Abstraction Bridges

We have found that teachers see robotics as offering great opportunities to teach STEM. We also found that many teachers miss these opportunities because solving the robotics project becomes the focus of the class and the STEM concepts in the lesson are either assumed or implied instead of foregrounded, scaffolded and made explicit. In order to foreground the academic STEM content, our team has developed a concept that we call an abstraction bridge. Abstraction bridges are easy for teachers to implement and are designed to:

- *Refocus the teacher and student's attention to the academic component of the problem.*
- *Provide a set of everyday problems designed to develop generalized set of problem solving strategies across multiple contexts for the student.*
- *Provide formative assessment tools for the teacher enabling individualized remediation.*
- *Tie the lesson to outcomes measured by NCLB standardized tests.*

An added benefit to the development of the abstraction bridge concept is that it can be used by all STEM teachers who are using project-based learning and authentic assessment to teach.

Robot math demonstrates specific mathematical principles in a focused-applied setting. Students apply ratio, proportion, conversion of units, and measurement when they program their robots; the robot math context is much different than what is being taught in the mathematics classroom and assessed on NCLB-required state standardized tests. The abstraction bridge concept is designed to enable students to form a cognitive bridge between what they learn in a focused-applied robotics setting and the types of mathematics that students encounter every day. The Robot Algebra abstraction bridge model is a tool that the teacher will use every day. Students will be required to solve at least one non-robotic math problem per day for the duration of the project. Initially, the problems will be solved in class as a group; eventually the problems can serve as warm-up activities checking student understanding or will become homework assignments. Students will be required to both solve the problem and also explain how they derived their answer. Documentation will be kept in the student engineering journal.

Example Problems are below:

Robot Problem: Faster Robot

Directions: Show all work, describe how you got the answer using mathematics and words, and circle your final answer.

Problem: Dontay has the choice of placing two different diameter wheels on his robot; 5.6 cm or 8.15 cm. Which robot wheel will go faster? *Explain your answer using math and words.*

Generalized Problem: Better Deal

Directions: Show all work, describe how you got the answer using mathematics and words, and circle your final answer.

Problem: Two girls got into the theater on State Street for $3. Five boys got into the theater on Main Street for $6. Which group, the girls or the boys, got the better deal? *Explain your answer using math and words.*

So for the above robot problem example, in the physics problem you can ask the exact same question, and then follow up with a question on how much more torque is needed. This teaches conservation laws and a deeper lesson that you don't get something for free. In fact, the latter, the deeper life lessons, is the final thing I like to get out of the robotics courses. So for me, robots:

1) captivate the students
2) provide a vehicle to learn math and science
3) can teach deeper lessons, even if they are design ones

Books on a Shelf

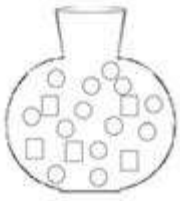
Directions: Show all work, describe how you got the answer using mathematics and words, and circle your final answer.

Problem: If 6 books are 2/3 of all the books on Robert's shelf, figure out how many books are 5/9 of the books on his shelf. *Explain your answer using math and words.*

Halloween

Directions: Show all work, describe how you got the answer using mathematics and words, and circle your final answer.

Problem: Suppose you are making treats to hand out on Halloween. Each treat is a small bag that contains that contains 5 Jolly Ranchers and 13 Jaw Breakers. If you have 50 Jolly Ranchers and

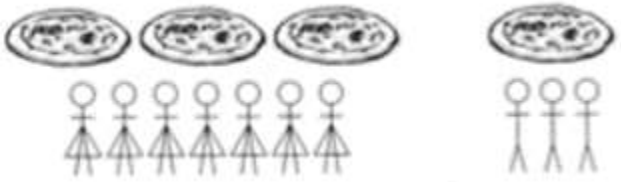


125 Jaw Breakers, how many complete small bags can you make?

Better Deal

Directions: Show all work, describe how you got the answer using mathematics and words, and circle your final answer.

Problem: Who gets more pizza, a girl or a boy? *Explain your answer using math and words.*



How Far

Directions: Show all work, describe how you got the answer using mathematics and words, and circle your final answer.

Problem: Car A and Car B are leaving the same place and going in the same direction. If it takes Car A 6 hours to get to the destination driving 20 miles per hour, how long will it take Car B to get to the same destination driving 50 miles per hour? *Explain your answer using math and words.*

Proportional Equation Example

Directions: Show all work, describe how you got the answer using mathematics and words, and circle your final answer.

Problem: Write an equation for the following statement: *There are six times as many students at this school as there are teachers at this school.* Use "S" for the number of students and "T" for the number of teachers. *Explain your answer using math and words.*

Functional Understanding

Directions: Show all work, describe how you got the answer using mathematics and words, and circle your final answer.

Problem: Angela makes and sell special-occasion greeting cards. The table below shows the relationship between the number of cards sold and her profit. Based on the data in the table, which of the following equations shows how the number of cards sold and the profit are related. *Explain your answer using math and words.*

	Mon.	***Tues.***	***Wed.***	***Thurs.***	***Fri.***	***Sat.***
Number sold, *n*	4	0	5	2	3	6
Profit, *p*	$2.00	$0.00	$2.50	$1.00	$1.50	$3.00

1. p = 2n
2. p = 0.5n
3. p =n – 2
4. p = 6 -n
5. p = n + 1

Scale Factor Problem Example

Directions: Show all work, describe how you got the answer using mathematics and words, and circle your final answer.

Problem: Roxanne plans to enlarge her photograph, which is 4 inches by 6 inches. Which of the following enlargements maintains the same proportions as the original photograph? *Explain your answer using math and words.*

5 inches by 7 inches | 5 inches by 7 ½ inches

Proportional Reasoning Example

Directions: Show all work, describe how you got the answer using mathematics and words, and circle your final answer.

Problem: A giraffe moves forward 10 meters every step that she takes. A lion moves forward 2 meters every step that she takes. If the giraffe takes 80 steps, how many steps must the lion take to cover the same distance? *Explain your answer using math and words.*

There are limitless numbers of ratio and proportion problems that can be developed as part of this project. Below are the strategies that we will use to create a user friendly database for teachers to access:

• *Continue to build, sort, and qualify the database of ratio and proportion problems that currently reside at the Robot Algebra site. (This database will have many potential users as it is can be used by all teachers incorporating authentic assessment STEM challenges ensuring that math is covered in their lessons.)*

• *Develop a structure in the database that helps teachers to quickly identify different types of problems in the database i.e. ratio word problems, graphs, tables, proportional algebra problems, fractional relationship problems…*

• *Rate the problems from basic to sophisticated*

• *Provide ongoing teacher training in the form of webinars, seminars, and multiday classes that will enable teachers to become expert math teachers.*

• *Continual upgrade of the database based on teacher usage and research.*