DEVELOPING AND TESTING A TEACHING MODEL USING EXPERIMENTAL DESIGN AND INTERVIEW ANALYSIS

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The process of developing and testing a teaching model in teaching statistical concepts at the introductory level is discussed. The model comprised three components, provision of supplementary notes, working in pairs and teaching concepts in worked examples, which were tested using a 2^3 randomised factorial block design with confounding. The development of the teaching model is supported by an interview study of teachers and lecturers in Scotland. The results suggested that the concepts are best presented within a concrete example but that the provision of notes is only useful when students work in pairs. The whole study provided information on the experimental paradigms and showed that it is possible to carry out a complex experiment within a teaching environment. The key teaching combinations of the model require further testing in a wider environment.

INTRODUCTION

A number of teaching and learning difficulties have been reported by teachers and students with regard to elementary classes in Statistics . These include a lack of motivation, poor prior ability, a lack of relevance, difficult concepts, rote learning with little understanding. We present results from a small scale study which sought to investigate the effect of three teaching factors on students' understanding of statistics..

This study was conducted in an attempt to make the teaching of statistics more manageable and understandable and full details are presented in Mahmud (1997). The essential aspects involved, interview and questionnaire studies of students to ascertain the factors that they perceived as influencing their ability to learn statistics, in-depth structured interviews with teachers and lecturers to explore factors that were associated with students understanding the concepts of Statistics and a number of classroom experiments to estimate the effect of different teaching factors on students understanding of statistical concepts. There is also a related issue that the investigation of methods to improve statistics teaching leads to an investigation of the methodologies of experimenting, observing and analysing the teaching of statistics.

There has been some discussion on experimentation of teaching methods involving appropriate designs and methodological techniques suitable to the needs of the respective studies (Marcoulides, 1990; Davies, 1996; Harding et al., 1981). Most of these

studies used the treatment versus control group design of experiment to investigate the effectiveness of different types of teaching methods in teaching statistics. The advantage of such a design is that one is able to compare the effectiveness of a new teaching method against a control group. However, this type of design is not able to investigate the effectiveness of the three teaching components identified in the teaching. To complement the treatment versus control group design, a 2^3 factorial block design with pre- and post-testing was used to investigate the efficacy of the teaching components. This paper shall focus on the development and testing of the teaching model components.

FRAMEWORK OF THE TEACHING MODEL

The basic framework of the teaching model was divided into three factors each at two levels: (1) Teaching Concepts (C); (2) Provision of Supplementary Notes (N); (3) Working in pairs or individually (P). In the first component, concepts were either discussed and incorporated into the worked examples or discussed completely separately from the examples. Supplementary notes were either given or not given to the students during the course of instruction. In the third component, students either worked individually or worked in pairs on the classroom assignment. Working in groups came out consistently as a method of improving learning from the literature review (Dees, 1991; Dietz, 1993; Webb, 1982), the provision of notes was the most consistent factor mentioned by students in the survey, and the method of introducing the concepts to the students was the main hypothesis of the investigator.

The aims were to investigate: (1) the effect of teaching concepts in worked example as opposed to separately from worked example, (2) the extent to which the printed notes has an effect on students' learning, (3) the effect of working alone as opposed to working in pairs, (4) the effect of any combination of the teaching components on students' learning. Any combination of the three components, say, 'pc' would involved students being exposed to the teaching of concepts in worked examples with no supplementary notes given and working in pairs. This constitutes one of the eight treatment combinations.

EXPERIMENTAL DESIGN

The experiments were not able to be carried out under the ideal controlled situations as the experiments were to be conducted under classroom conditions. The students all attended the main introductory statistics class at Strathclyde University in Scotland. There were 400 students in the class. There was one hour long lecture per week and a laboratory every two weeks. In addition there were two remedial classes, each of one hour duration per week attended by about 30 students, in total.

Due to the organisation of the class and the difficulty in changing the timetable, it was not possible to carry out the experiment in the lectures or laboratories. Also the class was an economically important one for the department and any teaching disasters as a result of the experiment may have had serious repercussions. Consequently, the experiment was carried out in the remedial class. This was acceptable to the students who were all informed that there would be some testing and experimenting. The major drawback of this approach was that we were unable to randomly select the students to attend the remedial classes.

