Science Assessment System Through Course Task

Tugboat Wars

Grade Level:
3

Phenomena:
Effects of Forces on Objects – 1 Dimension

Science & Engineering Practices:
Developing and Using Models
Constructing Explanations and Designing Solutions

Crosscutting Concepts:
Cause and Effect

Designed and revised by Kentucky Department of Education staff
in collaboration with teachers from Kentucky schools and districts.

Preparing to implement Through Course Tasks in the Classroom

What is a TCT?

- TCTs are 3-dimensional tasks specifically designed to get evidence of student competency in two dimensions, Science and Engineering Processes (SEPs) and Crosscutting Concepts (CCC), untethered from Performance Expectations (PEs)/standards. Tasks are sense-making experiences.
- Tasks are to be used formatively. The goal is for both students and teachers to understand areas of strength and improvement for the SEP(s) and CCC assessed within the task.

How do I facilitate a Through Course Task (TCT)?

- TCT facilitation is a collaborative process in which teacher teams calibrate understanding of the expectations of the task and refine strategies to be used during task facilitation.

Before the task:

1. Complete the TCT as a learner – compare understanding of task through the lens of success criteria (identified in the task) in order to understand expectations.
   Success criteria include:
   - What is this task designed to get evidence of?
   - What is the task asking the students to do?
   - What might a student response look like?
2. Identify the phenomenon within the task. Consult resources to assure teacher teams have a deep understanding of associated science concepts.
3. Collaborate to generate, review and refine feedback questions during facilitation.
4. Identify potential "trouble spots" and plan for possible misconceptions.

During the task:

5. Collect defensible evidence of each student's competencies in 3-dimensional sense-making for the task.
6. Ask appropriate feedback questions to support student access and engagement with the task in order to elicit accurate evidence of student capacities.

After the task:

7. Reflect on the task as a collaborative team.
8. Review student work samples to identify areas of strength and areas of need.
9. Determine/plan next steps to move 3-D sense making forward through the strengthening of the use of SEPs and CCCs.

Using the materials included in this packet:

- **Task Annotation:**
  - The task annotation is a teacher guide for using the task in the classroom. Additionally, the annotation gives insight into the thinking of developers and the task overall.

    - Each task has science and engineering practices, disciplinary core ideas, and crosscutting concepts designated with both color and text style:
        - **Science and Engineering Practices**
        - *Disciplinary Core Ideas*
        - Crosscutting Concepts
- **Student Task:** The materials to be used by students to complete the TCT.

Tugboat Wars Task Annotation

After **developing and using force models to assess** the effects *of forces acting on an object (barge)*, **develop and use a model to explain** the effect of a situation where *the forces acting on an object (the barge) are balanced (equal and in opposite directions).*

Phenomenon within the task

The phenomenon in this task is that when forces on an object at rest are balanced/equal and in opposite directions, the object does not change speed or direction. If the forces on an object at rest are unbalanced/unequal then the object will move in the direction of the largest force. This task is only considering forces acting in one dimension (tugboats pulling on the barge).

This is the context for the phenomenon: *Sally spends the summer with her Grandmother who lives beside the Ohio River. Sally enjoys watching the tugboats pull the barges down the river. She is very excited when she hears that there will be a Tugboat War nearby. She knows that a tugboat war is similar to the game of tug of war, and thinks about what she learned about forces in a tug of war. When the forces in a tug of war are balanced/equal, no one "wins." If the forces are unbalanced/unequal then there is a winner. The side with the largest force "wins," and the barge moves in the direction of the larger force.*

How the phenomenon relates to DCI

This phenomenon relates to the following DCI's:

PS2.A: Forces and Motion

- Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) (3-PS2-1)
- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) (3-PS2-2)
- By the end of grade 2 students should have working knowledge that objects pull or push each other when they collide or are

connected. Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. An object sliding on a surface or sitting on a slope experiences a pull due to friction on the object due to the surface that opposes the object's motion.

