Visualizing patterns of interview conversations regarding students' learning difficulties in statistical concepts via QMDScaling techniques

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Abstract: Many attempts were made by researchers and practitioners to analyze interview conversations. Due to different variations in the interview analysis techniques, it can lead to inconsistencies in the interpretation of the interview conversations. Through QMDScaling techniques, not only that interview conversations can be interpreted precisely and accurately, patterns of the interview conversations can also be visualized and interpreted via a joint-dimensional space. One area which is gaining popularity in research involving the use of both qualitative and quantitative data is in the research of statistical education. On that note, the purpose of this paper is to describe the methodological techniques used in visualizing patterns of the interview conversations regarding students' learning difficulties in basic statistical concepts as perceived by the statistics educators. The process involves reducing and categorizing the interview conversations into themes. This leads to the transformation of the themes into codes and finally transforming the themes into a binary matrix and into a joint-dimensional space. These techniques had shown that inconsistencies in the interpretation of the interview conversations can be avoided and it has helped to understand issues and reveal findings which could not be elicited and interpreted precisely through the conventional technique.

Key-Words: - Interview conversations, learning difficulties, statistical concepts, qualitative matrix, multidimensional scaling

1 Introduction

Many researchers have recognized that the mixed-mode or triangulation method in the analysis of their research data to some extent has provided them with a significant and informative result of their studies. However, the methodological techniques used are wide and it varies across various disciplines and areas of research. The rationale for choosing suitable triangulation methods also lies within each respective research study. Many qualitative techniques have been used in capturing conversational data which otherwise could not be captured using a survey instrument alone. One of the techniques, namely the interview is widely used by researchers in gathering qualitative data. Interview is defined as a two-person conversation initiated by the interviewer for the specific purpose of obtaining research relevant information [1]. It has many purposes, among them which includes assessing a person in some respect; for testing or developing hypotheses; for gathering data, as in surveys or experimental situations; for sampling respondents' opinions, as in doorstep interviews.

Interview method in research has long been debated and has created its own history of literature collections. 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 (attitudes and beliefs) [2]. Although the research purposes govern the questions asked, their content, sequence and wording are entirely in the hands of the interviewer. In some cases, it may be used in conjunction with other methods of data collection [3]. Although in these situations the respective roles of each respective method may vary and the motives for taking part may differ, a common denominator is the transaction that takes place between these methods towards achieving the research outcome in accordance with the research objectives. Depending on the objectives and types of the interview, the question lies on whether or not one or the other persons provide similar or different responses throughout the interview.

One area which has an extensive number of researches involving the analysis of both qualitative and quantitative data is in the research of statistical education. On that note, one of the purposes of this paper is to describe the methodological techniques

used in examining the relational patterns of students' learning difficulties in basic statistical concepts as perceived by the statistics educators. This paper also examines how these patterns can be visualized and interpreted using MDS two-dimensional solutions. The process involves the use of qualitative technique, namely the matrix data display in capturing the interview conversations, classification of text into themes and codes and eventually transformation of text into binary codes for the purpose of examining the learning difficulties patterns. The triangulation approach used had revealed findings which otherwise could not be seen through a single approach. In a nutshell, this paper is meant to illustrate the feasibility of using multidimensional scaling within the qualitative data approach.

2 Student Assessment and Learning of Statistics

Based on past and recent experience, students learn better if they receive consistent and helpful feedback on their performance. Learning is enhanced if students have opportunities to express ideas and get feedback on their ideas. Feedback should be analytical, and come at a time when students are interested in it. There must be time for students to reflect on the feedback they receive, make adjustments, and try again. For example, evaluation of student projects may be used as a way to give feedback to students while they work on a problem during a course, not just as a final judgment when they are finished with the course [4]. Since statistical expertise typically involves more than mastering facts and calculations, assessment should capture students' ability to reason, communicate, and apply their statistical knowledge. A variety of assessment methods should be used to capture the full range of students' learning (e.g., written and oral reports on projects, in class problem solving exercises reflecting students' understanding of material, or semi-structured questions included on exams). Teachers should become proficient in developing and choosing appropriate methods that are aligned with instruction, and should be skilled in communicating assessment results to students [5].

Students learn to value what they know will be assessed. Another reason to expand the assessment beyond the exclusive use of traditional tests, is that students will only apply themselves to those skills and activities on which they know they will be evaluated. If students know they will be evaluated on their ability to critique and communicate statistical information, or to work collaboratively on a group project, they will be more willing to invest themselves in improving skills required by these activities.

