DOCUMENT RESUME

ED 401 128 SE 059 195

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TITLE Classroom Video-Recording: When, Why and How Does It Offer a Valuable Data Source for Qualitative Research?
PUB DATE 14 Oct 96
NOTE 17p.; Paper presented at the Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education (Panama City, FL, October 14, 1996).
PUB TYPE Viewpoints (Opinion/Position Papers, Essays, etc.) (120) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Data Collection; *Educational Research; Elementary Secondary Education; Foreign Countries; *Videotape Recordings

ABSTRACT

Video recordings are being used more and more in educational research; however, it is uncertain when they actually form the data and when they merely facilitate its collection. This and other issues related to the use of classroom video-recording as a data source for qualitative research are discussed in this paper. Research investigating the phenomenon of 'folding back' in the growth of mathematical understanding is used to illustrate the strengths and weaknesses of video recordings in classrooms as a research tool. The techniques of both video-stimulated recall and think-aloud protocols are discussed. The paper closes with a pragmatic look at how to get the most out of one's video-tapes. Contains 46 references. (Author/JRH)

Classroom Video-Recording: When, Why and How Does It Offer a Valuable Data Source for Qualitative Research?

by
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Video recordings are being used more and more in educational research, but when do they actually form our data and when merely facilitate its collection? Why is video-recording becoming such a popular tool? How can we appropriately exploit the strengths of this form of data? Research investigating the phenomenon of 'folding back' in the growth of mathematical understanding is used to illustrate the strengths and weaknesses of video recordings in classrooms, as a research tool. The techniques of both video-stimulated recall and think-aloud protocols are discussed and the paper closes with a pragmatic look at how to get the most out of ones video-tapes.

There has been increased interest in ethnographic research within the mathematics education community over the past decade leading to a rich and varied collection of insights into aspects of the mathematics classroom culture and its psychological impact on teaching and learning. Much of this research is based on classroom observation by outside researchers, but a growing voice is being given to teachers, bringing to our attention their own, unmediated, personal perspectives. An expanding proportion of this research involves video-cameras in classrooms. If, as researchers and readers of research, we wish to understand the work of others, to evaluate the psychological implications that are claimed, to explore the relevance to our own environment, of research done in other contexts and cultures, then it is vital that we know precisely on what data studies are based. Not only do we need to examine the tools with which the data were gathered, but also the nature of the data themselves. This is not as simplistic a statement as it may seem, particularly with reference to video-data.

In any research, with every question we ask we create a bias in the data, making, albeit unconsciously, a decision to leave other questions unasked. All research is to some degree subjective. We see what interests us; we look with a purpose. The field notes we take are already an interpretation of the phenomenon that we study. We rationalise as best we can the value of the data we gather and the worthlessness or irrelevance of that which we do not. Video-recording has been claimed as a way to capture everything that is taking place in the classroom, thus allowing us to postpone that moment of focusing, of decision taking. Yet this is misleading: who we are, where we place the cameras, even the type of microphone that we use governs which data we will gather and which we will lose. What video-tapes *can* do is give us the facility through which to re-visit the aspect of the classroom that we have recorded, granting us greater leisure to reflect on classroom events and pursue the answers we seek. At one level at least, a video-tape buys us time. This paper places video-recording, as a means of data gathering, under scrutiny, acknowledging its strengths, while exposing its weaknesses and illuminating the need for honesty, both with ourselves and with others, as to the true nature of the data we are analysing.

Possibly the best metaphor that I have met for the vast complexity of classroom research was written by Adams and Biddle (1970[1]), in one of the earliest books to document the use of video data. They liken it to trying to describe a flowing river, where, although it "moves on steadily and continuously, there are eddies, ripples, and currents. These eddies disturb the surface and have a character of their own although they are never completely independent of the main current. The great bulk of the river is impressive, but the ripple patterns, eddies and currents are all intriguing too." Extending this metaphor, we can guess at the rocks and fallen branches that lie beneath the surface creating the still pools and whirling currents that characterise a particular stretch of the river. The kingfisher and the trout, however, have

[1]I am grateful to Donald Cudmore for introducing me to this delightful little book. The analysis that they advocate is quantitative, however, and therefore not specifically applicable to this paper.

very different perspectives - neither can ever see the "whole river". In this paper, I intend to illustrate some of the variety of occasions when a video-recording of this "river" can furnish us with a particular perspective that offers evidence for valuable analysis. I shall focus my discussion through reference to my current, on-going research interest, namely the occurrence of the phenomenon of 'folding back', and in particular 'collecting'[2], in the growth of students' mathematical understanding. It is not necessary, for the purposes of this paper, for the reader to understand these concepts in detail[3] It suffices to know that, within the Pirie-Kieren theory for the dynamical growth of understanding[4], the process of mentally (or indeed physically) returning to earlier mathematical understandings with the intention of illuminating some current outer level problem is known as 'folding back'. Within this phenomenon we have distinguished different mental activities. That which has been termed 'collecting', is a process of knowing that one knows what one needs to know, but of needing to review it, and possibly adapt it, in the light of the new situation. We distinguish it from instant recall and also from the need to substantially work on a concept before it is applicable to the problem in hand. (Pirie et al, 1996)

