Do Students in Mathematics and the Sciences at Miami University Cheat on Exams Using Graphing Calculators?

An Unrelated-Question Randomized Response Experiment

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The use of graphing calculators as a tool in mathematics and the sciences is widespread and continues to expand with the development of technology. Graphing calculators allow students to perform tedious mathematical calculations with great ease and considerably shorten the amount of time needed to work some difficult problems. However, it is possible to store information, such as formulas or definitions, in graphing calculators and use this information to cheat on exams. In order to address this issue, an unrelated-question randomized response experiment was conducted at Miami University in Oxford, Ohio. To compare the percentages of students that have cheated on exams using graphing calculators among different departments, samples were taken from among mathematics, chemistry, and physics students.

The unrelated-question randomized response method applies to this situation because some people may feel uncomfortable responding truthfully to direct statements regarding sensitive issues, such as cheating on exams. Relative to standard randomized response, this method yields a smaller variance. The smaller variance given by the unrelated-question randomized response method allows a shorter confidence interval to be constructed.

Procedure

To gather data in a convenient and efficient manner, the experiments were conducted in classrooms. The participants were given oral and written instructions on how to complete the experiment. The following statements were presented to the participants:
1. I have cheated on a test using a graphing calculator.
2. I was born in the month of December.

The participants were given a penny, which they flipped twice. If participants received two heads, they responded to statement two. Otherwise, the participants responded to statement one. Thus, the probability, (p) that any participant would respond to statement one was 3/4. The probability, ($1-p$), that any participant would respond to statement two was 1/4.

Assumptions

To ensure that the statistics are as accurate as possible, several assumptions must be made. Since the experimenters do not know the statement to which the participant responded, it is assumed that students are honest in their responses. It is also assumed that students who take summer courses represent the general population of students in mathematics and the sciences at Miami University.

Mathematics Department Data

In the mathematics department, there were 48 participants. The experiment yielded 11 participants that responded yes and 37 that responded no. This data can be used to analyze the actual proportion of students who have cheated on exams using graphing calculators, denoted π_A. The estimated proportion of students who have cheated on exams using graphing calculators is denoted $\hat{\pi}_A$.

In order to calculate the number of students who responded yes (m) out of the total number of participants (n), the following equation is used:

$$\hat{\phi} = \frac{m}{n} = \frac{11}{48} = .229$$

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The subsequent equation estimates the proportion of mathematics students who have cheated on exams using graphing calculators. π_μ is the probability that a person was born in the month of December, which is equal to 1/12.

$$\hat{\pi}_A = \frac{\hat{\phi} - \pi_\mu(1-p)}{p}$$

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Thus,

$$\hat{\pi}_A = \frac{\frac{11}{48} - \frac{1}{12}\left(\frac{1}{4}\right)}{\frac{3}{4}} = .278$$

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Therefore, the estimated percentage of mathematics students at Miami University who have cheated on exams using graphing calculators is 27.8 percent.

In order to calculate the confidence interval for π_A, the estimated variance must be determined.

$$\hat{V}(\hat{\pi}_A) = \frac{\hat{\phi}(1-\hat{\phi})}{np^2} = \frac{\left(\frac{11}{48}\right)\left(\frac{37}{48}\right)}{48\left(\frac{3}{4}\right)^2} = .00654$$

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Therefore, the 95 percent confidence interval for π_A is $\hat{\pi}_A \pm z\sqrt{\hat{V}(\hat{\pi}_A)}$, where z is the normal percentile, which is equal to 1.96.* Thus, with 95 percent confidence it can be concluded that the actual proportion of mathematics students at Miami University that cheat on exams using graphing calculators is between .119 and .436, or 11.9 percent and 43.6 percent.

Chemistry Department Data

In the chemistry department, there were 46 participants. The experiment resulted in 17 participants that responded yes and 29 that responded no. The same method from the previous section was used to estimate the proportion of chemistry students who have cheated on exams by using graphing calculators.

