AN ASSESSMENT OF THE PACE STRATEGY FOR AN INTRODUCTORY STATISTICS COURSE

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Statistics is considered by many students a difficult and boring subject. In the recent years, educators began to rethink how students learn statistics and how to teach introductory statistics. The PACE approach is among the newly developed approaches developed by the author. PACE stands for projects, activities, class lectures and exercises. The approach begins with in-class hands-on activities and cooperative team work. The class lectures are organized to provide the basic concepts and guide students through the activities using team work and computer to help students understand the concepts and problem-solving strategies. Projects are self-selected by students under some guidance provided by the instructor. Report writing and oral presentation are emphasized. This article reports an assessment of the PACE model applied in an introductory statistics class.

INTRODUCTION

Introductory statistics has often been considered by many students a boring subject. Causes that result this impression are complicated. The traditional lecture and note taking approach is certainly one of the causes as discussed by Hogg and et al.(1992): "*Statistics are seldom designed with any idea of what it is that students are supposed to be able to do as a result of having taken the course.... Statistics is seen as a "subject", rather than a problem solving tool to be used in the scientific method, or a useful way to look at the world around us*". In recent years, statistics educators have been actively rethinking of different ways to teach introductory statistics. The results are very fruitful. It is now accepted that introductory statistics should be taught by using real world data, getting students actively involving in class activities, taking the advantage of computer technology, incorporating team work and projects into the class. Many successful implementations can be found in the literature (e.g., Scheaffer, et al., 1996.) The MAA Notes #26 (edited by Gordon and Gordon, 1992) collected a list of interesting and useful ideas and innovative curricula. Cobb (1993) discussed more than twenty projects supported by the National Science Foundation. The Journal of Statistical Education and the International Statistical Review are two rich resources for issues related to statistical education. Most recently, Moore (with discussants) (1997) gave a thorough discussion on the issues of contents, pedagogy and technology for developing and teaching introductory statistics.

THE PACE MODEL

Many educators pointed out that people learn best by constructing knowledge themselves (e.g., Garfield, 1995.) However, as pointed out by Moore (1997), one must be cautioned on how to apply the constructivism learning theory into teaching. Both radical constructivism (von Glasersfeld, 1995) and social constructivism (Gergen, 1995) do not seem to take into account the fact that learning difficult concepts and new knowledge needs a great deal of instruction, well-designed guidance and practice.

PACE stands for “Projects”, “Activities”, “Cooperative learning”, and “Exercises”. Rationales behind the PACE model are based on the following principles:

- People learn better by constructing knowledge themselves through guided processes.
- Practice and feedback are essential ingredient for sustaining new concepts.
- Active problem-solving in a team work environment promotes active learners.

Each component of the PACE strategy is not new. There have been many developments targeted at a specific component. The PACE strategy attempts to provide a structured framework to integrate projects, hands-on activities that are conducted cooperatively in a computer classroom environment. The paradigm emphasizes:

- actively engaging students in their learning process,
- closely relating statistics as a scientific tool for solving real world problems,
- providing opportunity for students working as a team,
- actively involving students into report writing and oral presentation.

The PACE model intends to integrate the new innovative techniques and to maintain the advantage of the traditional approach of organized structure and reinforcement. This model provides an approach to carry out the three components of content, pedagogy and technology addressed in Moore (1997) for an introductory statistics course.

A typical class begins with an in-class activity, an instruction sheet and a worksheet. Each activity is designed to introduce several new concepts and to review previously learned concepts. Students are guided to conduct the activity, work on the data collected from the activity, two students as a team, in a computer class room. Teams are

randomly selected to present their brief report for discussion. The use of self-selected projects is an important component of the PACE model. The concepts of sampling design, experimental design, two-sample data, categorical data, regression and correlation data are introduced in the very early stage. Students are given an instruction sheet for conducting their projects. They are asked to search for data sets that are resulted from two independent, paired sample experiments, or for regression modeling, respectively. Three reports are required from the project. The first is the description of the data set, data source, experiment and the data type. The second report is the descriptive analysis and graphical presentation. The final report is the analysis of the data using appropriate methods and writing conclusions. A detailed discussion of the implementation is given in Lee (1997).

The author has experimented various hands-on activities and different type of projects. The complete implementation of the PACE model was conducted in the Fall of 1996. The class size was 28. Students were from departments related to science and technology. These students had at least precalculus background with little or no exposure to statistics. Male and female students were about equal. The assessment was conducted using an opinion survey and an interview study. This paper presents the results from the survey.

THE ASSESSMENT OF STUDENTS' LEARNING THROUGH OPINION SURVEY

A survey was conducted during the last day of the class to gather the information about the effectiveness of the PACE model, their understanding of each concept covered in class and the effectiveness of using computer. The survey is summarized into the following tables.

Table One indicates that students liked the approach well. The use of computer, projects, lab problems, and in-class activities received overwhelmed satisfaction from students. The computer room did not have enough space for note taking. Students sat on the back usually were blocked by the monitors. This made it difficult for discussion. Computer technology is a necessary tool in the PACE model. A mobile computer lab will solve the problem faced in a typical computer lab. Graphing calculator is another alternative. The cost and portability of graphing calculators seem to make it more suitable for large class sizes. Table Two indicates that students enjoyed hands-on activities, and were asking for more. However, students also felt that there were too many topics covered

and too much home work and labs were assigned (approximately 20%). In general, these activities were well accepted by majority of students as “Just-Right”.

