NYU·poly

POLYTECHNIC INSTITUTE OF NEW YORK UNIVERSITY

Solving with Seesaws

Subject Area(s) Math

Associated Unit None

Associated Lesson None

Activity Title: Solving with Seesaws

Header Insert Image 1 here, centered

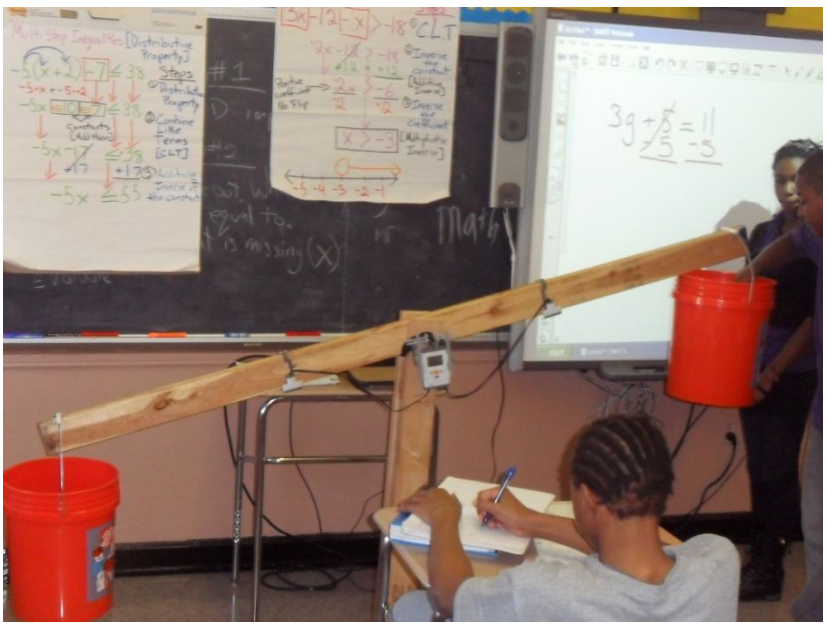

Image 1
ADA Description: A photo of the seesaw setup
Caption: Seesaw setup
Image file name: kids_seesaw.jpg
Source/Rights: Copyright © 2011 Ronald Poveda. Used with permission

Grade Level 6 (5 - 7)

Activity Dependency: None

Time Required: 45 mins.

Group Size: 4-5

Expendable Cost per Classroom: US $25-$50 (varies depending on wood and other materials)

Summary

Students during this activity are using a simple machine to demonstrate an analogous visualization of solving two or three-step equations in mathematics. Students in the classroom will not only solve two-step equations on a provided worksheet, but will also solve the equations using the seesaw balance. The use of sensor equipment for proper position monitoring is used to aid students in balancing the structure, as well as balancing the equation as they solve it on paper.

Engineering Connection

Proper step-by-step visualization of a design or plan is crucial for all scientists and engineers when performing scientific inquiries and experiments. In the engineering world, small-scale structures and/or systems are used to test calculations and engineering concepts, particularly when dealing with the research and development of the structure or system. Active tinkering, especially when operating a structure or a system, is what allows for a successful engineering design, and it generally helps the engineer visualize and assess his/her own design in action.

Engineering Category

Category #1: relates math concept to engineering

Keywords: variable, coefficient, constant, inverse operations, Lego Mindstorms NXT, sensor

Educational Standards

New York Math, 2011:
6.A.1: Translate two-step verbal expressions into algebraic expressions.
6.A.3: Translate two-step verbal expressions into algebraic equations.
6.A.4: Solve and explain two-step equations involving whole numbers using inverse operations.

Pre-Requisite Knowledge

Basic understanding of solving equations with one unknown.

Learning Objectives

After this activity, students should be able to:

- Understand how to solve two-step equations
- Identify terms in the mathematical equation
- Understand the use of sensors in a system, especially in feedback control

Materials List*

*Note: A local machinist may assist in the construction of the seesaw, however, the seesaw can be constructed with parts from local hardware stores. Any seesaw can be used for the activity, as long as sensors can be attached to the moveable beam to demonstrate balance.

