**What does math have to do with data analytics?**

**Video Link:** <https://youtu.be/2483RcIAiec>

**Lesson Plan**

**Teacher Note:** Please preview the entire video and pre-work the questions in order to anticipate students’ needs, misconceptions, and materials unique to your classroom.

While the calculations in the video are middle school level, the context and terminology are extensive and may be more challenging. Many high school students may benefit from this lesson as well. You will also need to determine the background knowledge of your students regarding the following topics and decide the best method for providing that background in order to support the conceptual understanding of the mathematics shown in the video.

* Know how to convert between decimal and percent.
* Know how to convert hours into minutes or minutes to hours.
* Be able to pick out the needed information from context to use in formulas.

**Common Core Mathematical Content Standards**

* **7.EE.B** Solve real-life and mathematical problems using numerical and algebraic expressions and equations.

**Common Core Mathematical Practice Standards**

 1. Make sense of problems and persevere in solving them.

 2. Reason abstractly and quantitatively.

 3. Construct viable arguments and critique the reasoning of others.

 4. Attend to precision.

**Company Information**

Sargento Foods Inc. is a family-owned company comprising four business divisions:  Consumer Products, Food Service, Food Ingredients and Culinary Solutions. The company employs more than 1,500 people at four Wisconsin facilities. The Consumer Products Division is a leading national packager and marketer of natural shredded, sliced, snack and specialty cheeses sold under the Sargento brand.

**Summary**

Manufacturing companies that package food, such as Sargento, must consider many variables to create and package their product. In addition to maintaining a clean environment, the production process is often analyzed to determine how to increase efficiency. Data related to the production process is constantly collected, updated, and displayed. The information can then be analyzed to determine if there are areas of the process that need improvement. This video shows how that data might be used to make production decisions.

**Differentiation**

* The questions on the student handout are scaffolded to meet the needs of students who may need extra support.
* Students with strong computational skills may benefit from looking further into the numbers shown on the displays as not all of them are discussed directly in the video.

**Pre-Activity Discussion**

* This video opens with a machine operator explaining how there are many different parts in the system to prepare and package the products. In order to be efficient and produce a quality product at minimal cost, variables are shown on a digital display that the operators and team leads need to understand. These numbers help them make decisions regarding changes or improvements in the production lines. It will be helpful for students to discuss some of the terminology used in a manufacturing company. A formula sheet will be provided to help students keep track, but students need to have some discussion about the vocabulary prior
* **Vocabulary**
* **Production Line** – The system in which product is formed, transported, and packaged.
* **Runtime** – The amount of time the production line can run during a shift.
* **Downtime** – The amount of time that the production line is stopped during a shift.
* **Availability** – The ratio comparing the actual amount of time the line runs to the amount of time

it takes to complete the product.

* **Run Rate** – The number of packages produced during the shift.
* **Max T Rate** – The maximum possible number of packages that can be produced during the shift.
* **Performance** – The ratio comparing the run rate to the max t rate. It represents the percentage

of the potential production that has been reached.

* **Overpack %** – When product is filled, there is often more product in a tray than intended. This number is the percentage of the target weight that trays have been overfilled.
* **Overpack Pounds** – When product is filled, there is often more product in a tray than intended. This number represents how many pounds over the target weight the trays have been filled.
* **Quality** – The percentage of packages that make it into completed cases compared to the total number of packages produced.
* **OEE** – This is the overall equipment effectiveness and represents how the production line is running as a whole. The company would like to see this number over 80%.

**Information Needed to Solve:**

* The problems posed in the video are based on a 6 hour and 20 minute runtime for a product. This is stated in the video but does not appear on the screen until the solution is given. Point this out to students.
* Part 5 requires that students know the length of the shift. This is stated as 8 hours in the video, but not displayed on the screen until the solution is given. Point this out to students.
* There is a formula sheet provided. Please have a copy for students to refer to.

**Part 1 (0:00 – 2:27)**

BREAK 1

* Prior to answering the question, small groups of students should make a list of everything they can think of in production that could affect the price of the item being produced.
* Have students calculate the availability and the performance for the posed questions given that the current run time is 6 hours and 20 minutes. It is recommended that students round their answer to the nearest ten thousandth and then convert to a percentage for both values.

