Science Assessment System
Through Course Task

Ana's Sunglasses

Grade Level:
5

Phenomena:
Monthly Variation in Day Length Throughout Year

Science & Engineering Practices:
Using Mathematics and Computational Thinking
Constructing Explanations and Designing Solutions

Crosscutting Concepts:
Patterns
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.

Ana’s Sunglasses Task Annotation

After **using mathematics and computational thinking about data** *for daylight hours throughout the year* **in order to identify and describe** the *varying* pattern *in daylight hours*, **explain** how the *variation in daylight hours* affects the types of activities you engage with during a particular season.

Student Task

A. Use mathematical computation to complete Ana’s data chart by calculating the length of the day and night for each remaining date listed.
B. Analyze the data in Ana’s chart to create a graph that will show a **pattern** of change in day and night over the year.
C. Describe the pattern that is revealed by your graph.
D. The pattern of change in day and night over the year may affect how you spend your time during each of the seasons: winter, spring, summer and fall. Choose one (or two) of the seasons, and describe how the amount of daylight hours during that season affects your activities during that season.

Phenomenon within the task

Ana has observed changes in sunrise and sunset times between summer, fall and winter. These changes have impacted her everyday activities (driving to school, playing outside after dinner). She is beginning to sense a pattern of change and decides to look more closely at the data to figure it out. This task seeks to engage students in determining those seasonal patterns in day and night times and then reflect back to how these changes impact their everyday activities, as well.

In our experience, when intermediate students’ attention is focused on this phenomenon of the annually repeating pattern of changes in day length, they have typically become generally aware of seasonal differences in day length. Their thinking, however, has not involved a complete understanding of the observable pattern or of the underlying cause. With its focus on mathematical computation and data analysis, this TCT does not necessarily solicit student ideas about the *cause* of seasonal changes, but investigation in this direction is a logical next step for classroom instruction. As few students tend have a scientific understanding of the causal factors (Earth’s orbit, rotation and tilt relative to the sun) they may create inaccurate explanations based on observations (e.g., cloudiness in winter to explain the phenomenon of shorter days in winter) or incomplete background knowledge (e.g., changes in distance between Earth and sun).

How the phenomenon relates to DCI

Disciplinary core idea ESS1.B states: *The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.*

Information Used by Students to Complete the Task

All of the work that students must do in this task involves calculation, analysis and graphical representation of the data provided to them in Ana's chart. While the task may prompt students to consider their own experiences with and ideas about the relationship between the Earth and Sun, successful engagement with this task will not require any specific *scientific* background knowledge. Instead, task completion depends on foundational skills in mathematical calculation, strategic thinking in relation to numbers and experience with creating graphs (most likely, bar graphs) from sets of data. As such, this task exists in the region where science and math overlap and is most likely to give teachers insight into their students' mathematical capabilities (e.g., calculating elapsed time, analyzing patterns in data sets, representing data in graphical form).

Ideas for setting up the task with students

This task was field tested in the fall of 2017 as students were beginning to notice the shift in sunrise times as it impacted their travel to school. We set the stage for consideration of the phenomenon with a discussion of student observations of changes in daylight hours from summer to fall. In the context of this discussion, some students shared their (naïve) ideas about causal factors at play. In this way, the task served the purpose of establishing the observational *facts* of the phenomenon – what exactly is the pattern of daylight changes during the year? Later, in an investigation rich in modeling and evidence collection, we can investigate the causes of this pattern.

Based on our experiences in the field tests, this task has been set up to be scaffolded in order to accommodate all students at their current level of sophistication with math and data analysis. As a formative assessment, the task will function to allow teachers to see what their students can do and where they need support. Scaffolding provided for individuals, small groups or entire classes will not undermine the validity of the information collected about student strengths and limitations. We have included a list of potential scaffolds on page two of the task so that teachers can more easily track the scaffolds required by their students. Teachers who find that other scaffolds are helpful or necessary are welcome to add to this list.