Since folding back can only be observed by close attention to the activities and talk of students as they work at a mathematical problem, the examination of classroom video recordings would seem to be the least intrusive (they will not be interrupted by my questioning them as they work), yet most inclusive, way of studying the phenomenon, particularly if it is coupled with a study of the students' written work and my field notes of what is going on in the classroom in general. However, all choices as to methods of data gathering must be dependent on ones research questions, so what were some of mine? Let us consider just two of my questions. Firstly:

"Do different types of teacher interventions favour or discourage folding back?"[5]

Before deciding on what I need as data, a decision must be taken as to whether to use pre-existing categories of teacher interventions or whether to create my own. If the former, I need to identify moments of intervention, classify them according to the typology I have selected and record whether they led to folding back or not. The videos, here, are no more my data than the original classrooms were. Certainly they allow me time to make considered judgements on classification or whether an episode did or did not result in folding back, but they are not essential data to be studied per se. I can reflect on and revisit the recorded scenes at will, but the videos themselves are simply a vehicle, as is the classroom, for *gathering* the data with which I shall work. The *data* are the numbers within the categories, relating interventions with occurrences of folding back, which I shall manipulate, analyse and interpret.

The question, however, appears misleadingly simple. In reality, I do not know what would be fruitful ways of categorising the interventions in this instance. Identifying episodes of folding back is, comparatively speaking, unproblematic, but what is it about the surrounding environment, context and nature of the interventions that might be influencing the occurrence of this form of mental mathematical activity? To answer this, it is the videos themselves that I need to study. I do not know till after the event what will be a context for folding back. The classroom *could not* provide me with my data; it can only be gathered with hind-sight. It is here that the videos themselves become my data.

My methodology is such that I can examine any suitable existing video tapes and gather further specific data as and where I see the need. The method is based on the notion of

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[2]This label was originally coined by Lyndon Martin, a DPhil student of mine studying the phenomenon of folding back

[3] See Pirie & Kieren 1991

[4] See Pirie & Kieren 1994 for fuller description

[5]I am fully aware that there is a multitude of other considerations to be taken account of in dealing with this and all other research questions, but it must be remembered that my purpose *in this paper* is to focus solely on the role of video recordings *as data*.

grounded categories emerging from the constant comparison of episodes identified through theoretical sampling.[6]. It is a method which allows me to look for anything in the intervention that might be an influence, give it a category label and confirm or discount its relevance through examination of other episodes. I might note tone of voice, class grouping, gender of teacher and student etc. I let what I see on the video suggest ideas to me. Here it *is* the video recordings that are my data. It is the tapes themselves that form the basis of my interpretations. I could not do this analysis any other way. It is essential, not merely luxurious, to be able to re-examine the episodes, what went before and what came after. It is at this point. too, that I can exploit one of the real strengths of video as data. I can have others watch the episodes and suggest categories. The focus of the categorising remains the same, but I benefit from my data being looked at through different eyes and experiences. The categories, of course, will always remain subjective, in that there are no 'right' labels but the analysis becomes more powerful and more revealing as the perspectives of others are brought to bear on my task. "Rich descriptions, that explore the meaning structure beyond what is immediately experienced, gain a dimension of depth." (van Manen, 1988)

So far I have talked vaguely about "video-taping", without specifying what it is that I am hoping to record and this is in fact an all-important decision. It is at this juncture that the decisions are made, on what will not be captured for future scrutiny, and it is important to look at it from this negative perspective as well as from the more obvious stand of "what do I want to see?". The more focused the camera, the more detail will be available but also the more general information will be lost[7]. To elicit moments of folding back, I needed to have a continuous, detailed record of the working of specific students, together with a record of any teacher interventions that impinged on their working. I chose to focus a fixed camera on each of one or two specific, pre-selected groups of students, thereby losing any record of what other students were doing. The camera was close enough to carry the outline of what the students were writing, but not so close that I was not able to see all their faces and body language. I was able to supply the detail of their writing by matching the video with copies of their written records at the end of the session. I placed a high quality rifle microphone on the table that the students were working at, which was able to pick up everything that was said by the group, excluded general classroom noise, but picked up any pronouncements made by the teacher to the class as a whole as well as specific interactions with the targeted students. I lost almost all the remarks made to the students by other students outside the range of the microphone. This method of data collection resulted in one or two tapes (depending on the number of groups I was interested in) per lesson to analyse.