**Part 2 (2:33 – 3:41)**

BREAK 2

* Have students calculate the number of overpack pounds given that there are 6000 cases and each case weighs 2 pounds. Please note that the .95 overpack percentage displayed is in fact a percent. Students are likely to attempt using this number rather than .0095 (the percent as a decimal).

**Part 3 (3:47 – 4:30)**

BREAK 3

* Have students use the formula to figure out how many packages had been produced. Note that the formula for quality may be misleading. The number of packages into a finished case represents all packages that made it into finished cases.
* Have students explain in a sentence or two what this result means in the context of the production situation.

**Part 4 (4:36 – 5:15)**

BREAK 4

* Have students use their values from the previous problems to calculate the OEE. Please note that it will not be the 58.7% from the display as that may have been a real-time value at some point and does not match the parameters posed in the question.
* This is a good opportunity for small or whole group discussion about what this number means to the company.

**Part 5 (5:20 – 6:01)**

BREAK 5

* Have students calculate the downtime cost for an 8 hour shift.
* Have the students calculate the overpack cost.
* Have students calculate the quality cost.
* Students should write a sentence or two explaining the following: “If you were in charge of addressing issues on the production line, which of the three areas would you address first and why?”

**Extension**

* In order to reinforce the concepts of the lesson a class could create a production simulation in which they create several copies of a simple product (paper airplane, object from Legos, etc.). Roles can be assigned for deciding which products cannot be boxed, timing of the production, timing and stop times etc. Students can then use actual numbers for their simulation to make the calculations from the video.

**Student Handout – What does math have to do with data analytics?**

Name(s):\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Pre-Activity Discussion:** *Notes on necessary background information.*

**Problem:** *Determine the variables of production that have the largest impact on production cost.*

**Break 1**

* Before making any calculations, your group should create a written list of all the things that you think might affect the cost of a product being produced.

* If the current run time for the product is 6 hours and 20 minutes, determine the ***availability*** and ***performance***. Show your calculations. Round to the nearest ten thousandth prior to converting into a percent.

**Break 2**

* Calculate the number of overpack pounds given that there are 6000 cases and each case weighs 2 pounds. Show your calculations. (Be Careful! The value in the display is .95%.)

**Break 3**

* Given that there were 6000 cases that each contain 4 packages, determine how many packages did not make it into the cases if the quality was the given 98.5%. Show your calculations.

**Break 4**

* Use your previous results to determine the OEE (Overall Equipment Effectiveness). The number displayed in the video is not the correct answer for the situation given. Show your calculations.
* As a group, discuss and write a few sentences explaining what this number means to the company.

**Break 5**

* Calculate the following:
	+ The downtime cost for an 8 hour shift.
	+ The overpack cost.
	+ The quality cost.

Show all of your calculations.

* Write a sentence or two explaining the following: “If you were in charge of addressing issues on the production line, which of the three areas would you address first and why?”
* **Extension**
* Create your own simulation of a simple product that your class can create and place into packages. You will have to determine factors such as runtime and downtime. You can then try to determine the other values from the video for your class situation.

**Answer Key – What does math have to do with data analytics?**

**Pre-Activity Discussion:** *Notes on necessary background information.*

**Problem:** *Determine the variables of production that have the largest impact on production cost.*

**Break 1**

* Before making any calculations, your group should create a written list of all the things that you think might affect the cost of a product being produced.

**Sample:** *Time available, temperature, number of workers, number of machines running, time spent fixing machines, incorrect setup, lines running too fast or too slow etc.*

* If the current run time for the product is 6 hours and 20 minutes, determine the ***availability*** and ***performance***. Show your calculations. Round to the nearest ten thousandth prior to converting into a percent.

