Math-in-CTE Lesson Plan

Lesson Title: **Spaghetti Bridge**	Lesson #02

Occupational Area: Technology
CTE Concept(s): Problem Solving Model
Math Concept(s): Order of Operations
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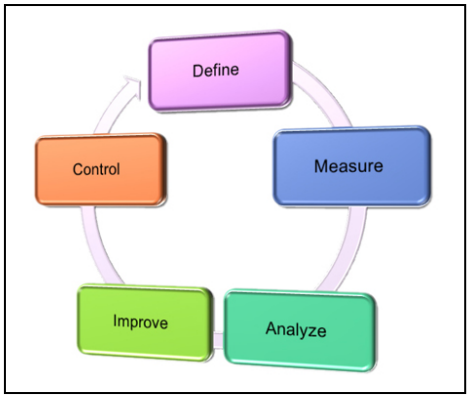
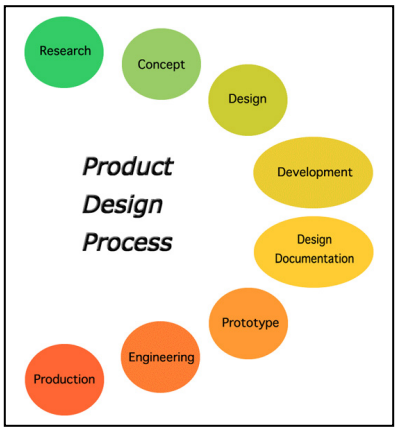
Lesson Objectives:	1. Describe the general problem-solving/design process. 2. Define a technological problem or opportunity. 3. Describe the technological problem-solving/design process. 4. List the major steps in solving technological problems and meeting technological opportunities. 5. List the steps to identify a technological problem or opportunity. 6. List the criteria and constraints in the problem-solving design process. 7. List general methods of gathering information for the problem-solving/design process. 8. Describe the foundational information that must be gathered to solve technical development projects. 9. Design a bridge using 1 pound of noodles. 10. Build the bridge. 11. Test the bridge's efficiency by first weighing the bridge, then placing a load on the structure. 12. Record the amount of weight your bridge can support.
Supplies Needed:	Glue (for paper) Paper Utility knife Straight pins Spaghetti noodles Cardboard
Key Terms:	Constraints Criteria Descriptive methods Design Process Scientific information Technological knowledge Technological Opportunity Technological problem Order of Operations Human information Legal information Problem solving Descriptive methods Ethical information Experimental methods History Information Historical methods Mechanical Advantage

THE “7 ELEMENTS”	TEACHER NOTES (and answer key)
1. **Introduce the CTE lesson**. All technology is created for purpose. It is designed to meet human needs or wants. All technology was developed by people who wanted to solve a problem or address an opportunity. **Discussion:** Ask students to: 1. Provide an example of problem solving. 2. Provide an example of the design process.	Evaluate each answer individually. (You may substitute these discussion topics based personal experience and comfort level of discussion.) Problem Solving EXAMPLES: 1. Getting ready for school 2. Designing a home and/or any product.
2. Assess students’ math awareness as it relates to the CTE lesson. Write the following key terms on the board. Have students define them. 1. Order of operations 2. Problem Solving (graphically) 3. Design Process (graphically) 4. Mechanical Advantage	**Order of operations** Do you ever get confused about which part of a math problem to solve first? REMIND students of the phrase “**P**lease **E**xcuse **M**y **D**ear **A**unt **S**ally.” How does that help? It’s an acronym or mnemonic device for *order of operations*. **P**=Parenthesis **E**=Exponents **M**=Multiplication **D**=Division **A**=Addition **S**=Subtraction **Problem solving** 

	Design Process  **Mechanical advantage** is a measure of how much a simple machine multiplies the input of force put into the machine.

