ANALYSING INTERVIEW DATA FOR CLUSTERS AND THEMES

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This paper outlines a qualitative approach for analysing interview transcripts. The approach involves identification of comments related to research interests, formation of clusters to group comments and then confirmation of themes in the data related to pre-determined research interests. Descriptions of each participant's views on each theme are summarised as case-studies. Illustrative examples from teacher interview data on teaching and learning will show how the approach can be implemented. The approach used is based on the work of Chesler who used grounded theory to explore views of a group of professionals.

Theme analysis is a common approach used to analyse interview transcripts (see for example Strauss & Corbin, 1990). This paper will outline an approach for theme analysis and for developing case studies related to themes. The approach will be illustrated using data from a study on teaching and learning mathematics with technology.

Given that themes are statements that encapsulate recurring ideas in interview transcripts and are likely to 'emerge from them on intensive analysis' (Tesch, 1990, p. 60) it is important to find a way to identify themes. In theme analysis there is the possibility to explore all themes emerging from data or else restrict the identification of themes to those which are related to specific research interests. The approach in this paper limits the themes by identifying only those related to specific research interests. Flick (2006) and Chesler (1987) also reported approaches where themes were focussed on specific areas of interest. This differs from some approaches to theme analysis where all emerging themes are identified in interview transcripts, often as an initial stage in the formation of theories (Strauss & Corbin, 1990).

The next section will outline one method for identifying themes based on an approach described by Chesler (1987). Chesler provided a seven step sequential analysis for development of theories and the first four steps in his approach can be used to identify emerging themes related to specific research questions. His approach, also reported in Miles and Huberman (1994), can be used to provide a description of phenomena under investigation. In this paper use of pen-and-paper or technology (in this case a computer algebra system, or CAS) for understanding in a secondary mathematics classroom will be used to provide illustrative examples of the approach

used for theme analysis. The context of the study is discussed further in the section describing the data used to provide illustrative examples.

Chesler's approach for analysing interview transcripts

The first step of Chesler's analysis required researchers to "underline key terms in the text" (p. 9). This involved reading the transcript and underlining key terms deemed to be relevant and important to the research questions.

The second step, carried out concurrently with underlining of key terms, was to "restate key phrases in the margin of the text" (p. 10) using words as close as possible to the text in the interview transcript. Chesler stressed the need to be able to use the restatements of the key phrases to go back to comments in the transcript.

The third step was to "reduce the phrases and create cluster" (p.10) by placing phrases with the same focus together in a cluster. Chesler suggested checking the original transcript when assigning phrases to clusters as he believed it could be difficult to know the exact meaning of a phrase in the absence of the context of the original text. This highlights the importance of step two in Chesler's approach where the researcher ensures that the restated phrases are able to be used to return to the original transcript. Next, 'constant comparison' (see for example Bryman, 2004, p. 403) was used to reduce the number of clusters to form 'meta-clusters'. Strauss and Corbin (1988) acknowledge the role that the researcher's experience and knowledge plays in grouping of comments.

> Later, as we move along in our analysis, it is our knowledge and experience (professional, gender, cultural, etc) that enables us to recognize incidents as being conceptually similar or dissimilar and to give them conceptual names. It is by using what we bring to the data in a systematic and aware way that we become sensitive to meaning without forcing our explanations on data (Strauss & Corbin, 1988, p. 47)

Analysis of the meta-clusters provided the overriding themes emerging from the data. Finally, prior to developing a theory, Chesler's fourth step involved generalisation of the phrases within a cluster to provide an analysis of the meaning of the cluster.

Data to illustrate approaches

The data used to illustrate the process of theme analysis and development of case studies in this paper is from teacher interview transcripts. These interview transcripts are from a study that was part of a Victorian research project investigating the implementation of CAS in year 12 mathematics (see Stacey, McCrae, Chick, Asp, & Leigh-Lancaster, 2000). CAS is a technology which is able to automate many mathematics procedures and when this research project was undertaken it was the first time that CAS was allowed in year 12 examinations in Victoria. The teachers and students were the first to undertake a year 12 mathematics subject where CAS was allowed in all aspects of the course. Students were provided with a handheld CAS for use in class, at home and in examinations.