It is important for me to state here that when analysing my data I work exclusively with the videos at this stage, never with transcripts. I feel that it is important that we be totally honest when stating the nature of our data. Working with the tapes as opposed to transcripts is neither intrinsically better or worse, but it *is* different (Cennamo, Chung, Leuck, Mount and Turner-Vorbeck, 1995). In many areas transcripts have proven advantages. There is a great deal of information available surrounding working with text-based data; indeed there exist specialist computer packages which code, file, group and retrieve texts to the enhancement of their analysis. Such analysis is based within a history of other qualitative research and can thereby claim a certain reliability and validity. It is certainly true to say that new insights can be had from repeatedly re-viewing video-tapes, but such insights can equally well be had from the re-reading of texts, although it would seem that the written word is less seductive, and once categorised and analysed, we rarely return to the text for a completely fresh reading. It is also true that one has the possibility of revisiting the video-tapes after working with the transcripts, but one must be aware of the danger that only what is looked for may be seen and what has been concluded, confirmed. When working with video

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[6]This has its roots in Glaser and Strauss' approach (1967). See Pirie(forthcoming) for detailed description

[7]The options available to me in this regard are laid out in detail in Appendix 1. Here I will merely state the choices I made.

data, the task is undoubtedly harder. We have to deal with a greater range of sensory perceptions, most relevant of which, to me, are how the words are said and what actions accompany them. Is "a closing of the eyelid .. a twitch, a wink, or a conspiratorial communication"? asks Goldman-Segall (1993)". I must ask in addition, "Is it in any way relevant to my research issue?". It is herein that one of the weaknesses of working with video data lies. There are as yet no accepted ways of analysis through qualitative methods. We, as a research community, must build our own history, and for this very reason we must be as explicit and as public as possible about what it is that we do. For me, analysis involves connecting my computer to the VCR and, using the software package CVideo[8] (a later version of VideoNoter[9]) to record my analyses as I watch the tapes. This technique allows me to time-tie my observations and comments to the video episodes and enables me to move easily and quickly from one episode to another by using a search on particular words or a time reference. I engage in a lot of 'sit, look, think, look again', frequently followed by persuading others to look with me because, quite apart from the insights they have to offer, I personally find that having to articulate and argue for my perceptions helps to crystallise them into either useful or inappropriate descriptions. A weakness of video data is that one can watch hours of video which turns out to have no relevance to the purpose in hand. One cannot, at least initially, 'skim' as one can when reading. In brief, transcriptions are frequently easier to work with, and in some cases more appropriate, but there will always be a loss of data and the researcher must *consciously* address the relevance of this loss. In addition, those to whom we would communicate should be informed of the true nature of the data on which the analysis was based, and if it *was* video data, on how that analysis was conducted. (Incidentally, had my question been concerned with particular types of *verbal instructions* I might possibly have considered working with transcriptions. The ease of analysis might have outweighed the loss of tone of voice.)

To return to the methods I use to address my actual research question above: at this stage anything, not merely the verbal, may be relevant, and it is for this reason, that I have chosen to video the classroom rather than use audio tapes, hence I stay with the video tapes as data. Once the categories have begun to stabilise through saturation (Glaser and Strauss, 1967) or have been discarded as irrelevant, I am in a position to work with these now defined categories and their relation to the phenomenon of folding back. I am now working with a new set of data: the categories and incidence of folding back.

The second question I wish to explore is:

"How do students decide what mathematics to 'collect' for any given task, particularly when they are problem solving, where the overt clues may be few?"

If, as was the case in this research, a new avenue of interest opens out of existing explorations, video data comes into its own. It was the efforts of Martin[10] , to examine in detail and flesh out the phenomenon of folding back, that gave rise to the label 'collecting'. We had not gathered data with this notion in mind but the second major strength of video data is the ability it affords to return to what has been recorded and view it again with some different purpose or focus. Of course, as we shall see, all that one needs is not necessarily to be found; the trout, from its position below the river's surface, cannot know of the kingfisher's nest high up in the river bank. From the already identified episodes of folding back, I now need to extract those which fall within our description of 'collecting'. To do this I return to the video data and re-examine each episode to classify it more precisely. I pull out the examples of 'collecting' and start to examine what led up to them. Once again, I do not have a clear idea of what I am looking for. I record all and anything that seems to have bearing on the student's decisions. I classify these tentative category descriptors by student, by mathematical topic, by working groups, by interventions - from both teachers and peers - I involve others, ... till patterns start

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[8]See Rochelle, 1992

[9]See Roschelle, Pea and Trigg, 1990

[10] Lyndon Martin. See footnote 1.

to suggest themselves. Now I have some pointers, now I can gather fresh, specific data to tease out details, to confirm or destroy conjectures.

