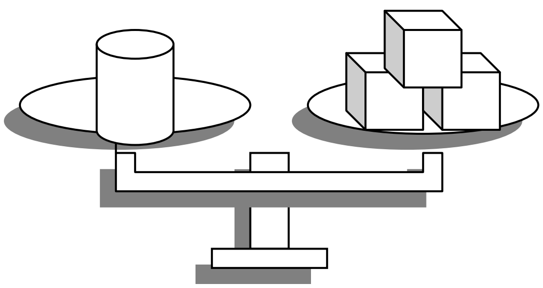


The scale above is balanced. A scale will stay balanced if you add the same amount to both sides or take away the same amount from both sides.

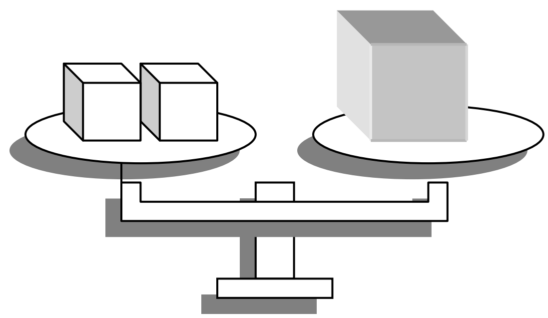
1. What algebraic expression can you write for the amount on the left side of the scale?
2. What amount would you have to take away from the left side of the scale to have the variable (box) alone?
3. If you take away the same amount form both sides to have the variable alone, how much is left on the right side of the scale?

More on Equations

Scale A and B below are balanced. The objects shown are the same in all pictures.



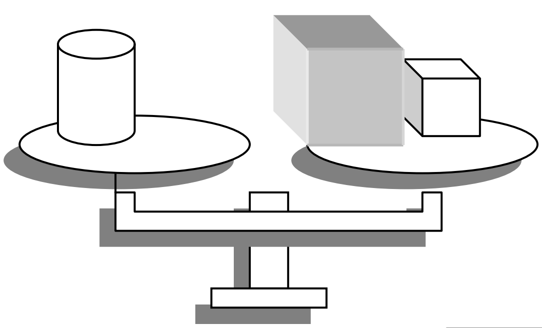
A



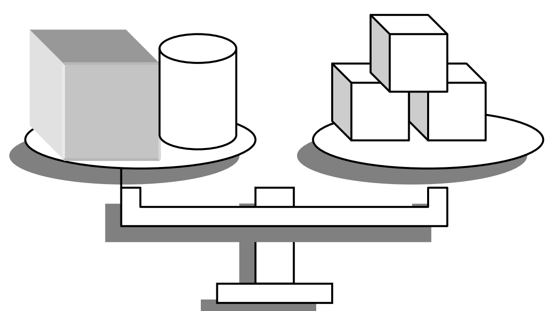
B

Decide which of these scales are really balanced.

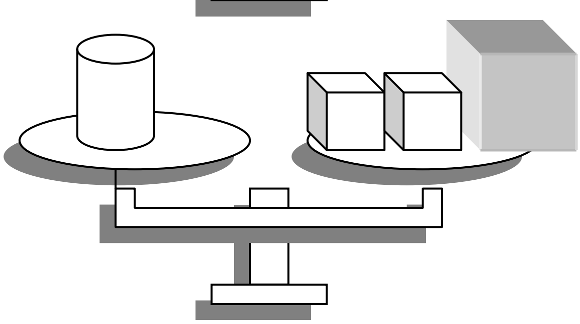
1.



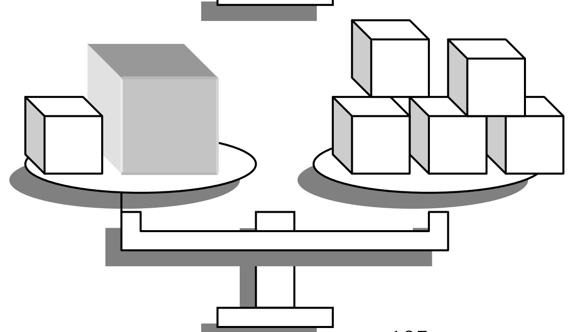
2.



3.



