## Multitasking Mania!

**Lesson 2: Measure the Difference**

**Problem Statement:**

Your task is to create both a computer-based task and non-computer-based task that helps employees evaluate the effectiveness of multitasking and helps them plan their work efficiently.

**Lesson Overview:**

In this lesson, students will learn some basic mathematical concepts of data analysis and apply them to the data they collected in the lesson 1 experiment. This lesson will involve basic statistics, such as determining maximum and minimum values, calculating an average, and optionally to more advanced concepts such as standard deviation and statistical distribsutions. Students will also be introduced to graphical data representation.

**Learning objectives:**

* Analyze data from a simulation
* Create a graph of data
* Draw conclusions based on data analysis results

|  |  |
| --- | --- |
| Science (NGSS) | |
| MS-ETS1-3. | Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. |
| Language Arts (CCSS) | |
| [CCSS.ELA-LITERACY.RST.6-8.9](http://www.corestandards.org/ELA-Literacy/RST/6-8/9/) | Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. |

**If relevant to a single lesson, include:**

**Soft skills:**

* Collaborate in a group
* Build mathematical skills

**Locally and/or personally relevant for students:**

N/A

**Connections to career and educational pathways:**

Engineering, Data Science, Laboratory Technician, Statistics, Design of Experiments

**Materials:**

Lesson 1 data (or sample data tables provided in lesson resources)

**Lesson preparation:**

Provide each student a copy of the Lesson 1 data, or a copy of the data tables in lesson resources.

Each student should have resources necessary to perform mathematical calculations:

* Teacher preferred method for showing work
* Calculator
* Access to a spreadsheet program (Google Sheets, Microsoft Excel, Numbers for Mac, etc)

An exit slip

**Time required:**

45 minutes

**Grouping of students for instruction:**

Students may work individually, or in pairs/small groups.

**The Instruction:**

In this lesson, students will explore and analyze a simple set of data. In future lessons, students will use the data analysis and critical thinking techniques practiced in this lesson to evaluate a video game they will code that has a multitasking theme. The problem starts with students reviewing “raw”, unprocessed data and attempting to draw conclusions. Students will then explore and apply different analysis techniques to improve the development of observations and conclusions. Lesson 11 will apply the techniques introduced here.

**Launch the Problem:**

In this lesson, the students will explore different ways to analyze data and draw conclusions from the data analysis. The data was collected as part of the experiment performed in Lesson 1. Students are developing the skills they will need to attack the problem.

In the experiment (Lesson 1), we recorded time data (start time and end time)[[1]](#footnote-0) for two different ways to complete a RED project and a BLUE project, using the same resources. In the multitasking phase of the experiment, each worker switched back and forth between the RED and BLUE projects. In the non-multitasking phase, each worker finished all of their RED project tasks before starting on the BLUE project.

Without doing anything with the data, what conclusions can we make about the two different ways to complete the projects?

**Teacher:** introduce students to the data table (sample data or the lesson 1 data). Copies of the data should be made available at this time. Lead discussion about conclusion that can be drawn from the raw, unprocessed data as presented. The discussion should demonstrate the difficulty in drawing conclusions based only on raw data. Students conclusions should be challenged at this stage as there should be very little evidence to draw meaningful conclusions[[2]](#footnote-1) beyond which team or which colored project was the fastest or slowest.

*NOTE: an example “narrative” using the sample data is presented on Page 6 of this lesson below.*

Now perform the following tasks on the data:

**OPTION A:**

If using the sample data, or if the data was recorded as “start time” and ”stop time”, the students will first need to manipulate the data to determine the “total time”:

* Calculate the total time for each project and phase (group, individual, or team exercise)
  + Teacher will introduce methods of subtracting time (see References/Resources Section)
  + Students will use the data from Lesson 1 (or the Sample Data provided in References/Resources) and calculate the “total time”. Collaboration should be encouraged (small groups work together to process the data).
* Teacher leads discussion about conclusions that can be drawn at this stage
  + Which team/project had fastest and slowest times?
  + Have students order the data by time, least to most, etc.
  + What conclusions can we make now that we know the total time.