The teachers were experienced year 12 mathematics teachers who had taught year 11 maths with CAS, but this was the first time they had taught a Year 12 mathematics subject where CAS was assumed in the examinations. Semi-structured interviews were conducted with each teacher mid-year and also following the end-of-year examinations in November. The interviews were intended to cover a number of issues, as part of data collection for the research project, so there were numerous foci for questions. As a

result, it was necessary to decide on an approach for analysing interview transcripts to investigate particular research interests for this study, which was part of the larger research project (for further information about the research project see Ball & Stacey, 2005a, 2005b, 2006; Flynn, 2003; Stacey, 2003).

The research area investigated in this paper is the use of pen-and-paper or CAS in senior secondary school mathematics. For the purposes of this paper it is useful to know that the teachers had to come to personal decisions about the extent and nature of pen-and-paper and CAS use in their classrooms, in the context that students were allowed to use CAS in examinations. In the following sections the examples used to illustrate the analysis are related to use of pen-and-paper or CAS.

Analysis of interview transcripts to determine themes

This section describes the nine-stage approach used for analysis of interview transcripts to determine themes in this paper. Figure 1 provides an overview of the analysis process, which comprises nine stages. The two terms 'theme' and 'emerging theme' indicate the results of two different aspects of the analysis of interview transcripts. *Emerging themes* are the product of stages 1–3 and *themes* will be confirmed following stage 6. There are two additional stages for the development of case studies which are shown in Figure 5 and which will be described later in this paper. Stages 1–2 will now be described.

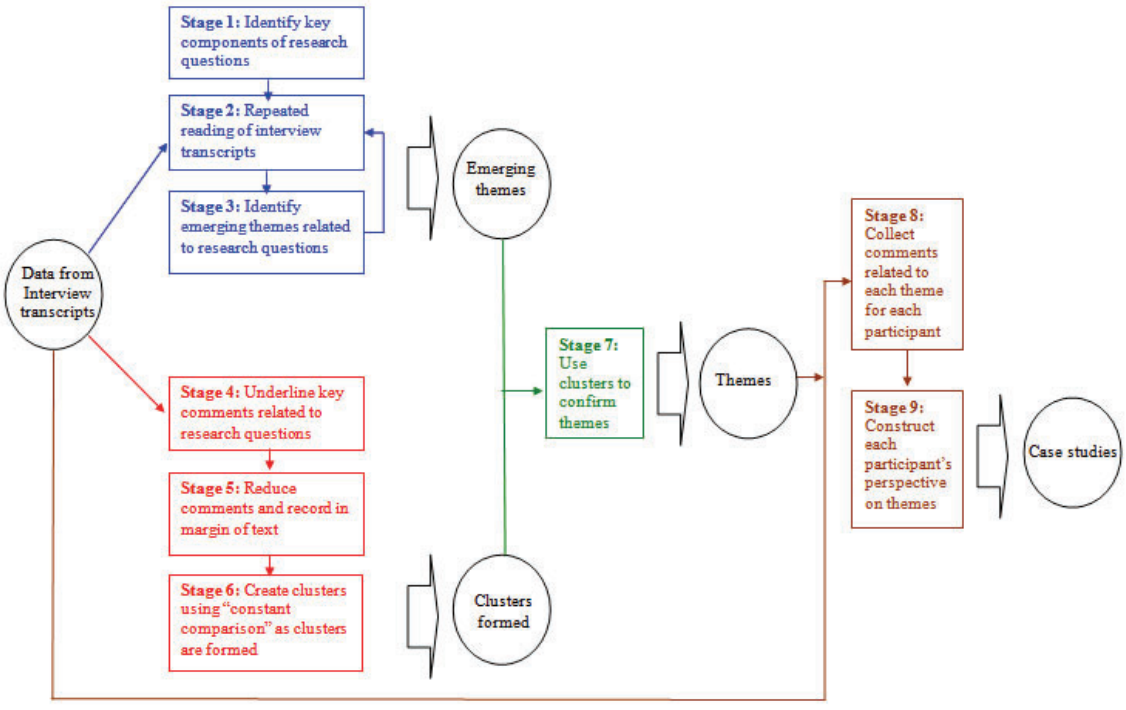

Figure 1. Cycle for analysis of interview transcripts to determine themes and produce case studies.

