AN ELECTRONIC LEARNING ENVIRONMENT FOR APPLIED STATISTICS: QUALITY CARE AND STATISTICS EDUCATION IN HIGHER EDUCATION

Gilberte Schuyten and Hannelore Dekeyser,
Department of Data-Analysis, University of Gent, Belgium

In response to calls for 'Innovation in Higher Education' from the Flemish Community in Belgium, an innovative course 'ILO' is being developed as an alternative approach to traditional introductory statistics courses. It is a cooperative project of the universities of Gent, Leuven and Brussel. The innovative course is characterized by: independent learning, adaptation of the delivered materials to student profiles, multi-media approach and flexible functionality (applicable to different phases of the curriculum). Preparatory studies leading to this innovative course concept are presented.

INTRODUCTION

Teaching statistics in social sciences is determined by the characteristics of a very specific student population: (often very large) groups of students with very heterogeneous prior knowledge, motivation and preference for mode of representation of information (verbal, graphic or symbolic) (Schuyten, 1991). In higher level courses they often feel they lack ability to use the knowledge they learned in the lower level courses. The efficiency of lectures addressing these heterogeneous and large groups is questionable. In order to determine critical variables affecting the quality of learning statistics in social sciences and to construct an alternative approach that meets the specific needs of this student population, several studies were set up. These preparatory studies are grounded on the movement of 'Quality care' and the current reform of Statistics Education.

QUALITY CARE

Nowadays academic quality is a very strong issue. The movement started as 'Total Quality Management' (TQM) in industry and found its way to social services such as health care and education. TQM is primarily concerned with increasing customer satisfaction through an integrated framework that examines the relationships between various systemwide elements and makes data-driven decisions to reduce errors and waste in processes (Hogg et al., 1995, p. 35). Translated to education in Belgium and The Netherlands 'Quality Care' is the systematic, structured attention for quality oriented toward maintenance and improvement of quality. Instruments used are 'Visitation commissions' for extern quality care and 'Self studies' for intern quality care (Gids voor

Onderwijsvisitaties, 1995, p.6). In this context of quality care the Flemish Community of Belgium launched a program 'Innovation in Higher Education' stressing the implementation of methods and techniques from open and distance learning into traditional education and in particular the role of new technologies and electronic devices.

REFORM IN STATISTICS EDUCATION

The current reform effort in statistics education is influenced by the reform in mathematics education, the role of mathematical probability and the role of technology. According to Vere-Jones (1995) and Moore (1997) the *democratization of mathematics* is an element for the changing context in which statistics education takes place. In Belgium the recent Standards for mathematics (so-called Final Terms) express a change of culture toward functionality of mathematics, emphasizing the ability to use mathematics. I agree with David Moore when he states "They (the reformers) offer pedagogical reasons, but they are also responding to the pressures of democratization" (Moore, 1997, p. 124). The recommendations given by the joint curriculum committee of the American Statistical Association (ASA) and the Mathematical Association of America (MAA) are clear: "Emphasize the elements of statistical thinking by coring on data and variability, incorporate more data and concepts, fewer recipes and derivations, wherever possible automate computations and graphics."(Moore, 1997, p.127) The role of mathematical probability is more and more questioned (Schuyten, 1991).

Contents as well as didactics might be affected by using new *technologies*. Technology enables exploratory data analysis, simulation as an alternative to formal treatment, 'doing statistics' with statistical software. Multiple representations can be linked and translations can be stimulated. Multi-media systems may enable active independent learning tailored to student needs.

RESEARCH FINDINGS

Based on the main ideas of quality care and reform in statistics education a series of studies is set up in order to elaborate guidelines for an innovative approach for statistical education for students in social sciences. These studies focus the legitimization of implementing methods from open and distance learning (independent learning and a technology based *delivery mode*), detection of *characteristics of students* in the social

sciences relevant for teaching statistics and *democratization* of statistics (competent users).

DELIVERY MODE

Two central issues are addressed in this study: the legitimization of implementing independent learning in traditional university lecture sessions and the legitimization of providing this independent learning by means of an electronic interactive learning environment (ILE). The target group contains students enrolled in an applied statistics course at the department of Psychology and Educational Sciences at the University of Gent. Two experimental variables resulted in three treatment conditions: an electronic based independent learning condition, a paper based independent learning condition and a lecture (control) condition. Although study outcomes are expected to be higher in the independent learning conditions, no significant differences are found. Students in the independent learning modes report a better-perceived structure in the materials, but all students prefer traditional lectures. Students report the need of social contact with peers or tutors. Since the two independent learning conditions -computer and paper delivered- showed no significant differences on study outcomes, it seems to be justified to deliver the materials electronically.

STUDENT CHARACTERISTICS

In order to detect student characteristics that could be relevant for student profiles several variables are investigated. This study reveals some significant effects of following variables on cognitive and affective learning outcomes: prior knowledge (positive relation with cognitive outcomes), student perception of mathematical knowledge, attitudes toward statistics and attitude toward computers (positive relation with perception of structure in the materials). No impact of affective student characteristics on cognitive learning outcomes can be observed in this study.