**OPTION B:**

If the data was recorded as total time (using stopwatches, for example), the students can skip the exercise of calculating total time described in Option A and simply extend the discussion to include fastest and slowest times, ordering the data (least to most), and conclusions based on total time.

The teacher can also elect to start with the “total time” in the sample data worksheet.

**DATA ANALYSIS:**

Now that we have the “total time” for each team, project, and version of the experiment, the students will explore additional data analysis techniques to help them draw conclusions.

* Calculate the Mean (Average) for each project color (RED/BLUE) and for each experiment (multitasking and non-multitasking). Calculate the Mean (average) of all projects for each experiment.
  + Teacher will introduce Mean (Average) (See example lesson, using the sample data, starting page 6 of this lesson)
  + Students will use the “total time” data (either calculated above or as available in the data) to determine the following Mean values (6 values):
    - Mean/average of all RED projects; multitasking and non-multitasking
    - Mean/average of all BLUE projects; multitasking and non-multitasking
    - Mean/average of all projects (RED and BLUE); multitasking and non-multitasking
  + Teacher leads discussion about conclusions that can be drawn from the results. Ask the questions:
    - If we took this experiment to a different group of students which project would we expect to take the longest? Why?
    - Do we expect that the multitasking experiment would take longer? Why? Students should be able to cite the data and analysis to support their conclusions
* EXTRA: In addition to calculating the Mean, students also determine the Median.
* EXTRA: Plot the Data, Mean (and optional Median)
  + If a graphing tool or spreadsheet tool with graphing capability is available, students can use a tool to generate a graph of the results and compare each individual result (time to complete each project in each phase) against a straight line median and mean.
  + If one is not available, students can sketch a plot of the data on paper (graph or gridded paper is preferred)
* EXTRA: Discuss the concept of “statistical significance”
  + “Significance” does not necessarily mean “important” or “valuable”
  + Students discuss the data, the results, and “how close” some values may be in terms of the concept of “statistical significance”

**Accommodations:** No additional accommodations will be necessary for exceptional needs students, beyond those already present. Advanced students and classes should explore the optional activities and methods.

**Extensions:** Explore the extra activities described above

**Assessment:**

Students will present, in a teacher preferred format, their calculations and results (averages).

Extra topic material may require additional assessment criteria

**References/Resources:**

Sample Google Sheets data: [Lesson 2: Sample Data](https://drive.google.com/open?id=1kHWdt7u5tmziKpu7oSv0suBmoRveExyLo7JyXLKa7gU)

“Lesson Narrative Using Sample Data” - next page

**Lesson Narrative Using Sample Data:**

Table 1 is copied from Google Sheets data: [Lesson 2: Sample Data](https://drive.google.com/open?id=1kHWdt7u5tmziKpu7oSv0suBmoRveExyLo7JyXLKa7gU)

Use of this data is optional to the data recorded in Lesson 1, keeping in mind the data and analysis begins with start and stop times. If preferred for lesson timing, start with Table 2 and begin discussion with the “total time” for each project.

**TABLE 1: Sample Raw Data Table**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **TEAM** | **Project** | **Ph 1, Start** | **Ph 1,**  **End** | **Total Time**  **Ph 1** | **Ph 2, Start** | **Ph 2, End** | **Total Time**  **Ph 2** |
| 1 | RED | 12:40:20 | 12:55:10 |  | 1:40:20 | 1:45:10 |  |
| 1 | BLUE | 12:40:30 | 13:01:25 |  | 1:42:30 | 1:46:15 |  |
| 2 | RED | 12:40:10 | 12:52:15 |  | 1:40:30 | 1:48:15 |  |
| 2 | BLUE | 12:40:20 | 12:55:25 |  | 1:41:30 | 1:51:25 |  |
| 3 | RED | 12:39:50 | 12:50:10 |  | 1:41:00 | 1:49:20 |  |
| 3 | BLUE | 12:40:00 | 12:59:00 |  | 1:43:10 | 1:51:00 |  |
| 4 | RED | 12:41:00 | 12:57:40 |  | 1:41:20 | 1:47:55 |  |
| 4 | BLUE | 12:41:10 | 12:52:25 |  | 1:45:30 | 1:52:10 |  |

