LEARNING STATISTICS IN A TECHNOLOGICAL ENVIRONMENT[1]

DANI BEN-ZVI

WORKING DRAFT

Department of Science Teaching, *The Weizmann Institute of Science*

P.O. Box 26, Rehovot 76100, Israel

1. INTRODUCTION

In the past decade, topics in data handling have begun to play a more prominent role in mathematics curricula in many countries (Shaughnessy, et al. 1996). The emphasis now is on organization, description, representations, and the analysis of data, with a considerable use of visual displays and, in many cases, technology. Roughly the approach can be summarized by the slogans (Curcio, 1987; Shaughnessy et al., 1996) - *look at the data* (preliminary analysis), *look between the data* (comparisons), *look beyond the data* (inference) and *look behind the data* (context). Thus, data handling in the curriculum has become an approach to dealing with data, a frame of mind, an environment within which the student explores data - not just specific statistical knowledge.

Computers, graphing calculators and the World Wide Web have also entered the mathematics classroom. A technological learning environment can have considerable impact on the statistics curriculum, allowing one to stress conceptual understanding, mathematical modeling, problem solving, real-world applications, multiple representations and new methods of analyzing data (Hawkins et al., 1992; NCTM, 1989).

With a computer, the technical aspects of computation and graph drawing become relatively trivial. The students can pursue investigations, can be made less reliant on the teacher, can cooperate with fellow students, and can be provided with feedback on progress. Thus students can take a more active role in their own learning, by asking their own questions and exploring various avenues to solve them (Heid, 1995) . On the other hand, when students begin an investigation by familiarizing themselves with the problem, posing a question, and collecting data, they are unlikely to predict any obstacles, such as wrong data type, missing variables, or tabulating difficulties and have to learn to evaluate progress and to persevere (Hancock et al., 1992) . This accustoms them to the faculty of working in conditions of uncertainty.

2. THE STATISTICS PROJECT

We have developed a statistics curriculum for middle school (grades 7-9), using an interactive computerized environment. The development is accompanied by classroom implementation and teacher courses, as well as research on learning processes and the role of teacher and student in the new environment.

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[1] Ben-Zvi, D. (1997). Learning statistics in a technological environment. *Proceedings of the 51st Session of the International Statistical Institute, I*, 411–415. Ankara, Turkey: State Institute of Statistics.

The instructional activities (Ben-Zvi & Friedlander, 1997) aim to promote the meaningful learning of statistics, through the investigation of open-ended situations using spreadsheets. Students are encouraged to develop intuitive statistical thinking, to collect and interpret their own data. A similar approach is reported in Graham (1987) and Green & Graham (1994). In all three projects the core concept of the curriculum is based on the PCAI cycle - *pose the question and produce an hypothesis, collect the data, analyze the results, interpret the results* - see figure 1.

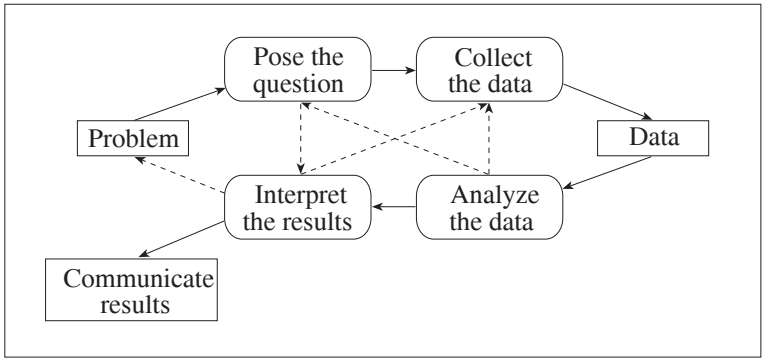

Figure 1: The PCAIC cycle for statistical investigation.

(Dotted arrows illustrate possible research paths.)

Data handling is introduced as "mathematical detective work", in which the student is expected to:

- become familiar with the problem, identify research questions and hypothesize possible outcomes;
- collect, organize, describe, and interpret data;
- construct, read, and interpret displays of data;
- develop a critical attitude towards data;
- make inferences and arguments based on data handling;
- use curve fitting to predict from data;
- understand and apply measures of central tendency, variability and correlation.

Our statistics curriculum combines two parallel strands:

(a) concept learning through a sequence of *structured activities* ("basic concepts and skills");

(b) a *research project* ("free enterprise").

(a) *Structured activities*

Each activity is based on an open-ended problem situation, investigated by students in a complete PCAI cycle. The situations focus on topics close to the students' world (sports,

weather, people's names, salaries, cars, etc.), and provide the background for statistical concepts and methods. In most cases the data is presented (as opposed to being collected by the students) in spreadsheet format. Statistical concepts include types of data, critical issues in posing questions and collecting data, statistical measures, graphical representations and their manipulation, and intuitive notions of inference and correlation.

In the investigations the students are encouraged to pose their own research questions, and choose tools and methods of inquiry, representations, conclusions, and interpretation of results. Most learning is collaborative in pairs, and students get assistance from fellow students, as well as from the teacher. The role of the teacher is to introduce the investigation, to foster communication among groups, to raise questions, to encourage thinking, to guide the students through technical and conceptual difficulties, and to conduct the summary discussion. The activities are interspersed with more traditional class work, designed to reinforce statistical concepts.

