THE CLASSROOM LEARNING PROJECT: Its aims and methodology

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ABSTRACT

This paper reports a project in which multiple interpretive accounts of a common body of classroom data are integrated for the purpose of studying learning in classroom settings. Classroom research has been greatly assisted by the emergence of a variety of technologies to support both data collection and analysis. The Classroom Learning Project is a qualitative study of learning in classroom settings which aims to elaborate a constructivist model of situated learning. Videotaped classroom data are augmented by video-stimulated reconstructive accounts by students and teacher in interview. Fieldnotes and transcriptions of classroom and interview dialogue are integrated into a single text document time-tagged to the video record. This integrated data set is then analysed by an inter-disciplinary research team, who construct complementary accounts of the classroom events from distinct theoretical perspectives. The research process, whereby these complementary accounts are synthesised in a coherent portrayal of classroom learning, bears significant similarity to the negotiative learning processes that it seeks to model. This paper outlines some key aspects of this research approach and illustrates methodological points with preliminary research findings.

INTRODUCTION

The research procedure reported in this paper was developed in an attempt to study learning in legitimate classroom settings, while minimizing researcher inference regarding participant thought processes and maximizing the richness of the research data base. Classrooms are complex social settings, and research that seeks to understand the learning that occurs in such settings must reflect and accommodate that complexity. This accommodation can occur through a data collection process that generates an appropriately rich data set. Such a complex data set can be adequately exploited only to the extent that the research design employs analytical techniques sensitive to the multifaceted and multiply-connected nature of the data.

It is unlikely that any individual has the extensive expertise or the time required to adequately analyse such complexity. The formation of multi-disciplinary research teams for the purpose of analysing such complex data sets is an obvious step. As a consequence, the interpretive process enacted by such teams has become the subject of methodological

discussion (Davidson Wasser & Bresler, 1996). This paper outlines the generation and integration of the multiple accounts developed by such research teams through their interpretation of classroom data. Included in the multiple accounts of classroom data are the voices of the classroom participants, whose retrospective reconstructions of events become another form of data for interpretive analysis by the research team.

Underlying the research approach outlined in this paper is the question of whose meaning is the product of such research. Much of classroom research is fundamentally about meaning: The content-related meanings constructed by students during classroom activity; the meanings ascribed by the participants to the social activity by which classroom interaction is sustained; and the meanings constructed by the researcher for the observed practices of a particular classroom. It is a trite but essential observation to assert that a research report can only ever document the researcher's constructed meanings. When the researcher's goal is the portrayal of the process whereby children construct mathematical meaning (for example), the question of whose meanings are the matter of the research report must be addressed with care. When the single researcher is replaced by a multi-disciplinary research team, the reconciliation of alternative meanings becomes a methodological issue of significance.

This paper arises in large part from the researcher's awareness of the extent to which the research process mirrors the process being researched, and the conscious attempt by the researcher to subject methodology to a form of scrutiny and analysis comparable to that being applied to the data. The similarity between classroom learning and the activity of an interpretive research group, as argued in this paper, could be interpreted: (i) as the projection of the researcher's theoretical perspective onto and into the data; (ii) as evidence of the coherence of the researcher's methodology with the theoretical perspective by which the data is interpreted; or (iii) as a recognition that research is a form of institutionalised learning and that descriptions of both practices will inevitably converge.

It should be evident from the discussion thus far, that this paper and the Classroom Learning Project in general, are predicated on a conception of the researcher as learner. Given this, the consistency in application of conceptions of negotiation, meaning, complementary accounts, and sources of conviction, to the activities of both learner and researcher, has led to a high level of correspondence between research practice and applied learning theory. The researcher has an obligation to anticipate the possibility that this correspondence might become prescriptive, constraining rather than informing data interpretation. The use of a multi-disciplinary research team has the virtue of subjecting each team member's account to the critical scrutiny of several colleagues.

