TEACHING EXPERIMENTS FOR A COURSE IN INTRODUCTORY STATISTICS

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Appreciation of college students on the statistical science relies to a large extent on how the introductory course is managed. Two groups of students (undergraduate statistics majors and non-statistics majors) were exposed to teaching an introductory course. Within each group, half is exposed to fun games intended as enrichment activities, the other half served as the control. Grades after one semester were analyzed and treatment effect is computed through Heckmans' Selection Model. While the treatment (games) is beneficial for the non-statistics majors, it is disadvantageous for the statistics majors. For students with inherent interest in statistics, the introductory course will only require a clear presentation of concepts that will help them appreciate the discipline. However, the non-statistics majors or those with negative perception on statistics, fun activities like games can help conceal their dislike for statistical science and help improve the eventual outcomes in the course.

INTRODUCTION

Appreciation of people in the workplace or society in general on the statistical science can be traced back on how they were introduced to the discipline. Those who were not been convinced that statistics is important will remain to have the same perceptions even after they finished university work. It is a big challenge for teachers of introductory statistics course on how to introduce the course to attract attention of the students that will hopefully be translated into cognition and subsequently appreciation of the discipline.

Students may develop interest in an academic discipline depending on how pleasant their experience was the first time they were exposed in that area. It is postulated that statistics can be better introduced to college students in a more casual and fun setting like in an ordinary game. Thus, an experiment where one group, aside from the usual instruction, enrichment activities (intervention) in the form of a game is introduced, the other group receives nothing but plain classroom instruction alone. This paper aims to compare the performance of students with and without interventions and to identify possible factors contributing the outcomes in and introductory statistics course.

METHODS

An experiment is conducted to enhance student learning. Two sections of introductory statistics course for statistics majors and two sections of introductory statistics course for non statistics majors from the University of the Philippines Diliman were identified to participate in the study. Each group were sub grouped further into control where instructions for one semester was undertaken using the usual classroom instructions. The other subgroup received the treatment were in addition to classroom lectures, enrichment activities are done before, during, and after the presentation of a concept or a method. The purpose of such activities is to make the topics fun and more interesting for easier internalization and appreciation of the subject matter by the students.

Activities given before the new lesson are intended to elicit the students' interest and to have them desire to crave for more on the topic to be discussed. On the other hand, the activities given after learning the lessons are intended as a wrap up, to unwind the class session, and to emphasize important concepts. All the activities are ways to make the classroom experience more interesting and pleasurable for the students. According to Leblanc (1998), good teaching is also about style. It may be in forms that are entertaining but not necessarily lacking substance.

The activities like quotations and games serve to stimulate their interest before the discussion of a new lesson. A quotation relevant to the new lesson/topic initially sets the mood to get the interest of the students and to make them yearn for more. The teacher does not give only the quotation but also explains its implications. As an introduction to the definition and uses of statistics, the teacher can use the quotation by Florence Nightingale. It states, "*Statistics is the most important science in the whole world; for upon it depends the practical application of every*

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science and of every art; the one science essential to all political and social administration, all education, all organization based on experience, for it only gives results of our experience." After explaining the quotation, the teacher now defines what statistics is and follows it up with its varied applications and uses. This allows the student to realize the magnitude of its usability not only in his/her field but also in other fields as well.

For the lesson on data presentation using statistical charts, a good quotation is from an ancient Chinese Proverb that states"*One picture is worth ten thousand words.*" This explains that once we put data in a chart, we obtain many significant findings. Hence, it is comparable to a painting wherein we can make different interpretations. On the other hand, if the teacher does not want to sound very philosophical, he/she can cite the first line of the song "If" by Bread that says "*If a picture paints a thousand words….*" the meaning of which is analogous to what was discussed

Before the discussion of the different summary statistics like measures of central tendency and measures of dispersion, another quotation worth mentioning is by H.G. Wells (1929). It says"*The time may not be very remote when it will be understood that for complete initiation as an efficient citizen of one of the new great complex worldwide states that are now developing. It is as necessary to be able to compute, to think in averages, maxima and minima, as it is now to be able to read and to write."* This may sound profound, however, we let the students realize that being statistics literate is analogous to knowing how to read and write. Every individual equipped with statistical tools has an edge in life. So many data are available but not enough researchers to do the analysis. Only a few have the statistical capability. The teacher emphasizes the fact that there is power in understanding figures.

