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The Evaluation of Group Paced Audio Visual Structured Problem Solving Tutorials in Basic Statistics.

by
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PROGRAMMING METHODS

In the present experiment the Basic Statistics subject (STAT S 1013/ QUAN B 1013) was divided into ten major topics each being in turn divided into two or three sub-topics. A problem appropriate to each of the main sub-topics was selected and scripted by writing a linear programme.

The word 'programming' suggests the small step, verbal, Skinner-type frames found in many programmed texts. These are generally trivial and boring; at worst consisting of a series of sentences, each with a key word missing, that word then being printed immediately below.

Following the style of Le Marne (1972), the present scripts were not programmed in the above sense, but rather structured in a manner suggested by the systematic analysis of problem solving skills. Reference was made to standard texts on programming methods (Austwick, 1964; Leith, 1966); but the most valuable sources proved to be a study by McIntyre (1966) and a review paper by Leith (1969). These suggested that the important characteristics of programming were:

(i) the detailed definition of objectives;
(ii) the logical sequencing of material;
(iii) the provision of mechanisms for active student response;
(iv) the reinforcement of correct responses by stating correct results as soon as possible.

Experience suggested that the decomposition of problems in this fashion was an appropriate teaching strategy as it follows normal classroom teaching methods. Each problem to be dealt with in a tutorial was broken down into the following steps:

(a) the reading and comprehension of the problem statement;
(b) the organisation of the data, and the construction of a suitable diagram or table;
(c) the recalling of relevant formulae and principles;
(d) the logical combination of selected formulae and principles in a manner likely to lead to a solution;

(e) the recall of any necessary mathematical skills;
(f) the calculation of a result;
(g) the consideration of the reasonableness, significance and application of the result.

On this basis a series of questions and answers were written designed to lead students step by step to the solution of each problem, and some discussion and revision material was added at crucial points. While keeping in mind the desirability of achieving a high correct response rate, an attempt was made to ensure that individual question frames were sufficiently challenging to maintain student interest. Some questions were designed for quick answers (a few seconds) and others for more lengthy calculations (a few minutes). Frames likely to take longer than this to answer were avoided so as to minimize waiting times by the faster workers in a group.

Each step was fully explained in the answer frames, so that failure on one question frame was unlikely to lead to failure in the next.

In general, the scripts did not require students to suggest a strategy for solution at the beginning of each problem. Usually this was stated by the programme, the intention being to teach by example the types of steps necessary to arrive at a satisfactory solution. For example the tutorials revealed that a few of the students had previously realised the importance of abstracting a data summary, diagram, or table from the problem statement.

The scripts were designed to help students to familiarise themselves with the structure and applicability of the formulae, to understand the basic principles of elementary statistics, and to develop mathematical skills.

SELECTION OF EXPERIMENTAL AND CONTROL GROUPS

Approximately 120 students enrolled in the Basic Statistics subject at Riverina College of Advanced Education in Autumn Semester 1974. The study was confined to students similar in past and current learning experiences by selecting experimental and control groups from those who had sat for the N.S.W. Higher School Certificate in 1973. Random stratified sampling yielded E and C groups each of 19 members which did not differ significantly in mean scores in either H.S.C. Mathematics or H.S.C. aggregates (scaled best 5 matriculation subjects).

The correlation between H.S.C. Mathematics scores and total scores on two examinations in the Statistics subject was later found to be 0.56. This is significant at the 0.01 level, supporting the stratification of the population according to H.S.C. results.

EXPERIMENTAL PROCEDURES

All students in Basic Statistics attended one hour per week of explanatory lecture and were set a programmed text ("Statistics" by Donald J. Koosis, Wiley & Sons, Sydney 1972).

In addition, experimental group students attended 2 hours per week of the special audio visual (A–V) structured problem solving tutorials, while the control group students attended normal problem solving tutorials conducted by lecturers and tutors. Both the E and C groups were subject to the same subject assessment and attendance requirements throughout the semester, these requirements having been established by the Statistics lecturers independently of the experimenters.

Tutorial attendance was compulsory for all full-time, on-campus students regardless of whether they had been allocated to ordinary or to A–V classes. There was a 97 percent attendance rate by the E group members with no individual missing more than two sessions in all.

Students other than those in the E and C groups attended both types of tutorials as blinds and no student was informed either of the composition of the E and C groups or of selection criteria. In conventional tutorials, students attempted problems under the guidance of a tutor who provided assistance when asked, and provided solutions at the end of each session. Students in the A–V tutorials completed two programmes during each weekly session. For the first three weeks of a semester a tutor supervised the A–V tutorials to introduce students to the equipment and to the programming style, as well as to resolve any difficulties with terminology and conventions.

During the remainder of the semester a tutor was present briefly before each A–V session to distribute problem sheets, and afterwards to answer students' questions. He also visited the tutorial room occasionally to check that the equipment was functioning satisfactorily. Otherwise, A–V classes worked unsupervised, the pace being determined by the group.

