

Teaching Strategies Involving CAT's and the Statistical Validation of the Results

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ABSTRACT

During the 2008 fall term, the authors conducted an experiment to study the effect of the application of CAT's on the rate of success of our students. Two MAC 1114 day classes were chosen, with similar characteristics in their composition. A set of CAT's were given to one of the groups (experimental group) and no CAT's whatsoever were given to the other group (control group). At the end of the semester the information regarding the behavior of both groups was gathered and compared by using a hypotheses testing procedure, which was the well-known and documented inference about the difference between two sample proportions. The results of this experiment as well as our recommendations are described in this paper.

Theme: Educational Research

Key words: Statistics, Hypothesis Testing, Classroom Assessment Techniques.

1. Introduction

How the students perform at Miami-Dade College is the main concern for both administrators and faculty members in this institution. As instructors, it is very important for us that the students learn the material and consequently pass our classes with the highest possible grade.

Classroom Assessment Techniques (CAT's) have been extensively reported in the literature (1), and also extensively applied by the instructors in their classes. On the other hand, statistical procedures are available to assess and validate the results obtained from the application of these CAT's. We consider that the hypothesis test for two proportions constitutes a very powerful tool. In this paper we report on the application of this technique to validate the results obtained from the piloting of two MAC 1114 classes during the 2008 fall semester.

2. Body

The CAT's used in this experiment were the Minute Paper, the Muddiest Point, and the RSQC2 (Recall, summarize, question, connect, and comment) (1).

The format of the actual surveys given to the students is given below.

Minute Paper

Course: _____ Date: _____

This survey is anonymous

At this point I want to evaluate your learning for a reason other than to assign a grade. I want to assess how much and how well you are learning so I can help you learn better.

The analysis of the results of this assessment will permit me to learn more about how you are learning in order to improve it.

1) What was the most important thing you learned today?

2) What questions remain uppermost in your mind as we conclude this class session?

Muddiest Point

Course: _____ Date: _____

This survey is anonymous

At this point I want to evaluate your learning for a reason other than to assign a grade. I want to assess how much and how well you are learning so I can help you learn better.

The analysis of the results of this assessment will permit me to learn more about how you are learning in order to improve it.

What was the muddiest point of my lecture today?

RSQC2

Course: _____ Date: _____

This survey is anonymous

At this point I want to evaluate your learning for a reason other than to assign a grade. I want to assess how much and how well you are learning so I can help you learn better.

The analysis of the results of this assessment will permit me to learn more about how you are learning in order to improve it.

1) Make a list – in words or simple phrases – of what you recall as the most important or meaningful points from the previous class.

2) Use a sentence to summarize the essence of the previous class.

Class Selection and Processing the Results of each CAT

A total of five CAT's were applied to the MAC 1114 experimental group. The control group did not receive any CAT. Both are morning classes with similar characteristics and enrollment. The results of each of these five CAT's were summarized, tabulated, and discussed with the students the day after its application. This contributed to improve the communication with the students. We consider of high importance that the results of the CAT's should be ready for the next meeting with the students. Also, every single aspect that was pointed out by the students in their surveys must be discussed and clarified. If they see that we don't put too much attention to this, they will lose interest. Actual student survey papers are available from the authors upon request.

Statistical Validation of Results

The final passing rate was greater in the experimental group, 72% Vs 46% in the control group. Now, the research question is whether the fact that the passing rate in the experimental group was greater than the passing rate of the control group is due to chance or sampling, or the application of CAT's does help the students to better their performance. To answer this question we decided to run a hypothesis test procedure.

Description of the Statistical Tool

The hypothesis testing procedure utilized in this experiment was the well-known and documented inference about two proportions, described in (2), (3), (4), and (5). A significance level of $\alpha = 0.05$ was considered, which is the most frequently used in studies like this.

The notation and formulas that are used in this work are described next.

