USE OF PROJECTS FOR TEACHING SOCIAL STATISTICS: CASE STUDY

Theodore Chadjipadelis and Ioannis Andreadis
Aristotle University of Thessaloniki, Greece
chadji@polsci.auth.gr

Modern teaching methods require students to be active participants in the learning process. Assigning projects to students sets a frame which cultivates the interactivity between the instructor and the students and motivates the students to explore the field. The objective of this paper is to present the results from the use of individual directed projects in the introductory statistics course at the Department of Political Sciences of Aristotle, University of Thessaloniki. We compare this group with another group of students who were taught the introductory statistics course with conventional methods. The results indicate that students in the project-based group grasped statistical concepts and ideas at a higher rate than students in the control group, had a better attitude towards statistics, and did not think that statistics is as hard to learn as students in the other group.

INTRODUCTION

The majority of social sciences students in Greek Universities approach statistics with fear, mainly due to their poor mathematical background. This situation originates from the "mathematics anxiety" that they have developed because of previous bad experience with mathematics in the lower levels of education As a result, many students are possessed by the fear of failure in the final examinations.

The problem is worsened by the way students choose to deal with it. Some students choose to demonstrate limited interest; their effort to comprehend Statistics is minimal. They justify this behavior by stating that they prefer to take a more theoretical approach to their science, and consequently, they claim that Statistics is useless to them. Of course, the majority of these students change their minds regarding the usefulness of statistics soon after encountering the first examples of statistical techniques applied in the context of their science. On the other hand, helping students to overcome their fear and anxiety towards statistics requires a more complex treatment.

The use of (individual or group) projects for teaching Statistics can, under suitable conditions, help in correcting erroneous perceptions and misapprehensions (Chadjipadelis and Gastaris, 1995, 1998). Assigning projects to students sets a frame which encourages interactivity between the instructor and the students, and motivates students to explore the field (Chadjipadelis 1998a, 1998b; Chadjipadelis and Primerakis, 1998). The following sections describe the incorporation of directed individual projects into the introductory social statistics course at the Department of Political Sciences of Aristotle University of Thessaloniki and the positive effects of this approach on students' learning experience. The process was supported by the resources of the Laboratory of Applied Political Research of the Department.

DESCRIPTION OF THE PROJECT

One of the main objectives of the statistics instructor should be to help students develop statistical thinking (Lovett and Greenhouse, 2000; Pfannkuch and Wild, 2003; Wild and Pfannkuch, 1999). In our effort to introduce our students to the process of statistical reasoning, we have tried to lead them to a series of actions that resembles the statistical treatment of a real problem: a) formulation of questions, b) data collection, c) data analysis, and d) presentation of results.

According to this plan, students were asked a number of questions about their consuming habits during our first meeting in early October 2004. Typical examples of questions are as follows: "Do you think that your expenses are uniformly distributed between the different days of the week?," "Do you believe that there will be an important difference between your expenses in November and December?" We also discussed different factors that affect their expenditure decisions, including quality, price, previous knowledge of the product, advertisements, and how these factors are differentiated depending on the kind of expense.

After a discussion with the students on how they could answer the questions, the need for data collection became obvious. Thus, the students were asked to keep records of every expense they would have in the first week of November 2004. The discussion indicated that each record should contain the following fields:

- Date of expenditure
- Time of expenditure (coded in 5 categories)
- Amount
- Type of expenditure (coded according to the General Secretariat of National Statistical Service of Greece in 12 main categories: food, drinks and smoke, apparel and services, housing, imperishable goods, health care, transportations, communications, entertainment and culture, education, hotels and restaurants, and other expenditures)
- Expenditure decision (a binary variable indicating whether the expenditure was a result of a last minute, in-store decision)
- Frequency of expenditure (coded in 6 categories)
- Necessity of the expenditure
- Level of satisfaction
- Quality effect
- Price effect
- Previous knowledge effect
- Advertisements effect

The last six variables are five-points Likert-type items with 1 being the most negative response (Disagree Completely) and 5 being the most favorable response (Agree Completely).

After entering the data in a PC, the students proceeded with the analysis of their consumption habits with *SPSS*. The same process was repeated in the first week of December 2004. For the completion of work it was required by the students to apply techniques and methods from the fields of descriptive and inferential Statistics that correspond to the following topics: Descriptive Statistics and two-way tables, Normal distribution, comparison of means, X^2 test for goodness of fit, X^2 test for independence, and linear regression. At the end of the semester students submitted a report in which they presented their results and evaluated their findings.