Statistics educators should think about and continually assess their personal theories of learning and teaching in light of the evidence classroom experience provides. Teachers should experiment with different teaching approaches and activities and monitor the results, not only by using conventional tests but by carefully listening to students and evaluating information reflecting different aspects of their learning. In this way, teachers may continually analyze and refine their theories of how students learn statistics. Students should also be encouraged to assess their own learning as well as their notions of how they learn, by giving them opportunities to reflect on the teaching and learning process. Use of the suggested methods of teaching will not ensure that all students will learn the material. No method is perfect and will work with all students. Several research studies in statistics as well as in other disciplines show that students' misconceptions are often strong and resilient-they are slow to change, even when students are confronted with evidence that their beliefs are incorrect. Students' belief in part is also related to their attitudes toward statistics. Many statistics educators and most statistics students believe that attitudes toward statistics are important in the learning process [6]. This is only part of the problem and whether students struggle enough in learning new statistical concepts and ideas remain to be investigated.

3 The Conceptual Framework

This study employed the interview method in order to gain information from the statistics educators concerning factors that influence students' learning difficulties in basic statistical concepts. The interview was guided by the conceptual framework and research questions pertaining to the relationship between learning difficulties, learning strategy and misconception in basic statistical concepts. The conceptual framework is illustrated in a schematic diagram as shown in Fig. 1. For the purpose of illustrating the use of qualitative data matrix and multidimensional scaling methods, this paper shall only examine the relational patterns of students' learning difficulties as perceived by the statistics educators.

The conceptual framework is associated with several research questions as follows:

1. What are the factors that educators thought would contribute to students' difficulties in learning and understanding the concepts?
2. Do factors that contribute to students' difficulties in understanding the concepts associated with their misconceptions in statistics?

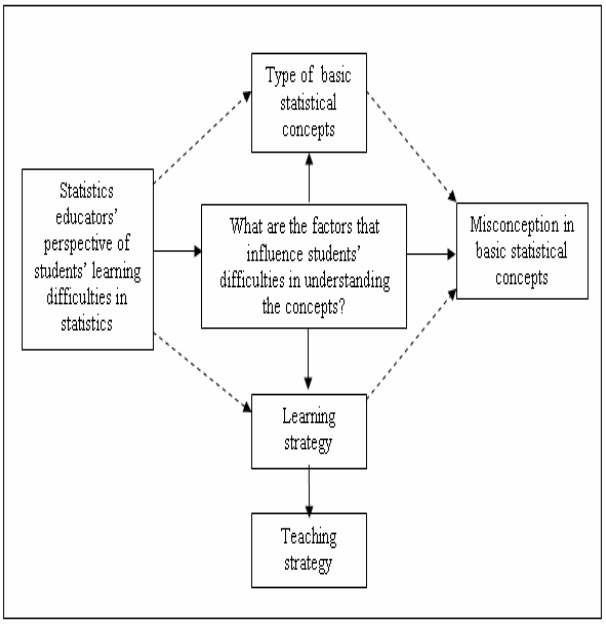

Fig.1 Conceptual framework of students' learning difficulties

The arrows in the diagrams indicate the flow of the research activities and the direction in which the investigation was carried out. Initially, the interview data were analyzed using qualitative data matrix approach. The transformation into quantitative data then took place using multidimensional scaling which was illustrated in the form of two-dimensional solutions.

4 Structure of the Interview

Thirty educators of statistics from three local private universities were interviewed. All of them had at one point in time taught statistics at the introductory level within the first five years of their teaching career. The interview questions were constructed with the research questions and the objective of the study in mind. The questions asked did not necessarily follow the sequence in which they were prepared but it was based on the responses given by the educators. The data for this analysis comprised of 30 interview responses which were digitally recorded and transcribed. Each interview took approximately 30 minutes to complete and between 45 minutes to 1 hour to transcribe.

