Career Orientation and Training in Statistics for Secondary School Students in Puerto Rico

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1. Introduction

This paper summarises the work done on the National Science Foundation sponsored Young Scholars' Programme on Statistics for secondary school students in Puerto Rico. The project emerged out of the basic idea that statistical analyses would be of most interest to students if they collected the data themselves, with definite research objectives. Because of the abstract nature of concepts as presented in the introductory courses in statistics, most students lose interest and failure rates are generally high. It was also felt that students were unaware of the career possibilities in statistics, causing a general dearth of well-trained statisticians in research and industry.

In this project, thirty top students were selected from the high schools of the western region of Puerto Rico. During a summer camp of six weeks, the students were exposed to the field of statistics through classroom instruction, computer practice, individual projects, and field trips to industries, where they learned about the use of statistics in the real world. Students were also given several conferences in research methodology and ethics. The summer camp had a follow-up programme during the academic year when the students worked on individual research projects under the guidance of mentors who were professors or industry experts. Statistical analyses and inference were made more meaningful to the students by letting them collect their own data of particular interest to them, analyse it, and arrive at proper conclusions. These projects included various themes in science, engineering, and business. This paper reports the outcomes of the project and how the students gained significant knowledge of the use of statistics in research and industry, although they had no prior background in statistics. It is expected that several of these students will pursue their interest in statistics through graduate studies and future careers.

2. Literature review

Several countries are now starting statistical education at the secondary school level. Many papers in the professional journals indicate this trend. Geiger and Wallace (1987) presented activities for teaching statistics in a high school mathematics programme in Australia. Miwa (1986) reported the status of probability and statistics in the current Japanese high school curriculum. Kelly and Beamer (1986) discussed experiences in elementary statistics that involve describing data and instructional strategies that are appropriate to students in secondary schools. Fong et al. (1986) described four experiments showing that statistical training enhanced everyday reasoning.

In the United States of America, the Quantitative Literacy Series (1986) developed by the American Statistical Association (ASA) and the National Council of Teachers of Mathematics (NCTM), introduces concepts of probability, data analysis, survey sampling, and techniques of simulation. The major focus of these series is to develop a programme that can be used by middle and secondary school teachers of mathematics, science, and social sciences for teaching statistical and probabilistic skills to grades K-12.

3. Description of the project

The programme consisted of three phases:

Phase 1 (Pre-summer): The main purpose of this phase was to identify and recruit from the western region of Puerto Rico, a group of thirty talented secondary school students who had at least one year of high school algebra. Some of the activities of Phase 1 included visits to schools to address the students, publicity through the news media, orientation conference for teachers, and a written examination for students.

Phase 2 (Summer): An intensive summer programme of six weeks was offered to immerse the students in activities designed to create interest in the field of statistics. These activities included classroom instruction, problem-solving, computer practice, and field trips to industry. Special conferences were also organised on professional ethics and critical thinking. Experts from industry and academia were invited to give lectures and serve as mentors to students. At the end of the summer, each student chose a project on a real-world problem in consultation with a mentor.

Phase 3 (Follow-up): The third phase consisted of work on research projects during the academic year following the summer programme. Once a month, the students met on a Saturday with their mentors and the project staff who reviewed their progress and gave whatever help was necessary. They also had computer practice in the use of statistical software. The project staff kept in close touch with both the students, their mathematics teachers, and mentors. A Statistics Fair was held at the end of the year where the students presented their projects, and the community was invited to attend.

4. Activities in the project

(i) *Orientation in statistics:* Students participating in the programme did not have any prior knowledge of statistics. They were introduced to statistics with lectures,

problem-solving, video presentations, and computer laboratories. The topics included scope of statistics, types of data, graphical presentation of data, statistical measures, probability, probability distributions, nature of sampling, sampling surveys, estimation, concepts of error, tests of hypotheses, and use of a statistical package on a micro-computer.

(ii) *Training in research methodology:* Training sessions on the utilisation of scientific and general research skills and writing of scientific reports were offered, including conferences by university faculty and researchers. The topics included critical thinking, problem identification and formulation, research proposal development, and fundamentals of experimental design.

(iii) *Career awareness activities:* Career awareness activities were conducted during all the three phases. In Phase 1, project staff coordinated with the Education Department and arranged a conference for the mathematics teachers of schools, at which orientation was given about the young scholars' programme and statistics as a career option for bright young men from their schools.

In Phase 2, a career week was celebrated at the Mayaguez Campus where lectures were given by researchers from industry and educational institutions about real-world research using statistical methods in various fields. Other activities included visits to research laboratories and field trips to industry which provided first-hand experience in understanding the use of statistics.

In Phase 3, the presentation of projects by students in their schools on Statistics Day, and at the Statistics Fair at the Mayaguez Campus, made the role and the career of a statistician clear and interesting to the participants and other students.

(iv) *Philosophy and ethics of science activities:* Lack of professional ethics can adversely affect the government, industry, and the general public. The National Science Foundation was specially interested in including ethics in the programme. Statisticians and researchers also explained the need to be truthful in collecting the data, to check the assumptions made in the analysis of data, and to give correct interpretations of the results. The responsibility of the researchers to the community and humanity in general were emphasised.

(v) *Student research projects:* A few of the more interesting student projects are described below. In one project, the growth of corn was tested at four different levels of nitrogen in an experimental plot at the university. The student used analysis of variance and regression analysis and observed that the diameter of the third node increased and the height of the plant decreased with increased levels of nitrogen. The student determined the optimum level of nitrogen from analysis.

Several students used statistical methods to investigate social problems such as child abuse, mistreatment of the elderly, and the coping strategies of families when caring for children stricken with leukemia. Some interesting observations were that 93% of the parents of children with leukemia coped with the tragedy using religion. Another student concluded that the elderly are rejected in society.

Two projects involved quality control in local industries. The students investigated what defects were most common and which shifts produced defects more frequently. Students also learned about total quality control in industry besides statistical process control. In the area of transportation, one student carried out research into the relationships between highway accident rates and pavement surface characteristics, such as pavement friction.

One student collected data about the incidence of earthquakes in Puerto Rico and other parts of the world, and also conducted a survey about the knowledge of earthquake precautions among students. He found that most people are unaware of safety precautions. He even developed an earthquake alarm to alert people to seismic movements.

(vi) *Project evaluation and outcomes:* The students started with no knowledge of statistics and were not aware of even simple concepts of measures of central tendency or graphical representation of data. At the end of the project year the students' projects demonstrated a good knowledge of basic statistics, use of statistical software on microcomputers, and report writing using graphical outputs. A questionnaire was administered to the students to assess their experience and opinion. More than 95% agreed that the project increased their interest in statistics. About 80% felt that the project stimulated increased interest in research. A high percentage of students said that they would consider studying statistics at graduate level though the majority prefer to study engineering at undergraduate level.

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