The games are forms of entertainment. This activity enhances thinking, cooperation, and unity among the students. Games open doors in communicating to students new concepts they need to learn. Students like to play. They enjoy doing activities and interacting with others. When the teacher incorporates games in class, this creates excitement and enthusiasm on the subject matter.

On data organization, the game "Arrange Yourselves" is appropriate. There should be at least 10 members in a group. Students arrange themselves by using quantitative variables like age, weight, height, foot size, and waistline. Instructions should be specific whether they will arrange themselves from lowest to highest or from highest to lowest. For the last game of "Arrange Yourselves", there is no more grouping. The entire class needs to arrange themselves according to the given variable. After the game, the teacher processes the activity by stating that the objectives are 1) to show different ways of arranging individuals and 2) to know the advantages and disadvantages of arranging individuals. Then, the teacher elicits insights from the students regarding what they learned from the activity. Begin first with arrangement of individuals per group followed by the arrangement of all the students without the grouping.

After processing the activity, the teacher discusses the raw data and the array and relates it to the game. Emphasis is on the convenience of obtaining the lowest and the highest observations and where the observations are concentrated in the array. The teacher recalls the last game played where there is no more grouping and all the students arranged themselves according to magnitude. Students cite difficulties encountered in the last game and stress is placed on sorting being cumbersome when the number of observations is large. This is now a good opportunity to introduce the frequency distribution as better way of organizing the data and its benefits.

Another activity that can serve as an appetizer is the "Find the Word" game. This is helpful in introducing the different terms that the student should be acquainted with. The topic "Inferential statistics", in particular, involve the use of so many terms students are unaware of. The game will allow the student to be conscious of the different terms utilized in inferential statistics. The students need not understand the meaning/s of the words yet but rather to give them exposure. This game familiarizes them with the different terms.

To end a topic in statistics, the teacher gives integration activities to summarize the lesson, to lighten up the class session, and to highlight essential points. Giving jokes, quiz crossword, trivia, and quiz bee are activities given after the discussion of a topic. We give a joke for purposes of reducing the seriousness of the atmosphere and to create a relaxed mood in the classroom. Kher, et al (1999) say that humor is often overlooked as a teaching tool and that laughter releases stress

and tension for both instructor and student. The joke given to the students is related to the subject matter and thus there should be understanding first on the part of the student before he/she appreciates the joke. Adding humor lightens a rather difficult subject matter.

A quiz bee is given as the final activity before the semester ends. The contest serves as a review of all lessons covered and as a preparation for the final examination. As an incentive, the teacher gives prizes to the top three students winning the contest. This activity motivates and challenges the students to study harder, do further readings, and be competitive. In addition, this creates an atmosphere of fun and excitement.

THE DATA

There are 58 statistics majors and 55 non statistics majors involved in the experiment. We collected almost the same set of variables for both groups: examination scores (long exams and final exam), grade, sex, age, height in inches, weight, daily physical activity, daily stress level, average weekly allowance, average weekly expense, member of an organization, location of residence (urban, rural), status of current residence (1 – lives with parents, 2 – lives with relatives, 3 – lives with friends, 4 – lives in a dormitory, 5 – lives alone, 6 – lives in a boarding house, 7 – lives with family members), family status (1 – both parents living together, 2 – separated both parents alive, 3 – separated but one parent deceased, 4 – both parent deceased, 5 – one parent deceased), highest educational attainment of father, highest educational attainment of mother, number of siblings, course, no. of semesters in the University (for non-statistics majors), no. of semesters in the current program (for non-statistics majors), status of current program, grade in high school algebra, grade in high school geometry, grade in high school trigonometry, grade in college algebra, with honors in high school, type of high school (1 – private, 0 – public), study habits (1 – studies everyday, 2 – studies 4 to 6 times a week, 3 – studies 2 to 3 times a week, 4 – studies once a week, 5 – studies only when there is an exam, 6 – does not study), attitude with numerical courses (1 – very interested, 2 – interested, 3 – neither, 4 – uninterested, 5 – very uninterested), number of times taken Stat 101 (for Stat 101 students only), and overall impression of Stat 114 or Stat 101 (1 – very important, 2 – important, 3 – neither, 4 – unimportant, 5 – very unimportant).