ISSUES IN USING PROJECTS

Data-Related Issues

Neil Binnie (2002) reports that data should be collected by the students, so that they have familiarity with the context of their research. On the other hand, it is considered desirable to avoid overloading the students with the time-consuming data collection usually involved with the use of questionnaires. In addition, in countries that have only recently started paying attention to the Internet, the web resources offering relevant national data sets are still limited. A procedure that provides real data of interest and importance to the students, and at the same time, does not require excessive effort can be possible if the data consist of elements of the students' daily routine. This is exactly the kind of data that were used in the aforementioned consuming habits project. As far as the data are concerned, the project is consistent with one of the basic principles that resulted from the calls for reform in Statistics education: the use of real, interesting, relevant data. Of course, the data alone are not enough to arouse students' interest. There was an effort to have our students conduct a research study with stimulating questions, and at the same time, we tried to keep the questions compatible with the statistical methods that are included in the course.

Assessment of Students

Group projects incorporate a significant problem with regard to the assessment of the students. Johannes Ledolter (1995) has dealt with "free-loaders" by asking students to report group members who fail to participate. This is not a pleasant situation for students. Thus, we decided to assign a project to each individual separately, although working in groups offers a number of advantages known in the literature (Chadjipadelis, Ghinis and Bersimis, 2003; Ghinis, Chadjipantelis and Bersimis, 2005; Nolan, 2002; Smith, 1998). The assignment of individual

projects allows a more objective evaluation of students, because with individual projects students are judged based on their own work.

Active Learning and Use of Technology

During the classes the instructors often used the educational software "*ActivStats* for *SPSS*" (Mills and Johnson, 2004). The software proved particularly useful for the easier comprehension of statistical concepts (e.g., the central limit theorem), mainly due to the simulation examples it provides. The software is also installed in some of the laboratory computers and the instructors often advised students to use the software activities that corresponded to the different topics of the course.

The students had to do a lot of their job in front of a PC. In addition to data entry and data analysis, they were also asked to use a PC for the preparation of the report with their results. For this reason, a computer seminar was organized by the laboratory personnel at the beginning of the semester. This was an important aid for the small percentage of students who had minimal previous experience with a PC.

SURVEY OF ATTITUDES TOWARDS STATISTICS

In order to measure the influence of teaching Statistics with projects on the students' attitude towards Statistics, we used the questionnaire "Survey of Attitudes towards Statistics" (SATS-36). SATS is a cross-cultural tool and it has been used with success internationally (Schau, Stevens, Dauphinee, and Del Vecchio, 1995).

SATS was collected from two groups of students. The first group consisted of 37 students who participated in the new form of the course with the use of projects. SATS was handed out to them during our last meeting in class, and after they had finished their projects. The second group consisted of 33 students who had been taught Statistics without the use of projects. The second group was used as a control group for the analysis. The students in both groups have taken the same math courses in high school and they have also attended the same math course in the previous semester as University students.

Description of SATS

The older version of the questionnaire (SATS-28) was designed to assess four components of attitudes toward statistics as follows:

a) Affect - positive and negative feelings concerning statistics,

b) Cognitive Competence - attitudes about intellectual knowledge and skills when applied to statistics,

c) Value - attitudes about the usefulness, relevance, and worth of statistics in personal and professional life, and

d) Difficulty - attitudes about the difficulty of statistics as a subject.

SATS-36, which was used in the current study, constitutes the newer version of the questionnaire. It has 8 new items that concern 2 new components:

e) Interest of students for Statistics, and

f) Effort to learn Statistics.

Each one of the aforementioned components is assessed with a series of Likert type items in a scale from 1 to 7, where 1 corresponds to the answer "strongly disagree," and 7 corresponds to the answer "strongly agree." The students are requested to respond to every item and in case where they neither agree nor disagree with an item, they are advised to select answer 4.

The score of each component is defined as the mean of the scores of the items that constitute the component. For each component there are some negatively worded items. For these items, the researcher reverses the answers (1 is replaced by 7, 2 by 6, etc.) before their use in the calculation of the component score. In this manner, higher scores always mean more positive attitudes.

SATS incorporates additional items concerning students' demographics (e.g., age, sex etc). During the design of the questionnaire we had to take a difficult decision whether to collect more detailed data about the students or protect their anonymity. For instance, we could ask them to write down their names along with the rest of their answers. In this case we could have access

to their exact grades in previous math exams but we would worry about the reliability of their answers. Our choice was to keep the questionnaire anonymous. We have records about which student belongs to each group but we do not know the student – questionnaire correspondence. Thus, we asked the students to take into account their previous math grades and answer to two items about their mathematical background: (1) performance in high school math courses, (2) self-concept regarding mathematics. Both of these items are also scaled from 1 to 7. The score of the latent variable "Mathematical Background" is defined as the mean of these two items. This latent variable offers the opportunity of analyzing students' attitudes towards Statistics for each level of mathematical background separately, without revealing the students' identity.