The point estimate of the proportion of chemistry students who have cheated on exams by using graphing calculators is .465, or 46.5 percent. The estimated variance of $\hat{\pi}_A$ was determined to be .00900. The 95 percent confidence interval for π_A is (.279, .651). Therefore, with 95 percent confidence is can be concluded that the actual percentage of chemistry students at Miami University that have cheated on exams by using graphing calculators is between 27.9 and 65.1 percent.

Physics Department Data

There were 38 participants in the physics department. Eight of the students responded yes and 30 responded no. The results were again calculated in the same manner as the mathematics department results.

The estimated proportion of physics students who have used a graphing calculator to cheat on an exam was determined to be .253, or 25.3 percent. The estimated variance of

* There is 95 percent confidence in the process used to construct the interval in which the true proportion lies.

$\hat{\pi}_A$ was calculated to be .00778. Thus, the 95 percent confidence interval constructed is (.0801, .426). This means that with 95 percent confidence it can be stated that the actual proportion of physics students who have used a graphing calculator is between 8.01 and 42.6 percent.

Comparison

Departments	*Point Estimate*	*Confidence Interval*
Mathematics	27.8%	11.9%-43.6%
Chemistry	46.5%	27.9%-65.1%
Physics	25.3%	8.01%-42.6%

The table above shows that the point estimates of the percentage of students that have cheated by using a graphing calculator are lowest for the physics department and highest for the chemistry department. However, the estimated proportion of mathematics students who have used a graphing calculator to cheat on exams is virtually identical to the estimated proportion for physics students. This data does not imply that physics students are less likely to cheat using graphing calculators than chemistry students because the confidence intervals overlap.

Overall Data

By compiling data from the three departments, the proportion of students in mathematics and the sciences at Miami University who have used graphing calculators to cheat on exams was estimated. Combination of the data gives a larger sample size and therefore a better approximation of the actual proportion. Increasing the sample size has another positive effect on the calculations, because it allows for a reduction in the variance.

The aggregate number of participants in the experiment was 132. Among the participants, 36 responded yes, while 96 responded no. The proportion of students in mathematics and the sciences who have cheated on exams by using a graphing calculator, π_A, was estimated to be .336, or 33.6 percent. The estimated variance of $\hat{\pi}_A$ was calculated to be .00267. The 95 percent confidence interval for π_A was determined to be (.235, .437). Therefore, with 95 percent confidence it can be concluded that the actual proportion of students in mathematics and the sciences at Miami University who have cheated on exams by using graphing calculators is between 23.5 and 43.7 percent.

Conclusion

Since a limited number of courses are offered during the summer, the sample size was not large enough to accurately estimate the proportion of students in mathematics and the sciences at Miami University who have cheated on exams by using graphing calculators.

$$n = \left(\frac{z\sqrt{\frac{\hat{\phi}(1-\hat{\phi})}{p^2}}}{m} \right)^2 = \left(\frac{1.96\sqrt{\frac{\left(\frac{36}{132}\right)\left(\frac{96}{132}\right)}{\left(\frac{3}{4}\right)^2}}}{.03} \right) \approx 1506$$

With a margin of error (m) of $\pm .03$, the optimal sample size for the aggregate data can be calculated using the following equation:

$$n = \left(\frac{z\sqrt{\frac{\hat{\Phi}(1-\hat{\Phi})}{p^2}}}{m} \right)^2 = \left(\frac{1.96\sqrt{\frac{\left(\frac{36}{132}\right)\left(\frac{96}{132}\right)}{\left(\frac{3}{4}\right)^2}}}{.03} \right) \approx 1506$$

Thus, to have a margin of error less than $\pm .03$, the sample size must be greater than or equal to 1506. The margin of error for the compiled data can be calculated using the following equation where s is the standard deviation of the sample.

$$m = z(s) = 1.96\sqrt{.00267} = .101$$

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Due to the small sample size, the margin of error calculated for the aggregate data is unacceptably high. Therefore, it can be concluded that if the margin of error were lower, the actual proportion of mathematics and science students at Miami University who have used a graphing calculator to cheat on exams could be more precisely estimated.