To illustrate the structure of an activity, I describe briefly one example - the '*Work Dispute*' - in a printing company. The workers are in dispute with the management, who has agreed so far to a total increase in the salary bill of 10 percent. How this is to be divided among the employees is a complicated problem - and thereby hangs the dispute. The students are given the salary list of the company's one hundred employees, and an instruction booklet to guide them in their work. They are also provided with information about average and minimum salaries in Israel, Internet sites to look for data on salaries, newspaper articles about work disputes and strikes, and a reading list of background material. In the first part of the activity, students are required to take sides in the debate, and to clarify their arguments. Then, using the computer, they describe the distribution of salaries and use central tendency measures, guided by the position they have adopted in the dispute. The students learn the effects of grouping data and the different uses of averages in arguing their case. In the third part, the students suggest alterations to the salary structure without exceeding the 10 percent limit. They produce their proposal to solve the dispute, and design representations to support their position. Finally the class meets for a general debate and votes for the winning proposal. Thus, throughout this extended activity, students are immersed in complex cognitive processes: problem solving with a 'purpose' in a realistic conflict, decision making and communication.

(b) *Research project*

The research project is an extended activity, also performed in small groups. Students identify a problem and the question they wish to investigate, suggest hypotheses, design the study, collect and analyze data, interpret the results and draw conclusions. At the end they submit a written report and present their main conclusions and results to fellow students and parents in a "statistical happening". The teacher schedules dates for each stage, guides the students individually to scaffold their knowledge, and actively supports and assesses student progress. Some of the topics students have chosen to investigate are: *superstitions among students, attendance at football games, student ability and the use of Internet, students' birth month, formal education of students' parents and grandparents, road accidents in Israel.*

The structured activities supply the basic statistical concepts and skills needed for the project design, and introduce students to the PCAI cycle, the computerized tools, and methods of investigation. On the other hand, the project work motivates the students to become responsible for the construction of their knowledge and methods of inquiry, and affects them with a sense of relevancy, enthusiasm, and ownership.

3. FEEDBACK (PRELIMINARY RESEARCH)

During the first three years of experimental implementation, the teaching materials were field-tested in a number of schools, presented in in-service courses, and then published. In order to study the effects of the new curriculum, we have analyzed video recordings, classroom notes, student and teacher interviews, and projects. In general there is considerable evidence that students become aware of the role of statistics in society, the power of statistical thought, and the use of statistical methods for decision making.

In my talk I shall consider the following cognitive aspects of the learning environment, obtained from our analysis of student activity.

(a) *Patterns of student statistical thinking in a technological environment*

We observed the following statistical thinking modes (Ben-Zvi & Friedlander, 1996) :

Uncritical thinking, in which the technological power and statistical methods are used randomly rather than "targeted".

Meaningful use of a representation, in which students use an appropriate graphical representation or measure, can explain their choice, and are able to perform modifications and transformations of the representation, in order to answer and justify their research questions and interpret their results.

Meaningful handling of multiple representations, in which students are involved in an ongoing search for meaning and interpretation to achieve sensible results, and in monitoring their processes. They make decisions in selecting graphs and measures, consider their contribution to the research questions, and make corresponding changes in the data analysis.

Creative thinking, in which students decide that an uncommon method would best express their thoughts, and they manage to produce an innovative graphical representation, or self-invented measure, or method of analysis.

(b) *Integration of data handling into the mathematics curriculum.*

Algebra and data handling can be linked beneficially in the mathematics curriculum. Some of the students we observed, also used spreadsheets in their algebra studies, to explore patterns, to generalize, to model mathematical problems, to create and use formulae, and to draw graphs. The use of spreadsheets in an exploratory learning environment, in both algebra and statistics, allows them to shift, albeit with some difficulty at first, from the precision of mathematical models to the exploratory nature of statistical reasoning and modeling. Data handling can also enrich the algebra studies with its investigative approach.

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SUMMARY

Recent developments in technology, including graphing calculators and statistics software packages, have the potential to transform the data handling curriculum, and how it is taught. We describe a middle school statistics curriculum, based on the PCAI cycle (*pose*, *collect*, *analyze*, and *interpret*) , and the use of a spreadsheets. It consists of two strands - structured activities and a research project. We report on several aspects of the learning environment, such as patterns of student statistical thinking in a technological environment, and data handling as part of the mathematics curriculum.

RÉSUMÉ

Certains dévelopements récents liés à la technologie comme les calculateurs graphiques ou les logiciels statistiques, sont suceptibles de transformer le curriculum sur la manipulation de données et la manière de l'enseigner. Nous décrivons ici un curriculum pour école secondaire (pour la quatrième et la troisième) qui est basé sur le cycle "PCAI" (*poser le problem, collection de données, analyse des données, et interprétation*) et sur l'usage d'un tableur. Ce curriculum comprend des activités structurées et un projet d'équipe. Des résultats preliminaires sur l'environnement sont rapportés. Nous décrivons en particulier certains modèles de raisonnement statistique, et l'intégration d'activités qui relèvent de la manipulation de données dans le curriculum général de mathématiques.