Comparison Results

Firstly, we should note that there is not a significant difference for the male-female ratio between the two groups. In addition, we compared the mathematical level of the two groups. The Mann – Whitney test indicated that we cannot reject the hypothesis of equal mathematical level means between the two groups (p= 0.280). Both groups showed an average level of Mathematics with mathematical level mean values around 4.5.

Table 1 shows the comparison between the two groups with regard to the six components of SATS-36. It is noted that higher scores for the variable "Difficulty" correspond to students who believe that Statistics is easy to learn.

Table 1: Comparison of SATS components between groups

	Projects		Control		
	Mean	St. Dev.	Mean	St. Dev.	p-value
Affect	4.99	1.20	4.18	1.63	0.020
Cognitive Competence	5.50	1.02	4.92	1.27	0.038
Value	5.54	0.86	4.84	1.18	0.005
Difficulty	4.41	0.87	4.37	1.14	0.864
Interest	5.42	1.24	4.61	1.58	0.019
Effort	6.14	0.78	5.61	1.23	0.031

The results in Table 1 indicate that, at a significance level α=0.05, an important improvement of the students' attitude towards Statistics is observed in the first group of students for all the SATS components apart from the component "Difficulty." For further analysis of the component "Difficulty" we should take students' mathematical background into consideration. Usually, students who have serious difficulties with Mathematics, also tend to have difficulties with Statistics. In order to use the mathematical background in the analysis of the component "Difficulty," the students were separated into two groups as follows: The students who scored lower (up to value 4) in the latent variable "Mathematical Background" were placed in the first group. The second group constituted of the students who considered their mathematical background to be better than the average.

The mean values of the component "Difficulty" for each subgroup are presented in Figure 1. It becomes obvious that if we deal only with students with a low mathematical background, we observe that the Control group shows a mean value of difficulty score at 3.68, and the Projects group shows a mean value of difficulty score at 4.44. On the other hand, if we deal only with the students with a higher mathematical background, we observe that the Control group shows a mean value of difficulty score at 4.87, and the Projects group shows a mean value of difficulty score at 4.40. These conclusions are also supported by the ANOVA results (p= 0.013 for the interaction between the variables "Group" and "Mathematical background"). Consequently, as far as the difficulty component is concerned, we can assume that the incorporation of projects in teaching Statistics is more beneficial for the students with a lower mathematical background, than for those students who do not face serious problems with mathematics.

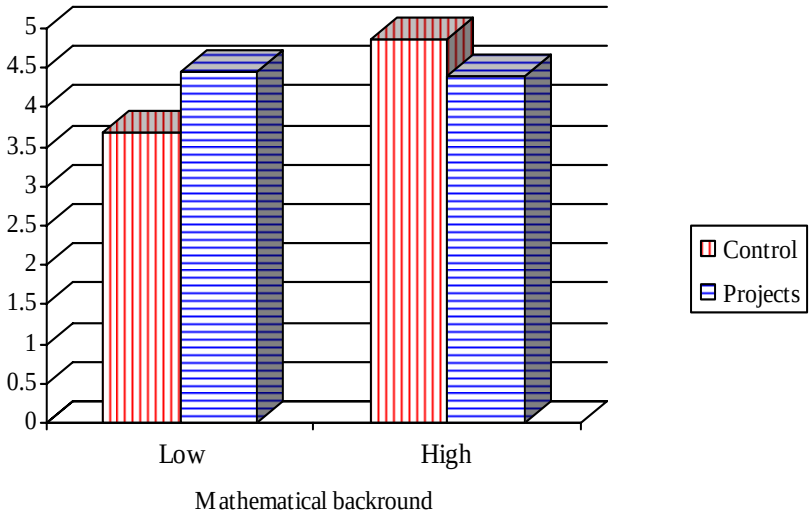

Figure 1: Mean Values of Difficulty Scores

A Firm Grasp of Statistics

It is the impression of the authors of this case study that students in the project based group developed better understanding of the statistical concepts than those in the control group. This was demonstrated by the students' final grades. According to the Greek universities grading system, grades range from 1 (worst grade) to 10 (best grade). The mean values of final grades were 7.08 for the project based group and for 5.82 the control group. The Mann – Whitney comparison showed a significant difference between the two groups ($p = 0.02$). We do not report this result as a proof of the aforementioned impression. It is acknowledged that the assigned grades do not always correspond to the exact level of the grasped knowledge. In addition, the grades were assigned in different ways to the students of each group. The students in the control group were assessed by their performance in the final exams, where they had to deal with a set of questions and exercises. The final grade assigned to students of the project based group was a weighted mean of their written report and oral examinations.

On the other hand, all grades were assigned by the same instructors. Evaluations were objective and based on quantitative criteria. Both groups were examined for their understanding of the same subjects. Thus, the significant difference of the mean grades between the two groups could be used as a supporting indicator of the difference between the two groups with regard to the level and quality of grasped knowledge.