One thing stands out: all my information comes from tapes of students working in small groups. I have no video tapes of students working alone for the reason that up till now the use of language has been my prime interest, and students need to be in small groups for me to have access to this facet of their learning. When they talk together I can glean clues as to their thought paths but what is the effect of such grouping on the 'collecting' process? Do students work in the same ways when working alone? How can I know? Two different paths of procedure are needed. I can ask students to 'think-aloud'[11] as they work alone through problems and I can video tape them as they do this. I will then be able to watch what it is they are doing, writing[12], recording, as they reveal their thoughts. This fresh data can then be analysed alongside previous data. On the other hand, to illuminate further the thinking processes of students working in groups an interview would seem appropriate. What I am trying to get at, however, is not what they think about the problem after they have finished working on it, but what their thoughts are *as they think their way through the problem for the first time.* My best approach to achieving this is through a technique called stimulated recall. This involves the participants viewing with me the tape of their original group working and my stopping the tape at what I consider critical points and asking them to recall what they were thinking at that moment. This does not appear to be a very commonly used technique, and I felt that a pilot study should precede is more general use.

It is perhaps worth glancing here at the scant literature on video-stimulated recall. According to Calderhead (1981).a rationale for the technique was "that the cues provided by the audio-tape or videotape (would) enable the participant to 'relive' the episode to the extent of being able to provide, in retrospect, an accurate verbalised account of his original thought processes". Bloom is traditionally credited with being the creator of the technique in 1954, but Calderhead sets out to question the reliability and accuracy of such thought-accounts. His focus was on teachers as subjects, but there is no reason to think that students would be any more reliable. One problem was that teachers had been shown to find watching themselves on video a highly stressful activity, and it seemed reasonable to assume that this might well colour the extent to which they were prepared to report on what they recalled. Certainly my pilot study revealed the need for students to be given what became known as "giggle-time". I allowed them to spend some time overcoming their embarrassment at seeing themselves on video, before showing them the portions on which I was hoping they would be able to comment. Their willingness to recall their thinking was remarkably improved by this 'pre-viewing'.

A second problem suggested by Calderhead might occur due to the teacher's "tacit knowledge", that is knowledge that has been built up through experience and is not readily available for spontaneous verbalisation. This would seem to be less of a problem with the students I was interested in, as I was wanting to question them about their in situ mathematical thinking, rather than their personally built beliefs. There was still the danger, however, inherent also in all interviewing, that the students would seek to offer explanations of what they thought they *ought* to have been thinking, to impose a "degree of post-hoc rationality upon their behaviour."(Calderhead 1981). The probability of this seemed high to me, since mathematics has the aura of "right answers" associated with it. Calderhead suggests that the reliability of the responses might be tested by seeking recall of 'checkable' (sic) behaviours, but that there were several reasons why one might not be able to infer from this the accuracy of recalled "covert cognitive behaviour". He then cites "probably the only comparative study, Gaier (1954)" which reported that "recall of events was found to be considerably greater in the stimulated recall context." . Wear and Harris (1994) confirm this finding. When being . questioned about their thinking, the students that I interviewed were frequently able to talk about events and speech that was to be seen on the next, *unviewed* portion of the tape, and I was

[11] See later in this paper for a review of the literature on think-aloud protocols.

[12] See appendix for tips on video recording students' written work

able to take this as some indication of their ability to recall at least their behaviour accurately.

Foster (1984) has reported on the use of video in stimulus presentation, which although not my precise interest nonetheless has some relevance, and Marland (1984) offers the rationale for "retrospective self-reporting techniques" that they be used when "think-aloud methods would cause an unacceptable degree of interference with the task performance." He points out that the student or teacher can also be the one who is in control of stopping the tape, depending on the focus of the research. He raises questions as to the efficacy of the technique with young children and certain personality types. He also warns against over long interviews and poor quality video-recording. He concludes with very detailed guidelines for the conducting of stimulated recall interviews. Bryan et al, (1990) suggest one further problem, which is that teachers in one study appeared to view videotapes of their classrooms through an already formed mind-set, rather than 'seeing' every child's behaviour equally objectively.

Bloom (1954) and McConnell (1985) suggest that recall sessions are best conducted as soon as possible after the event to be reviewed. This is undoubtedly the ideal situation, but we were able to obtain what we could, following Calderhead, consider as reasonably reliable data as much as seven days after the videoed lesson. In view of the retrospective nature of some of my analysis, however, the need to interview relatively soon after the event proved problematic for me. It was clear that I could not go back to students appearing on tapes taken weeks or months ago and hope to get much useful data. What seemed to be a relevant feature of the ability of our students to recall with clarity over a seven day period, was the fact that we interviewed them as a group and they were clearly drawing on prompts from each other as well as from the video.

My pilot study confirmed the general findings of this seemingly sparse literature, that is, that for my purposes, much - but certainly not all - is to be gained using the technique of video stimulated recall. I would also add the following suggestion to those using this data gathering method, that, for fear of influencing hind-sight recall, care be taken not to let participants see recorded events to which they would have had no access in the lesson. An example of this might be not showing teachers the conversations of students which would have been out of ear-shot of the teacher in the classroom, or, conversely, not showing students video coverage of other students interactions which would not have been audible to them at the time.