The hardware of the system and the electronic control circuits have been described in detail in a Report to the Commission on Advanced Education (Le Marne, Stephens and Wheeler, 1975).

EVALUATION

A. Sources of Data

The effectiveness of the tutorial course was evaluated by comparing the E and C groups on the basis of:

(i) scores in the two subject examinations in Statistics;
(ii) responses to attitude questionnaires on:
  a. attitudes towards the study of Statistics and
  b. attitudes towards the solving of Statistics problems;
(iii) replies to a questionnaire designed to test confidence in attempting Statistics examinations. This was based on a standard college anxiety questionnaire.

An additional questionnarie was completed by students who had received the audio-visual tutorials to obtain their comments on these teaching methods.

Copies of the above measuring instrument have been included as Appendices B, C, D, E and F to the Report to the Commission on Advanced Education (1975).

The two subject examinations were of the unseen, open-book type, and were set and marked by the subject lecturers. The scores in take-home assignments were not used in the analysis because of observed student collaboration.

The questionnaire designed to compare the attitudes of the E and C groups towards the study of Statistics and the solving of Statistics problems, was designed along the lines described by Mackay (1970). This questionnaire included 10 questions relating to each attitude, 5 expressing a positive attitude and 5 expressing a negative attitude in each case. Some distractor questions were included in random order.

B. Results

(i) Comparisons of Examination Performance.

The results revealed no significant differences between the mean scores of the E and C groups in the first examination; in the second examination; or in the aggregates of the two examinations. Similarly, no signficant differences were detected for major sub-groups, and analysis revealed no significant difference between the E and C groups in the mean gains in scores between the first examination and the second.

(ii) Comparison of Responses to the Attitude Questionnaire.

Scores on this questionnaire revealed no significant differences between the E and C groups in either their attitudes to solving Statistics problems, or their attitudes to the study of Statistics, and no significant differences were detected for major sub-groups.

(iii) Comparisons of Tests of Confidence in Attempting Statistics Examinations.

No significant differences were detected between E and C groups in confidence in attempting Statistics examinations.

(iv) A–V Tutorial Questionnaire

Of the students who have received the A–V tutorials:

a. 73% thought that the tutorials would most benefit students of average general ability;
b. 58% considered that the tutorials would most benefit students of average mathematical ability;
c. 88% stated that they enjoyed the tutorials;
d. 90% stated that they preferred the tutorials to any other type;
e. 75% regarded the pace of the tutorials to be about right;
f. 98% rated the problem selected to be about right in difficulty;
g. 95% stated that they would prefer the tutorials to working through the same material arranged as a programmed textbook;

h. 71% believed that the tutorials should be offered throughout the entire Statistics course.

OBSERVATIONS

In general student reaction to the A–V tutorials was observed to be very favourable. Students reported that:

a. they maintained a high level of concentration throughout each session, they worked hard, and the time seemed to pass easily and quickly;
b. they appreciated the A–V presentation as opposed to ordinary teaching styles for the interest it created, for the activity and involvement it demanded, and for the opportunity to work at their own pace (it was remarked that these factors assisted motivation in a subject normally considered by many to be dull);
c. they considered the A–V tutorials to be more interesting and comprehensible than either programmed texts or live tutorials;
d. they appreciated the structured problem solving style and the increased understanding produced by its step by step explanations;
e. they gained confidence in problem solving by actively working through problems, and they favoured the assurance that the set problems would be completely solved during a given tutorial session (these features were commended mainly by students possessing low mathematical ability and/or confidence);
f. they perceived the A–V tutorials as being structured more logically, and as involving much less digression than "live" problem solving tutorials (this comment was made by members of a part-time "live" tutorial group after being given a trial A–V tutorial session).

Whereas early in the semester students appeared to compete to be first to press their "ready" button, later in the semester increasing amounts of co-operation and discussion were evident within the groups.

The desired homogeneity of groups with respect to ability was not attained due to difficulties caused by student timetable commitments and by the small size of the E group. It was difficult to re-allocate students to different tutorial times, and impractical to conduct a large number of small homogeneous classes, hence the slower students in each group found the pace a little fast while the faster one thought that the pace was too slow. However these difficulties tended to be reduced as co-operation and discussion habits developed during the semester, the faster workers coming to tolerate delays and the slower ones benefitting from discussions.

Some students complained that particular question frames were too simple. This could have been overcome by modifying the scripts and by streaming the students into homogeneous groups.

Initially some students attempted to proceed quickly through the programme without making the required responses. However they quickly modified their behaviour when they realised that the programme would advance only after 70% of the class had responded.

It became very obvious to some students that on certain types of question frame they were much slower than their peers, and this was equally obvious to any tutor present. This capacity to highlight areas of student weakness suggests that the system would be very useful for diagnostic purposes.

INTERPRETATION OF RESULTS.

