INVESTIGATING PATTERNS OF INTERVIEW CONVERSATIONS AMONG LECTURERS IN THE MALAYSIAN INSTITUTES OF HIGHER LEARNING ON THE TEACHING OF STATISTICS AT THE INTRODUCTORY LEVEL

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This paper will discuss the methodological aspect and analysis of in-depth interviews conducted upon lecturers of statistics with regards to the teaching of statistics. The main aim of the interviews was to elicit information from the subjects on matters which are related to difficulties in teaching some statistical concepts and factors that contribute towards students' difficulties in understanding the concepts. The other aim was to identify the existence of any distinct patterns which may arise from the interview conversations using the elements of qualitative data analysis (QDA) via transcription, content analysis and identifying conversation themes and codes. The approach taken to link the conversation themes and codes was also meant to illustrate the application and investigation of the feasibility of using multidimensional scaling within the qualitative data approach.

INTRODUCTION

The purposes of interviews in the wider context of life are many and varied. It may be used, among others as a means of evaluating or assessing a person in some respect; for gathering data, as in surveys; or for sampling respondents' opinions. As Tuckman (1972) describes it, "By providing access to what is *inside a person's head*, [it] makes it possible to measure what a person knows (knowledge or information), what a person likes or dislikes (values and preferences), and what a person thinks, his attitudes and beliefs." In other cases, it may be used in conjunction with other methods in a research undertaking. Although in each of these situations the respective roles of the interviewer and interviewee may vary and the motives for taking part may differ, a common denominator is the transaction that takes place between seeking information on the part of one and supplying information on the part of the other. Cannell and Kahn (1968) defined research interview as "a two-person conversation initiated by the interviewer for the specific purpose of obtaining research-relevant information, and focused by him or her on content specified by research objectives of systematic description, prediction, or explanation." Kerlinger (1970) noted that although the research purposes govern the questions asked, their content, sequence and wording are entirely in the hands of the interviewer.

This paper intends to focus on the process in which open-ended interview data is described using qualitative data analysis, multidimensional scaling and cluster analysis. From the literature, it was discovered that the combination of these techniques has not been tried on a large scale interview data in statistical education. Hence, it is the intention of the researcher to investigate the feasibility of using these techniques for use in large scale study in statistical education. This coincides with the methodological principle in studies by Konold (1989), Pfannkuch and Brown (1996) and Mahmud (1997) where the information which they gathered from their interviews were used as the basis for the design of a larger study. This paper also intends to review the process of the interview and data collection followed by the techniques used in the analysis before presenting the results. The interview responses are first analysed using qualitative data analysis (QDA) which is later combined and used together with multidimensional scaling (MDS) and cluster analysis techniques.

THE STUDY

We conducted a small scale study using a face-to-face interview technique at four public universities in West Malaysia. The study was carried out to investigate: (1) factors that contribute to lecturers' difficulties in teaching certain statistical concepts; and (2) factors that contribute to students' difficulties in understanding the concepts (from lecturers' perspectives). The interview data was gathered from 25 lecturers who teach statistics at the first year introductory level. The interviews took place at their respective working places in which the responses were tape

recorded and transcribed word per word. Each interview took about 40 minutes to complete and between two to three hours to transcribe. We begin the analysis process with the description of the methodological technique of QDA.

THE METHODOLOGICAL TECHNIQUES

QDA is used by social scientists among others to study conversation and communication (Heritage, 1988) and in educational studies to study opinions, attitude and behaviour towards a certain programme or institution (Huberman, 1978; Miles & Huberman, 1980). QDA is chosen for the interview study because it is suitable for processing interview transcripts and provides methods that could reveal findings which otherwise could not be elicited through self-administered questionnaires. In QDA, three streams of research activities will be employed, that is, data reduction, data display and conclusion drawing and verification. In QDA, the analysis is often guided by research questions. For the purpose of assisting with the description of QDA, the discussion based on three research questions will be illustrated, that is, (1) *What are the factors that the lecturers thought would contribute to students' difficulties in understanding the concept of hypothesis testing?, (2) What are the factors that contribute to lecturers' difficulties in teaching the concept of hypothesis testing? (3) What are the areas of misconception?* The process of data reduction involves going through each of the 25 transcripts to look for responses that would match the research question. Responses were differentiated using colour codes and symbols (such as red, blue, #, *). The following example illustrates the process.