To return to my need to access the thinking of students when working alone: 'think-aloud' methods were suggested by several authors as an alternative to stimulated recall and this approach would certainly seem more profitable in this particular situation. The think-aloud process has a long history as a research technique, though much of it is in connection with the study of reading and writing, rather than mathematics. The process can be used in essentially two ways: as a means of improving a student's thinking abilities, or as a means to study students' existing cognitive abilities. It is only the second of these that overtly concerns me, although given the method's widely reported success as a teaching/learning technique - Norris (1989) provides a notable denial of this finding - I needed to consider whether a possible improvement in mathematical performance by my subjects was of any consequence to my research question. Since I was not interested in performing any ability-related differentiation among the students, I decided that I could discount this issue, at this stage. (I needed to keep the decision overt, however, in case I should in the future wish to use this video-data for some other exploration of mathematical understanding.)

Clearly the value of think-alouds as data sources is dependent on the meta-cognitive abilities of the students. This issue has been addressed by Schoenfeld (1987), where he distinguishes between reflecting on one's own thinking processes, controlling those thinking processes and being subject to and influenced by one's basic beliefs. My interest lies in the students reflecting on their thinking processes. Indeed I would rather they did not try to control or alter them, for herein lies the teaching/learning function of thinking aloud. Nonetheless, once again, I must be aware of the influence that beliefs, as to the nature of mathematics, can have on the students' verbalisations.

The method of think-aloud has been used to explore a variety of aspects of students' cognition: to assess abilities (Davis, 1993), to diagnose difficulties (Randall, Fairbanks and Kennedy 1986; Meyers, Gelzheiser and Pruzek 1989), and to investigate strategies (Marr 1983; Montague and Applegate 1993; Shavelson, Webb, Shemesh and Yang, 1987) and processes (Afflerbach, et al., 1988; Clement 1988; Crismore, 1982). Probably the most extensive use within mathematics education has been that made by Schoenfeld . He discusses "those aspects of cognitive processes that this methodology will illuminate and those it will obscure." (Schoenfeld, 1985a and 1985b) The reliability of this method of data collection is not seen as totally unproblematic, however. Ericson and Simon (1980), Scardamalia and Berieter (1983) and Afflerbach and Johnston (1984) all suggest that it is not possible to act efficiently in some mental capacity and think about that thinking at the same time; either the meta-thinking will prove impossible, or the mental activity will itself be in some way altered. Garner (1988) comments on the additional problem of automated mental actions that the student can no longer verbalise; in the words of Phelan (1965), "It is possible to attain and use concepts ... that are not available to verbalisation." Phelan further reveals the positively dangerous nature of thinking aloud, that "incorrect verbalisation can negate the concept or the originally functioning concept can be "forgotten" (sic) in favour of the verbalised version. ... A recently formed concept can be destroyed by the unsuccessful attempt to verbalise it.". Fortunately there seems to be no other research supporting this terrifying statement! To set against this prediction, I take courage from Fawcett (1993), who, after reviewing some of the think-aloud research literature, states that "these studies indicate that at least some children are consciously aware of their thinking process and can articulate them". As with the use of stimulated recall, it seems that although I may not get at the whole picture, something of value will be revealed.

So what is now needed to address my second research question is a new round of data gathering which I shall structure in two ways: one by videoing groups of students problem solving and using stimulated recall to try to tease out their thinking processes while 'collecting', and the other by videoing students working alone, talking aloud as they do so.

Up to this point this article has been based on my own research agenda. How are others using video data? I think it is appropriate here to mention some of those who currently do use video data and whose methods are different from mine *because their questions are different.* Two of the most extensive users over the longest time span are probably Davis and Maher. Their techniques include the use of multiple (3 or 4) cameras, some static, some mobile, to capture students' work, their interactions with other students and the teacher. In addition, they conduct small group and individual task-based interviews. All their tapes are transcribed and these transcripts, together with the student's work, the researcher's field notes and the analyses comprise a video portfolio for each student. This personal history of a students is known as a "trace", and the captured moments of student insight are termed "critical moments". Davis and Maher are concerned with longitudinal studies of small groups of students - some portfolios cover 8 years - and so they have less of a problem surrounding the issue of getting the students familiar with the disruptive presence of the cameras and crew. The video tapes are also exploited as proof that children *are* capable of mathematical actions that are generally considered unlikely. (e.g. Davis and Maher, 1990.)