Identification of emerging themes

The product of stages 1–3 will be a list of emerging themes evident in the interview transcripts and related to specific research questions (refer to Figure 1). These three

stages are different to the initial steps described by Chesler, who started his analysis by underlining key terms and then paraphrasing these key terms in the margin of the text.

Stages 1–3

In stage 1, the researcher identifies the key component of the research question. The reason that the term key component is used is that some research questions may have a number of components which need to be investigated. For this paper the key component is use of pen-and-paper or CAS in class.

Stages 2–3 are carried out concurrently. To identify emerging themes the interview transcripts need to be read a number of times. The process is commenced by reading the interview transcript and recording a draft list of emerging themes. This list is a first attempt at emerging themes and will be modified (either by adding, deleting or rewording) as interview transcripts are re-read a number of times. In this analysis the goal is not to find all emerging themes in the data but instead to find those specifically related to research areas of interest. Themes unrelated to the research questions are not considered.

As outlined previously, Strauss and Corbin (1988) stressed the importance of a researcher's experience and knowledge in recognising similarity and differences in comments and this will be important when identifying themes. To recognise recurring ideas in data requires the ability to recognise words and expressions that may be referring to a common idea, hence the need to have appropriate experience and knowledge of the research area. Themes are not going to be repeatedly stated in interview but instead will need to be in inferred by the researcher. As a result it is important, using the illustrative examples in this paper, that the researcher is able to recognise recurring ideas associated with pen-and-paper or CAS. The documentation following stages 1–3 is a list of emerging themes. The final wording of the confirmed themes will be decided in stage 6.

As there is no documentary evidence for stages 1–3, except for a list of emerging themes, it is only possible to provide a statement of a theme here to illustrate the stages. One emerging theme was "students' understanding" in the context of classes with access to both pen-and-paper and CAS.

Following are descriptions of the other stages (4–6) used to confirm themes with the illustrative examples related to the emerging theme "students' understanding".

Formation of clusters

The goal of stages 4–6 is to produce a list of clusters, each of which contains paraphrased comments with the same focus related to the research interest (see Figure 1). These three stages are independent of stages 1–3 and hence the emerging themes are not referred to for stages 4–6. To carry out stage 4 it is necessary to go back to the data and do a separate analysis of the interview transcripts.

Stage 4

First return to the interview data and research question/s and highlight key comments related to each research question. This process will most likely require re-reading of the interview transcripts a number of times, particularly if each research question is considered separately. Note that a sentence may contain more than one key comment, particularly if sentences are lengthy.

Figure 2 provides an illustrative example of the outcome of stage 4 using an excerpt from a teacher interview. This excerpt was chosen as there is a focus on *understanding*, which linked directly to the emerging theme being used as an illustration in this paper. In this case the research question was related to use of CAS or pen-and-paper in class and four comments are highlighted. It is important to note here that the researcher had observed many classes where CAS was available and this aided in the ability to recognise words that signalled pen-and-paper or CAS use. To conduct stage 4 the researcher recognised words or phrases that identified relevant comments to be highlighted. Some examples in Figure 2 are the terms "by-hand" and "manual" which referred to *pen-and-paper* in the context of the research question. Part of the third highlighted comment "if they didn't fiddle with it a bit themselves they didn't have a strong sense of ownership over it" may seem irrelevant at first. However, in the context of the fully highlighted comment this statement suggested that students needed to have an understanding of the mathematics by performing some pen-and-paper or CAS work (i.e. "fiddling with it") so that they would not be perturbed by unexpected technology displays or outputs. This stresses the need for the researcher to be able to interpret the interview comments in the context of the study and to recognise relevant comments, rather than only look for key words. If a researcher only highlights comments with the terms *by-hand* or *pen-and-paper* or similar then the third highlighted comment "there was an element of magic with a lot of the things ... they were less able to say well that's just a case of this or I know why that's doing it now" would be excluded. The second highlighted comment "A more likely sequence is for me to start with manual" where the term "manual" refers to pen-and-paper may also be missed. The ability to interpret the comments made by the teacher in the context of the research questions is essential here in order to be able to identify relevant phrases and comments to highlight.