PART A

In field tests, relatively few children could independently complete Part A, calculating elapsed time, in a reasonable amount of work time. *Just how much time passes between 7:08 AM and 8:06 PM?* Observing students struggle with this part of the task gave us insight into how incompletely many of our students understand our number system for measuring time. Although students should have had multiple years experiencing the calculation of elapsed time both as an arithmetical exercise and within the context of problem-solving, they had great difficulty calculating the elapsed time for daylight, and even more difficulty in how to determine nighttime without more information. Without a solid sense of the meaning of numbers in the context of time, some students were likely to use inappropriate math strategies (such as adding times). Many students required a mini-lesson on strategies for calculating elapsed time before they were able to engage successfully with this challenge. Multiple strategies can be found by searching “ways to calculate elapsed time.” Successful completion of Part A after the mini-lesson thus serves as evidence that students have acquired and applied a new strategy for understanding numbers. In fact, prior to administering this task, it would be wise to give students a simple pre-assessment on calculating elapsed time, to discuss strategies for solving elapsed time problems, and/or to teach this skill to those students who need it. Finally, as necessary, for students who are unable to do the calculations, data may simply be provided so that they can proceed to the graphing challenge of Part B. Note that, if data is provided, students will not have the opportunity to catch their own calculation mistakes when they confront numbers that don’t fit the pattern in their graph.

PART B

Can students independently analyze data in a table and represent the data in a graphical display? If not, what are the points in the process where they need support? As listed on page 2 of the task, we identified six likely scaffolding strategies. Again, if teachers suspect or have evidence of student weakness at graphing, any or all of these scaffolds could be the subject of a lesson provided to students *prior* to the task. These are the areas in which we found in field tests that students may need scaffolded support on an individual, small group, or whole class basis:

Data Categories

There is a lot of data in Ana’s chart. Can students identify which sets of data to graph to reveal a pattern, or do they need support? While most students choose to compare date and daylight hours in a bar graph, it is possible to graph the relationship between date and sunrise/sunset times, to use the “hours of darkness” data instead, or to graph daylight and darkness in a single display. But first, students must choose which numbers to work with.

Graph Type

What graphs do students know how to make? While line graphs would be ideal for showing changes in sunrise/sunset times? The NGSS SEP only specifies that 5^{th} graders can use “bar graphs, pictographs and/or pie charts.” All are possible ways to display this data, but students may need a push to choose one.

“Cheat Sheet”

Does the student draw a blank when asked what types of graphs he or she knows how to make? You may consider creating a “cheat sheet” of ones that students may choose.

Graph Set-up

Having chosen the numbers and the graph type, is a student able to set their graph up in a way that will reveal a pattern, or do they need assistance? (e.g. *What will you put on the x axis? The y axis?*) Consider providing examples for those students who need an additional scaffold.

Scale

The numbers provided in Ana’s chart are the actual times of sunrise and sunset in Central Kentucky for the dates chosen. This task could be simplified by adjusting numbers so that day lengths are rounded to even increments of ten minutes, or quarter hours. Changing the TCT in this way is perfectly okay – the task will still yield valid information on student strengths and weaknesses even if simplified for accessibility. Working with the numbers as provided, however, will put students in an authentic situation in which they need to do some rounding of numbers. *How much does every minute matter to the pattern of change from month to month?* Students need to decide how to scale their graphs, how much each increment will be worth and how to plot the data against this scale. Students inexperienced with graphing, especially those who have only analyzed premade graphs or those provided by their teachers, are likely to need additional assistance.

Data Revisited

If a student has miscalculated in Part A, they may notice that the wrong number disrupts the pattern on their graph, and may return to their calculations to try to fix their work. If they do not take this step independently, they may need feedback at this point to retrace their steps to find the error. We found that this scaffold was an opportunity to reemphasize the value of patterns as a meaning-making lens in science.

PART C

In field tests, student fatigue and time-constraints may have contributed to less complete answers to Part C than anticipated. Students who have correctly graphed the data will likely be able to see a pattern in their graph, but may need assistance to fully articulate their understanding of the relationship between month of the year and day length. When scaffolding students with Part C, it may be helpful to break the analysis into two stages. First, ask the student to articulate what is happening in the physical features of the graph (e.g. *"The bars get longer from January to July and then get smaller again"*). Second, prompt the student to interpret what these graphical features actually mean (e.g. *"The days get longer from January until July…"*).

PART D

Part D was added to allow the students to consider the impact of the daytime and nighttime patterns to their own everyday activities and provide an opportunity for students to make sense of the phenomena in terms of how it influences and affects their lives. Consider brainstorming seasonal activities with students prior to the task so that they have a "bank" of activities to choose from. Their task then becomes connecting the changes to the activities based on the patterns of day and night time changes.

