Connecting Industry to Mathematics Instruction
NSF ATE Award # 1954291

# Solutions: Be the Statistician - Virus Growth and Vaccine Production Student Activity Sheet

## Student Activity Sheet Key

Name: _____

Date: _____

In partnership with

WAKE TECH

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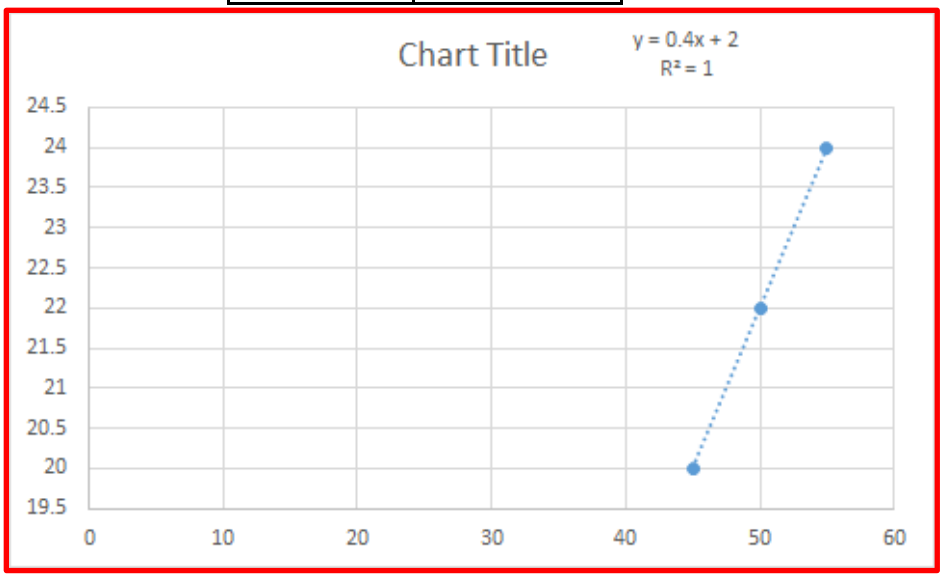
### Prerequisite Skills Check

1. Use the table below to create a scatter plot and insert a trendline that models the data.

| Temperature (°C) | Yield (ug/mL) |
|---|---|
| 45 | 20 |
| 50 | 22 |
| 55 | 24 |




2. Create a 95% confidence interval of proportion for seroprotection for the vaccine tested in 50 patients in which 40 showed seroprotection. Explain the meaning of this confidence interval.

$CI = 0.8 \pm \sqrt{\frac{0.8(1-0.8)}{50}} \rightarrow CI = 0.8 \pm 0.566 \rightarrow (0.743, 0.857)$

**Your Task #1**

1. Below are four sets of data showing virus yield at various temperatures after a 24-hour period using different growth media. Determine the best function (linear or quadratic) that models each set of data, and determine ideal conditions under which to grow each virus for each growth medium in order to maximize virus yield.

| Media A | | Media B | | Media C | | Media D | |
|---|---|---|---|---|---|---|---|
| Temperature (°C) | Yield (ug/mL) | Temperature (°C) | Yield (ug/mL) | Temperature (°C) | Yield (ug/mL) | Temperature (°C) | Yield (ug/mL) |
| 32 | 16.9 | 29 | 6.2 | 29 | 7.5 | 33 | 16 |
| 29 | 7.6 | 35 | 29.5 | 32 | 19.9 | 31 | 15.7 |
| 34 | 13 | 32 | 19.9 | 33 | 25.3 | 30 | 12.7 |
| 35 | 8 | 35 | 30.1 | 34 | 27.5 | 30 | 12.6 |
| 36 | 1.3 | 36 | 33.6 | 36 | 34.3 | 34 | 13 |
| 32 | 16.6 | 33 | 23.2 | 35 | 32.8 | 33 | 15.9 |
| 35 | 8.1 | 34 | 28.4 | 30 | 13.7 | 29 | 7.2 |
| 36 | 1.8 | 30 | 11.3 | 32 | 18.7 | 30 | 11.9 |
| 33 | 15 | 32 | 20.1 | 33 | 24 | 32 | 16.6 |
| 34 | 13.1 | 36 | 33.4 | 31 | 18.3 | 35 | 8.4 |
| 36 | 1.7 | 31 | 17.2 | 34 | 26.3 | 31 | 15.6 |
| 32 | 16.8 | 29 | 8.3 | 30 | 12.4 | 29 | 7.4 |

| **Linear** | | **Linear** | | **Linear** | | **Linear** | |
|---|---|---|---|---|---|---|---|
| Better Model? | No | Better Model? | Arguably | Better Model? | Arguably | Better Model? | No |
| Ideal Temp | 29 | Ideal Temp | 36 | Ideal Temp | 36 | Ideal Temp | 35 |
| Yield | 18.092 | Yield | 34.123 | Yield | 35.159 | Yield | 14.657 |
| **Quadratic** | | **Quadratic** | | **Quadratic** | | **Quadratic** | |
| Better Model? | Yes | Better Model? | Can Argue | Better Model? | Can Argue | Better Model? | Yes |
| Ideal Temp | 32 | Ideal Temp | 36 | Ideal Temp | 36 | Ideal Temp | 32 |
| Yield | 16.545 | Yield | 33.234 | Yield | 34.582 | Yield | 16.747 |