Lecturer 2 said that, *Students have not been exposed to any kind of statistics syllabus before* which is related to prior knowledge in statistics. On the other hand Lecturer 6 said that, *Some are not able to think through the ideas quickly* which is related to students' natural ability. These responses were categorised accordingly and transformed into summary phrases and quotes which were then cross-referenced with the interview transcripts. The process of data reduction is repeated for the other research questions as well. In essence this process involves repeatedly going through the transcripts for relevant sentences or phrases. The process continues to the second stage of analysis activity, i.e., data display which comprised of a list of subjects together with their associated phrases extracted from the transcripts. This is a form of qualitative data matrix where the rows correspond to the subjects and the columns to the research questions. The entries in the cells are the phrases and quotes extracted from the transcript which are relevant to the research question. It is at this second stage that the analysis leads to new findings which includes looking for similar responses among the subjects and identifying the possible relationships between the themes and codes. In the third stream of the research activity, the meanings emerging from the data and the conclusions are confirmed and verified with the aims of the interview, the research questions and are cross-referenced with the interview transcripts.

RESPONSE THEMES AND CODES

Data reduction has led to the process of organising and compressing the response data in the form of a matrix display. The compressed data come in the form of "summary phrases and quotes". These compressed data which represent the responses from different subjects may be formed into several themes. For example, Lecturer 2 said that, *Students have not been exposed to any kind of statistics syllabus before.* Lecturer 7, on the other hand said that, *Students are not used to statistics, they have never done it before...* Judging from these responses, both have a similar response theme even though the structures of the answers are different. To enable us to recognise and access the themes easily, the themes had to be categorised. Accordingly, "codes" were used to represent the themes. Here, the themes can be associated with the amount of student's prior knowledge in statistics or any information that is closely related to it. Hence, the appropriate code for that would be "PKNOW" which stands for "Prior Knowledge". Coding in this way is another form of data reduction. The process of data reduction led to the construction of a 25 x 5 matrix display as shown in Figure 1. In this display, the themes and codes are associated with the 25 respondents in a two-dimensional array where they are placed in respective cells in the last three columns below the three research questions. Based on this, multidimensional scaling and cluster analysis are then developed to assist with further analysis.

Level of Experience	Subject	What are the factors that contribute to students' difficulties in understanding the concepts?	What are the factors that contribute to lecturers' difficulties in teaching the concepts?	What are the areas of misconception?
3 years	L1	**PKNOW**: "Students still think statistics is an extension of mathematics. Their main objective is to get a numerical answer rather than try to interpret it. It is different from everything else they have ever done before and this is their first time learning statistics in a conceptual manner."	**LEX:** Lecturer have little experience In presenting the logic of hypothesis testing.	**THEO**: Fail to formulate null and alternative hypothesis. Cannot differentiate between a one-tailed and two-tailed test. **COMP**: Arrived at a numerical answer too quickly-no basis of understanding. Prone to careless mistakes. **INT**: Could not interpret results of hypothesis testing
3 years	L2	**PKNOW**: "Students have not been exposed to any kind of statistics syllabus before."	**LCON2**: Lecturer finds statistics more difficult than any other subjects. **LEX**: "In the first year, I was not sure how to go about introducing each concept.I find it very difficult to be sure of doing the right thing"	**THEO**: The notion of the degrees of freedom, the purpose of finding them, what exactly do they have to do with it. The notion of the null hypothesis, what to test. **INT:** What to do with the results
8 years	L3	**PKNOW**:"It doesn't relate to every thing else they have done in Maths" **ABLE**: Some students do not have the natural ability to assimilate ideas." **ATT**: Didn't do background reading themselves **TF1**:"They need more time to think about the concepts and problems related to the concepts."	**LEX**: "I don't fully understand everytime I do it and tend to accept formula from the book."	Ambiguous Answer

Note: The full matrix display should consist of responses from 25 subjects based on the three research questions

Figure 1. A Matrix Display of Summary Phrases and Quotes.

MULTIDIMENSIONAL SCALING (MDS) AND CLUSTER ANALYSIS

So far we have touched on the QDA techniques of data reduction, display and summary. This is a subjective approach and we have tried to make it more objective by providing rules to govern the data reduction and display. This is as far as this QDA goes. However, there is a possibility to suggest an improvement by linking QDA into multivariate analysis techniques such as MDS and cluster analysis. MDS works by trying to find points representing the codes by calculating the distances and similarities between the codes. However, the weakness of MDS is that it may not be able to measure distances between the codes if the codes are not created. To illustrate further the relationship between the codes and themes, we used agglomerative methods of hierarchic classification such as the complete linkage clustering in the form of dendrograms (Everitt & Dunn, 1991). This method is suitable because it allows codes with similar themes to be fused or grouped together. The majority of the MDS and cluster analysis begin with the calculation of a matrix of similarities or distances between codes.

The matrix display was converted into a 25 x 17 matrix of binary codes where the rows are the subjects and the columns represent all the response codes. The (i,j)th element of this 25 x 17 matrix takes the value of "1" if interviewee *i* mentions code *j*, otherwise it takes the value of "0". In this matrix display, there are 25 subjects and 17 codes ranging from PKNOW, ATT,..., LEX, LCON2,...THEO, COMP and INT. This is illustrated in Figure 2.