4.1 The Interview Conversations

For example, Educator A was asked, "Did you find that your students experience difficulties in understanding the differences between the concepts of correlation, causation and association*?* Educator A responded *"Yes it is quite often that students find it difficult to differentiate between these concepts"*. Upon her response, she was prompted another question, *"Why did they find these concepts difficult to understand?"* Educator A responded *"Well, there are several reasons for that. One would be that they could not understand my lecture. Another could be they did not read the text before coming to class. They also tend to learn by reading and rote learning and not through practical work and exercises."* From the first question, Educator B had responded quite differently, that is, *"They need more time to come to terms with the statistical terms and procedures. Everything be rushed towards the end of the course."* His response on the other question was *"Some pupils are not able to think through the ideas quickly. They lack the prior knowledge in statistics. Many learn by rote and they need more time to let the ideas grow on them. Given more time they may have a greater awareness and understanding."* The excerpt of the interview conversation is shown in Table 1.

5 Qualitative Data Analysis (QDA)

QDA is used by social scientists among them to study human social behaviour [7], [8], conversation and communication [9] and in educational studies to study opinions, attitude and behaviour towards a certain programme, body or institution [10]. QDA was chosen for the interview study because it is suitable for processing interview transcripts and provides methods that could reveal findings which could not be elicited by quantitative methods. In QDA, the three streams of research activities will be employed, that is, data reduction, data display and conclusion drawing (see Fig. 2). The diagram shows that the three research activities, that is, data display, data reduction and the activity of data collection itself form an interactive, cyclical process. The process involved moving among the four nodes, (1) during data collection and then shuttle (2) among reduction (3) display and (4) conclusion drawing and verification.

Table 1 Excerpt of Interview Conversations

Interviewer: "Did you find that your students experience difficulties in understanding the differences between the concepts of correlation, causation and association?"
Educator A: "Yes it is quite often that students find it difficult to differentiate between these concepts". [Upon her response, she was prompted another question]
Educator B: "They need more time to come to terms with the statistical terms and procedures. Everything had to be rushed towards the end of the course."
Interviewer: "Why did they find these concepts difficult to understand?"
Educator A: "Well, there are several reasons for that. One would be that they could not understand my lecture. Another could be they did not read the text before coming to class. They also tend to learn by reading and rote learning and not through practical work and exercises. Some prior knowledge in statistics would help."
Educator B: "Some pupils are not able to think through the ideas quickly. They lack the prior knowledge in statistics. Many learn by rote and they need more time to let the ideas grow on them. Given more time they may have a greater awareness and a greater understanding."

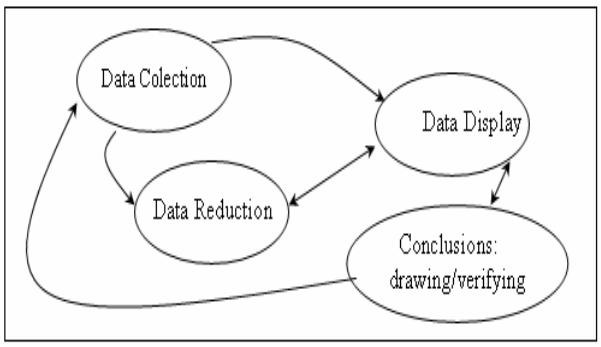

Fig. 2 Components of Data Analysis: Interactive Model

In QDA, the analysis was guided by the components in the conceptual frameworks and its associated research questions. The process of data reduction involved repeatedly going through the transcripts for relevant sentences or phrases. After data reduction, the process continued to the second stage of analysis activity which was matrix data display. Generally, a data display is an organized, compressed assembly of information that permits conclusion drawing and action. Matrix display is used to help qualitative researchers to understand what is happening and to do something either analyze further or take action based on that understanding [11], [12]. In the matrix display, the rows correspond to the respondents and the columns to the research questions. Entries in the cells were phrases extracted from the transcript. It is at this second stage that the analysis led to new findings. The analysis included looking for similar responses to the research questions among the educators and identifying possible relationships between the variables. The third stream of analysis activity was conclusion drawing and verification. The final conclusions may not appear until the process of data collection, data reduction and data display is over. In this interview study, conclusions were drawn as the analysis proceeds within the second flow of research activity, that is, the data display. The meanings emerging from the data and the conclusions were confirmed and verified with the aims of the interview and the research questions.