The classroom seesaw setup needs:

- 2 buckets or containers with large handles
- 1 2x4 wooden beam, 6 ft. long
- 2 2x4 wooden beam, 3 ft. long

- 2 2x4 wooden beam, 2 ft. long
- 4 wood screws, 2-3 in long
- Metal rod, ¾ inch diameter
- 2 Rubber bands
- 1 elastic (bungee) cord
- Ball bearing (same inner diameter as metal rod)
- LEGO Mindstorms kit
    - with LEGO parts
    - 1 NXT with two ultrasonic sensors
- LEGO Mindstorms NXT 2.0 software
- Multiple objects of the same weight and size (Suggestion: bulk packages of water bottles)
- Several plastic bags or containers for the objects

Introduction / Motivation

Two-step equations may not look pleasant on paper. However, learning how to solve equations is very important in solving many kinds of real-world problems that come up in math and science. There are even times where two-step equations come up in daily life. Figuring out how many boxes of cereal you can get with $15 while taking into account coupons or discounts is one example of using two-step equations. Calculating if a cardboard box with a weight limit can hold smaller boxes of cans along with other loose cans is another example. The list goes on. A simple example of a two-step equation is shown below. Such an equation is composed of variable terms and constant terms which can appear on either side of the equation. (Write equation below, along with corresponding terminology. Solve step-by-step, and you ultimately obtain n = 12.) Solving an equation like this involves moving terms from one side to another, keeping the equation "balanced".

Image Insert Image 2 here, centered

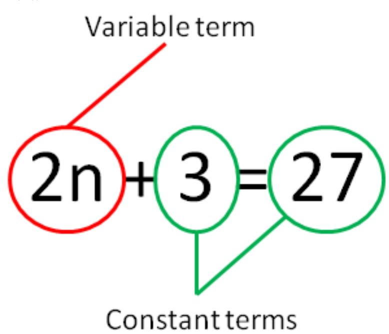

Image 2
ADA Description: Example of a simple two-step equation
Image file name: Example Equation.tif
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A good physical example of the use of two-step equations is the **seesaw** or a physical balance. It is a simple machine that simply embodies an equation. (Draw a diagram of a seesaw beneath the equation, where the fulcrum is positioned under the equals sign). We don't have an equation if there is no balance. In this way, it helps to physically view what you need to do to solve an equation. For example, the equation shown in Image 2 can be used as follows: you have 27 loose bottles of water on one side of a seesaw, and 3 loose bottles on the other, which are placed alongside 2 full bags of bottles. With the equipment we have today, we're going to use the help of **sensors**, which are electronic devices that measure the changes in a system as it is being used. Sensors can be used to measure temperature, distances, the level of light and darkness in a room, weight, and other things that can be measured. In our activity today, we will be using this balance system that will help us see if the equations we solve by hand (and by using the seesaw) are "balanced".

Vocabulary / Definitions

Word	Definition
Seesaw	Simple machine that balances weight along a bar
Sensor	Device that measures or "senses" something (temperature, distance, level of light/darkness

Procedure

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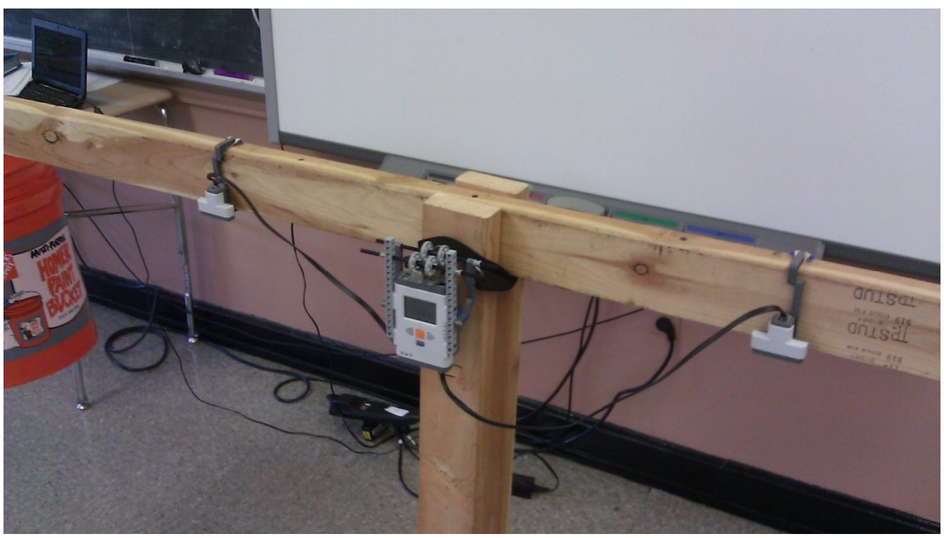