In their work together, Cobb, Yackel and Wood, exploring questions of learning within a social context, have depended heavily on detailed, line-by-line analysis of transcripts of classroom video. In Cobb and Whitenack (1996) details of their collection of data and what they analysed for are discussed, but not *how* they did the actual analysis and it is this, that is typical of most qualitative research. A situation, however, that is not the case for quantitative research, where we are always told the statistical tests used and on what basis they were interpreted. In her current work, Wood deals with large quantities of tapes by initially creating "logs" which are part descriptive and part verbatim, but not as precise as transcripts. These logs are then coded to some pre-constructed scheme, and actual transcriptions are made of particular episodes if they are considered necessary. There is often movement back and forth between the logs and the video tapes to check the on-going interpretative analysis.

Clarke's (1996) approach is similar to my own, although he uses two cameras, one focused on the teacher, who is wearing a radio microphone, the other on a small group of students. The difference lies in the fact that he mixes the images on site, to produce a single picture composed of the student group, with the teacher's image superimposed in one corner. He too uses stimulated recall to access student thinking and CVideo for his classroom notes and comments. To this he also adds time-tagged transcriptions and transcripts from the audio-taped interviews. To analyse this text-based data he uses the NUDoIST computer package (Qualitative Solutions and Research,1994)

Mousley and Sullivan are currently using data in a rather different sense. They are compiling video-discs of mathematics classrooms as part of a multi-media package with a view to providing pre-service teachers with a data base from which they can examine qualified teachers in their own classrooms. Mousley and Sullivan have analysed their classroom data into categories according to a variety of constructs, rather than in answer to one research question, and this allows their students to call up and work with different aspects of classroom practice. (Mousley and Sullivan, 1996)

While not specifically focused on the mathematics classroom, Goldman-Segall is also working with the construction of an approach to use classroom data in flexible ways. She has created the research tool 'Constellations' as a method of layering the interpretations of multiple viewers and enabling the search for patterns across multiple perspectives, exploiting the power of the visual to contain a variety of interpretations. The selection from the original video tapes of what is to be digitised inevitably results in a loss of data but does not inhibit ever more refinement leading to "chunks within chunks" being established by a multiplicity of viewers. Goldman-Segall, 1995).

It must be remembered that the use of the latest technology is not essential to good analysis! Towers' use of video is supported by an analysis method dependent on free-flowing, hand-written notes made during repeated viewings of the tapes. At each reviewing, she elaborates on or revises her comments and ideas, while writing new notes. The original notes are retained unaltered, creating an ever more detailed dossier that still retains the facility to return to original notions for comparison and verification. (e.g. Towers, 1996)

Other issues related to video data and their collection abound and I make no pretence to having covered all the relevant areas concerned with working with video data in mathematics education research. I shall, however, end here with a brief consideration of the ethical implications of working in this way. Traditionally, as researchers, we have offered confidentiality to those we study, promising that nothing will be written that contains their names, or leads to them being identified, that only a small, named group of people will ever see the 'raw' data, that teachers will not see the tapes of students, so that students will not suffer any reprisals from the teachers consequent on any events captured as part of the data. The advent of video data has put all these guarantees in doubt. If we are to exploit the richness of the data form, we will, as mentioned above, wish others to see it, to add their analysis to our own. Going even further than this, is the notion that we might gain insights for our own research from the viewing of data, gathered by others, for their own, possibly very different, purposes and perspectives. Data sharing is an issue that we as a community of researchers need to address. Using video playback in presentations at conferences is fast becoming a popular and effective way of talking about our work, but of what value is an intention to change the names of participants in the written text, if their faces can be seen on the video recording? Traditionally the issue of consent has been dealt with through written permissions from the participants, but one of the dangers of video-tape is that other students, while taking no active part in the data gathering may inadvertently be caught in the background. What is involved if we are to make our video data available on the internet, where the audience is much wider than our normal sphere of transmission and students may be recognised for reasons totally unconnected with the research? One suggested method for dealing with this is to give the students the right to view the final tape and have erased any portions they are uncomfortable with. Will this, however, compromise the data as far as the research is concerned? Along with the consideration of the ethical issues comes the question of ownership of the recordings. Who

owns the images and who decides the purposes to which they may be put? In summary, the

situation probably reduces to ensuring that all potential participants are genuinely giving us their *informed* consent, and this may be at times difficult to guarantee.

A paper such as this on the use of video data would not be complete without considering the practical and pragmatic decisions that have to be taken in addition to those more theoretically based, and discussed above. I have therefore attached an appendix which gives consideration to this aspect of the research, with mention of the decisions that must be taken on what and how to make video recordings, with practical hints on both creating the most flexible video data and tips for making analysis easier[13].

I leave untouched the issue of reporting the results of analysis of video data. Currently we are restricted to writing on the printed page, thereby, by definition, loosing vital evidence - else why would we have chosen to use video in the first place? At presentations we can - and I do - illustrate our analysis with video clips, but until the day when PhD theses can regularly include compilation video tapes and papers appear on the internet containing video clips from the data, we, the researchers must rely heavily on your, the readers', belief that our interpretation comes fairly from the data. The best that we can offer is a detailed account of precisely what our data was, and how exactly we analysed it.