Stage 5

The purpose of stage 5 is to reduce the data to assist in formation of clusters in stage 6. Highlighted comments will be paraphrased and the paraphrased comments will be recorded in the margin of the interview transcript. The intent here is not to focus on the precise wording of the paraphrased comments, as they are not used for reporting, but instead to ensure that each paraphrased comment accurately summarises the key idea highlighted in the interview transcript. This will assist in stage 6 when paraphrased comments with a common focus are collected to form a cluster. As stated previously some sentences may contain multiple foci and hence one sentence may result in more than one paraphrased comment.

Paraphrasing will enable teacher comments with a common meaning, but different wording, to be represented by the same or similar comments. Referring again to Figure 2 it can be noted that the last three paraphrased comments all refer to learning mathematics with pen-and-paper prior to use of CAS, even though the wording of each phrase is slightly different. The difference reflects the additional focus of the teacher comments, namely the ability to "deal with syntax and unexpected outputs" (i.e. for working with CAS) and "for simple cases to develop understanding of mathematics" (i.e. to perform simple cases using pen-and-paper to develop mathematical understanding). Figure 3 provides additional examples of paraphrased comments related to pen-and-paper or CAS. Implicit in the teacher's second highlighted comment in

Figure 3 is that pen-and-paper should be used to develop mathematical understanding ("Once they understand how they've got it") before a CAS can be used ("then use the calculator" implies following pen-and-paper). Again, the researcher needs a good understanding of the research context in order to recognise this.

Stage 4 – Highlighted interview comments related to research question	Stage 5 – Paraphrased comments
Sometimes, when I'm getting them to look for patterns and things and see if they can see anything that's there I might start with that and then use that as the basis for exploring why that might be the case and then often we would go back to then doing something by-hand. A more likely sequence is for me to start with manual because I kept getting the feed back in different ways from the kids and from their work that there was an element of magic with a lot of the things and if they didn't fiddle with it a bit themselves they didn't have a strong sense of ownership over it and once they got lost in the syntax or they got lost in the unusual nature of the output, an unfamiliar output, then they were less able to say well that's just a case of this or I know why that's doing it now because this is just a separated fraction or (...). So I think I kept feeling reinforced in the view that with all the new procedures you really needed to spend some time to make sure they could do the simple cases by-hand and if you didn't you were battling, you were battling with the majority of the kids (...) because they don't know (...), they don't know what the building block was. So I'm more reinforced about the view than I was even when I was doing graphical calculator stuff (...)	Sometimes CAS used to generate patterns for exploration and then pen-and-paper. Normally start with pen-and-paper Pen-and-paper first to understand mathematics and be able to deal with syntax and unexpected outputs Pen-and-paper first for simple cases to develop understanding of mathematics.

Figure 2. Interview excerpt illustrating stages 4-5 (Teacher 1 end-of-year).

Well I think that's when you have to do things by-hand. I feel you need to be able to show them how to come up with things by-hand so that they can understand where this part of the equation comes from, where the solution might come from, and how it all fits together. Once they understand how they've got it, they can then use the calculator (...)	Pen-and-paper for understanding Once students understand the maths (using pen-and-paper) students can use CAS – teacher legitimizing CAS use.

Figure 3. Interview excerpt illustrating stages 4-5 (Teacher 2 mid-year).

Stage 6

The purpose of stage 6 is to form a number of clusters, with each cluster containing a group of paraphrased comments with the same focus. This is the last stage where the paraphrased comments are used.

Two or more paraphrased comments will be required for formation of an initial cluster. "Constant comparison" (see for example Bryman, 2004, p. 403) is used to finalise the clusters and occurs as paraphrased comments are assigned to clusters. Constant comparison involves comparison of paraphrased comments within and across clusters as they are formed to ensure that each cluster accurately reflects the data within it. Where a paraphrased comment appears to belong to two clusters the comment will be compared to other comments in each of the two clusters, searching for similarities and differences. If it is still not evident which cluster the paraphrased comment belongs to then the two possible clusters will be reconsidered to determine if they are sufficiently

different to warrant two clusters, or whether they should be consolidated to form one cluster. If the two clusters are combined then each paraphrased comment will be individually reconsidered to determine appropriateness for inclusion in the new combined cluster.