**Lesson Discussions/Actions on Sample Data:**

Which team and project took the longest amount of time?

Very difficult to tell with only start and end times - since most of the start times were close to the same time, it looks like the Team 1 Blue project took the longest in Phase 1.

Which team and project took the shortest amount of time?

Harder to tell… The phase 2 times should contain the shortest, based on the Lesson 1 experience, it looks like Team 1 Blue took the shortest time in Phase 2!

Let’s manipulate the data to make it easier to tell which were longest and shortest. For each phase of each project, subtract the start and end times to calculate the total amount of time, in minutes and seconds, that it took to complete the project.

How do we subtract one time from another?

First:

If the times are in “AM/PM”, convert them to 24 hr time. “AM” times don’t change, but we convert “PM” times by adding 12 hours. For example, 1:00 PM in 24 HR time is 13:00 HRS, because 1+12 = 13. 2:00 PM = 14:00 HRS, 3:00 PM = 15:00 HRS, etc.

(if using sample data, discuss the conversion step, but do not perform on the sample data)

Second:

Subtract the “Start” hours from the “End” Hours

Subtract the “Start” minutes from the “End” Minutes

Subtract the “Start” seconds from the “End” Seconds

If the seconds are negative, then add 60 seconds, and subtract 1 from the minutes

If the minutes are negative, then add 60 minutes, and subtract 1 from the hours

Example: Subtract 12:25:15 from 13:01:05:

13 hrs minus 12 hours is 1 hour

01 min minus 25 min is -24 minutes

05 sec minus 15 sec is -10 seconds

Seconds are negative, so add 60 seconds to get 60 + (-10) = 50 seconds

Seconds were negative so subtract 1 from minutes to get -24 - 1 = -25 seconds

Minutes are negative, so add 60 minutes to get 60 + (-25) = 35 minutes

Minutes are negative so subtract 1 from hours to get 1 - 1 = 0 hrs.

The result is therefore: 0 HRS, 35 MINUTES, 50 SECONDS, or 0:35:50.

Verify by counting up from 12:25:15:

12:25:15 + 35 minutes = 12:60:15… but 60 minutes is an hour, so it adds to the hours (12+1 = 13)... 13:00:15 + 50 seconds = 12:00:75… but 60 seconds is a minutes, so it adds to the minutes (0 + 1 = 1), leaving 15 seconds left over… So 12:25:15 + 0:35:50 = 13:01:05, same as the end time.

**TABLE 2: Sample Raw Data with Total Time Results**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **TEAM** | **Project** | **Ph 1, Start** | **Ph 1,**  **End** | **Total Time**  **Ph 1** | **Ph 2, Start** | **Ph 2, End** | **Total Time**  **Ph 2** |
| 1 | RED | 12:40:20 | 12:55:10 | **0:14:50** | 1:40:20 | 1:45:10 | **0:04:50** |
| 1 | BLUE | 12:40:30 | 13:01:25 | **0:20:55** | 1:42:30 | 1:46:15 | **0:03:45** |
| 2 | RED | 12:40:10 | 12:52:15 | **0:12:05** | 1:40:30 | 1:48:15 | **0:07:45** |
| 2 | BLUE | 12:40:20 | 12:55:25 | **0:15:05** | 1:41:30 | 1:51:25 | **0:09:55** |
| 3 | RED | 12:39:50 | 12:50:10 | **0:10:20** | 1:41:00 | 1:49:20 | **0:08:20** |
| 3 | BLUE | 12:40:00 | 12:59:00 | **0:19:00** | 1:43:10 | 1:51:00 | **0:07:50** |
| 4 | RED | 12:41:00 | 12:57:40 | **0:16:40** | 1:41:20 | 1:47:55 | **0:06:35** |
| 4 | BLUE | 12:41:10 | 12:52:25 | **0:11:15** | 1:45:30 | 1:52:10 | **0:06:40** |

Now, look at the results - which team and project took the longest and shortest time?