 ***Availability = (Runtime – Downtime)/Runtime***

 **= (6 hours 20 minutes – 2 hours 34 minutes)/(6 hours 20 minutes)**

 **= (380 minutes – 154 minutes) / 380 minutes**

 **= 226 minutes / 380 minutes**

 **= 0.5947**

 **= 59.47%**

 ***Performance = Run Rate / Max T Rate***

**= 156 packages per minute / 224 packages per minute**

**= .6964**

**= 69.64%**

**Break 2**

* Calculate the number of overpack pounds given that there are 6000 cases and each case weighs 2 pounds. Show your calculations. (Be Careful! The value in the display is .95%.)

***Overpack Pounds = Target Cases \* Average lbs. per Case \* Overpack % (as a decimal)***

***= 6,000 cases \* 2 pounds per case \* 0.0095***

***= 114 pounds***

**Break 3**

* Given that there were 6000 cases that each contain 4 packages, determine how many packages did not make it into the cases if the quality was the given 98.5%. Show your calculations.

***Quality % = (# of Packages into a finished case/Total Packages Produced)\*100***

***98.5% = ((6,000 cases \* 4 packages per case)/ Total Packages Produced))\*100***

 ***98.5/100 = (24,000 packages into finished cases / Total Packages Produced)***

 ***0.985 = (24,000 packages into finished cases / Total Packages Produced)***

***Total Packages Produced = 24,000 packages into finished cases / 0.985***

***Total Packages Produced = 24,365 packages produced***

***Total Packages not into finished case = Total Packages Produced – Total Packages into Finished Case***

***Total Packages not into finished case = 24,365 packages – 24,000 packages***

***Total Packages not into finished case = 365 packages***

**Break 4**

* Use your previous results to determine the OEE (Overall Equipment Efficiency). The number displayed in the video is not the correct answer for the situation given. Show your calculations.

***OEE = Availability (as a decimal) \* Performance (as a decimal) \* Quality (as a decimal)***

 ***= 59.47% \* 69.64% \* 98.5%***

 ***= 0.5947 \* 0.6964 \* 0.9850***

 ***= 0.4079***

 ***= 40.79%***

* As a group, discuss and write a few sentences explaining what this number means to the company.

**Sample:** *The OEE (Overall Equipment Effectiveness) gives an idea of how well the line is operating. Typically, they would like to see the OEE be at least 80%. The OEE of 40.79% indicates that one or more factors in the process need to be addressed in the production of this product*.

**Break 5**

* Calculate the following:
	+ The downtime cost for an 8 hour shift.
	+ The overpack cost.
	+ The quality cost.

Show all of your calculations.

**Downtime Cost = Initial Downtime\*(Initial run length / Shift Run length) \* Line Production Time**

 **= 2 hour 34 minutes \* (6 hour 20 minutes / 8 hours) \* $300 per hour**

 **= 2.567 hours \* (380/480) \* $300 per Hour**

 **= 2.567 hours \* (0.7917) \*$300 per hour**

 **= $609.68**

**Overpack Cost = Overpack Pounds \* Overpack Cost**

 **= 114 pounds \* $2.50 per pound**

 **= $285.00**

**Quality Cost = Total Packages not into finished case \* Package Cost**

 **= 365 packages not into finished case \* $0.10 per package**

 **= $36.50**

* Write a sentence or two explaining the following: “If you were in charge of addressing issues on the production line, which of the three areas would you address first and why?”

**Downtime because the impact of downtime is 3X the impact of the Overpack and 16X the impact of Quality.**

**Data Analytics Formulas**

**Availability = (Runtime – Downtime)/Runtime**

**Performance = Run Rate / Max T Rate**

**Overpack % = ((Actual Package Weight/Target Package Weight)-1)\*100**

**Overpack Pounds = Target Cases \* Average lbs. per Case \* Overpack % (as a decimal)**

**Quality % = (# of Packages into a finished case/Total Packages Produced)\*100**

**OEE = Availability (as a decimal) \* Performance (as a decimal) \* Quality (as a decimal)**

**Downtime Cost = Initial Downtime\*(Initial run length / Shift Run length) \* Line Production Time**

**Overpack Cost = Overpack Pounds \* Overpack Cost**

**Quality Cost = Total Packages not into finished case \* Package Cost**