5 Response Themes and Codes

Based on the initial discussion of data display, this has led to the process of organizing and compressing the response data in the form of matrix displays. The compressed data which come in the form of "summary phrases and quotes" were obtained as a result of data reduction. These compressed data that represented the responses from different educators may be formed into several themes. For example, Educator B said that, *"Students have not been exposed to any kind of statistics concepts before". Students are not used to statistics, everything is so new."* Educator C, on the other hand said that, *"The first statistical concept they meet. Students are not used to statistics, they have never done it before..."* Judging from these responses, the educators have provided similar response theme even though the structures of their answers were different. The theme was then categorized and coded accordingly. In this case, the themes can be associated with the amount of students' prior knowledge in statistics or any information that were closely related to it. Hence, the appropriate code for that would be "PKNOW" which stands for "Prior Knowledge". This leads to the construction of 30 x 2 interview conversation matrix display where the themes and codes were associated with responses from 30 educators in a two-dimensional array and seven identified theme codes. Excerpt of the interview conversation matrix display is shown in Table 2.

Table 2 Excerpt of the interview conversations showing the themes and codes relating to students' learning difficulties

Educators	*Factors that contribute to students' difficulties in understanding basic statistical concepts*	*Areas of Misconception*
Educator A	**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." **ATT**: "Students were used to being spoonfed. They were used to having things on the board" **CONF**: "Students were not trained to be more competent before they reach 1st year. They lack confidence and needed more support and encouragement from the lecturers." **ABLE**: "Some students do not have the natural ability to assimilate ideas. Students tend to learn by rote, thus no real understanding of the concepts."	**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
Educator B	**PKNOW**: "Students have not been exposed to any kind of statistics syllabus before. Students are not used to statistics, they have never done it before. They said everything is just so new. They don't understand why they are doing it" **ABLE**: "Some are less able to think through the problems on their own, need more coaching. Most are mathematically less able, some simply don't like mathematics."	**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.
Educator C	**PKNOW**: "The first statistical concept they meet. Pupils were not used to statistics, they have never done it before..."' **ABLE**: "Some students are not able to think through the ideas quickly. Some learn by rote. Some are not able to think through the problems on their own. They are poor at their own initiatives. They are too exam-oriented." **ATT**: "Some couldn't be bothered and would rather be told what to do."	**THEO**: Fail to formulate the null and alternative hypothesis. **COMP**: "Pupils often rush into the calculation part. They are keen to end the calculation." Prone to making mistakes. **INT**: Could not interpret results properly.

6 QMDScaling

In this analysis, we suggest an improvement by linking QDA with a multivariate analysis technique, namely, MDScaling. MDScaling starts with a data set of proximities, which indicate the degree of similarity or dissimilarity among elements in a defined set. The objective of MDScaling is to take the proximities data and represent the elements in a small dimensional space, so that the distances among the elements in the space accurately represent the original proximity measures [13], [14]. It works by trying to find points representing the codes such that these distances between the points are related to the similarity between the codes. The MDS begins with the computation of a matrix of similarities or distances between items (or codes).

In this analysis, the matrix display was converted into a 30 x 7 binary matrix where each row represents an educator and the columns represent all the codes identified in the matrix display (see Table 3). The (i,j)th element of this 30 x 7 matrix takes the value of '1' if educator *i* mentioned code *j*, otherwise it takes the value of '0'. In Table 3, there are thirty educators and seven codes, namely, Prior Knowledge (PKNOW), Attitude (ATT), Confidence (CONF), Ability (ABLE), Theory (THEO), Computation (COMP), and Interpretation (INT).

Table 3 The binary matrix of response themes

Educators	PKNOW	ATT	CONF	ABLE	COMP	THEO	INT
A	1	1	1	1	1	1	1
B	1	0	0	1	1	1	1
C	1	0	0	1	1	1	1
D	1	1	0	1	1	1	1
E	1	0	1	1	0	1	1
F	1	0	0	1	1	0	1
G	1	0	1	1	1	1	1
H	1	0	1	1	1	1	1
I	1	0	1	1	0	1	1
J	1	0	1	1	1	0	1
K	1	0	0	1	1	0	1
L	1	0	0	1	0	1	1
M	1	0	0	1	0	1	1
N	1	0	0	1	0	0	1
O	1	0	0	1	0	1	1
P	1	1	1	1	1	1	1
Q	1	0	0	1	1	1	1
R	1	0	0	1	1	1	1
S	1	1	0	1	1	1	1
T	1	0	1	1	0	1	1
U	1	0	0	1	1	0	1
V	1	0	1	1	1	1	1
W	1	0	1	1	1	1	1
X	1	0	1	1	0	1	1
Y	1	0	1	1	1	0	1
Z	1	0	0	1	1	0	1
A1	1	0	0	1	0	1	1
B2	1	0	0	1	0	1	1
C3	1	0	0	1	0	0	1
D4	1	0	0	1	0	1	1