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[13]I wish to put on record my gratitude to graduate students of mine, Donald Cudmore, Lai Leng Soh, and Jo Towers for the help they have given me in compiling this section of the paper.

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APPENDIX

I have divided this appendix into six sections, arranged in roughly chronological order of decision taking. My intention is simply to share ideas and suggestions that my students and I have found helpful when trying to produce the best possible data-set *within a given situation.* It is this last phrase that I see as all important. It is inevitable that pragmatic decisions *will* have to be made, at many points in the research process, but these should be made under your control, rather than forced upon you unexpectedly by circumstances. It is to this end that I offer the following suggestions.

What is your subject focus?

Clearly your focus will be dictated by your research question, I would merely like to suggest here that if you are choosing students to be videoed, random choice or convenience sample may not be the best method of selection. To gather video data you frequently need to select articulate students in order to make the data of any value: an hour of silent book-work will give you little information! Specific subjects, usually pre-selected on the advice of the teacher, may therefore be more appropriate, in spite of the caveats that such sample choice brings with it.

In what context do you need to set your subject?

Do you want a record of the whole classroom, the general scene, at any moment throughout the lesson? Beware the trap of thinking that you can capture "everything". Do you, in fact, mean that you want to see all the students? Focusing on all the students will inevitably mean that you will see none of them in close-up, you will be unable to see their written work and it is likely that some of them will be masked from the camera by other students. Do you mean

all the students and the teacher? the students, the teacher and the chalkboard? In any classroom arrangement, if you wish to also include the teacher then many of the students will be filmed from behind, and this is exacerbated if you try to also include the chalk board. Think carefully what you really need to video record, and what could be captured in your field notes. If you decide to make notes of what goes up on the board, devise beforehand a system for recording what gets changed, overwritten or filled in, as the board is used. It is very rare that the board is written on systematically and finally. It is more often used to refer back to, and to erase and replace existing writing as a new but related question is addressed.

You cannot take a camera into the classroom and pretend that nothing has changed. If it is not, however, your intention to be an active part of the learning environment, you can make your presence as unobtrusive as possible by taking a few precautions. Seat yourself as far away from the students and the camera as possible, keep overtly busy, avoid eye contact with anyone and refer all questions back to the teacher in a neutral tone of voice. Decisions made on camera positions etc. (see below) must be tempered by the disruption caused by the need to move students to other than their normal places in the classroom. Cover, with masking tape, the red light that is visible on many cameras when recording. This draws less attention to the fact that the camera is 'watching them'.

What details do you wish to record?

If your focus is the teacher, or an individual or group of students, then perhaps it is better to sacrifice the "general picture" to what you can note down in your field notes and concentrate on filming the specific people with whom you are concerned. This may enable you to now see the students' written work or to capture in close-up all the teacher's interactions with individual students, but you may have lost the ability to see unexpected activity elsewhere in the room. Does this matter to *your* research question? If the answer is "yes", then you will need to take some decisions as to equipment to be used (see below).

In what detail do you want to be able to hear what is going on? Is the video camera's microphone sufficient, or do you want to ensure that you capture all the talk from one group of students by placing a remote microphone on the table that they are working on? If the teacher or target students are going to be walking around, it might be safer to have them fitted with radio microphones. This ensures that you capture audibly everything in the interactions with which you are concerned.

What equipment do you need?

So far, I have been talking as if you were using one, static camera - the easiest (both in terms of data gathering and analysis), cheapest and least disruptive scenario. Is one camera sufficient, however, or do you need to focus on several events at any one moment? Do you want to record the students working together as a group, but also have a simultaneous record of the detail of what they write or draw? Do you need individual detail and also the whole classroom? If so, can this be dealt with by innovative use of alternate panning and close-up shots (Bryan et al, 1990) or do you really need a complete record of both? Can the cameras be set-up and left to run, or are you going to need to track the teacher and the students as they move around the room?

If you are opting for more than one camera do you want to end up with multiple tapes of the same lesson from different perspectives or will you, using a split screen, combine the tapes into one record? If this is the case, consider whether you want to do this using a mixer at the back of the classroom as the lesson unfolds or at your leisure after the end of the class? Remember that choice of the latter route greatly increases the time you will spend on this exercise, before getting down to the actual analysis. An alternative technique to capture individuals and the whole class is to regularly, say every five minutes, pan the classroom for a general view before returning to the specific focus. While losing some information, this does at least provide you with only one tape to analyse. Are you still being caught by the desire to catch "everything" and merely procrastinating, putting off the decision as to what you need in the way of data? Indeed, a serious consideration at some point, preferably before you disappear

beneath a surfeit of tape, is, how many hours of video tape can you really handle? This is perhaps one of the most important decisions of all. The temptation is to get as much as possible on tape and postpone the moment of decision making. The problem here is that the videos must, at least on first viewing, be seen in real-time. I wonder how many thousands of miles of tape around the world, lie unanalysed by researchers who wanted to "capture it all" but found that they had not the time to do it all justice. This is a more serious loss than it might at first seem to be. If you take the decision to film both the whole class, the teacher and a specific group of students on three separate cameras, for a series of lessons, then you are unlikely to have duplicated any of this data in your field notes. If time constraints then dictate that you only work with one or two of these tapes per lesson you may have lost more significant data than if you had mixed the tapes into one record during the lesson, because at that point you would have been making a conscious decision as to what to discard, it was not made for you by expediency.