Table 1. Degree of Satisfaction for Activities Used in the Class

	Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
Use of computer for data analysis	9(34.6)	14(53.9)	1(3.8)	2(7.7)	0
Projects and Lab problems	13(50.0)	10(38.5)	1(3.8)	2(7.7)	0
In-class Hands-on activities	11(42.3)	12(46.2)	3(11.5)	0	0
Computer room set up for lecture	3(11.5)	4(15.4)	7(26.9)	8(30.8)	4(15.4)

Table 2. The Adequacy of Each of the Activities in the Class

	Too Much	Just Right	Too Little
Computer Work	3(11.5)	23(88.5)	0
Topics Covered	6(23.1)	18(69.2)	2(7.7)
Hands-on Activities	0	20(76.9)	6(23.1)
Home Works and Labs	5(19.2)	20(76.9)	1(3.9)
Number of Tests	0	17(65.4)	9(34.6)

Table Three gives students’ opinions on how effective of various methods for learning data analysis using computer and writing reports. The methods used in this class were “integrating computer and lecture” and “using cooperative team work for in-class activities”. This two methods were well accepted as effective methods. “A separate course pack for software and report writing” was considered the most effective by students. On the other hand, students did not seem to favor a separate lab approach neither cooperative team work for large real world projects. Reasons that students did not favor these two methods may be because that extra lab and team work for large projects require either more scheduled class hours or extra meeting time with team members. In summary, a combination of integrated lecture with computer work and team work for in-class activities conducted in a mobile computer lab environment plus a separate course pack for computer software and reporting writing will improve the PACE model.

Table 3. The Effectiveness of the Methods for Analyzing Data and Report Writing

	Most Effective	Effective	Less Effective	Not Even Try It
A separate extra two hours of lab time	6(23.1)	11(42.3)	6(23.1)	3(11.5)
Better computer lab setup for note taking and lecturing	14(53.9)	8(30.8)	1(3.8)	3(11.5)
A separate course pack for the software and report writing	12(46.2)	12(46.2)	2(7.7)	0
An integrated lecture with computer work and lecture	7(26.9)	13(50.0)	4(15.4)	2(7.7)
Separating lecture and lab activities without extra hours	3(11.5)	11(42.3)	11(42.3)	1(3.9)
Cooperative team work for in-class activities	7(26.9)	14(53.9)	2(7.7)	3(11.5)
Cooperative team work for large real world projects	8(30.8)	8(30.8)	7(26.9)	3(11.5)

Table Four indicates that students seemed to think they understood most of the concepts well. While approximately a quarter of the class felt they did not understand well on probability, discrete distribution, central limit theorem, estimation and regression. When students were asked about how well can they learn without computer, students seemed to agree that most of the concepts are better learned by the assistance of computer. The exceptions were probability, discrete distribution and Central Limit Theorem. Students did not seem to think the computer simulation to demonstrate the Central Limit Theorem provided was of a great help in understanding this theorem.

Table 4. Level of Understanding the Concepts Using the PACE Model With/Without Computer

	Understanding the Topics				How Well can You Learn, if Without Computer				
TOPIC	Great Deal	Good	Poor	Lost	Much More	More	The Same	Less	Much Less
Descriptive/ Graphical Methods	6 (27.3)	16 (72.7)	0	0	0	2 (9.1)	0	7 (31.8)	13 (59.1)
Probability and Counting Rules	6 (27.3)	10 (45.4)	6 (27.3)	0	1 (4.5)	0	15 (68.2)	3 (13.6)	3 (13.6)
Discrete Distributions	5 (22.7)	12 (54.6)	5 (22.7)	0	1 (4.5)	0	9 (40.9)	9 (40.9)	3 (13.6)
Normal Distribution	7 (31.8)	14 (63.6)	1 (4.6)	0	1 (4.5)	0	6 (27.3)	10 (45.5)	5 (22.7)
Sampling Distribution Of Sample Mean	5 (22.7)	16 (72.7)	1 (4.6)	0	0	1 (4.5)	5 (22.7)	13 (59.1)	3 (13.6)
Central Limit Theorem	2 (9.1)	16 (72.7)	2 (9.1)	2 (9.1)	1 (4.5)	0	12 (54.5)	6 (27.3)	3 (13.6)
Point/Interval Estimation	2 (9.1)	13 (59.1)	5 (22.7)	2 (9.1)	0	1 (4.5)	6 (27.3)	12 (54.5)	3 (13.6)
On-sample Test	7 (31.8)	14 (63.6)	1 (4.5)	0	0	1 (4.5)	4 (18.2)	9 (40.9)	8 (36.4)
Two Independent Sample Test	6 (27.3)	15 (68.2)	1 (4.5)	0	0	1 (4.5)	4 (18.2)	9 (40.9)	8 (36.4)
Paired Test	4 (18.2)	14 (63.6)	4 (18.2)	0	0	1 (4.5)	4 (18.2)	8 (36.4)	9 (40.9)
Correlation	5 (22.7)	15 (68.2)	2 (9.1)	0	0	1 (4.5)	0	11 (50.0)	10 (45.5)
Regression Modeling	6 (27.3)	11 (50.0)	5 (22.7)	0	0	0	1 (4.5)	10 (45.5)	11 (50.0)
Statistical Software	7 (31.8)	13 (59.1)	1 (4.5)	1 (4.5)	0	0	0	2 (9.1)	20 (90.9)
Integrating Graphs, Tables into Reports	13 (59.1)	8 (36.4)	1 (4.5)	0	0	0	2 (9.1)	2 (9.1)	18 (81.8)

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