Codes

Subjects	PKNOW ATT ABLE TF1 ..... LEX LCON2 ..... THEO
1	1 0 0 0 ..... 1 0 1
2	1 0 0 0 ..... 1 1 1
.	.....
25	1 0 1 0 ..... 0 0 1

Figure 2. A 25 x 17 Matrix of Binary Codes.

Two types of similarity measures were considered. One is where the similarities are measured as the proportion of teachers who mentioned the same pair of themes or codes. The consequence of this measure is that items that are mentioned by the majority of people will

automatically have a large similarity and hence they will be clustered together. The same applies to items that are not mentioned by the majority. This provides us with information about the items that are frequently mentioned and are important to the subjects. The drawback is that it penalises codes or items that have a low recall frequency and hence tend not to cluster those items together even if the items were felt to be important jointly. The other type of distance measure is by using the Jaccard's coefficient. This technique measures the proportion of teachers who mentioned one or other codes and who mentioned the codes together. This proportion is attached to the codes that are not frequently mentioned but are mentioned together by most subjects. This technique on the other hand, reduces the possibility of penalising codes that have a low recall frequency but which were often present together in the interview transcript. As a result, Jaccard's coefficient is preferred and used to measure the distances between the codes in cluster analysis.

THE ANALYSIS: INTERVIEW PATTERNS

The process begins with the analysis of a 25 x 5 matrix display (Figure 1). It comprised of cells that contain interview responses in the form of short summary phrases and quotes and were gathered based on the research questions as shown in the respective columns. To assist the analysis further, relevant "codes" are assigned to each of the phrases and quotes. This process involved looking for relationships between the codes in one research question, the relationships between the codes across several research questions and the number of lecturers who mentioned similar themes. Finally conclusions were drawn concurrently from the matrix and graphical displays.

LEARNING DIFFICULTIES

Findings to one of the research questions, on *factors that would contribute to students' difficulties in understanding the concepts* showed that majority of the subjects, regardless of their experience mentioned "Prior Knowledge" as the main contributing factor. For example, Lecturer 2 quoted that, *"Students still think statistics is an extension of mathematics. Their main objective is to get a numerical answer rather than trying to interpret it. It is different from everything else they have ever met before and this is their first time learning statistics in a conceptual manner*. Lecturer 16 also mentioned that *students have very little statistical background. If statistical ideas were introduced at an earlier stage, students might find it easier to get into grips with the ideas".* It was found that of those who mentioned "Ability" as one factor that contributes to students' difficulties in understanding the concepts, also mentioned "Attitude " as another contributing factor. For example, Lecturer 4 mentioned that, *"some students are not able to think through the ideas quickly and some learned by rote".* Lecturer 16 also mentioned that, "*The weaker students have difficulties thinking through the ideas without some assistance from the lecturer".* The other contributing factor as mentioned by the subjects is "Time Factor." They felt that students need more time to come to terms with the statistical terms and concepts and to think about the problems related to the concepts. Lecturer 5 quoted that, "*They need more time to let the ideas grow on them. Given more time they may have a greater awareness and a greater understanding.* Lecturer 10 also responded that, *....with only 2 hours per week I was not able to do practical and investigative approaches that would help the students to understand the concepts better".* During the interview particularly those with less than 10 years of teaching experience, many of them strongly felt that they were not given enough time to teach the course.

GRAPHICAL DISPLAYS

This is accomplished by using the 25 x 17 matrix as shown in Figure 2. To investigate whether there is any relationship between students' difficulties in understanding and the areas of misconception, two-dimensional solution as shown in Figure 3 was constructed. From the subjects' perspective, students who failed to understand the "Theoretical" (THEO) aspect of the subject and have difficulties in "Interpreting" (INT) the results were related to students who do not have any "Prior Knowledge" (PKNOW) in statistics, who do not acquire the "Ability" (ABLE) to think through quickly and who required more time (TF1) to understand the concepts. Also, for those students who often rushed into the calculation and tended to do as quickly as they

could (COMP) without needing to understand the concepts can be associated with their "Attitude" (ATT) towards the subject. This can be seen where COMP and ATT are clustered together.

