Science Assessment System
Through Course Task

Data Detectives

Grade Level:
4
Phenomena:
Predictable Motion/Experimental Design

Science & Engineering Practices:
Planning Carrying Out Investigations
Analyzing and Interpreting Data
Engaging in Argument from Evidence

Crosscutting Concepts:
Cause and Effect

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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.

Data Detectives Task Annotation

After **evaluating the experimental design and resulting data from an investigation** *to explore the relationship between the height of a ramp and the distance a toy car travels*, **make a claim supported with evidence about why the experimental data is faulty, and propose changes to the experimental design** that will cause better experimental outcomes.

Phenomenon within the task

Although making sense of a scientific phenomenon is not central to the purpose of the task, the predictable motion of toy cars down an incline due to gravity is the embedded phenomenon. The exploration of this phenomenon provides the context for obtaining evidence about students understanding of key issues in experimental design (planning and carrying out investigations), and a task that supports obtaining evidence for this SEP is useful. The need for and challenges of controlling variables, the reality of human error in experiments, and the necessity of multiple trials to minimize the distortion of data are explored in the task.

Misconceptions: Some students have the idea that one trial is best because it is simpler and other students feel that there should ALWAYS be 3 trials, regardless of outcomes. For various reasons, 3 trials are often specified in school experiments, and this can lead to misunderstandings in experimental design. Experimental trials should be conducted until a consistent and reliable pattern is observed in the resulting data. Data that is far different from the pattern should be identified as outlying data and set aside as unreliable.

How the phenomenon relates to DCI, if applicable

Grade 3: PS2.A Each force acts on one particular object and has both a 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.)

The patterns of an object's motion in various situations can be observed and measured; when 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.)

What information/data will students use within this task?

Students will use the two data charts that are provided for Part A and Part C. For Part B, they will respond to three descriptions of experimental design and make a claim for which one will result in consistent data. They need to support their claim using evidence given in the descriptions of experimental design. They also will rely on foundational knowledge or prior knowledge learned from previous experiments: aspects of the experiment must be controlled or the resulting data may be flawed; human error is a factor in most experiments; good design requires that multiple trials be undertaken to minimize the human error; that repeated similar results are often an indicator of reliability; that results far from the "norm" are called outliers and need to be set aside.

Ideas for setting up the task with students

Important Prerequisite: Students need to participate in data collection and participate in a discussion about reliable data BEFORE attempting this task or it may be frustrating. I collected very simple data by asking a student to walk from his desk in the room to the closed door and knock on it. One student was asked to say, "Go!" and another was given a stopwatch to time how long it took him to knock. We repeated the activity 7 times (using different students on the timer and saying, "Go!") and noted the data on the board in a chart like this:

Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7

It is important to pick a variety of students (slower, faster, more meticulous, careless etc.) so that a range of results are obtained. Then ask the students why, when the task is the same, the resulting data could be so different. Discuss human error and where it comes to play in the experiment. (Student is not paying attention, moves slowly to push the start or stop buttons, student begins walking a second or two before or after the student says, "Go!" and even possible battery issues with the stopwatch.) Ask what would have happened had they only done one or two trials and they had been "off." (The experimental data would be less consistent.) Point out that repeated trials give data that is more reliable. School experiments often ask students to repeat the trial 3 times, however, there is nothing magic about the number three. Scientists need to repeat experiments until they get reliable and consistent results.

*When working with students with a limited background in science, you could show this [quick video of a car going down a ramp] (or set up a simple ramp with a ruler and a book). This would help them visualize the experiment. However, it is important to warn the students that this TCT is not focused on cars and ramps, but on consistent data.

Intent of the Task for Assessment

Part 1 asks students to analyze two students' evaluation of the data which records the distance traveled by a toy car for 5 trials. This requires students to analyze the data themselves, and then offers two options for how the data may be interpreted, softening entry into the task. A student can reflect on two differing interpretations of the data, and then decide who they agree with and why. The task specifically asks the student to explain what it was about the data that ***caused*** them to agree with one student over the other, requesting the student to use the data as evidence, rather than a potentially irrelevant cause, such as "my best friend's name is Amy." It probes into a whether a student can look at a set of data and recognize that an outlier is not a reasonable result.