7 Data Analysis and Findings

7.1 Qualitative Data Analysis

The first part of the analysis in this section refers to the 30 x 2 interview conversation matrix as shown in Table 2. This data display forms an overview of the interview data. The columns contain interview responses in the form of short summary phrases where relevant "codes" were attached to the phrases. The analysis includes finding similarities and dissimilarities between the theme codes as mentioned by the educators. Finally, conclusions were drawn concurrently from the matrix display and multidimensional display.

Responses to the first research question on *the factors that the educators thought would contribute*

to students' difficulties in learning and understanding basic statistical concepts which are reduced to summary phrases are presented in the matrix display. The latter was further summarized in Table 4. The table displays the frequency of themes mentioned by the educators. It shows that majority of the educators mentioned "Prior Knowledge", "Ability", "Theory", "Computation" and "Interpretation" as factors that contributed most to students' difficulties in learning and understanding basic statistical concepts. On the other hand, students' "Attitude" and "Confidence" towards statistics were the least mentioned by educators during the interview.

Regardless of their years of experience, the educators gave somewhat similar explanations with regard to students' "Prior Knowledge" in statistics. For instance, Educator B quoted that, *"Pupils 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"*. Educator G also mentioned that *"students have very little statistical background. If statistical ideas were introduced at the earlier stage, students might find it easier to get into grips with the ideas."* In the interview, majority of the educators mentioned that some students do not have the ability to think through the ideas quickly. For instance, Educator E mentioned that, *"Some students were not able to think through the ideas quickly and some learned by rote"*. Educator G also mentioned that, *"The weaker students have difficulties thinking through the ideas without assistance from the lecturer."*

7.2 Multidimensional scaling analysis

The second part of the analysis involved the transformation of the matrix display contents into binary codes which was further analyzed using multidimensional scaling and displayed visually through MDS two-dimensional solutions. The MDS output illustrated the normalized raw stress values, stress and fit measure, the final coordinates and Shepard residual plot.

Table 4 Frequency of themes mentioned by educators

Response Codes	Response Themes	Frequency of themes mentioned (Male Educators)	Frequency of themes mentioned (Female Educators)
PKNOW	Prior Knowledge	7	23
ATT	Attitude	2	2
CONF	Confidence	3	9
ABLE	Ability	23	7
COMP	Computation	12	6
THEO	Theory	16	6
INT	Interpretation	23	7

The raw stress values in Table 5 indicated that the original proximities are represented well by the distances in the final dimensional solution. Stress-I or Kruskal's stress in Table 6 showed a stress value of less than 0.10 which is excellent and a good fit between the original proximities and the derived distances. This indicates that the original proximities are represented well as distances in a multidimensional space. Further evidence of the reasonably high level of fit between the original proximities and derived distances can be seen in the Shepard diagram in Fig. 3 where the relationship approximate a straight-line relationship with minimal dispersion.

Table 7 show the coordinates of each of the four factors in a two-dimensional solution whereas Table 8 show the distances between the codes. To examine the relations between the theme codes mentioned by educators as factors that contribute to students' difficulties in understanding the concepts, MDS 2-dimensional solution was obtained.

Table 5 Raw stress values

Iteration History

Iteration	Normalized Raw Stress	Improvement
0	.08876[a]	
1	.00290	.08586
2	.00185	.00104
3	.00119	.00067
4	.00076	.00043
5	.00048	.00028
6	.00030	.00018
7	.00019	.00011
8	.00012	.00007[b]

a. Stress of initial configuration: simplex start.

b. The iteration process has stopped because Improvement has become less than the convergence criterion.

Table 6 Stress and Fit Measures

Stress and Fit Measures

Normalized Raw Stress	.0002
Stress-I	.0155[a]
Stress-II	.0318[a]
S-Stress	.0008[b]
Dispersion Accounted For (D.A.F.)	.9998
Tucker's Coefficient of Congruence	.9999

PROXSCAL minimizes Normalized Raw Stress.

a. Optimal scaling factor = 1,000.

b. Optimal scaling factor = 1,000.