COMPLEMENTARY ACCOUNTS METHODOLOGY

The focus of this paper is a qualitative research approach called *Complementary Accounts Methodology*. Available technology is utilized to combine videotape data with participants' reconstructions of classroom events. This integrated data set then provides the basis for complementary accounts constructed by the research team. Complementary Accounts Methodology is distinguished from other approaches to classroom research by:

- the nature of the data collection procedures, leading to the construction of "integrated data sets" combining videotape and interview data,

• the inclusion of the reflective voice of participant students and teachers in the data set,

• an analytical approach that utilises a research team with complementary but diverse areas of expertise to carry out a multi-faceted analysis of a common body of classroom data.

The theoretical constructs of meaning (Bakhtin, 1979), sources of conviction (Frid, 1992) and classroom negotiative processes (Clarke, 1996) informed the interpretive framework for the study, and therefore the method of data collection. Sources of conviction refer to how one determines facts, legitimacy, logicality, consistency and accordance with accepted mathematical or scientific principles and standards (i.e. academic content meanings), and the authorities cited by individuals to justify their statements, actions, or interpretations. Classroom negotiative processes, as conceived in this study, involve intersubjectivity, communication, refinement of "shared meaning" and accommodation. Such processes are most evident in situations characterised by student uncertainty, and those interactions whereby conjectures and arguments arising in classroom discourse are compared and assessed (including the development of social context meanings).

With regard to meaning: The presumptions of meaning are community, purpose and situation. It is futile to discuss the meaning of a word or term in isolation from the discourse community of which the speaker claims membership, from the purpose of the speaker, or from the specific situation in which the word was spoken. Indeed, it is not the word that has meaning, but the utterance. The emphasis on utterance, derived from Bakhtin (1979), is evident later in this paper in a discussion and illustrative analysis focussing on intersubjectivity.

The challenge for this type of classroom research was to portray the learning process of an individual participant in a highly complex social context. This learning process was taken to be an integration of not just the obvious social events which might be recorded on a videotape, but also the individual's construal of those events, the memories, beliefs and attitudes invoked, and the constructions which arose as a consequence. The research procedure recounted here was designed explicitly to achieve this integration.

The current data base for the project consists of videotape records of fifty-five secondary mathematics and science lessons obtained using two cameras, together with over 100 transcribed interviews with students. In constructing the videotape records, one camera was directed at the teacher, while the other camera was focused on a group of about four students. The teacher's utterances were recorded through a radio microphone, and a single microphone was used to record the conversations of all four students. The two video images were mixed on-site to produce a composite picture in which the students occupy most of the screen with the teacher image superimposed in a corner of the screen. This combined image was recorded onto video-8 tape using a compact video recorder attached to a laptop computer. The researcher, seated at the rear of the classroom, was able to listen simultaneously to both student conversations and teacher utterances and to record field notes onto a word processing document on the computer. The field notes were "time-tagged" to corresponding events in the video record using *CVideo* software (Roschelle, 1992). The field notes enabled the researcher to document impressions of classroom episodes and learning events as well as to provide reference markers for the subsequent interviewing of student subjects and the teacher. Student interviews were conducted immediately after the lesson and were intended to produce reconstructive accounts of the students' thoughts, feelings, motives, actions and perceptions relating to events during the lesson and to the lesson as a whole. For ethical reasons, the teacher reconstructive account was generated several months later.

The use of students' and teachers' verbal reconstructions of their motivations, feelings and thoughts requires justification en passant. The circumstances under which such verbal accounts may provide legitimate data have been detailed in two seminal papers (Nisbett & Wilson, 1977; Ericsson & Simon, 1980). Brief excerpts from these papers set out the principal points.

> Though people may not be able to observe directly their cognitive processes, they will sometimes be able to report accurately about them. Accurate reports will occur when influential stimuli are salient and are plausible causes of the responses they produce (Nisbett & Wilson, 1977, abstract).