Image 3
ADA Description: Sensor system on seesaw
Image file name: system_closeup.jpg
Source/Rights: Copyright © 2011 Ronald Poveda. Used with permission

Before the Activity

- Assemble the seesaw, as shown in the diagrams in Figures 1-3. The design of the seesaw can vary; what is provided in this lesson plan is simply a suggested design. One may wish to deviate from the specifications provided, as long as the beam is relatively balanced. A bungee cord wrapped around the bottom of the 6 ft. beam will assist in properly balancing the beam after each use. The hooks of the bungee cord can be attached to the metal rod on each side, and then wrapped around the legs.
- Attach two ultrasonic sensors to ports 1 and 4 of the LEGO NXT.
- Construct the setup shown in Figure 4, using the included building instructions. Once complete, attach the setup onto the seesaw, keeping both sensors equidistant from the seesaw fulcrum (legs). The sensors are attached by wrapping their respective attached structures around the 6 ft. beam, and using a rubber band on the pegs in the back of each structure to secure each of them.
- Create the NXT program that incorporates the two sensors, so that both sensors are incorporated and programmed with respect to a reference distance. Figures 5-6 denote the general structure of the program.

Figure Insert Figure 1 here, center

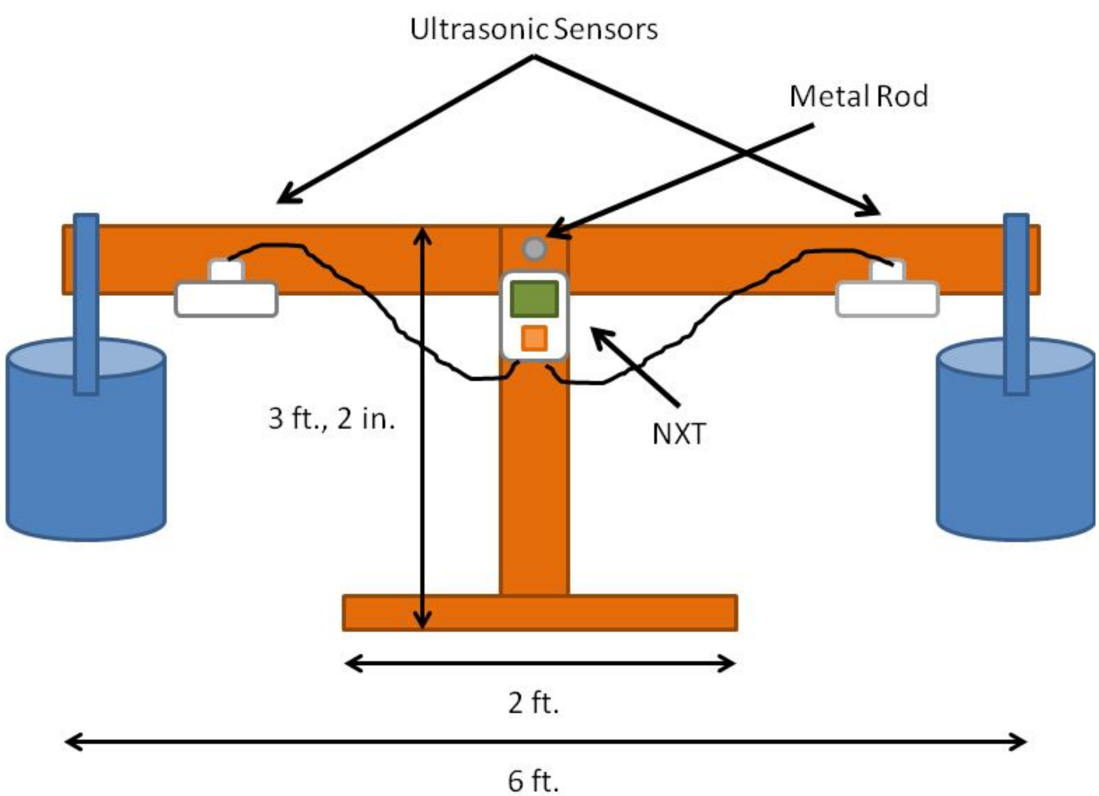

Figure 1

ADA Description: Seesaw Setup Diagram

Caption: Seesaws embody mathematical equations when balanced.