- By the end of grade 5 students will conclude that each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (adapted from https://www.nap.edu/read/13165/chapter/9#115)

PS2.B: Types of Interactions

- Objects in contact exert forces on each other. (3-PS2-1)
- By the end of grade 2 students should understand that when objects touch or collide, they push on one another and can change motion or shape.
- By the end of grade 5 students will need to recognize that objects in contact exert forces on each other (friction, elastic pushes and pulls). Electric, magnetic and gravitational forces between a pair of objects do not require that the objects be in contact—for example, magnets push or pull at a distance. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and for forces between two magnets, on their orientation relative to each other. The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (adapted from A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas)

What information/data will students use within this task?

Students will be required to draw on prior knowledge of what movements constitute a "push" and a "pull" and the effects they have on an object. Many students will have personal experiences with these concepts having participated in an actual tug-of-war, witnessed barges on one of our state's many waterways or with various toys that demonstrate pushing/pulling patterns of motion. If students are not familiar with barges and tugboats, they will need to learn about them prior to engaging with the task (see Ideas for Setting up with Students below). Modeling with toy boats can be effective.

Also, students will need to understand what a model is and how a force can be modeled with an arrow to represent "relative strength" or relative amount of force. For example, in the task Tug #1 and #2 are the same force strength represented by an arrow of the same length, and Tug #3 is twice as strong and #1 and #2; its arrow is twice as long. Tug #4 is twice as strong as Tug #3 and its

arrow is twice as long. Tug "strength" is in multiples of each other, allowing for setting some foundation for proportional reasoning even though this is not explicitly taught at this grade level.

A common issue with using traditional "tug of war" to explain the concept of forces is that the forces are acting on the "rope," which is not a solid object, and can cause confusion in modeling the forces. By applying the forces to a barge, it is easier for many to understand the model.

Ideas for setting up the task with students

Although this task presents the concept of balanced and unbalanced forces using tugboats pulling a barge, students would benefit from reviewing the concept of a ¨tug of war.¨

- Video Clip of Tugboats pulling barges: This resources will familiarize students with the parameters of the scenario
- Students would also benefit from watching a short video clip of tugboats to better understand the task.

Intent of the Task for Assessment

This task was designed to determine if students could identify situations where the forces acting on an object (like the barge) are balanced or unbalanced based evaluating force models in a variety of situations. Students will use their understanding of the models to explain the expected motion of the object/barge for situations where the forces acting on the barge are unbalanced or balanced.

The task structure supports getting the information as follows:

- Part 1: The first part of the task is designed to be completed collaboratively. Modeling the use of arrows to create "races" of different configurations allow the teacher to identify and address misconceptions as they occur. An important point to note (and to highlight in this lesson) is that students should get the same results for the same race (Tug #1 competes against Tug#3 and Tug #3 wins).
- Part 2: The second part of the task is to be completed independently. This will provide further indication of the student's ability to demonstrate understanding by transferring their experiences from the collaborative part of the task to the independent modeling and explanatory portion of the task.

Success Criteria

Evidence of Learning Desired based on Progression from Appendices

Developing and Using Models

- Develop and or use models to describe and/or predict phenomena. (Appendix F)

Constructing Explanations

- Use evidence (e.g. measurements, observations, and patterns) to construct or support an explanation. (Appendix F)

Cause and Effect

- Cause and Effect relationships are routinely identified, tested and used to explain change. (appendix G)

Success Criteria

- Student will create models and use them to explain whether forces the modeled situation (tugboat competition) shows balanced or unbalanced forces, and which direction the barge will move (or not move at all). (This occurs in part 1 of the task as a collaborative experience. Tugboat War Score Sheet and Grid with Barge Sheet.)
- Student develops a model to represent a tugboat competition in which the forces acting on the barge are balanced, i.e., Tug #1 vs Tug #2, Tugs #1 &#2 vs Tug #3, or Tugs #1, #2, and #3 vs tug #4.
- Student explains how the model demonstrates a balance of forces (forces are equal and in opposite directions).
- Student explains that balanced forces cause zero/no motion of the barge. (Grid with Barge Sheet)

Possible Student Responses

- The barge will not move because the forces are balanced on each side. The right side has a force of 5 and the left side has a force of 5.
- I think that the forces are equal/balanced because they both have 4 squares. The barge will not move because they are equal.
- I think it is equal because they both have a force of 4. The barge won't move because they have the same (4) force.
- I know the forces are balanced/equal because the forces on each side of the barge are the same length. The barge will not move.