Videotapes of classroom interactions constitute such salient stimuli, and that individuals' verbal reports of their thoughts and feelings during classroom interactions, when prompted by videos of the particular associated events, can provide useful insights into those individuals' learning behaviour. Ericsson and Simon (1980) identify conditions under which the validity of such accounts is questionable.

> Inconsistent retrospective reports can be produced as a result of probes that are to general to elicit the information actually sought, and as a result of subjects' use of inferential processes to fill out and generalize incomplete or missing memories (Ericsson & Simon, 1980, p. 247).

Videotapes provide a specific and immediate stimulus that optimizes the conditions for effective recall of associated feelings and thoughts. An individual's video-stimulated account will be prone to the same potential for unintentional misrepresentation and deliberate distortion that apply in any social situation in which individuals are obliged to explain their actions. A significant part of the power of video-stimulated recall resides in the juxtaposition of the interviewee's account and the video record to which it is related. Any apparent discrepancies revealed by such a comparison warrant particular scrutiny and careful interpretation by the researcher. Having relinquished the positivist commitment to identifying 'what really happened', both correspondence and contradiction can be exploited.

On-site production of the linked field notes and split-screen video record allowed the researcher to conduct the student interviews immediately after the lesson. The videotape record was used in the interview to stimulate student recall of classroom events. The use of the *CVideo* software enabled the researcher to locate within the field notes reference to actions of the student which seemed to be of significance either to the student or to the researcher. Having found a particular item in the word document, the software could be used to find very quickly the corresponding moment on the video record. This was then played back and discussed. Thus students were able to reconstruct their motivations, thoughts and actions, prompted by the video record of the classroom events. The audio record of the interview provided a third source of data. Interviews with the teacher were conducted at a later time. The teacher viewed the videotaped lesson and paused the tape whenever she wished to comment on events in the classroom which showed something important to her about teaching or learning. The audio record of the teacher’s commentary provided a fourth source of data. Eight "integrated data sets" have been generated from four mathematics and four science lessons. It is the analysis of these eight integrated data sets that constitutes the current activity of the research team.

For more details of the origins, rationale and practicalities of data collection see Clarke (1998), Rodrigues, Helme and Clarke (1997) and Helme and Clarke (1998). Results of the research to date are outlined in Clarke and Kessel (1995), Helme and Clarke (1996) and Clarke and Helme (1997). One example of an integrated word document is given in Appendix A (**bold** = researcher’s field notes; plain text = transcript from videotape;*italics* =

transcribed students' accounts; helvetica = transcript of the teacher's account). In combination, the researcher's field notes, the transcribed classroom dialogue, and the students' and teacher's accounts augment the video record to provide a rich data base for subsequent analysis.

These datasets and the corresponding videotape and audiotape records were made available to a multidisciplinary team of twelve university academics with expertise in areas such as mathematics, mathematics education, science education, developmental psychology, sociology, epistemology, values analysis, motivation, and metacognition. The participation of team members in the project was negotiated after their consideration of the available data sets and the development of a proposed analytical approach commensurate with the available data and consistent with the overall project goal of modelling learning in classroom settings. Individual members of the research team were encouraged to sample and interpret the data sets from a distinct, carefully articulated, theoretical perspective. The goal of this process was complementarity rather than consensus, and each researcher's interpretation was subject to the same criteria of coherence, consistency with the videotape data, and plausibility.

GROUP INTERPRETIVE RESEARCH AND MULTIPLE ACCOUNTS

Given that group-conducted studies, rather than lone-researcher studies, are becoming a widespread feature in educational research, it is somewhat surprising to find that there has not been a more thorough discussion of group interpretive processes (Davidson Wasser and Bresler, 1996). For example, group analysis of qualitative data characterised the recent study by Cobb, Bauersfeld and their co-workers (Cobb & Bauersfeld, 1995). The focus of the Cobb and Bauersfeld study was the function of mathematics classrooms in primary school. Of course, the analysis of large data sets by multi-disciplinary research teams is not restricted to qualitative data. The Third International Mathematics and Science Study (TIMMS) offers a current example of a large quantitative data base that is presently being analysed by research teams all over the world (Lokan, Ford & Greenwood, 1996). The integration of multiple analyses of data is not a simple matter of aggregation, whether the data is qualitative or quantitative. The integrative process is better characterized as synthesis, however different means may be employed to achieve this synthesis.