Image file name: Seesaw_diagram.tif

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Figure Insert Figure 2 here, center

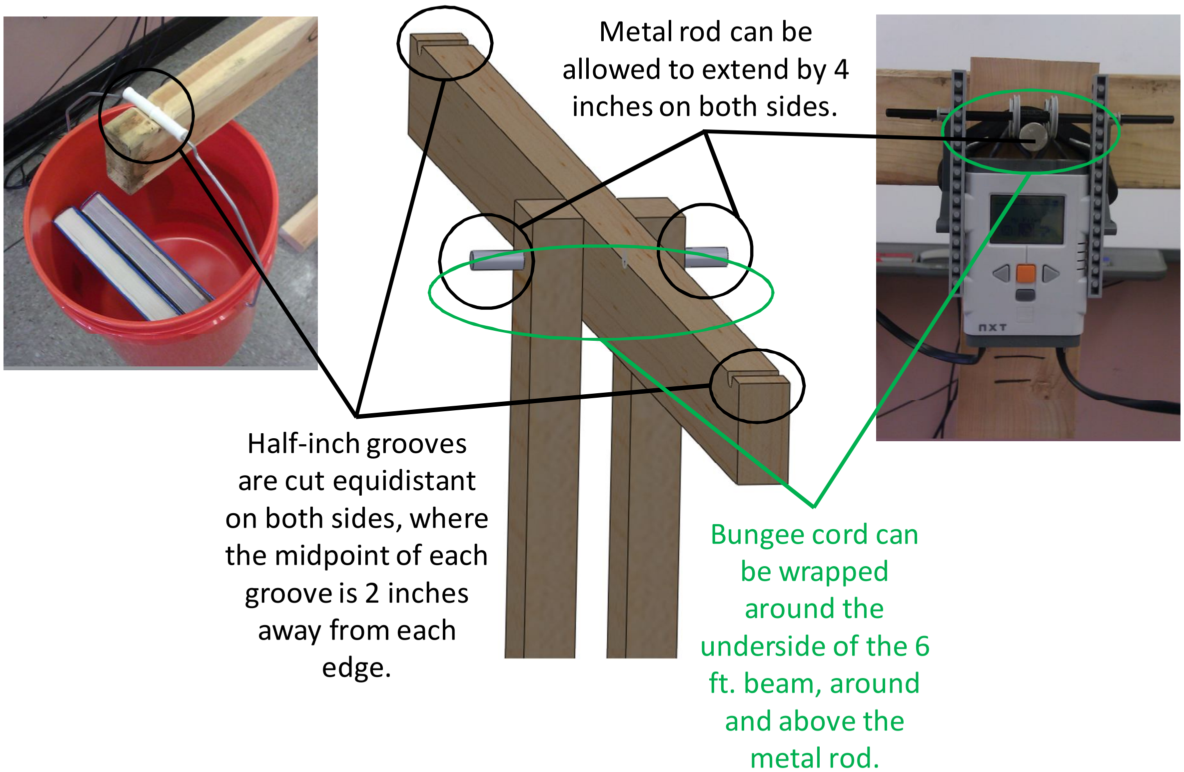


Figure 2

ADA Description: Seesaw construction on top beam

Image file name: Seesaw_construction.tif

Figure Insert Figure 3 here, center