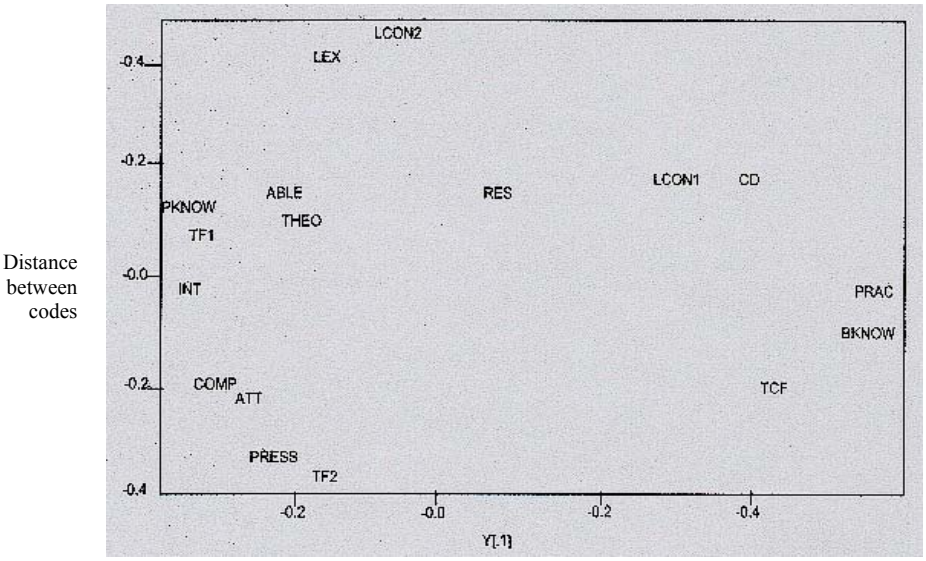

Figure 3. Two-dimensional solution from 25 x 17 matrix showing the relations between the response codes in the matrix display.

On the other hand, Figure 3 suggests no evidence that factors which contribute to lecturers' difficulties in teaching the concept were associated with the students' areas of misconception. This is indicated by codes such that LEX (Lack of Experience), LCON2 (Teacher's Lack of Confidence), PRESS (Pressure) and TF2 (Time Factor for subjects) are quite far apart from THEO (Theory), COMP (Computation) and INT (Interpretation) codes. In Figure 4, the relationship between the codes is also indicated by the clustering of these five codes (ABLE, PKNOW, THEO, TF1, INT). There is a resemblance in both diagrams in terms of the clustering of the codes but the two-dimensional solution tends to show a more informative display as the codes that are mentioned together by the subjects could easily be identified.

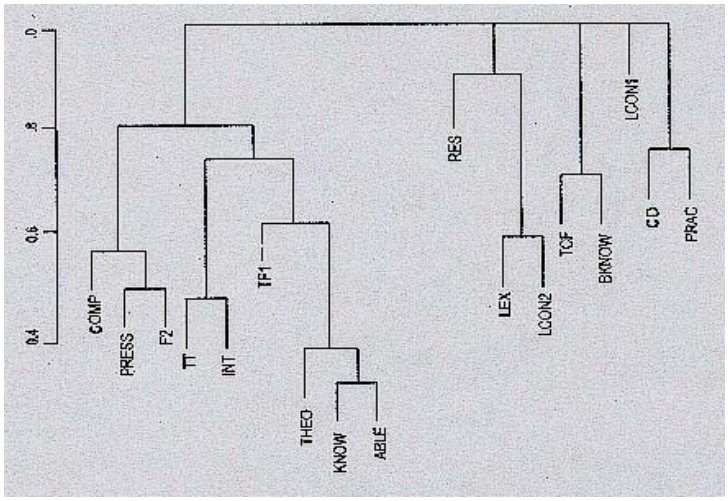

Figure 4. A complete linkage dendrogram showing the clustering of all codes in the matrix display.

CONCLUSION AND DISCUSSION

We have used QDA, MDS and cluster analysis techniques to look for factors that contribute to the teaching and learning difficulties in statistics and identify the conversation patterns. One of the advantages of QDA is that a thorough analysis of individual responses can be

done. The interview responses can be transformed into a set of meaningful findings with the assistance of MDS and cluster analysis that help to further refine the analysis and produce a more informative display of the responses. However, we discovered that QDA works best with detailed information on each subject. For MDS and cluster analysis to be successful, reliable estimates of similarity are needed, which also means having a large sample of subjects.

We recognized the possible criticisms over interpretation of scaling based on too few subjects and the contribution is due to random effects. Ideally, it would have been better to interview more subjects. However, such an investigation is feasible only with sufficient time and cost. However, part of the reason for this work is to investigate if QDA, MDS and cluster analysis can be successfully combined and the answer to this is 'yes.' From this small scale study, it can be concluded that factors which contributed to the teaching and learning difficulties are mainly due to

- students' lack of prior knowledge in statistics
- students' lack of ability in understanding basic statistical concepts
- students' poor attitude towards learning statistics
- lecturers' lack of experience in teaching (< 10 years experience)
- lack of teaching time
- pressure to teach effectively

The response patterns indicated an existence in the relationship between students' difficulties in understanding and the areas of misconception. The analysis also showed that those who mentioned that students who have difficulties with the interpretation and theoretical aspects of statistics also mentioned students' prior knowledge in statistics and their attitude towards learning the subject.

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