Notation

$n_1, n_2 =$ Sample sizes (enrolment of each class)

$x_1, x_2 =$ Number of successes (# of students who passed in each class)

$\hat{p}_1 = \frac{x_1}{n_1} =$ Sample proportion of successes in sample 1

$$\hat{p}_2 = \frac{x_2}{n_2} = \text{Sample proportion of successes in sample 2}$$

$$\hat{q}_1 = 1 - \hat{p}_1 = \text{Sample proportion of failures in sample 1}$$

$$\hat{q}_2 = 1 - \hat{p}_2 = \text{Sample proportion of failures in sample 2}$$

$$\bar{p} = \frac{x_1 + x_2}{n_1 + n_2} = \text{Pooled sample proportion of successes}$$

$$\bar{q} = 1 - \bar{p} = \text{Pooled sample proportion of failures}$$

p = population proportion ($p_1 = p_2$: The two population proportions are assumed to be equal in the Null Hypothesis)

$$z = \frac{(\hat{p}_1 - \hat{p}_2) - (p_1 - p_2)}{\sqrt{\frac{\bar{p}\bar{q}}{n_1} + \frac{\bar{p}\bar{q}}{n_2}}} = \text{Test Statistic for Two Proportions Hypothesis Test}$$

α = Significance Level of the Test

P-Value = Probability of getting a value of the test statistic that is at least as extreme as the one representing the sample data, assuming that H_0 is true.

Sample Requirements

Samples should be big enough: at least 10 successes and at least 10 failures (5). Other authors require that the four outcomes $n_1 p_1$, $n_1 q_1$, $n_2 p_2$, and $n_2 q_2$ are greater than 5 (2). Samples must be random and independent samples (4) & (5).

All these requirements are fulfilled in our samples. This means that we expect that the sampling distribution of the differences between the proportions of the two samples is approximately normal.

Sample Data

The data gathered from the two classes at the end of the semester is summarized in the following table.

Ref 475113 (TR)	Ref 475112 (MWF) (Control Group)
$n_1 = 29$	$n_2 = 28$
$x_1 = 21$	$x_2 = 13$
$\hat{p}_1 = 0.72413$	$\hat{p}_2 = 0.46429$

Hypotheses

The application of CAT's should enhance the learning capabilities of the students and therefore, it should contribute to better the performance throughout the semester and as a consequence, it should contribute to increase the passing rate. The formal hypotheses will be expressed as follows:

$$H_0 : p_1 = p_2 \text{ (Null Hypothesis)}$$

$$H_1 : p_1 > p_2 \text{ (Alternate Hypothesis) (Original Claim)}$$

The general approach, as in all hypotheses testing, is to assume that H_0 is true, and then see if the sample evidence goes against this assumption.

Calculations

The different formulas were fed with the sample data, and the calculations were performed as shown below.

$$\bar{p} = \frac{x_1 + x_2}{n_1 + n_2} = \frac{21 + 13}{29 + 28} = \frac{34}{57} \approx 0.59649 \quad \text{Pooled Sample Proportion of Successes}$$

Pooled Sample Proportion of Successes

$$z = \frac{0.72413 - 0.46429}{\sqrt{\frac{0.59649 \cdot 0.40351}{29} + \frac{0.59649 \cdot 0.40351}{28}}} \approx 2.00 \quad \text{Test Statistic}$$

P-Value = 2 (Area to the right of test statistic)

= 2 (1 - 0.9772) = 0.0456 (This can be interpreted as the probability of getting a value of the test statistic that is at least as extreme as the one representing the sample data, assuming that H_0 is true).

Critical Value = 1.645 (Corresponding to a right-tailed test with a significance level of 0.05, when using the z-distribution).

Decision Rule

If we use the traditional method of testing hypotheses, the decision rule would be expressed as follows: Reject H_0 if the test statistic is greater than or equal to the critical value. In our case, since $2.00 > 1.645$, we conclude that we will reject H_0 .

If we use the P-Value method, the decision rule is the following: Reject H_0 if the P-Value is less than or equal to the significance level of the test. In our case, since $0.046 < 0.05$, we conclude one more time in that we will reject H_0 .

3) Interpretation of the Results on H_0 , Conclusions, and Future Work

We report that at the significance level of 0.05, there is sufficient sample evidence to support the claim that the student passing rate in MAC 1114 is increased when CAT's are applied, and this result is statistically significant, according to (2).

On the other hand, there is a maximum probability of 0.05 of making a Type I Error, which is the one that is committed when a true null hypothesis is rejected.

Based on this experiment and the subsequent statistical analysis of the results, we have much better guidance when recommending a treatment based on the application of CAT's.

We are also considering extending this experiment to math preparatory courses.

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