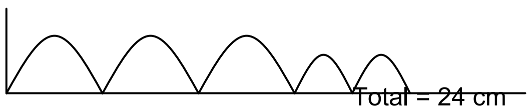
4.



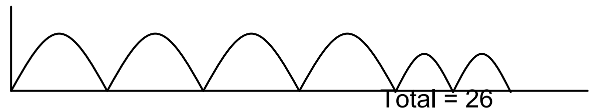
Exploring Equations in Two Variables

Jumps the same size are the same distance. All jumps are whole numbers. All jumps are greater than zero and less than 10. Big jumps represent distances that are greater than little jumps.

1.



2.



Conception III: Algebra as the Study of Relationships among Quantities

Under this conception, we include formulas: A=LW (the area formula for a rectangle). This describes the relationship between three quantities. There is not the feel for an unknown, because we are not solving for anything (Usiskin, 1988). In many cases, it is how we ask the question that makes a difference:

Find A when L=5 and W=7 (doing algebra)
Find n when 5 x 7 = n (not clear if we are doing algebra)
What number can I replace n by and make this a true statement? (treating as algebra)
What is the answer? (treating as arithmetic)

However, the most important distinction here is that the variables vary. For example,

What happens to the value of 1/ x as x gets larger and larger? (Usiskin, 1988)

This idea confuses many students. We are not asking for the value of x, so x does not represent an unknown. Also, we are not asking to translate a problem or generalize an arithmetic pattern. We are trying to generalize an algebraic pattern.

Here, variables are used as arguments (stand for a domain value of a function) or a parameters (stand for a number in which other numbers depend). Also, within this notion, we can talk about dependent and independent variables.

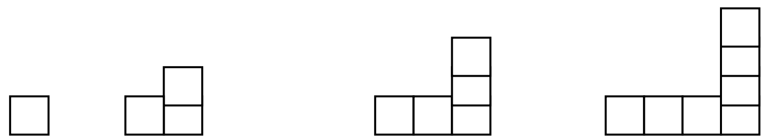
Graphing and Algebra

Graphing is very important aspect of algebra. Graphing Stories is an example of the type of intuitive understanding within this aspect of algebra. This activity is from one of the Principles and Standards for School Mathematics Series, Navigating through Algebra in Grades 3-5 (Cuevas, & Yeatts, 2001). The other three books in this series are the following:

- Navigating through Algebra in Prekindergarten-Grade 2 (Greenes, Cavanagh, Findley, & Small, 2001),
- Navigating through Algebra in Grades 6-8 (Friel, Rachlin, Doyle, Nygard, Pugalee, & Ellis, 2001), and
- Navigating through Algebra in Grades 9-12 (Burke, Erickson, Lott, & Obert, 2001)

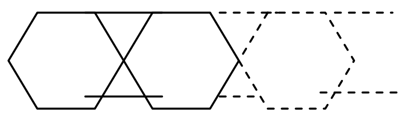
Use Objects, Look for Patterns, No Verbal Rule:

1. Copy and complete the table below. Use objects to build designs. Look for patterns to help.



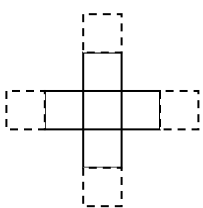
Area	1	3	5	7	9	11		
Perimeter	4	8	12					

2. It takes 2 hexagons to flank 2 triangles. It takes 3 hexagons to flank 4 triangles. How many hexagons are needed to flank 20 triangles? What is the total number of blocks that would be used?



Number of Hexagons	2				
Number of Triangles	2				
Total number of blocks	4				

Use Objects, Look for Patterns, Verbal Rule (from verbal rule to symbol rule)



Cross	Number of Squares
1st	5
2nd	
3rd	
4th	
10th	
30th	
Nth	Rule: ________

Problem Solving Make a Table

Language Development:
Spill two color chips to show ways to make 5, 8, 10.

Readiness Activity:
Stress the terms row and column. Ask students to write their initials: first name initial in the first column, last name initial in the second column and both initials in the last column.

First	Last	Both
E	O	EO

ESL: What is in the table? Familiarize children with the term top, bottom, column, row, first, second, third, next, and other words they might need to complete the tables. Ask students to locate the various positions and items on the table as you name them.
Use cubes to model the alternatives. Encourage children to say words aloud as they work.