2. Consider the following information:

- All mixtures above contain 100mL of solution.
- The incubator costs $250 per 24-hour period to operate at 25°C.
- It costs $120 per additional degree above 25°C to operate the incubator for a 24-hour period.
- The costs of growth media are:
  - $100 for A
  - $700 for B
  - $1,000 for C
  - $350 for D
- Make a recommendation to Dr. Johnstone about which media to use and at which temperature to grow the virus. (***Do not make temperature recommendations outside of the range of temperatures analyzed.***) Provide an analysis and proper justification for your recommendation.

Use the information below to make a recommendation. Answers will vary, but they should be supported with logical mathematical reasoning.

| **A Linear** | | **B Linear** | | **C Linear** | | **D Linear** | |
|---|---|---|---|---|---|---|---|
| Incubator Cost | $730 | Incubator Cost | $1,570 | Incubator Cost | $1,570 | Incubator Cost | $1,450 |
| Media Cost | $100 | Media Cost | $700 | Media Cost | $1,000 | Media Cost | $350 |
| Total Cost | $830 | Total Cost | $2,270 | Total Cost | $2,570 | Total Cost | $1,800 |
| Cost per ug | $45.88 | Cost per ug | $66.52 | Cost per ug | $73.10 | Cost per ug | $122.81 |
| **A Quadratic** | | **B Quadratic** | | **C Quadratic** | | **D Quadratic** | |
| Incubator Cost | $1,090 | Incubator Cost | $1,570 | Incubator Cost | $1,570 | Incubator Cost | $1,090 |
| Media Cost | $100 | Media Cost | $700 | Media Cost | $1,000 | Media Cost | $350 |
| Total Cost | $1,190 | Total Cost | $2,270 | Total Cost | 36$2,570 | Total Cost | $1,440 |
| Cost per ug | $71.92 | Cost per ug | $68.30 | Cost per ug | $74.32 | Cost per ug | $85.98 |

## Your Task #2

1. The seroprotections of two new vaccines are being compared to the seroprotection of the current vaccine being manufactured to treat the flu. The data collected from studies of these vaccines is summarized below. Create a 95% confidence interval of proportion for sero protection for each vaccine.

| | Current Vaccine | New Vaccine A | New Vaccine B |
|---|---|---|---|
| Sample Size | 80 | 135 | 110 |
| Subjects Showing Seroprotection | 72 | 123 | 80 |

CI for current vaccine: $CI = 0.9 \pm \sqrt{\frac{098(1-098)}{80}} \rightarrow CI = 0.9 \pm 0.034 \rightarrow (0.866, 0.934)$

CI for vaccine A: $CI = 0.911 \pm \sqrt{\frac{0.911(1-0.911)}{135}} \rightarrow CI = 0.911 \pm 0.024 \rightarrow (0.887, 0.936)$

CI for vaccine B: $CI = 0.727 \pm \sqrt{\frac{0.727(1-0.727)}{110}} \rightarrow CI = 0.727 \pm 0.043 \rightarrow (0.684, 0.77)$

2. Make a recommendation to Dr. Johnstone about which vaccine to use (the old one or one of the new ones). Provide proper justification for your recommendation.

   We should continue using the current vaccine. Since the confidence interval for Vaccine A overlaps with the confidence interval for the current vaccine, there is not sufficient evidence for switching production to Vaccine A. We should not use Vaccine B.

## Extension

Seqirus produces a flu vaccine that requires 35ug of the virus per vaccine. Consider that an alternative to this vaccine is being sold by a competitor at a price of $33 per vaccine. Determine conditions under which Seqirus can produce a vaccine to be sold at a cost lower than the competitor's while still maintaining a profit of 30% over the production cost. Make a recommendation to Dr. Johnstone on how Seqirus can pursue producing that vaccine given the profit requirements.

This should be assigned as homework or as classwork on a different day. Answers will vary, but some valuable information is summarized in the included Excel document. Cells may be adjusted in this document to verify that conditions proposed by students do yield a vaccine that can be produced under the given requirements.