Other information teacher teams might find useful when preparing to use this task in the TCT process:

When facilitating this task with students it may be helpful to consider the following:

- Some learners may find the arrows a bit small. Carefully monitor the cutting process to ensure that they do not compromise

the measurement during this phase OR precut the arrows before the TCT.

- Model all aspects. It was very useful to demonstrate the measuring of the arrows and the completion of the chart. After modeling how to measure arrows #1 and #2, students were more confident when measuring the rest of the force arrows.
- Some learners may find sentence stems helpful when completing Part 2. The following sentence stems were provided to struggling students:
    - I know the forces are balanced/equal because_____.
    - The movement of the barge will be _____.
    - The barge will _____.

Extensions and/or other uses after the task is implemented

The following activity would allow students to further explore the topic of balanced and unbalanced forces while examining a variety of factors that contribute to an object's movement.

- Tug of War with Grain: Excellent extension with ties to agricultural safety.

Through Course Task – Tugboat Wars

Name:_____ Date:_____

Sally spends the summer with her Grandmother who lives beside the Ohio River. Sally enjoys watching the tugboats pull the barges down the river. She is very excited when she hears that there will be a tugboat "war" nearby. She knows that a tugboat war is similar to tug of war and remembers what she learned about forces in a tug of war. When the forces in a tug of war are balanced/equal, no one wins. If the forces are unbalanced/unequal then there is a winner. The side with the greatest force wins. The phenomenon in this task is that when forces on an object are balanced/equal, the object does not change direction. If the forces on an object are unbalanced/unequal then the object will move in the direction of the largest force.

Part 1

- Cut out the force arrows on your handout.
- Using the grid as a guide, count and label the force of each arrow.
    - *Example: Tugboat #1 has a force of 4.*
- With a partner or group, evaluate tugboat competitions using the force arrows cut-outs.
    - Evaluate different tugboat competitions by arranging the arrows in different ways-some where the forces applied to the barge are unbalanced and some situations where the forces are balanced. *Example: Tugboat #3 and Tugboat #1 are in a competition. Arrange the arrows on your barge chart.*

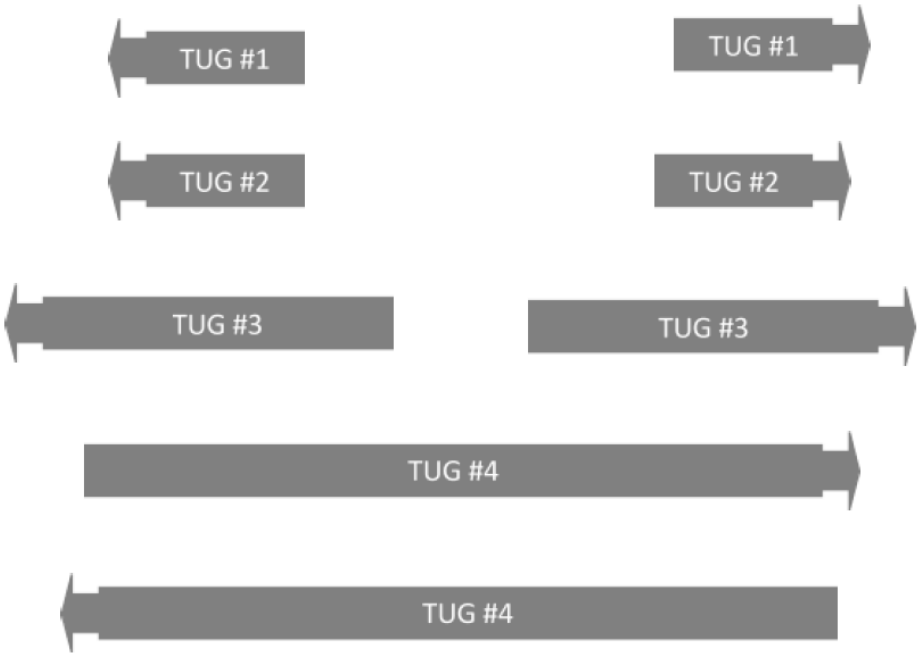
As you work, ask yourself the following questions:

- Who would win in each scenario you create?
- What direction does the barge move?
- Record your scenarios on the “Tugboat Wars Score Sheet”.

Part 2

Using your experiences in Part 1 and the *Student Answer Sheet*:

- Create a tugboat competition that would end in a tie.
  - You may use as many tugboats as you like in the competition.
  - Use the force arrows to represent the tugboats involved.
- Explain how you know the forces are balanced and describe the motion of the barge.


TUG #1
TUG #1
TUG #2
TUG #2
TUG #3
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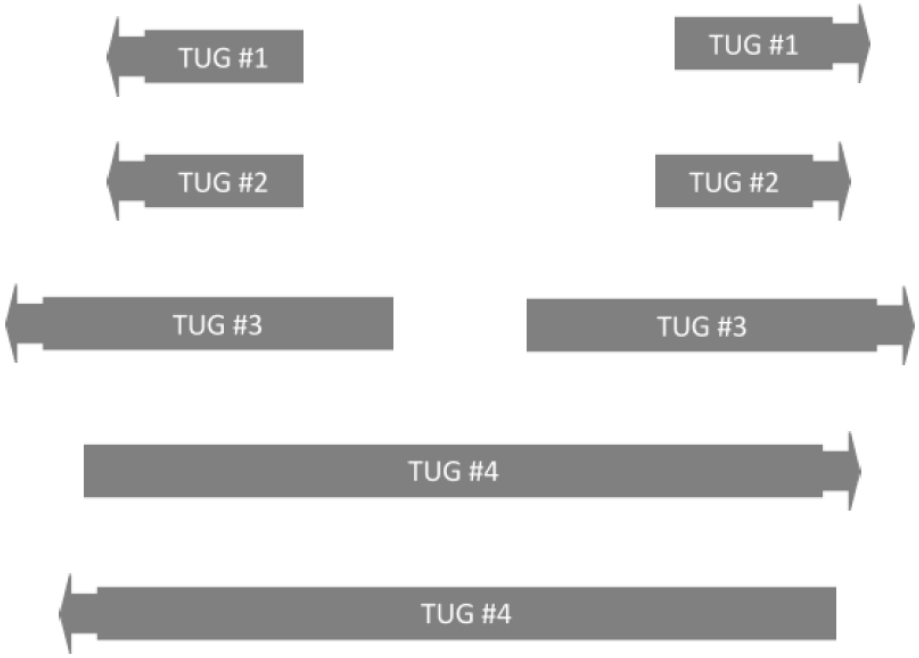
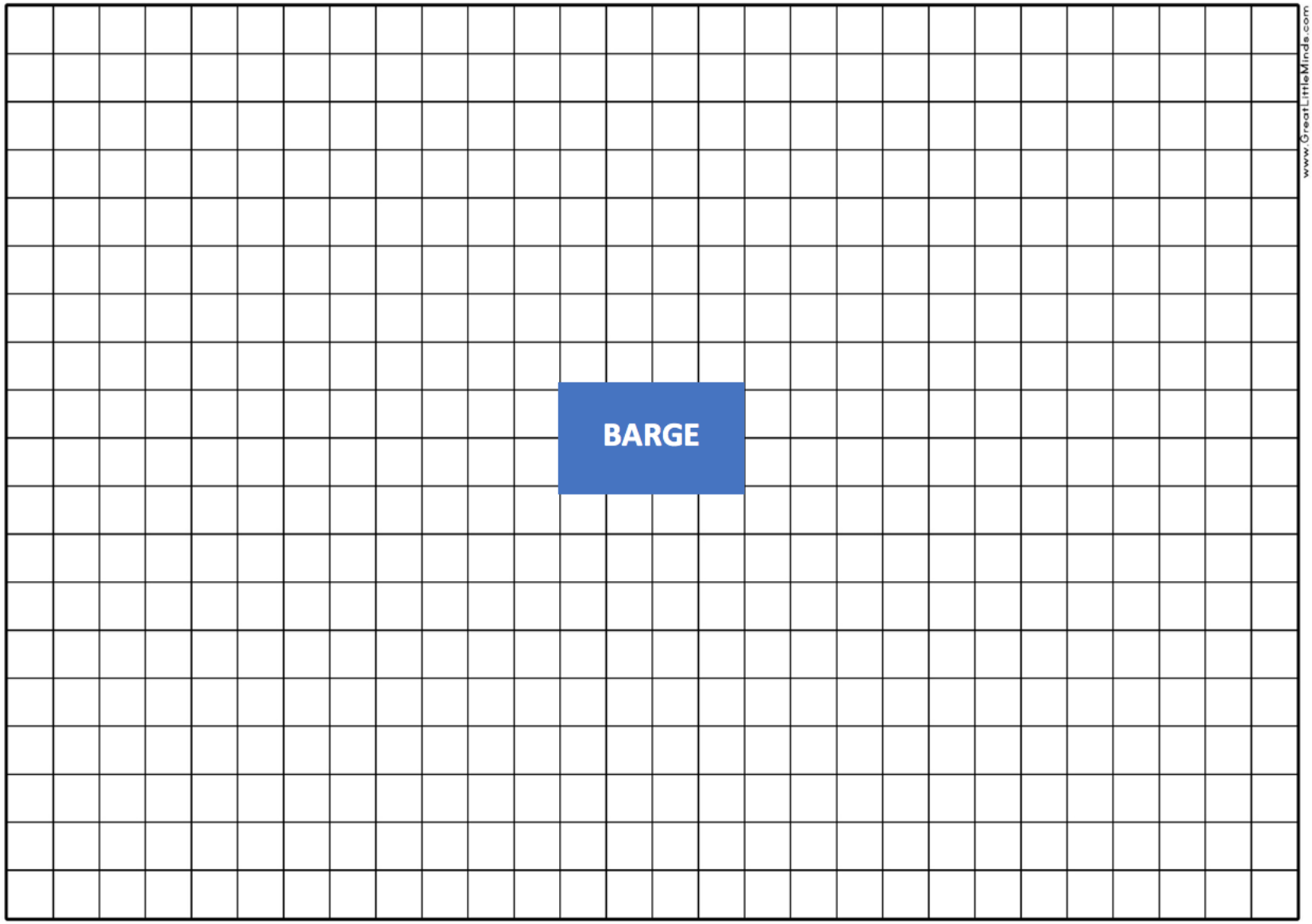
TUG #4
TUG #4


TUG #1
TUG #1
TUG #2
TUG #2
TUG #3
TUG #3
TUG #4
TUG #4

Part 1: Using the grid as a guide, count and label the force of each arrow. Use this grid to conduct your own "tugboat wars." Use the Tugboat Wars Score Sheet to record your results.



Part 2

Using your experiences in Part 1:

- Create a tugboat competition that would end in a tie.
    - You may use as many tugboats as you like in the competition.
    - Use the force arrows to represent the tugboats involved.
    - Glue or illustrate the tugboat competition on the grid that you will be describing.
- Explain how you know the forces are balanced and describe the motion of the barge.

Tugboat War Score Sheet

Tugboat(s) pulling on the left.	Tugboat(s) pulling on the right.	Who wins?	Which direction does the barge move?	Are the forces pulling on the barge balanced or unbalanced?