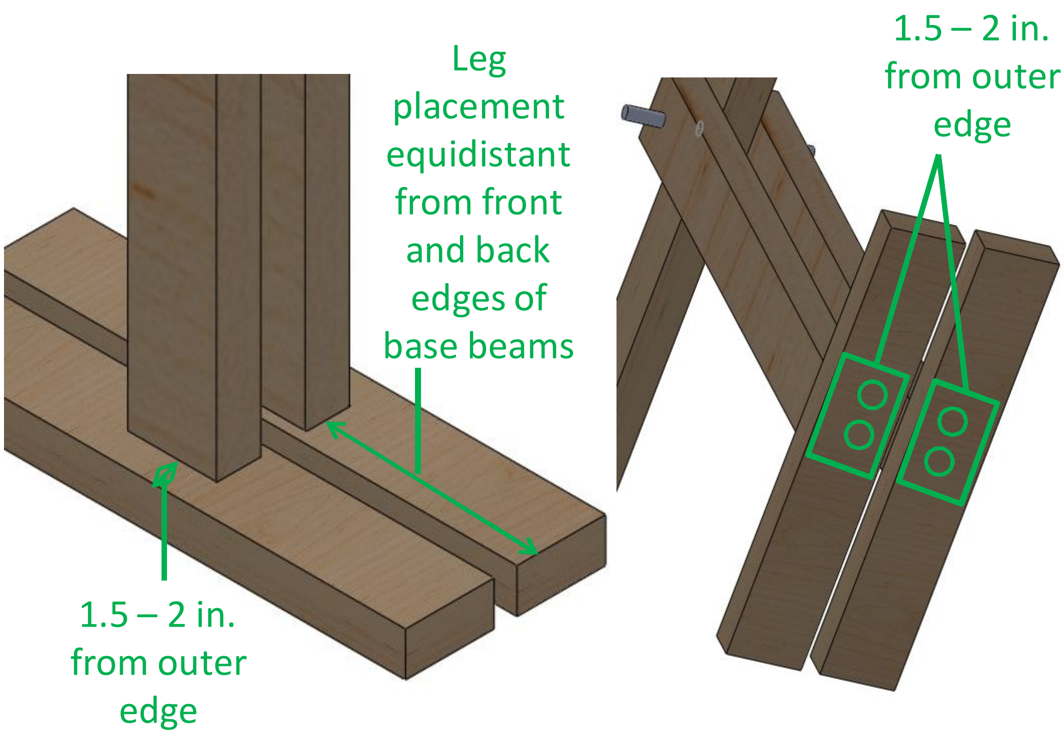


Figure 3
ADA Description: Seesaw construction on bottom base
Image file name: Seesaw_const_botbase.tif

Figure Insert Figure 4 here, center

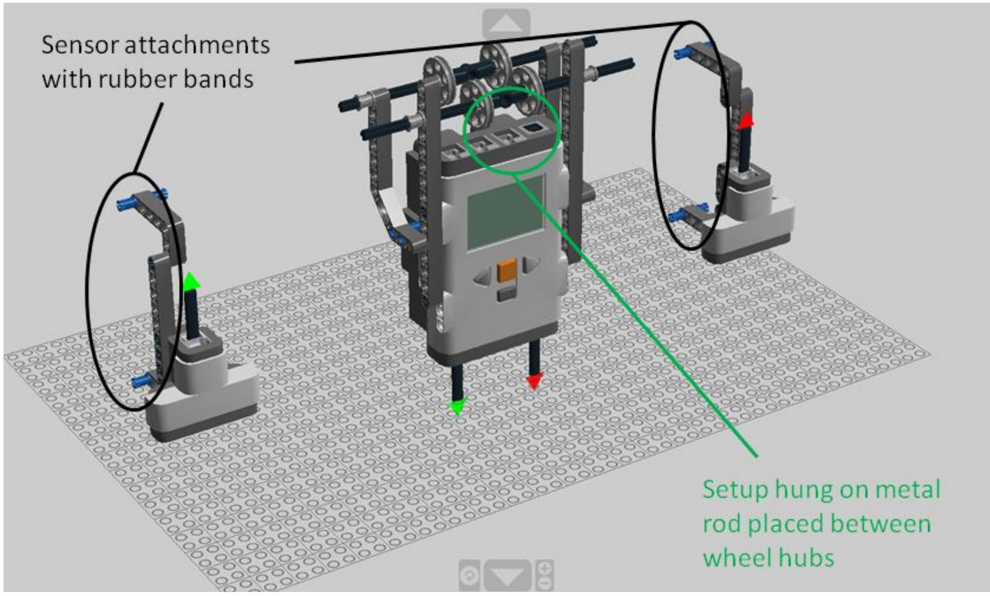


Figure 4
ADA Description: LEGO Digital Designer drawing
Image file name: LDD_setup.tif