Table 7 Final coordinates in two dimensions

Final Coordinates

	Dimension	
	1	2
Prior Knowledge	-.572	.071
Attitude	.913	-.183
Confidence	.491	-.361
Ability	-.571	.111
Computation	.239	.282
Theory	-.199	.058
Interpretation	-.571	.101
Male	.961	.240
Female	-.691	-.318

The conversation patterns are displayed in different dimensionality scales. This is to allow for consistent visualizations across the themes. Fig. 4 shows that PKNOW, ABLE, and INT are closer to one another in the left quadrant, an indication of a close proximities or distances between the codes. These codes also tend to be closer to COMP and THEO than with ATT and CONF. This indicates that one or other educators frequently mentioned similar or related themes during the interview. Codes which were furthest from the others were the least mentioned. Fig. 5 indicates the visual representation of the interview response themes via a different axis scales while Fig. 6 represents the subjects concentration. Finally, Fig. 7 illustrates the blended representation of the response themes and the subjects. It indicates the similarities and differences between the interview responses and the subjects that responded commonly to the questions asked by the interviewer. Interpretation remains a crucial part of the analysis and in this particular case study, the educators' mentioned that students who failed to understand the "Theoretical" aspect of the concepts and have difficulties in the statistical "Computational" activities were related to their lack of "Prior Knowledge" in statistics, their "Ability to think through the concepts quickly and were rather weak in their "interpretation" of the statistical results.

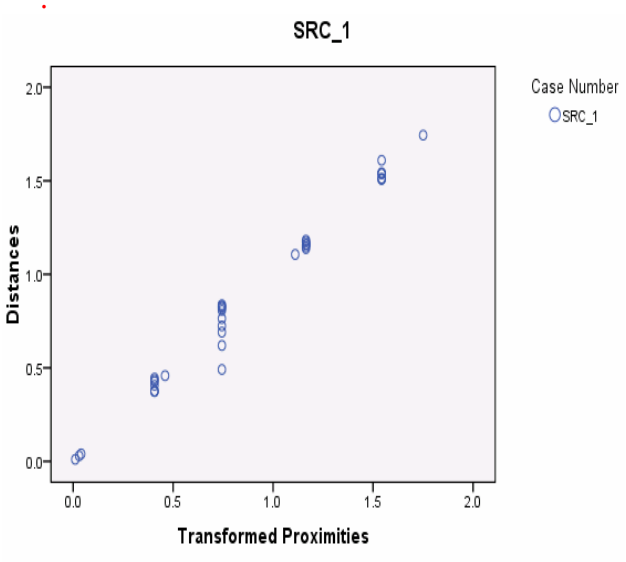

Fig.3 Shepard diagram between distances and transformed proximities

Table 8 Distances between the themes

Distances

	Prior Knowledge	Attitude	Confidence	Ability	Computation	Theory	Interpretation
Prior Knowledge	.000						
Attitude	1.576	.000					
Confidence	1.199	.977	.000				
Ability	.020	1.570	1.182	.000			
Computation	.697	.925	.971	.697	.000		
Theory	.451	1.618	.964	.431	.911	.000	
Interpretation	.057	1.572	1.231	.076	.679	.507	.000

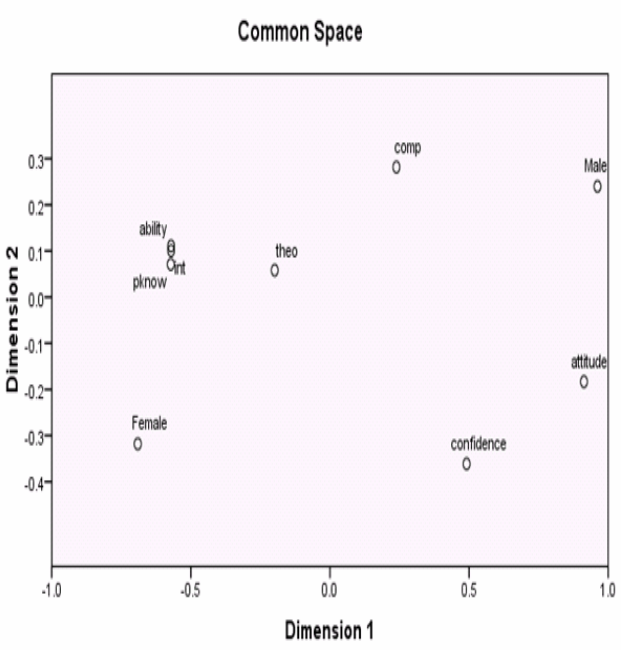

Fig. 4 MDS 2-dimensional solution of the response themes represented by distance coefficients