A. General

In interpreting the comparisons of performances and attitudes between E and C groups it should be noted that the analysis assumed simple random sampling rather than the stratified random sampling actually used. This was necessary since the samples consisted of almost all of the available population. Hence a stratified sampling analysis, with its smaller variance could not be used. However any error made would be on the side of conservatism, since stratification in sampling tends to narrow the distribution of sample means.

In addition, sample groups and sub-groups were unavoidably small, thus necessitating the use of t-tests even though the various populations of scores may not have been normally distributed.

In spite of the above reservations, it is fairly clear that the use of group controlled audio-visual system of structured problem solving sessions instead of normal teaching methods did not significantly affect examination performances, attitudes to Statistics, or attitudes to problem solving.

In the previous section it was stated that the E group students expressed strong positive attitudes towards the audio-visual methods of presentation. In view of the conclusions drawn above it seems likely that their positive responses were elicited by the novelty of the technique rather than by reliable appraisals of its contributions to their performances and attitudes.

COST-BENEFIT ANALYSIS.

Since A—V tutorials can apparently be safely substituted for live tutorials without loss to students, cost comparisons are relevant to criteria for selecting turorial methods.

At the time the present project was first suggested, Basic Statistics was a compulsory subject in most College courses, and it was expected that about 600 students would enrol in it in Autumn Semester 1974. In fact, because of changed course requirements only 120 students enrolled, thus affecting potential economics of scale. Only about 40 of these were eventually in the group served by A—V tutorials.

The total cost of providing the A—V tutorials in Autumn Semester 1974 was estimated to have been approximately $12,000. These figures included the costs of the time spent by a lecturer and a research assistant writing scripts, recording programmes and supervising tutorials. It also included the cost of typing the programme frames, photographing them onto slides, processing and mounting the slides, purchasing films and tapes, and purchasing hardware for the programme replay and student response systems. However it did not include the costs of electronic test equipment or of staff time devoted to research, development or evaluation at any stage of the project.

The value of academic staff time saved by substituting the A—V tutorials for live tutorials (for the E group only), was estimated on the basis of average subject teaching loads at first year level to have been approximately $3,000 (40 students). Had there been no special limitations imposed by experimental conditions all 120 students would have been able to take the A—V tutorials, yielding a staff saving of about $10,000; or $2,000 short of costs. An enrolment of about 150 to 200 students would be needed for savings to equal costs in a once only series of A—V tutorials.

The cost of live tutorials do not increase linearly with enrolments as economics of scale also accrue in conventional teaching methods. Allowing for this factor, it seems that if 600 students had enrolled in Basic Statistics (as forecast in 1973), staff savings would have exceeded costs by approximately $15,000 provided that the A—V tutorials had been unsupervised. Most of the tutorial costs ($12,000) were incurred in the purchase and preparation of equipment and materials, and repetition costs would be small. For example, if the $12,000 were to be depreciated to zero over six consecutive semesters, an enrolment of about 30 students per semester in Basic Statistics would be sufficient for savings from recurrent expenditure on staff to offset costs.

DISCUSSION.

In an earlier experimental evaluation of a series of group controlled audio-visual structured problem solving sessions in Physics (Le Marne 1972), performances of experimental students were found to be significantly better than those of controls. However in the earlier experiment, the E group attended A—V tutorials in addition to all normal lecture, laboratory and tutorial classes, whereas in the present experiment the E group attended A—V tutorials instead of live tutorials. It is reasonable to conclude firstly that group controlled A—V structured problem solving tutorials produce gains when offered as extras but produce no significant differences when substituted for more conventional teaching methods; and secondly that they would prove both educationally and economically effective as supports to any Mathematics based subject.

Traditional lectures, whether live or televised, tend to devote little attention to the details of problem solving procedures and to concentrate instead on the exposition and extension of course material. The effective use of small group tutorials is usually severely limited by large student/

staff ratios, and in normal problem solving assignments feedback is necessarily delayed, infrequent and lacking in detail.

Structured problem solving sessions can, however, actively involve students in the learning process, give them immediate knowledge of their results, and place emphasis on the process of problem solving rather than on the solution. Ideally it seems that such sessions should be conducted by a tutor either with individual students or with small groups. Where this is impossible the structured material can be presented through individual study carrels but only at considerable cost in resources, equipment and space. Alternatively, programmed problem solving texts can be issued. These certainly may prove useful to mature students but with the less mature there seem to be advantages in assigning set times, places and work quotas for learning sessions. The use of a group paced system not only reduced the costs normally encountered in installing a carrel system, but also may well benefit immature students by promoting co-operation in learning and by permitting them to compare their progress with that of their peers.

Inexpensive group learning systems, designed for specific purposes, and providing for active student response and control, appear likely to exert considerable influence on future educational practices, particularly where large student numbers and shortages of qualified staff create resource problems. Some possible areas for application are remedial teaching and the teaching of specific skills such as those used in problem solving.

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