Intent of the Task for Assessment

This task is designed to engage students in two overlapping and interrelated scientific practices:

- Using Mathematics and Computational Thinking
- Analyzing and Interpreting Data

Thus, teachers will be able to collect evidence of and gain insight into their students' abilities to employ these two practices.

Student calculations on Part A of the task require computational thinking of a strategic sophistication not typically demanded of 5th graders. Based on Kentucky Academic Standards for Mathematics, students have been taught and have been asked to complete problem solving tasks involving elapsed time to the minute since 3rd grade (KAS.MATH.CONTENT.3.MD.A.1, KAS.MATH.CONTENT.4.MD.A.2). But, can students consider how to calculate elapsed time using their arithmetic skills in the context of the daylight hours and nighttime hours over a 24 hour period? Can they assess whether their answers are reasonable by making meaning of numbers in terms of relative time over the day? Looking at a student's calculations on scratch paper and/or having conversations with a student surrounding Part A will enhance the evidence that may be collected about students ability to use mathematical and computational thinking in the context of this question. [Note: It is feasible to reduce the challenge of this part of the task by simplifying the numbers – see scaffolding ideas in the section on "Setting up the task" below].

In Part B, students create a graphical display to represent the data set in Part A. Creating a graphical display is a key component to both the scientific practices of this task. The majority of students' prior experience may be with interpreting pre-made graphs or filling in data into a graphical framework provided by the teacher (i.e., create a bar graph on this graph paper with axes and scale determined already by the teacher). Students will be creating their own graphs from scratch, determining type of graph, axes and scale, to demonstrate their ability to analyze the data and then use graphical display as a means to represent the pattern they have realized. Student graphs will serve as the primary evidence for successful task completion.

Finally, this task asks students to intentionally use the Crosscutting Concept of Patterns as a lens for understanding the phenomenon observed, the relationships in the data provided, and ultimately, the usefulness of their graphical representation in revealing the pattern in the data. Part C simply asks students to articulate their understanding of the pattern revealed by their graph. In Part D, students are asked to make sense of the pattern they have revealed in a purposeful way. Connecting the pattern to their lives provides a real-life context and a reason for the task. Students are asked to think about how the daylight hours affects the activities that they participate in during different parts of the year. Note that students also use cause and effect reasoning (in addition to the day length pattern) as they apply their understanding of how the pattern affects their lives.

Success Criteria

Evidence of Learning Desired based on Progression from Appendices

From Appendix F:

Using Mathematics and Computational Thinking (SEP 5)

- Use counting and numbers to identify and describe patterns in the natural and designed world.
- Organize simple data sets to reveal patterns that suggest relationships.

- Describe, measure, estimate and/or graph quantities (e.g. area, volume, weight, time) to address scientific and engineering questions and problems.

Analyzing and Interpreting Data (SEP 4)

- Represent data in tables and/or various graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships.
- Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics and/or computation.

From Appendix G:

Patterns (CCC 1)

- …identify patterns related to time, including simple rates of change and cycles, and use these patterns to make predictions.

Success Criteria

PART A

- Student accurately calculates elapsed daylight time between sunrise and sunset, and remaining hours of darkness, for each date.

PART B

- Student graph reveals a pattern of change, proceeding from January to July and then reversing direction from July to December, in the relationship between month of the year and the length of the day and/or night.

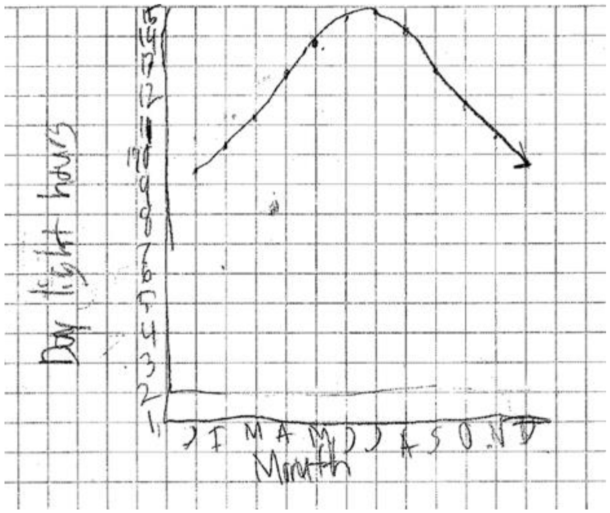
PART C

- Student clearly and accurately describes the pattern revealed by the graphical display in terms of the relationship between the chosen variables.