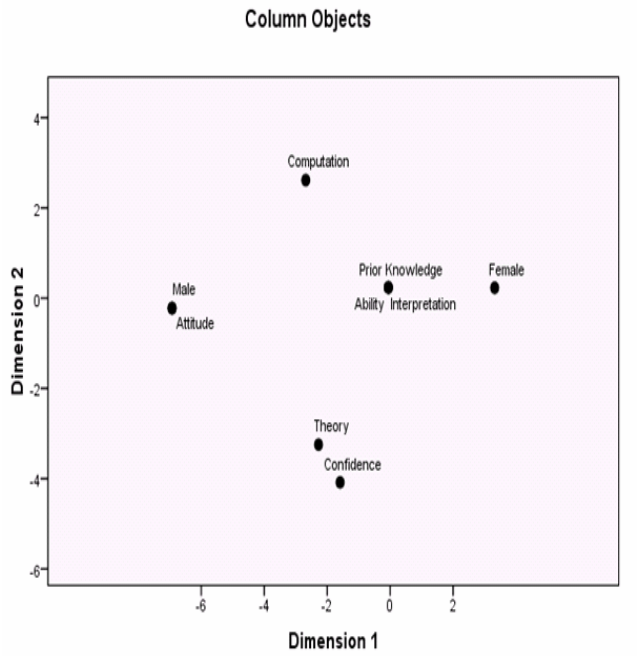

Fig. 5 MDS 2-dimensional solution of the response themes represented by coefficient

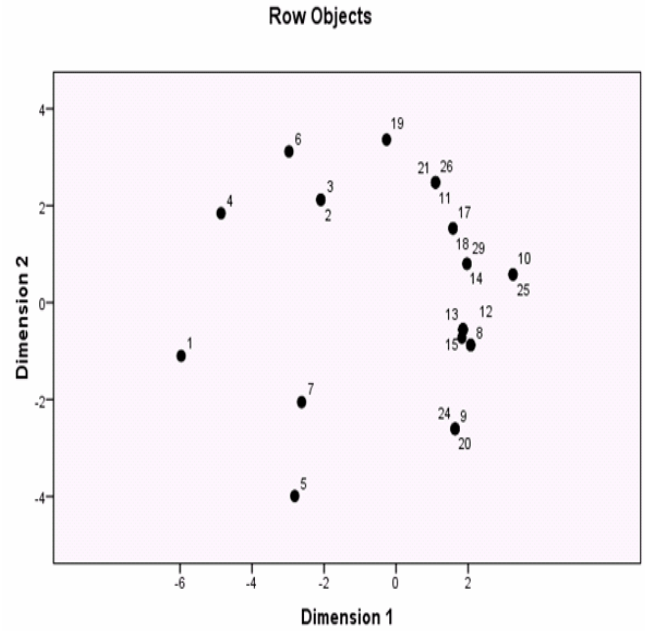

Fig. 5 MDS 2-dimensional solution of the subjects as represented by Jacquard's coefficient

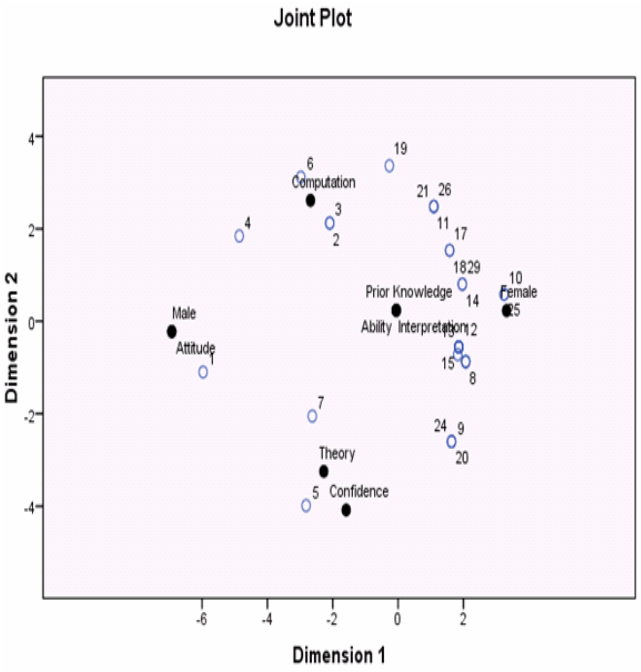

Fig. 6 Joint plot between the interview themes and subjects as represented by Jacquard's coefficient