Each cluster will be labelled with a name to represent the main focus of the paraphrased comments within the cluster. An example of a cluster with some associated paraphrased comments is shown in Figure 4. Note here that each comment refers to the order in which pen-and-paper or CAS is used in class. Some comments specifically state that CAS or pen-and-paper should be first, while other paraphrased comments, for example, to use "CAS for checking pen-and-paper sketching of graphs", suggested that pen-and-paper was first. One cluster, "students' choice of CAS or pen-and-paper", contains the paraphrased comment "Teacher encourages able students to use pen-and-paper first and then use CAS once they know how to do something". This paraphrased comment was originally assigned to the cluster "pen-and-paper or CAS first" (Figure 4), but then on reconsideration was placed in the "students' choice of CAS or pen-and-paper" as the focus was on the teacher encouraging able students to use pen-and-paper first. With a focus on mathematically-able students, there is a suggestion that there might be different decisions to be made, depending on students' facility with pen-and-paper techniques.

Pen-and-paper or CAS first	• Teacher demonstration of pen-and-paper first then CAS for speed • Teach pen-and-paper first and then CAS • CAS for checking pen-and-paper sketching of graphs • Always do graphs with pen-and-paper first and then check results

Figure 4. Example of cluster with some paraphrased comments in cluster.

Confirmation of themes

The intention of stage 7 (in Figure 1) is to confirm and hence finalise the themes. This involves clarifying the wording of the themes and checking that the themes are supported by the interview data. Stage 7 uses the outputs of stages 1-3 and 4-6, making use of the emerging themes and clusters.

Stage 7

First allocate each cluster to an emerging theme. Where clusters appear to align to two emerging themes, the statements of the emerging themes will be reconsidered and reworded if necessary to clearly distinguish the two themes. Themes will be discussed with a second researcher, who will also have read the teacher interview transcripts, to clarify descriptions of themes. Themes will be confirmed when they have one or more clusters listed under them. If an emerging theme does not have an associated cluster then this will not be included as a final theme.

Development of case studies using themes and teacher comments

The final two stages of the process (stages 8 and 9 in Figure 1) are used to produce case studies for each theme.

Stage 8

In this stage participants' comments related to each theme are collected. Note that individual participants may or may not make comments relating to every theme.

For stage 8 the researcher returns to the original interview transcript, considers each highlighted comment and assigns each comment to a theme. The result of this process is a collection of interview comments for each theme.

Figure 5 illustrates two teacher comments related to the theme "students' understanding". The first comment suggests that the teacher believes that students need to see pen-and-paper work ("by-hand") to understand the mathematics prior to use of CAS ("understand where this part of the equation comes from, where the solution might come from, and how it all fits together"). The focus for this comment appears to be the teacher's desire for students to develop understanding before using the CAS calculator. The second comment in Figure 5 also focuses on the importance that the teacher places on students developing understanding before using CAS.

- I think that's when you have to do things by-hand. I feel you need to be able to show them how to come up with things by-hand so that they can understand where this part of the equation comes from, where the solution might come from, and how it all fits together. Once they understand how they've got it, they can then use the calculator.
- ... it helps them to see how the actual solution is developed and what different parts of the solution refer to, and where they fit in. But then once they know how to do it and once they understand how to do it then they don't need to do that over and over again, they can use the calculator. So I think they do need to do that in order to develop understanding but then once they know how to do it, they know how to do it, and they can use the calculator.

Figure 5. Collection of sample interview comments related to a theme - students' understanding.

Stage 9

In stage 9 the comments for each participant for each theme are summarised to produce case studies. The case studies provide a summary of each participant's position in relation to each theme for which comments are provided. There is no illustrative example provided for this stage in this paper.

Conclusion

The cycle for analysis requires identification of terms, comments and emerging themes related to a given research question, familiarity with the research area and the context in which the participant (in this case the teacher) works. The paraphrasing of comments is a practical way for the researcher to engage with the interview data and decide on the key focus for each interview comment. The formation of clusters by grouping paraphrased comments provides a second opportunity to consider key messages in the data. The use of clusters to confirm themes provides yet further consideration of the data. This structured cycle for analysis of interview transcripts has proven helpful for identifying emerging themes, confirming these themes and then producing case studies.

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