The remaining two sections contain a list of tips, in no particular order, to make the actual filming process and subsequent analysis as smooth as possible.

When actually filming there are two cardinal rules:

1 Have a *written* 'action' check list that you have compiled *while* setting up all the apparatus for the first time - not before hand or from memory afterwards, as things will be left out this way. Write down everything you need to do in a chronological order, with those things that can be prepared before entering the actual classroom so indicated. This has a double advantage: you will not overlook some vital item, and you will minimise the setting up time at the start of each session.

2 Practise! Practise setting up the apparatus using your check list. Practise putting the equipment away - it may be necessary to be able to do this quickly if the room is to be used for some other purpose directly after the lesson you have be attending. Practise working with the camera in some quiet place. Practise actually filming the classroom. This latter instruction is not for your benefit alone. To minimise the distortion of your data, you need to acclimatise the students and teachers to having a camera in their midst, to having themselves filmed. The ideal scenario would allow you to give the students a chance to play with the equipment themselves, and to watch themselves on a video that you have taken of them so that they can feel less self-conscious, by the time you come to take the real film. The shorter your actual data-gathering time, the more vital this is. If you are filming three times a week for an entire term, you can cope with the odd mishap (and they will happen!), but if it is 'today or nothing' then you cannot afford to lose even a few minutes of your data.

Some useful tips:

- If you are going to be using a roving camera, check that you can physically get around the room to the places you want to access.
- If you can get away with simply filming from one place, by panning or zooming the camera, then always use a tripod unless you have one of the new cameras that compensate for a shaking hand.
- If you can leave the camera set up on its own, check occasionally that all is well with the recording, especially the sound.
- Loosing the sound is one of the most common and disastrous problems. Contemplate making a back-up audio tape using a small hand recorder. The audio tape can be recorded over each session as you do not need to keep it once you have checked that the video is fine.
- Avoid filming into a window if at all possible. If rearranging the classroom is not feasible, try to draw the blinds and use artificial light. For really top quality recording use studio lights - but remember the distraction and extra work they will cause.
- If you are not using the mains electricity, keep a careful eye on the battery levels. If you are using mains supply, check that the camera is not overriding this and still working off the battery. Keep a particularly close watch on the batteries of radio microphones if you are using them.
- Tape down or cover any flexes you need to have trailing across the classroom.

- Always carry an extension lead for that moment when one socket fails or you are obliged to move the camera position, possibly to another room altogether.
- Always make a back-up copy of your video tapes as soon as you get back to base. Tape quality is diminished by copying, and so thereafter, work with the copied tape so that, if disaster strikes, you will still have the original version to make a second copy from.
- Never be mean-minded with your tapes and try to fill them up before starting a new one. The time and frustration of working from tapes that do not contain whole episodes or are not sequentially recorded and labelled, or, worse, run out in the middle of a lesson because you are trying to economise, far outweigh the financial cost of a few extra tapes.
- Devise and stick to a coherent system for your labelling. Always include the date on the label. If you come back to the data in a year or so, you will not remember the "obvious" abbreviations that you jotted down at the time of recording!

Tips you will be grateful for when you come to analysing your data:

- If at all possible, have a small analogue clock within your camera's focus. This has one important advantage. It is, believe me, still frequently possible to go to major conferences or be invited to prestigious universities to give a presentation and be faced with a VCR that does not have a time counter. If you wish to move smoothly from one video section of your tape to another, you will probably have noted the time at which each section begins for ease of access. Faced with some non-standard numerical counter you will be lost! However, when fast forwarding or rewinding the video you can still watch the moving hands of the clock on the screen and so select the appropriate starting place.
- If you are collecting the students' work, try to keep the originals. If you are constrained to take a copy, scrutinise the original for signs of erased or 'tippexed' work and mark this on to the photocopied version, otherwise you will have written work that does not seem to relate to what you are seeing on the screen. Best of all, of course, is to ban erasers! At worst, you can watch the video for the moment when they appear to change their written work, even though you cannot know what they had originally written.
- If possible, have the students work at each new question on a separate sheet of paper - it makes spotting which question they are currently working on simpler when viewing the video. Best of all, have them using differing colours of paper.
- Watching the position, on the video, of the hand on the page is also a way to distinguish the work they are doing: you can line it up with their actual written work.

Good Luck!

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