4 Conclusion and Discussion

This study had described the use of qualitative matrix and multidimensional scaling as techniques which can be combined in the analysis of interview conversations. These methodological techniques have been used together to look for examining the relational patterns of the interviews regarding students' learning difficulties as perceived by the statistics educators. Most of these findings were determined and represented by the educators who mentioned two or more themes or codes and have provided relevant responses to the questions. The distances between the theme codes were higher when more educators mentioned the theme codes together than when few educators mentioned them together. The approach taken to link the themes or codes was also meant to illustrate the application of using multidimensional scaling within the qualitative data approach. The other intention was also to investigate the feasibility of using these techniques for use in a larger scale studies [15], [16].

Future works may involve investigating similar aspects of teaching and learning of statistics using questionnaire based on the information gathered from this study. This would be ideal for educators who do not wish to be interviewed or want to stay anonymous in providing their responses to the above issues. In view of the economics of the situation, this approach would be feasible because such an investigation tend to incur less cost and time compared to the interview technique. The possible criticism would be, "Can the questionnaire alone be used to ensure that adequate responses be obtained?" Hence, the answer would lie in the extent to which how both questionnaire and interview techniques are combined and used together effectively as means of eliciting adequate information from the respondents.

References:

[1] M.B. Miles, and A.M. Huberman, *Qualitative Data Analysis: A Sourcebook of New Methods (2nd Ed.)* Sage Publications, 1994.

[2] B.W. Tuckman, *Conducting Educational Research.* Hartcourt Brace, Jovanovich, New York, 1993.

[3] F.N. Kerlinger, and H.B. Lee, *Foundations of Bevavioural Research (4th Ed.)* Harcourt College Publishers, 2000.

[4] J.Garfield, and R. delMas, Reasoning about chance events: Assessing and changing students' conceptions of probability. *Proceedings of the 11th Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education,* Vol.2, 1989, pp. 189-195.

[5] J.B Garfield, Beyond testing and grading: Using assessment to improve student learning. *Journal of Statistics Education,* Vol. 2, 1994.

[6] Z. Mahmud and M.S. Zainol, Examining postgraduate students' perceived competency in statistical data analysis and their attitudes toward statistics. *WSEAS International Journal of Education and Information Technologies, Issue 1, Vol. 2,* 2008, pp. 79-86.

[7] A.M. Huberman, *Evaluation of Three Objectives of an Experimental Primary School: Summary of Outcomes.* Bern, Swiss Scientific Research Council, 1978.

[8] D.C. Lortie, *School Teachers: A Sociological Study.* Chicago, University of Chicago Press, 1975.

[9] J. Heritage, Explanations as accounts: A conversation analytic perspective. In C. Antaki (ed.) *Analyzing Everyday Explanations: A Casebook of Methods,* 1988, pp. 127-144.

[10]M.B. Miles, and A.M. Huberman, *The Realities of School Improvement Programs: Analysis of Qualitative Data.* Proposal to National Institute of Education, 1980.

[11] M.B. Miles, and A.M. Huberman, *Qualitative Data Analysis: A Sourcebook of New Methods.* Beverly Hills, CA Sage, 1984.

[12] Z.Mahmud and R.A. Rahim, Examining relational patterns of students' learning difficulties in statistical concepts using qualitative matrix and multidimensional scaling of interview data. *2nd WSEAS International Conference on Multivariate Analysis and its Application in Science and Engineering*, pp. 34-40, 2009.

[13] M.Buscema, S.Terzi, An evolutionary approach to the problem of multi-dimensional scaling. *WSEAS Transaction on Information Science and Applications*, No. 9, 2006, pp. 1704–1710.

[14] J.F. Hair, B. Black, B. Babin, Multivariate Data Analysis, Prentice Hall, 2006.

[15]C. Konold, Informal Conceptions of Probability. *Cognition and Instruction*, Vol.3, No.3, 1989, pp. 430-450,

[16] M.Phannkuch, and C. Brown, Building on and challenging students' intuitions about probabililty: can we improve undergraduate learning. *Journal of Statistics Education*, Vol. 4, No. 1, 1996.