From a feasibility study on teaching methods (Mahmud, 1997), there was indication that the teaching had some effects on the students' learning as measured by the difference in pre- and post-tests, even though it was small. The study also highlighted that it was not feasible to randomise the students to treatment groups because their participation to the experimental classes were voluntary as it was not conducted during normal teaching hours for the course.

The experiments were conducted in two phases and only one person was involved in conducting the experiment. In Phase 1, 34 students attended the classes on one of two days per week for eight consecutive weeks covering the eight treatment combinations on eight separate statistical topics. There were two replicates in Phase 1 (weeks 1-4, replicate I, and weeks 5-8, replicate II) with different treatment effects being confounded in each replication. In Phase 2, 24 students attended the classes for four consecutive weeks only, repeating replicate I from Phase 1. Eight treatment units were assigned randomly between the two days in each week and between the first four weeks in replicate I and the remainder weeks in replicate II. The statistical topics taught in weeks 1-4 were Sampling Distribution, Confidence Interval (large sample), Confidence Interval (small sample) and Hypothesis Testing (large sample) and in weeks 5-8 they were Hypothesis Testing (small sample), Chi-square Goodness-of-Fit Test, Chi-square Independence Test and Linear Regression.

In replicate I, all three main effects N, P, C and the three factor interaction (NPC) were estimated and interaction factors NP, NC and PC were confounded with weeks. In replicate II, factors C, N, NP and PC were estimated while P, NPC and NC were confounded with weeks. A random allocation of treatment combination was used with a different allocation in the two phases.

Each experimental class lasted for one hour, beginning with a multiple choice pre-test, then a presentation by the teacher, practical work by the students and finishing off with a post-test. This arrangement was necessary to control for the different abilities of the students, the different difficulties of statistical concepts being taught and the need to complete the experiment within the framework of normal classroom teaching.

The data were analysed using a logistic regression model. The response variable was the number of questions answered correctly in the post-test and the explanatory variables were the pre-test score, the week, and the three teaching factors and their interactions.

IMPORTANT RESULTS OF THE EXPERIMENT

In testing the effects of the teaching model components, three logistic regression models were used. The first model looked at the pre-test to investigate different levels of difficulty over the weeks. The second model looked at the post-test to investigate the effects of the teaching factors adjusted for pre-test. The third model looked at the post-test to investigate the effects of the teaching factors adjusted for pre-test and the weeks. In Phase 1, the median number of questions students answered correctly on the pre-test was 2 (out of 5) and there were significant differences among the pre-test scores over the weeks ($p = 0.02$) with confidence interval (large sample) being the hardest and linear regression the easiest. The main finding was that there exists an interaction between notes, pairing and concepts (NPC) on the post-test adjusted for the pre-test score ($p = 0.04$). The fact that there is interaction suggests that the combination of the teaching components is important in increasing students' learning when method of teaching the concepts in the worked examples is used. Phase 2 experiments had provided further evidence to substantiate the findings from the Phase 1 experiments. The main findings from Phase 2 was that the interaction between notes, pairing and concepts (NPC) on the post-test adjusted for the pre-test score was again important ($p = 0.03$).

The estimated effects, on the logit scale, are presented in the figures. These show some similarities over the two phases, and suggest that the teaching of the concepts through the worked example may be more effective when the students work in pairs with notes (Phase II) or with individual work and no notes or pairs and notes (Phase I).

INTERVIEW ANALYSIS

Using questionnaire and interview survey, the development of the teaching model was supported by views gathered from school teachers and university lecturers who were involved in the teaching of statistics at the introductory level. The main teaching methods used were worked examples, notes and lectures, with little practical use of investigations or projects. Using Qualitative Data Analysis linked with multidimensional scaling and cluster analysis, the interviews revealed the important relationships gathered from 28 respondents. In the factors that contribute to students' learning difficulties, the main findings (as indicated by the teachers) pointed to students' lack of prior knowledge in statistics and students' lack of ability and too much material to cover in the time allocated for the course. These factors are all seen to be out with the

CONCLUSION

Technically, the study showed that it was possible to carry out a relatively complicated educational experiment. This study is not the final answer; there are many drawbacks and this study should only be considered as a pilot investigation. There is a need to test the more effective combinations in a large scale treatment versus control study, using different investigators and materials. Observational studies, questionnaires, interviews and controlled experiments were all used in this research. All techniques give different information but it is our conclusion that the greatest advances in investigating

different teaching methods are to be made with the use of controlled comparative experiments, preferably in as 'normal' teaching setting as possible.

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