3. Work through the math example embedded in the CTE lesson. *The Law of Equilibrium:* A Greek mathematician who lived more than two thousand years ago actually proved the law behind the workings of the LEVER. Archimedes observed how a small force can move a great weight. From this observation, the following law of equilibrium was created: A lever is in equilibrium when the product of the weight (W1) and distance (D1) on one side of the fulcrum [the center of gravity] is equal to the product of the weight (W2) and distance (D2) on the other side of the fulcrum. The formula is **W1 x D1=W2 x D2**. 1. So, if Roberto, who weighs 150 pounds, is 2 feet from the fulcrum of a seesaw, how far from the fulcrum would Becky, who is 60 pounds have to sit to achieve equilibrium? 2. If Isaac, who weighs 120 pounds, is 3 feet from the fulcrum how far from the fulcrum would Josie who is 90 pounds have to sit to achieve equilibrium.?	**Solution** using the law of equilibrium formula: 1. Using W1=150, D1=2 and W2=60 we can calculate the distance (D2) as follows: a. 60 x D2=150 x 2 b. 60 x D2=300 c. D2=300/60 d. D2=5 So, Becky would need to sit 5 feet from the fulcrum. 2. Using W1=120, D1=3 and W2=90 we can calculate the distance (D2) as follows: a. 90 x D2=120 x 3 b. 90 x D2=360 c. D2=360/90 d. D2=4 Thus Josie would need to sit 4 feet from the fulcrum.

4. **Work through *related, contextual* math-in-CTE examples.**

Problem Statement:

The objective of this activity is to design and build the lightest bridge possible, capable of supporting the heaviest load when weight is hung, or placed on a given span, using specified materials and guidelines. In addition, the students create a PowerPoint or other presentation describing what they learned about bridge design and function.

PARAMETERS:

1. Bridge must span an opening of 6" (minimum). (The distance between the center-most pillars.)
2. Roadbed width must be 4" (minimum) and there must be at least 3" above the road of empty space. (This is where the wooden block is placed.)
3. Roadbed base must be 3" above the ground (minimum).
4. Length 6" to 18" and Width 4" to 8".
5. Roadbed height 3 1/2" (minimum)
6. Complete order of operations Khan Academy examples at https://www.khanacademy.org/math/pre-algebra/pre-algebra-arith-prop/pre-algebra-order-of-operations/v/order-of-operations.
7. Create a 10-slide PowerPoint about Bridge Design at the conclusion of the project. (cover slide, objective slide, vocabulary, photos, body of the presentation (including statistics and insights), conclusion slide, source slide)

MATERIALS & SUPPLIES:

Noodles	One pound
Glue	Elmer's or Super Glue

Evaluate the projects individually.

Analysis: Meet as a class and analyze the material processing activities using the following questions for each student/student team:

1. Which material processing tools were used?
2. Which measuring tools were used?
3. How could the speed of the manufacturing process have been increased?
4. What changes in the material processing actions would be made to improve the quality of the product?
5. What has this activity taught you about the problem solving method?
6. How can you relate this information to your other courses?
7. Describe how this activity relates to the information we covered in class so far.
8. Given the opportunity how would you redesign this activity?

BRIDGE Data:

1. Width = _____
2. Height = _____
3. Length = _____
4. Weight = _____
5. Load Carried = _____
6. Bridge Efficiency (Bridge Weight / Load Carried) = _____

SUGGESTED PROCEDURES:

1. **Read and analyze the problem statement** carefully prior to formulating the procedures and techniques necessary to construct a solution.

2. **Review the accepted steps in the problem solving process.**
   a. Identifying
   b. Developing
   c. Evaluating
   d. Applying

3. **Be creative.** Do not be limited by the drawing above. There are unlimited possibilities for solving the problem.

4. **Prepare to discuss** your solution with the class. (Student reports may contain working drawings, description of problem solution, etc.)

TESTING:

1. Center the bridge on the platform.

2. Place a wooden or metal block 4" by 6" on the roadbed.

3. Add weights in a continuous fashion until the bridge fails. [NOTE: A fail is the inability of the bridge to carry any additional load without breaking, or with any part of the bridge extending more than 2 cm.