Many research teams using videotape as their fundamental data source establish group negotiative processes aimed at constructing consensus accounts of the data. In discussing the emergence of mathematical meaning in a second-grade classroom, Krummheuer (1995) invoked Goffman's (1959) notion of a "working consensus" as the immediate goal of classroom argumentation. This conception of working consensus, the authority of which derives from its local and immediate viability, can be applied to describe the interpretive processes followed by many research teams engaged in interpretive research into complex social settings such as classrooms. It is useful to identify the difference between the working consensus of students and teacher and the working consensus achieved by a research team undertaking classroom research. Students and their teacher may participate in the construction of a class consensus relating to mathematical meanings which are ultimately subject to criteria of consistency with the tenets of mathematical correctness as endorsed by the mathematics community. In such negotiations, the goal of the consensus process is clear and conforms to established classroom conventions. When the object of argumentation is the interpretation of classroom data, Goffman's conception of a working consensus as a transient convergence on a locally viable interpretation is a particularly apt characterisation of the goal of the consensus process operating in group interpretive research teams.

Explicit in Goffman's conception of the working consensus is the need for resolution of the competing claims of different interpretations. Since the goal of the interpretive process in classroom research is not the identification of "what really happened" but rather the development of viable accounts, care must be taken in specifying the criteria by which the relative merits of competing interpretations might be compared. Scholle (1992) has provided reassurance as to the legitimacy of such comparisons of merit.

> The question mark that postmodernism puts on the 'truth' of all discourse means only that all knowledge is contextual, not that all knowledge is false, nor that one cannot support the validity of one claim over another in a specific circumstance (Scholle, 1992, p. 276).

Any augmentation of the videotape data by the accounts of participants cannot be undertaken for purposes of "validating" a particular account (participant's or researcher's) but for the insights offered by discrepancies and consistencies between accounts. "Triangulation" in such research is employed because of the intrinsic value of multiple perspectives and not with the aim of determining "what really happened."

Central to the process by which a research team carries out its interpretive activities is the question of whether the goal of that interpretive activity is consensus or complementarity. In the case of the Classroom Learning Project, consensus was sought within the research team with regard to the consistency of a particular account with the available data; that is, consensus as to 'fit'. There was no requirement of consensus across the team as to the 'truth' or 'correctness' of the account other than with respect to this consistency with the data. It is to be expected that an interpretation of classroom data emphasizing volitional control of cognition will differ from an interpretation of the same data focussing on the use of mediating artifacts, and both will differ from a values analysis. Significant negotiation occurred within the team regarding the meaning of the key terms from which the various interpretive accounts were constructed.

Key synonyms of 'complementary' for the purposes of this study were 'interrelated' and 'parallel.' That is, while the various accounts refer to a common body of data and may resemble each other in some details, the recruitment of the research team was intended to maximize the variety of perspectives represented and the breadth of research expertise. The resultant interpretive accounts can be read for their individual validity, and for their combined differences and similarities. Their 'interrelatedness' is intended to facilitate synthesis and the identification of transcendent structural features of classroom learning. It is in this sense that complementarity is invoked as the distinguishing characteristic of this approach to classroom research.

The Classroom Learning Project and its methods raise interesting questions about the interpretive process and in particular the distinction between data collection and data analysis. It has become recognised in qualitative research that there can be no clearly defined point where data collection ends and data analysis begins. Miles and Huberman (1994) refer to this issue in their discussion of qualitative research methods, emphasising the continuous and cyclic nature of this process:

> "Even before the data are actually collected, anticipatory data reduction is occurring as the researcher decides (often without full awareness) which conceptual frameworks, which cases, which research questions and which data collection approaches to use. As data collection proceeds, further episodes of data reduction occur (p. 12)."