PART D

- Student clearly and accurately describes how the pattern revealed by the graphical display affects their everyday activities.

Possible Student Responses



"The times of each month are getting longer until the middle of the year at midsummer. That's when the days start to get shorter."

Extensions and/or other uses after the task is implemented

As mentioned above, this task could be used as an entry point into an examination of patterns of observable changes the causes of which can be explained by investigating and modeling the relationships between the Earth, moon and sun. In this study, it is helpful to distinguish between daily changes (caused by Earth's rotation) and seasonal changes (caused by Earth's orbit). Engagement with this task could also prompt a renewed instructional look at data and ways to represent data to reveal patterns. While this is a critical scientific practice, it is also a truly cross-curricular skill. Students encounter and analyze graphs in literacy, math and social studies, but how often are they asked to create their own graphical representations of data collected in these contexts?

Through Course Task – Ana's Sunglasses

As school began in August, Ana started to wear her sunglasses each morning in her mom's car. Driving east to school, the sun would hit her right in the eyes as it came up over the horizon. Without the glasses, she'd get a headache.

Later in the fall, she noticed that she didn't need her sunglasses. In fact, for a while in November it was actually dark as school was starting. Setting the clocks back an hour at the end of Daylight Savings Time helped with the dark mornings, but not for long. Ana started to get curious.

One day in winter, Ana stayed after school for a basketball game. On her way home she realized that the sun was actually setting *before* dinner. She thought back to the beginning of the school year. She and her friends could play outside in the daylight for a couple hours after dinner. She thought further back to the Fourth of July. Didn't they have to wait *forever* after dinner until it got dark enough for fireworks? *What's going on with the day and night?* she wondered.

After dinner, she did a quick search and found month by month lists of sunrise and sunset times for every day of the year. She couldn't see a pattern in the data this way, so she made a chart and copied down just the times for the first day of each month. Now she was starting to see a pattern in the numbers, but she needed more information, and probably needed a graph to really understand the data. Beginning with January, she used the sunrise and sunset times to calculate the length of the day and night. She had just finished August when she fell asleep. Her data chart is on the next page.

TASK

A. Use mathematical computation to complete Ana's data chart by calculating the length of the day and night for each remaining date listed.

B. Analyze the data in Ana's chart to create a <u>graph</u> that will show a **pattern** of change in day and night over the year.

C. Describe the pattern that is revealed by your graph.

D. The pattern of change in day and night over the year may affect how you spend your time during each of the seasons: winter, spring, summer, and fall. Choose one (or two) of the seasons, and explain how the amount of daylight hours during that season affects your activities during that season.

Sunrise and Sunset Times for Central Kentucky

Date	Sunrise	Sunset	Hours of daylight	Hours of darkness
January 1	7:54 AM	5:29 PM	**9 hours 35 min**	**14 hours 25 min**
February 1	7:41	6:01	**10 hours 20 min**	**13 hours 40 min**
March 1	7:08	6:32	**11 hours 24 min**	**12 hours 36 min**

DAYLIGHT SAVINGS STARTS – CLOCKS MOVED FORWARD ONE HOUR

Date	Sunrise	Sunset	Hours of daylight	Hours of darkness
April 1	7:21	8:01	**12 hours 40 min**	**11 hours 20 min**
May 1	6:40	8:29	**13 hours 49 min**	**10 hours 11 min**
June 1	6:16	8:55	**14 hours 39 min**	**9 hours 21 min**
July 1	6:19	9:04	**14 hours 45 min**	**9 hours 15 min**
August 1	6:41	8:46	**14 hours 5 min**	**9 hours 55 min**
September 1	7:08	8:06		
October 1	7:34	7:19		
November 1	8:04	6:38		

DAYLIGHT SAVINGS ENDS – CLOCKS MOVED BACK ONE HOUR

Date	Sunrise	Sunset	Hours of daylight	Hours of darkness
December 1	7:36	5:18		

TEACHER USE ONLY: SCAFFOLDS PROVIDED

PART A

- ○ Calculator
- ○ Elapsed time mini lesson
- ○ Data provided

PART B

- ○ Data categories
- ○ Graph set-up
- ○ Graph type
- ○ Scale
- ○ “Cheat Sheet”
- ○ Data revisited