4. Check all construction requirements and dimensions prior to testing.

5. Work through the *traditional math* examples.

1. Which of the following expressions is equal to $\frac{1}{x+2} - \frac{2}{x+1}$?

   A. $\frac{-1}{2x+3}$

   B. $\frac{-x-3}{x^2+2}$

Solutions

1. D

C. $\frac{-1}{x^2+3x+2}$

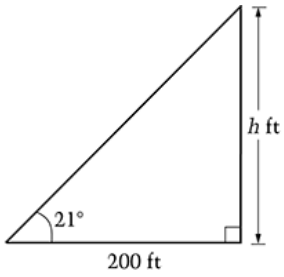
D. $\frac{-x-3}{x^2+3x+2}$

E. $\frac{-x+5}{x^2+3x+2}$

2. What is the solution to the system of equations $\begin{cases} 3x - 2y = -7 \\ x + y = 11 \end{cases}$?

Answer: x = _____
y = _____

3.



Note: Figure not drawn to scale.

On level ground from a distance of 200 feet, the angle of elevation to the top of a building is 21°, as shown in the figure above. What is the height h of the building, to the nearest foot?

A. 72
B. 77
C. 187
D. 201
E. 521

2. *X=3, y=8*

3x-2y=-7
x+y=11

3x+-2(11-x)=-7
3x-22+2x=-7
5x-22=-7
5x=15
X=3

3+y=11
y=8

3. B

4. In a certain restaurant a whole pie has been sliced into 8 equal wedges. Only 2 slices of the pie remain. Three people would each like an equal portion from the remaining slices of pie. What fraction of the original pie should each person receive? Answer: _____	4. 1/12
5. The remainder when a number *n* is divided by 7 is 2. Which of the following is the remainder when 2 *n* + 1 is divided by 7 ? A. 1 B. 2 C. 3 D. 4 E. 5	5. E
6. A cat lies crouched on level ground 50 feet away from the base of a tree. The cat can see a bird's nest directly above the base of the tree. The angle of elevation from the cat to the bird's nest is 40°. To the nearest foot, how far above the base of the tree is the bird's nest? A. 32 B. 38 C. 42 D. 60 E. 65	6. C
6. Students *demonstrate their understanding.* 1. Students complete the handouts provided by the instructor and complete any other projects being created in class. 2. Student find solutions to their problems using *order of operations*. 3. Student complete the hands-on activities provided by the instructor.	Projects similar to the Spaghetti Bridge task. For example: a. Spaghetti Bridge at http://techedchs.weebly.com/uploads/3/8/4/4/38449457/bridge-designs.pdf. b. Spaghetti Bridge at https://www.teachengineering.org/activities/view/wpi_spag_act_joy. c. Spaghetti Bridge at http://me.utep.edu/cmstewart/documents/ME1321/Project%20Overview.pdf. d. Other teacher-selected handouts, tasks/ worksheets, and/or projects.

7. Formal assessment.

1. Rosa is twice as old as Byron. Fred is one year older than Byron.

   If Fred's age is represented by *F*, which of the following represents the ages of Rosa and Byron, respectively?

   A. ½ (*F* - 1) and *F* - 1
   B. ½ (*F* + 1) and *F* + 1
   C. 2 (*F* - 1) and *F* - 1
   D. 2 (*F* + 1) and *F* + 1
   E. 2 *F* and *F* - 1

2. It takes 28 minutes for a certain bacteria population to double. If there are 5,241,763 bacteria in this population at 1:00 p.m., which of the following is closest to the number of bacteria in millions at 2:30 p.m. on the same day?

   A. 80
   B. 40
   C. 20
   D. 15
   E. 10

3. $\sqrt{8}\ N = 3^5$

   In the equation above, what is the value of *N*, rounded to the nearest tenth?

Answer:_____

4. $3^3 + 4(8-5) \div 6 =$

   A. 6.5
   B. 11
   C. 27.5
   D. 29
   E. 34.16

Solutions

1. C

2. B

3. 85.90

4. D