Specific attention is given to the student characteristic ‘Preference for a representation system’ and ‘Frequency of use of a mode of representation’. Compared to other courses at the department of social sciences statistics courses rely more on graphical and symbolical representations. Unfortunately a large part of this population prefers verbal information. Several authors conclude (Wetzel et al., 1994) that “learner skills interact with the task and the coding forms of the content”. If preference for a

representational system really matters the electronic learning environment should meet this student differences. Comparison of Verbal and Non Verbal Students (Vs and NVs) reveals the following relations. NVs received more mathematics during the last year of secondary school, they perceive themselves as being good in math, they report having no problems with statistics (measured before the start of the course) and have higher scores on the final statistics exam. Their prior knowledge is better and they have a more positive cognitive and behavioral attitude toward computers. Students not only differ in preference but also in handling and processing information represented in different representation systems. Frequency of use of verbal and non-verbal support devices is observed in log-files of 80 students working in the electronic environment condition of the first study. Preference of a mode is linked to frequency of use of support devices of that type in a subtle way: NVs consult fewer support devices represented in graphical mode, more support devices represented in symbolic mode and equally many support devices represented in Verbal mode. Vs benefit from intensifying their action on support devices that deal with tables and graphs with calculations. The quantity of their learning act seems to compensate for the quality. NVs interact with support devices in a more effective way, one consultation seems to be sufficient. They are more selective in choosing the support devices. Empirical evidence is given that the opportunity to use a variety of support devices, to choose between verbal, graphical and symbolical representation is effective for instruction. It seems that cognitive differences are compensated through different interaction with support devices, especially when the learning contents become more difficult and complex. Forcing students to use the same learning environment, the same learning materials obstruct this compensation A second finding is that NVs perform better. A rich variety of support devices might provide stimuli for Vs to use non-verbal representation of information instead of sticking to the verbal level. In order to control whether preference for non-verbal information is not merely an indicator of higher intelligence and therefore a stable trait, the changeability of this characteristic is investigated. A comparison of ‘Preference’ measured at the start and the end of the academic year showed a spontaneous change during this first year course and suggest that ‘Preference for representation system’ is trainable. (Dekeyser, 1997). It also fostered the idea of multiple processing of different representation systems and the importance of stimulating this multiple processing in order to compensate for the possible negative impact of preference for verbal information on learning outcomes.

DEMOCRATIZATION

The next group of studies focuses on the added value of standard scientific computer packages for affection (e.g. motivation toward doing scientific research) and cognition (learning and doing statistics) (Schuyten and Dekeyser, 1997). SPSS offers the possibility to make the course more data-driven and to core on data and variability. Students' views on the impact of the computer package on cognition and affection are collected with a structured questionnaire after an introductory course in working with SPSS. Although a starter questionnaire revealed that the motivation for the study of social sciences is more based on 'helping people' than on 'doing scientific research' we expected a positive change for 'doing scientific research' because of working with SPSS on their own data. The results were disappointing, SPSS was not beneficial to change student attitude toward statistics, self-confidence in doing statistics and interest in quantitative research. For cognitive aspects the findings were more promising. Students perceive SPSS as having a positive impact on understanding statistical concepts. SPSS promotes understanding of the following concepts: data matrix, frequency tables, histogram and variable and the understanding of research questions. Students perceive SPSS as a valuable asset for learning statistics. Student opinion concerning the impact of SPSS on doing statistics is also positive. The conclusion of this study is that a statistical computer package supports the component mental activities of statistical thinking. The results concerning enhancing intrinsic motivation are not encouraging. Working with self-made data helps, but confidence is not enhanced and attitude toward quantitative research has not been influenced in a positive way. It seems that more project-like work has a better impact on their attitude toward scientific quantitative research. A last series of observations focused the impact of project-like work on affective attitude towards statistics and 'doing statistical research'. These observation took place in an experimental implementation of research projects in a third year course, while working in small groups on real (not only realistic) and content-relevant data. From informal contacts with students and evaluation sessions at the end of the projects some evidence is given that this project-like work has a positive impact on self-confidence, function of statistics in student curriculum, attitude toward research, attitude toward statistics.

CONCLUSION

The studies give evidence that an electronic based independent learning environment can take its place in a traditional university setting. A reasonable mix of methods of distance education and traditional methods is justified, combining methods of independent learning (electronic or paper-based) with 'contact methods' such as lectures, workshops, seminars, projects, etc. The studies also contribute to detect student characteristics that are important to take into account in student profiles: prior knowledge, cognitive aspect of attitude toward computer and preference of mode of representation. In constructing an electronic learning environment such as ILO, the following attributes have to be taken into account. Information has to be represented in different representational systems, the learning path has to be tailored to students' needs and in order to stimulate students' cognitive functioning toward the symbolic level multiple processing of symbolic, graphical and verbal information should be encouraged.

REFERENCES

Dekeyser, H. (1997). Preference for verbal, graphic and symbolic information processing, Paper presented at the AERA-symposium on 'Learning strategies: person or context bound?', Chicago

Gids voor Onderwijsvisitaties (1995). Vereniging van Samenwerkende Nederlandse Universiteiten, Utrecht

Hogg, R.V. and Hogg, M.C. (1995). Continuous Quality Improvement in Higher Education, in: International Statistical Review, 1995, 63,1,p.35-48

Moore, D.S. (1997). New pedagogy and new content: the case of statistics. *International Statistical Review, 65*, 2,123-165

Schuyten, G. (1991). Statistical Thinking in Psychology and Education. In D. Vere-Jones (Ed.), *Proceedings of the Third International Conference on Teaching Statistics (ICOTS), Vol. 2, Teaching Statistics beyond School level*, ISI, Publications in Statistical Education, Voorburg, The Netherlands, 486-490.

Schuyten, G. and Dekeyser, H. (1997). Computer software in Statistics Education: Student Views on the impact of a computer package on affection and cognition, in: Garfield J. B. and Burrill G. (Eds.*), Research on the role of Technology in Teaching and Learning Statistics*, ISI, Voorburg, The Netherlands, 207-217

Vere-Jones, D (1995), The coming of age of statistical education. *International Statistical Review 63*, 3-23.