Figure Insert Figure 5 here, center

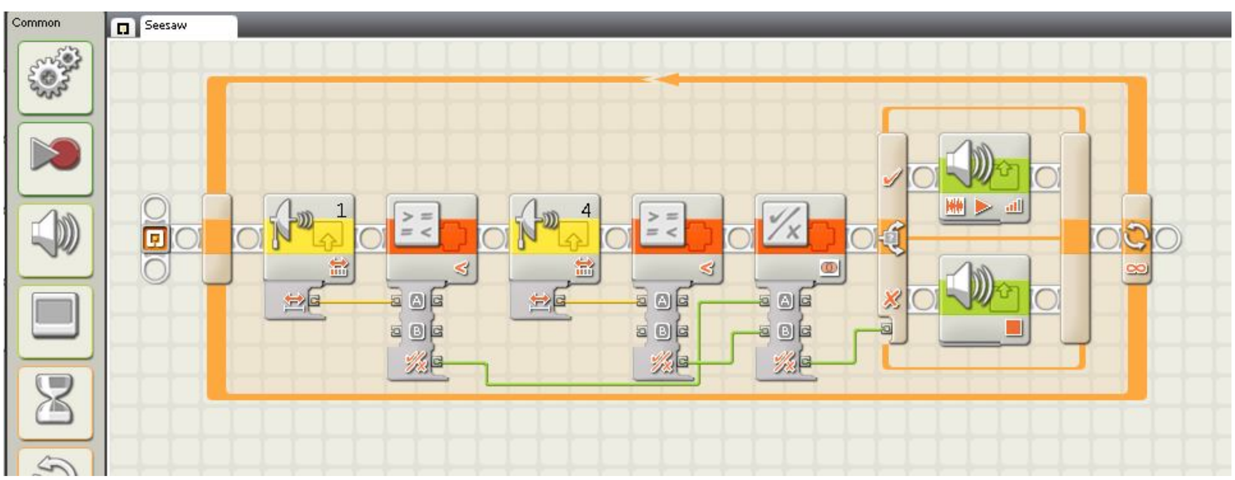
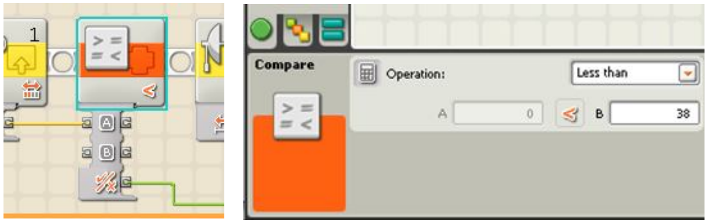
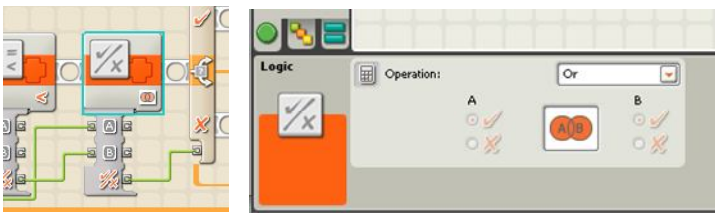


Figure 5
ADA Description: LEGO Mindstorms NXT-G program for seesaw
Caption: The NXT-G program for the seesaw, with two ultrasonic sensors attached to ports 1 and 4.
Image file name: whole program.tif

Figure Insert Figure 6 here, center



A "Compare" icon is attached to each sensor icon, where the values, where the value is set to less than the sensor height from the ground. In this case, it was 38 inches.



Both "Compare" icons are attached to a "Logic" icon, where the readings of each sensor are considered. The operation is set to "Or".

If the sensor at Port 1 or Port 4 reads less than the designated height of the floor, then there is an imbalance in the system. Therefore, the "Logic" icon is connected to a switch, which leads to the effect of both of these conditions. If there is an imbalance, then the NXT will beep repeatedly until there is a balance. The sound file that was selected was called "Error 02".

Figure 6
ADA Description: NXT-G program icons used for seesaw
Image file name: Seesaw_progicon.tif
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With the Students

1. Give students the included worksheet (Refer to SeeSaw_Worksheet.docx) of equations to work on for 15 minutes. Have them form groups of 4-5 students and work on the entire sheet.
2. Have buckets placed on both sides of the seesaw.
3. Select questions from the worksheet to carry out using the seesaw and the whiteboard. Using objects of equal weight and size (such as water bottles found in 24 packs), start placing the appropriate amount of objects on the seesaw. For example, in the equation $3n + 5 = 20$, you

would know in advance that n = 5. Therefore, 5 water bottles need to be placed inside 3 closed, opaque bags, since the coefficient in front of the variable "n" is 3. Along with 5 loose water bottles, the bags with the bottles inside need to be placed on the left bucket of the seesaw, since "3n + 5" is placed on the left side of the equation. On the right side of the equation, there is a 20. Therefore, 20 loose bottles need to be placed on the right bucket of the seesaw.

