NAME THAT SCENARIO: AN ONLINE STUDY TOOL FOR STATS 250

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Introduction

Name that Scenario (NTS) is an online learning tool that aims to help improve student learning in Stats 250 by offering students an opportunity to identify the correct statistical test from a given scenario. NTS was originally an application written in flash which was ported to JavaScript to improve its flexibility and generate better usage logs. The tool allows students to select up to 10 types of statistical tests about which they receive scenarios. NTS is made available to students 2 weeks before Exam 2 and is open until the end of the term.

Three Screen Shots of NTS

Design of NTS

NTS code follows a model–view–control design pattern which keeps the model code (application data), view code (display) and the control code (event handling) separate. This makes it easier to reuse and maintain. The scenario files are included in the application as JavaScript JSON files. Log events are fired from each of the event handlers in the control module to create log files from which we took the snapshots below.

NTS Usage

Analysis on the usage logs tells us when students use NTS, which statistical tests they chose, how many they at once, and how often they answer correctly.

PRE-EXAM 2	NTS_ANSWERS	PRE-FINAL	NTS_ANSWERS
9/6/13	1	11/15/13	3
9/10/13	4	11/19/13	1
10/4/13	5	11/21/13	10
10/21/13	10	11/22/13	26
10/31/13	82	11/24/13	6
11/1/13	10	11/25/13	25
11/3/13	6	11/30/13	3
11/4/13	12	12/2/13	2
11/5/13	12	12/3/13	17
11/6/13	41	12/4/13	66
11/7/13	329	12/5/13	30
11/8/13	352	12/6/13	84
11/9/13	336	12/7/13	73
11/10/13	667	12/8/13	332
11/11/13	1018	12/9/13	267
11/12/13	2517	12/10/13	540
11/13/13	3688	12/11/13	1181
11/14/13	5592	12/12/13	676

SCENARIO	FREQUENCY	CORRECTNESS RATE
PAIRED	1965	0.78
INDEPENDENT-T-TEST	1929	0.67
ONE-MEAN	1834	0.75
TWO-PROPORTION	1834	0.71
ONE-PROPORTION	1607	0.84
ANOVA	333	0.66
CHI-SQUARE-INDEPENDENT	314	0.70
CHI-SQUARE-GOODNESS-OF-FIT	312	0.58
CHI-SQUARE-HOMOGENEITY	312	0.64
REGRESSION	298	0.68

Analysis of Usage

On the left is a description of our matching algorithm which helps remove the selection bias in this observational data. On the right are four outputs from running this algorithm. There are 1632 students enrolled and 556 used NTS at least once. We look at usage for the Exam 2 study period and Final study period separately and group students in a period who are above the median usage in that period, comparing them on exam scores to everyone else.

First, select two mutually exclusive sets of students X, and Y based on treatment attributes. Let x,y be students in X,Y and N_X, N_Y be the number of students in each set respectively.

The simple difference in mean values of an attribute between groups ignores selection bias, but is given by:

$$\Delta_{simple} = \overline{X_{attribute}} - \overline{Y_{attribute}} \quad \text{(position of pink bar in output)}$$

The non-parametric probability of randomly finding this difference for an attribute in our sample can be estimated by a stochastic process where $\{X,Y\}$ is a combined set and $\{Q\}, \{R\}$ are random splits of $\{X,Y\}$ into subsets of size N_X, N_Y. This defines:

$$\Delta_{random} = \overline{Q_{attribute}} - \overline{R_{attribute}} \quad (1)$$

Taking the standard deviation σ_{random} of $10 \cdot (N_X + N_Y)$ such values of Δ_{random} gives a reasonable estimate for the width for a normal distribution $\mathcal{N}$ that can be thought of as an estimate for the probability distribution:

$$P(\Delta_{random}) \simeq \mathcal{N}(0, \sigma_{random}) \quad \text{(blue curve in output)}$$

In this way the significance of a difference Δ_{random} or Δ_{simple} can be estimated relative to σ_{random} and the uncertainty in the values of Δ_{random} or Δ_{simple} are estimated by the standard error:

$$SE_{random} = SE_{simple} \simeq \frac{\sigma_{random}}{\sqrt{N_X}} + \frac{\sigma_{random}}{\sqrt{N_Y}} \quad \text{(width of bars in output)}$$

Now, if a selection bias is observed (a difference in the distribution of an attribute known prior to treatment this attribute may be used for matching to partially remove the selection bias. Thus we define M_Y as all students in Y which match student x on an attribute to within a threshold T.

$$M_Y := \{y \text{ where } |x_{attribute} - y_{attribute}| \leq T\} \quad (2)$$

Using this we can add a new attribute to every member of Y which compares them to every matching member of X:

$$C_x := \{x_{attribute} - \overline{M_{Y attribute}}\} \quad (3)$$
$$C_y := \{y_{attribute} - \overline{M_{X attribute}}\} \quad (4)$$

Lastly, using this new attribute we define a matched differenced between X and Y that mitigates selection bias:

$$\Delta_{matched} = \frac{(N_X \cdot \overline{C_x}) + (N_Y \cdot \overline{C_y})}{(N_X + N_Y)} \quad \text{(position of green bar in output)}$$

Conclusions

We demonstrate the design of an online study tool which creates detailed usage logs and then use those logs to understand the tools adoption and effectiveness among students. We have found that students who used NTS and answered more than 20 questions prior to exam 2 did 3.3 / 75 points (~4.4%) better on that exam.

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