Part 2 challenges students' understanding of how many trials are necessary to get reliable experimental outcomes. Three experimental set-ups (with different approaches to trials) are provided and the student is to select the best approach. The prompt focuses the student by asking for support for their claim with evidence from each of the proposed experimental designs.

Part 3 is intended to uncover students' thinking around controls and consistency in experiments. Students are asked to make a claim about why each student collecting data got different data for the same experiment. The prompt is worded to direct students to use both the experimental procedure and the experimental results to support their claim, focusing their attention on how the procedure might have influenced the results (rather than the results being accepted as consistent). Then, students are asked to modify the experiment to improve the consistency of results, and explain why their "proposed modification ***will result*** in more consistent data," focusing attention on the causal relationship between intentional experimental design and consistency in resulting data.

Success Criteria

Evidence of Learning Desired based on Progression from Appendices

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations.

- Evaluate appropriate methods and/or tools for collecting data.

- Produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.

(Although students are not planning and carrying out investigations, the task has them provide evidence that they have some of these competencies by analyzing results, evaluating procedures, considering controls and trials and modifying procedures to improve legitimacy of experimental outcomes.)

Analyzing and Interpreting Data
Analyzing data in 3-5 builds on K-2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations.
Scientists must analyze data in order to derive meaning. Sources of error in the investigation must be identified and evaluated. (This text is taken from the general description of "analyzing and interpreting data" in Appendix F and is particularly relevant to this task.)

Engaging in Argument from Evidence
Construct and/or support an argument with evidence and data.

CCC- (3-5) Cause and Effect
Cause and effect relationships are routinely identified, tested and used to explain change. (In this task, the cause and effect reasoning required by the student is related to the effectiveness of the experimental design producing useful results.)

Success Criteria
Part A: Student makes a claim (identify the outlier data in the chart as unreliable) and supports it with evidence (does not fit with the other data which shows a pattern).

Part B: Student makes a claim (multiple trials are necessary) and supports that claim with evidence from the experimental design (a consistent pattern based on multiple trials is needed to ensure replicability and reliability).

Part C: Student makes a claim (choose an explanation for the variations in the sets of data), supports that claim with evidence (reasoning based on information or data given) and suggests modifications to the experiment to improve consistency.

Possible Student Responses (these are not "look fors")
Part A**:** Students agree with Amy. One number is clearly out of sync with the set of data. Human error in positioning the car or in measuring distance traveled might account for this. The 32cm should be eliminated as skewed data, and the four more similar results considered valid.

Part B: Students should agree with Kate. There is nothing magic about 3 trials! Tim has a 3-trial formula, but needs to realize that sometimes MORE than 3 trials are needed to get valid data. One purpose of trials is to minimize the effect of human error. Another purpose is that many trials make it easier to see a pattern or chose the most reasonable number. Jack's comment that many trials are a waste of time, shows a complete lack of understanding of the function of trials in producing reliable results.

Part C: Each student got different data most likely because of human error. (There could be also a problem with stopwatch function.) Asking students to start a stopwatch when Amy said, "Go!" introduced the variable of individual response time. They were all pushing the start button at slightly different times, and the stop button at slightly different times.
How could they improve the experiment and minimize the human error?

- Choose the student with the quickest reflexes to operate the stopwatch.
- Do 8 - 10 trials and see which time appeared most frequently (mode).

Let the person starting the car at the top of the ramp countdown "3,2,1, Go!" to give the person using the stopwatch anticipation time.

Other information teacher teams might find useful when preparing to use this task in the TCT process
Before students begin writing, it is helpful to post a Word Bank and review the words: **reliable or valid, trial, experiment, human error, scientist, mistakes**. This is a scaffold for ELs and also helps ECE students.

It might be helpful to preview a similar investigation before attempting this TCT like, The Car and the Ramp on you tube. In this video a teacher performs a similar experiment using a digital stopwatch and collects data with his class. The whole video is 12:06 minutes, but only the first 7:52 minutes are relevant to this TCT. (They go on to calculate and graph the speed of the vehicle.)

"Analyzing and Interpreting Data" – This Boseman Science video explains in depth this SEP from the NGSS. The first few minutes apply to elementary school, then it moves on to middle and high school expectations. This might be helpful to teachers in better understanding the SEP.