DISCUSSION

The incorporation of projects in Statistics instruction imposes a considerable increase in the amount of time spent by instructors, especially when they have to deal with very large classes. At the same time, instructors also have to deal with organizational problems and issues occurring from limitations in available infrastructures.

On the other hand, as findings of our study indicate, the use of projects offers significant advantages to social sciences students: The procedure helped students to acknowledge the necessity of collecting data in their effort to draw valid conclusions. Their findings helped reject the falsified and validate the correct of their hypotheses about their consuming habits. The request for written reports helped them to further integrate contextual with statistical aspects because the students had to communicate their statistical findings in terms of their characteristics as consumers.

The case study presented here has led to an improvement of students' attitudes towards Statistics. The comparisons between the project based and the control group indicate that students in the former group: a) had more positive feelings concerning statistics, b) scored better at cognitive competence c) believed more in the worth of statistics in personal and professional life, d) showed greater interest for Statistics, e) tried harder to learn Statistics and f) grasped statistical

concepts at a higher rate than students in the control group. As far as the difficulty component is concerned, it seems that the use of projects in teaching Statistics is more beneficial for the students who believe they have lower mathematical background, than for those students who do not face serious problems with mathematics.

There are a lot of alternatives and additions to the program that will assist students to further develop their statistical thinking. Some of them are as follows: a) the use of undirected, unstructured projects aiming to students' more freedom of choice about the subject of the research (Ledolter, 1995), b) requesting students to prepare oral presentations of their results, and c) assigning projects that require random sampling. Regardless of the exact form and details of the incorporation of projects in Statistics instruction, we believe that a similar process will be beneficial for students worldwide. We present this case study in the hope to help other instructors to use projects as part of their Statistics instruction.

Finally, we would like to thank the anonymous referees for their useful comments.

REFERENCES

Binnie, N. (2002). Using projects to encourage statistical thinking. In B. Phillips (Ed.), *Proceedings of the Sixth International Conference on Teaching of Statistics*, Cape Town. Voorburg, The Netherlands: International Statistical Institute.

Chadjipadelis, T. (1998). Statistics in education. A case study (in Greek). *Proceedings of the 13th Conference on Mathematics Education*.

Chadjipadelis, T. (1998). Teaching statistics by research: The organization of a survey. In L. Pereira Mendoza, L. Seu Kea, T. Wee Kee, amd W. Wong (Eds.), *Statistical Education - Expanding the Network: Proceedings of the Fifth International Conference on Teaching Statistics*, Singapore, Vol. 2, (pp. 77-83). Voorburg, The Netherlands: International Statistical Institute.

Chadjipadelis, T. and Gastaris, P. (1995). Difficulties of understanding and misconceptions in Probabilities and in Statistics (in Greek). *Eucledes*, C, 35-68.

Chadjipadelis, T. and Gastaris, P. (1998). Understanding concepts in probability theory (in Greek). *Proceedings of the 13th Conference on Mathematics Education*.

Chadjipadelis, T., Ghinis, D., and Bersimis, S. (2003). Directed projects, an effective way of the educational approach statistics in school. *Proceedings of 3rd Mediterranean Conference On Mathematical Education*, 475-482.

Chadjipadelis, T. and Primerakis, G. (1998). Projects in school (in Greek). *Proceedings of the 13th Conference on Mathematics Education*.

Ghinis, D., Chadjipantelis, T., and Bersimis, S. (2005). Experiences from teaching statistics using directed projects in Greek elementary schools. *Teaching Statistics*, 27, 2-7.

Ledolter, J. (1995). Projects in introductory statistics courses. *American Statistician*, 49, 364-367.

Lovett, M. C. and Greenhouse, J. B. (2000). Applying cognitive theory to statistics instruction. *American Statistician*, 54, 196-206.

Mills, J. D. and Johnson, E. L. (2004). An evaluation of *ActivStats* for *SPSS* for teaching and learning. *American Statistician*, 58, 254-258.

Nolan, D. (2002). Case studies in the mathematical statistics course. In B. Phillips (Ed.), *Proceedings of the Sixth International Conference on Teaching of Statistics*, Cape Town. Voorburg, The Netherlands: International Statistical Institute.

Pfannkuch, M. and Wild, C. J. (2003). Statistical thinking: How can we develop it? *Proceedings of the ISI 54th session*.

Schau, C., Stevens, J., Dauphinee, T. L., and Del Vecchio, A. (1995). The development and validation of the survey of attitudes toward statistics. *Educational and Psychological Measurement*, 55, 868.

Smith, G. (1998). Learning statistics by doing statistics. *Journal of Statistics Education*, 6(3).

Wild, C. J. and Pfannkuch, M. (1999). Statistical thinking in empirical enquiry. *International Statistical Review*, 67, 223-248.