Provide language for the lesson.

Solve problems by making a table:

How many ways can you put 5 □ into 2 □ □ ? Make a table to find out.

There are ____ ways.

□	□	In All

Describe patterns beginning to show in the tables: numbers in each column are in order, numbers go up in the first column, numbers go down in the second column.

Logo Computer Programming

This is a learning environment that can be used to teach mathematics (see Ortiz, 2001b, pp. 433-435). It has been used effectively to teach variables (Ortiz & MacGregor, 1991).

For Example, the following program will produce squares of different lengths:

```
TO SQUATE :LENGTH
        REPEAT 4[FD :LENGTH RT 90]
END
```

SQUARE 40 will make the turtle draw a square with 40 turtle's steps on each side.

Virtual Manipulatives

1. For ideas and examples of virtual manipulatives from the National Council of Teachers of Mathematics visit the following website: http://nctm.org
   a. Online Version of the Principles and Standards for School Mathematics: http://standards.nctm.org
   b. Electronic Examples: Interactive Activities that support Principles and Standards: http://standards.nctm.org/document/eexamples/index.htm

2. For Pattern Blocks visit the following website: http://www.arcytech.org/java/patterns/patterns_j.shtml

3. For Base Ten Blocks visit the following website: http://www.arcytech.org/java/b10blocks/b10blocks.html

4. For Cuisenaire Rods (Integers Rods) visit the following website: http://www.arcytech.org/java/integers/integers.html

5. For classroom activities and other links visit the following website by Dr. Margo Lynn Mankus: http://mason.gmu.edu/~mmankus

6. Illuminations by NCTM: Internet resources to improve the teaching and learning of mathematics for all students: http://illuminations.nctm.org/index2.html

7. For Fraction Bars visit the following website: http://www.arcytech.org/java/fractions/fractions.html

Conception 4: Algebra as the Study of Structures

This conception involves situations like the following:

Factor $3x^2 + 4a - 132a^2$.

The answer to this problem is $(3x + 22a)(x - 6a)$. Here, the variables are treated as arbitrary marks on paper (without having to go back to specific numbers).

Some General Ideas

Students should be able to move to one conception of algebra to another as necessary within a given problem. Some problems might require the use of two or more of these conceptions of algebra.

Knowledge of the Concept of Variable Instrument

Research evidence indicating students' misconceptions regarding different conceptions of algebra is abundant and strong. In general, researchers indicate that the students' misconceptions center on a lack of understanding of the algebraic process and ability to use different conceptions of algebra. The purposes of this study were to develop a valid and reliable group paper-and-pencil instrument that assesses students' knowledge of the concept of variable; explore the students', from a large and diverse population, response patterns for different uses of variables; and analyze the strength of the relationship between students' knowledge of the concept of variable and their cognitive development (see Ortiz, 2001a for more information).

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Materials Used

Pattern Blocks:

http://www.etacuisenaire.com:80/control/catalog.product?deptId=GEOMETRY&prodId=740

Algebra Tiles and Algebra Tiles Class Set

http://www.etacuisenaire.com:80/control/catalog.product?deptId=ALGEBRA&prodId=4490A

The class set has 30 a set of 32 algebra tiles, one for the overhead, and a guide. This could be divided among the participants. Or we could just by the algebra tile set individually.

Hands On Equation is another very useful tool:

http://www.borenson.com

I do not know if you have the Navigation Series for Algebra from NCTM (nctm.org): Navigating Through Algebra. This is a set of 4 books.

At least a copy of the Principles and Standard for School Mathematics should be available. I will bring my personal copy to the workshop.

http://poweredge.nctm.org/nctm/spec_itm.icl?passitemid=1405&eflag=0&icflag=0&orderidentifier=icat_orderid&sourcedoc=index.icl?orderidentifier=icat_orderid

Algebraic Thinking, Grades K-12: Readings from NCTM's School-Based Journals and Other Publications. Edited by Barbara Moses. At least a copy of this book would help too. I will bring my copy.

http://poweredge.nctm.org/nctm/itm_src.icl?orderidentifier=ID99295840623456632514565050&passidentifier=710&eflag=0&oneortwo=2&searchstring=algebraic+thinking&searchformat=by30s&searchnum

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