Extensions and/or other uses after the task is implemented

Marble Ramp data

A marble is positioned at different heights on a ramp ruler. As it rolls down, it hits a cube which then moves a certain distance down a track which is measured and recorded in a data chart. Words such as potential and kinetic energy are used as they describe the experiment results.

Application

Students might design and implement a similar experiment using different surfaces for the ramp (sandpaper, carpet, plastic, wood). They could collect data from several trials and analyze its validity and the possible sources of error in the experiment.

Students might add different amounts of mass to the car, roll it down the ramp, then collect data and analyze its validity.

They might design an experiment where several groups of students measure the temperature of a cup of water sitting in the sun for 1 hour, 2 hours, 3 hours etc., and compare the results to the temperature of a cup of dirt sitting in the sun for the same amounts of time. The students could compare the data collected by the different groups and analyze its validity.

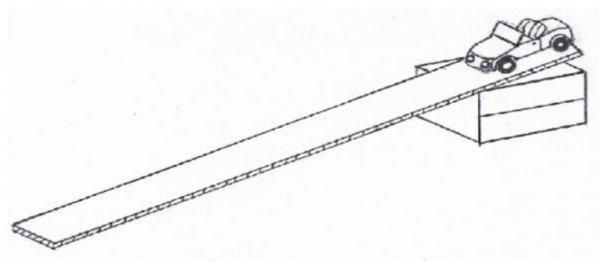
In any experiment students should be aware of the need for multiple trials and be sensitive to sources of bias and error.

Through Course Task – Data Detectives

Data Detectives

Your Mission: Scientists need to be able to understand the data (results of investigations= numbers) they collect. This TCT asks you to analyze three car and ramp investigations. You must decide if the data is reasonable and what should be changed in the investigation so that the data collected will be accurate.

Situation: Several groups of 4th grade students were rolling cars down a ramp and collecting data about the distance the cars traveled.



Part A – Is the Data Reasonable?

Sam's group ran the car down the ramp five times and collected their data in this chart:

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
Sam's Car	53 cm	57 cm	55 cm	32 cm	54 cm

Amy looked at the numbers and said there was a problem with the data.

Jack said the data looked fine and they should just pick any of the trials as their result.

Now it's your turn: Look at the data for each trial of Sam's car. Who do you agree with: **Jack** or **Amy**?

What did you notice about the data that caused you to agree with Jack or Amy? Be sure to provide evidence from the data to support your reasoning.

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Part B - Repeated Trials: Are they needed? Why? How many?

After they finished the first investigation, Sam said, "I wonder what would happen if we changed the height of the ramp, adding a block?" His teacher suggested he set up another investigation to find out. When Sam asked his group to help, he heard some interesting ideas:

Tim said, "Add one more block and roll the car down three times. That's how you always do science experiments. You've got to do it three times."

Kate said, "I agree that you should add one block to the ramp, but I think you need to roll the car down as many times as it takes to get results that seem reasonable."

Jack said, "Yeah, it's a good idea to add a block, but you don't need to do the trial ***many*** times. ***Once*** is enough, otherwise you are just wasting time."

Who do you agree with: **Tim**, **Kate** or **Jack**? Analyze the strengths and flaws of each student's proposed experiment and make a claim for the one you agree with. Support your claim with evidence from each student's design for the experiment.

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Part C - What are some causes of data variation?

Jack noticed that the car seemed to go not only further, but faster when they added more books to the ramp. "Hey, let's measure not only the distance it travels, but the time it takes. Then we can figure out how many centimeters the cars travel per minute. Go get some stopwatches!"

Jack added one book to the height of the ramp. Amy, Kate and Tim got stopwatches. Amy said, "Go!" and Sam let go of the car at the top of the ramp. The three students started the stopwatches when they heard Amy say, "Go" and stopped them when the car stopped, but every time they tried it, they got different data. Look at the data they collected below:

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**
Amy	15 sec	17 sec	14 sec	15 sec
Kate	22 sec	19 sec	23sec	21 sec
Tim	11 sec	12 sec	11 sec	13 sec

Make a claim about why each student got different data for the trials.

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Think about each student's investigation plan and **analyze** their thinking. For each student listed, **explain** what is good and what is not good about their plan.

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For each of the three students listed, explain how his or her plan could be changed to improve the consistency of the data. In your explanation, be sure to tell why your suggested change will result in more consistent data.

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