4. Allow each group to solve their assigned problem step-by-step using the whiteboard and the seesaw at the same time. For example, to solve for n in the above equation, we subtract 5 from both sides. Therefore, the group is also expected to remove 5 water bottles from each bucket. To finally solve for n, each side is divided by 3. In a similar fashion, the load in each bucket needs to be divided by 3. Therefore, one bag is left on one side, while a certain amount of water bottles will be left on the other side. In this way, students will have solved for the amount of water bottles in each bag, and students can open the bags to verify.

Image Insert Image 4 here, centered

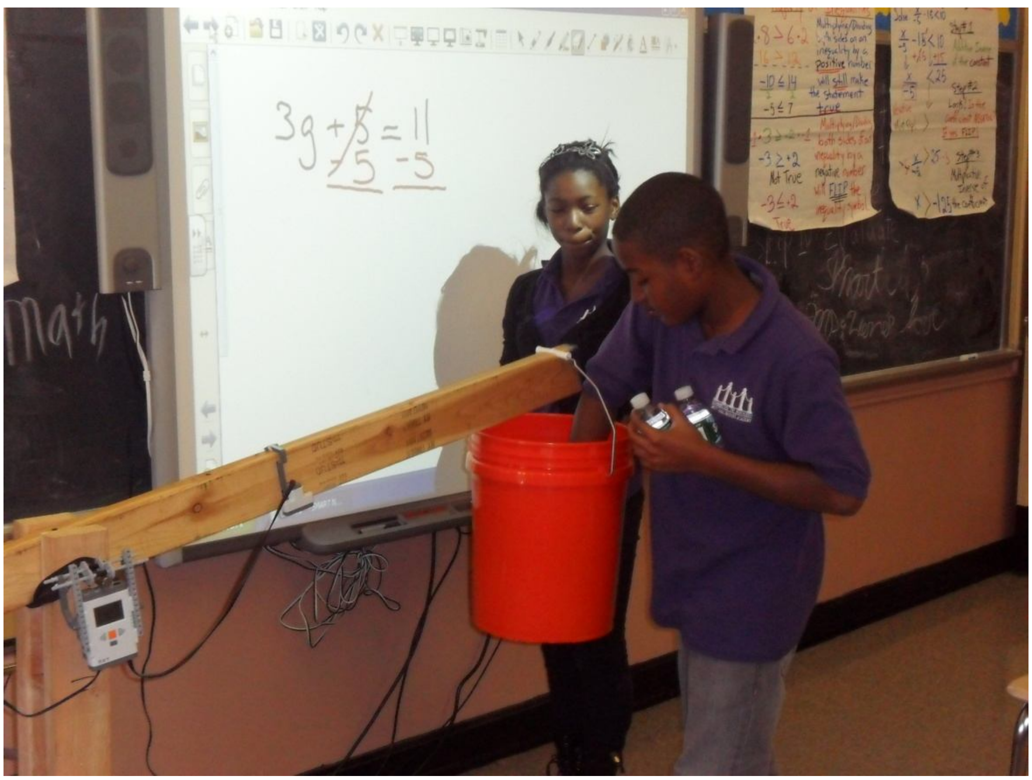

Image 4
ADA Description: Students moving objects from one bucket to another.
Image file name: kids_bottles.jpg
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Safety Issues

- Ensure that an adult stands by to control the motion of the seesaw as the students transfer weight from one bucket to another. It also helps that the students in the group using the seesaw setup stabilize the seesaw's motion as well and work together.

Attachments

SeeSaw_Worksheet.docx (also available in PDF format)
SeeSaw_Worksheet_Ans.docx (also available in PDF format)

Troubleshooting Tips

- After each transfer of weight, the seesaw should be leveled out by hand and then left to balance, so that the ultrasonic sensors can read the correct distance from the floor. Make sure that there are no objects (such as tables, desks, or your own arms, legs, and feet) that are too close to the sensors, since they may obstruct the sensor's readings.

Assessment

Activity Embedded Assessment
Analysis
There are two criteria that students should be evaluated on: cooperation in problem solving, as well as step-by-step reasoning using a physical analogy of the problem at hand. Since the students will be working in groups, all students in the group must participate and cooperate with each other. It is also important for each group to demonstrate a logical progression from step-to-step to understand how to solve basic two-step equations.

Activity Extensions

None

Additional Multimedia Support

LEGO Mindstorms NXT Software

Owner

Ronald Poveda

Contributors

Ronald Poveda, Vikram Kapila

Supporting Program

AMPS Program, Polytechnic Institute of NYU

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