ESTIMATION OF TREATMENT EFFECT

The experimental units are students from two sections of statistics majors group (divided into control and experimental groups) and two sections of non statistics majors (also divided into control and experimental groups). The control and treatment groups were given the same examinations for all topics covered. The examinations given are all multiple choice type.

One of the authors taught all four sections included in the study. However, self-selection bias is still inevitable in this experiment since the students are free to choose their teacher by enlisting to a section they prefer. Heckman (1979) noted that sample selection bias may arise in practice for two reasons. First, there may be self selection by the individuals or data units being investigated. Second, sample selection decisions by analysts or data processors operate in much the same fashion as self selection. When samples are not randomly assigned to their respective groups, biased estimates of treatment effects can lead to misleading information.

We used the Heckman's correction, a two-step statistical approach, which offers a means of correcting for non-randomly selected samples. The Heckman's selection model avoids the sample selection problem by estimating the model parameters by maximum likelihood. The model provides consistent, asymptotically efficient estimates for all parameters in the model.

Heckman's selection model is based on two latent dependent models:

$$Y_1^* = \beta' X + U_1 \qquad (1) \quad \text{(regression model)}$$

$$Y_2^* = \lambda' Z + U_2 \qquad (2) \quad \text{(selection model)}$$

where X and Z are vectors of regressors, the errors U_1 and U_2 are conditional on X and Z, jointly bivariate normally distributed with zero mean vector and variance matrix $\sum$ where the following holds $U_1 \sim N(0, \sigma^2)$, $U_2 \sim N(0,1)$ and $Corr(U_1, U_2) = \rho$.

RESULTS AND DISCUSSION

Final grade of the non-statistics majors is significantly affected by grade in college algebra ($p<0.000$), grade in high school trigonometry ($p<0.013$), whether they agree that numerical courses are important ($p<0.093$), and the treatment ($p<0.000$). The partial contribution of the treatment on final exam could increase the grade by 0.856 in the 9-point grading system (1 is highest, 3 is passing, 5 is failing).

Selection to participation in the intervention is significantly affected by the number of semesters they stayed in the university so far ($p<0.028$). Those in their junior or senior years do not need the intervention much as this is needed by the freshman and those in their sophomore years.

Counterfactual simulations show that had all the subjects went through the same intervention, the final grade in stat 101 is 1.94 compared to 1.98 had they not went through the intervention. This means an estimated treatment effect (due to the intervention) is about 0.0351 (or and increase of 1.78%), this is statistically significant ($p<0.000$).

Final grade of statistics majors is significantly affected by grade in high school algebra ($p<0.034$) and the treatment ($p<0.001$). Grade in high school algebra is a good indicator of performance in introductory statistics for statistics majors taken upon entrance in the program. The partial contribution of the treatment on final grade however, can lower the grade by 0.5449 in the 9-point grading system. While the intervention is an advantageous activity for non-statistics majors, it has adverse effect on statistics majors.

None of the identified determinants of selection as participants to the intervention can actually dichotomize who needed and who don't need the intervention among statistics majors.

Counterfactual simulations show that had all the subjects went through the same intervention, the final grade in introductory statistics is 1.85 compared to 1.81 had they not went through the intervention. The statistics majors are better off in an introductory statistics course not to participate in the intervention ($p<0.000$). It is recommended that similar interventions can be developed that are more suited to the cognitive level of statistics majors, or simply not to use the current activities as this is detrimental to student performance.

CONCLUSION

Learning becomes fun and interesting if we use various techniques to present an idea and engage different ways to motivate the students. Students learn more if they are participative and understand the importance of what they are studying. Learning techniques need to be flexible. There are many avenues for learning. Provision of these enrichment activities may entail some amount of time for the class but if it will make the students appreciate and comprehend more the topic then it is worth it.

The objectives of this study are twofold. First, the study compares the performance of students with and without interventions. Second, the study determines factors affecting the grade of students in introductory statistics. The study suggests that statistics majors do not need these activities to get their interest in studying statistics. However, non-statistics majors may need to have interventions to appreciate statistics, improve cognition, and subsequently better course outcomes.

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