Much easier to tell - Team 1, BLUE project too longest in Phase 1, and shortest in phase 2!

Based on what you see, would you expect the Blue Project to be slower than the Red project all the time?

Well, Team 4 RED project took longer than the BLUE project, so not all the time, but all the other teams had a faster RED project so, most of the time?

There are other ways to compare the two projects, by calculating the “mean” or “average” of the RED and BLUE times. What is a “mean” or “average”?

A “mean” is usually called the “average”. In this case, if we add up all the total times for the RED project, and then divide by the number of RED projects, we would have the average time to complete a RED project.

Another way to look at the “mean” is that it evenly divides something so that every grouping receives and equal portion. For example, if there are 100 marbles, and 10 people, for each person to share an equal number of marbles they would each receive 10 marbles, and the “average” number of marbles per person is 10.

Now imagine that our 10 people do not share the marbles equally. 9 people have 9 marbles each, which is a total of 81 marbles (9 x 9 = 81), and one person has the rest, or 19 marbles (100-81=19). There are still 100 marbles, and 10 people, and we can still say that the average (or mean) number of marbles per person is 10, even though none of our people actually have 10 marbles.

Now calculate the following averages (means):

* Red Projects, Phase 1 (multitasking) Average
* Red Projects, Phase 2 (non-multitasking) Average
* Blue Projects, Phase 1 (multitasking) Average
* Blue Projects, Phase 2 (non-multitasking) Average
* Red and Blue Projects, Phase 1 (multitasking) Average
* Red and Blue Projects, Phase 2 (multitasking) Average

***Example Calculation, Sample Data: Red Projects, Phase 1:***

First, list the total times for the Phase 1 Red Projects, and convert each to seconds:

Team 1: 14:50 = 14 min x 60 min/sec + 50 sec = 840 sec + 50 sec = 890 sec

Team 2: 12:05 = 725 sec

Team 3: 10:20 = 620 sec

Team 4: 16:40 = 1000 sec

Next, Calculate the total number of seconds : 890 + 725 + 620 + 1000 = 3235 seconds

Finally, divide the total number of seconds by the number of experiments, and convert back to time (mm:ss):

Average Seconds: 3235 seconds / 4 teams = 808.75 seconds

Convert to Time: 808.75 sec / 60 = 13.479 minutes = 13 + (0.479 x 60) = 13:29

**TABLE 3: Sample Raw Data with Total Time Results**

|  |  |  |  |
| --- | --- | --- | --- |
| RED Phase 1 Average: | **0:13:29** | RED Phase 2 Average: | **0:06:53** |
| BLUE Phase 1 Average: | **0:16:34** | BLUE Phase 2 Average: | **0:07:03** |
| All Phase 1 Average: | **0:15:01** | All Phase 2 Average: | **0:06:58** |

Based on the Average project times, which version of the projects, Multitasking (Phase 1) or Non-Multitasking (Phase 2) would you expect to take the shortest time the next time the experiment is performed? Why?

Does it matter if it’s a Red project or a Blue project? Why?

1. Sample data provided has “start” and “end” times expressed as time of day. If the experimental data is expressed as total time (minutes:seconds) adjust the lesson accordingly [↑](#footnote-ref-0)
2. In lesson 11 they will be gathering data on their own game and comparing what they find from their game results to the bead experiment results [↑](#footnote-ref-1)