The students who provided their own interpretations of their actions and motivations through the process of video-stimulated recall were engaging in a form of data analysis with the videotape providing the primary data. Their analytical tools were not those of the researchers and their accounts were grounded in a theory of classroom practice that was not known to the researcher and may never have been articulated explicitly by the students. Yet these students were the first analysts of the videotape data and their accounts are subject to similar criteria to those of the research team: consistency with other available data, coherence and plausibility.

What constitutes a "complete" data set? A data set is only "complete" to the extent that it meets the needs of the researcher. There is no doubt that the data collected in the Classroom Learning Project was richly triangulated, with the integration of many voices providing a dense resource. However, it is also possible that later analysis of the videotape might identify an event, the significance of which was not recognised at the time by either student, teacher, or researcher. As with any clinical interview, the researcher may miss one insight through the pursuit of another.

Transcription highlights the extent to which these issues are intertwined. The integrity of the integrated data sets, of which Appendix A provides an edited example, derives fundamentally from the conventions adopted during transcription and the manner in which these were applied. How detailed should the transcript be? Should facial expressions, gestures and tone of voice be recorded? Transcription is not (and never will be) a simple mapping of ‘classroom reality’ onto the page, nor can transcripts capture the social and political milieu within which the data was collected. However, having the data interpreted by a team of people from different theoretical perspectives reduces the likelihood that an important interpretive perspective has been omitted and subjects both the adequacy of the transcripts and the individual interpretations to a form of implicit scrutiny.

The complementary accounts which constitute the outcomes of the Classroom Learning Project are subject to the requirement of consistency with the available data (which might be termed 'vertical consistency'). They are not required to be consistent with each other ('lateral consistency') and indeed may be most informative when different accounts offer alternative explanations of classroom actions, practices, or events. However, consistent use of terminology is essential if the insights offered by different accounts are to be meaningfully interpreted and compared. The synthesis of such accounts is not a matter of unification through consensus into a single account, but rather the interweaving of accounts providing in their combination a richer portrayal of the classroom. Further, as will be illustrated later, an interpretation from one perspective may support, inform, justify and even explain the account constructed from another perspective.

ANALYSIS: FINDING STRUCTURE IN DIVERSITY

It is not the purpose of this paper to detail in full the analytic techniques employed in the Classroom Learning Project. There are many analyses that might be carried out on data such as that provided in Appendix A. The following discussion provides some illustrative examples of analytical approaches employed with the existing data set.

Complementary Participant Accounts

Comparisons can be made of the students' interpretations of a particular exchange. The following sample text includes two students’ reconstructed accounts of the same event, after viewing the video record of the interaction transcribed below.

00:39:27 to 00:41:30 T(teacher) asks students K and L what they've done. K explains, T is dubious, then says I think you're right, L explains, says we're right.

T: Where'd you get a hundred and eighty from?

K: Width. Equals forty–

T: Why did you multiply them together? Why not add?

K: To get the area. I know that much.

T:[to L] You've been tutoring her?

K: Equals forty-five thousand, therefore you'd need–oh, how'd I get that?

T: Forty-five thousand?

K: Forty-five thousand. That's what we got.

T: Forty-five thousand? Can you press that– can you press that– can you do that again? Two hundred and fifty times a hundred and eighty? Oh, hang on, hang on, I think you're right. Hang on. I think they're wrong.

K: Yup, they're wrong, we're right.

(L holds up calculator).

I(Interviewer with student L): *Uh huh. So why were you so sure your answer was right? Or were you sure your answer was right?*

L: *Um, because when she asked us what it was, she thought it was right too.*

I: *I'd like you to tell me this last bit. So say that again for me.*

L: *She came and asked us to do the answer that we found and we had a different answer to the one that another group had given her and when she heard our answer it must have clicked that, um, it sounded more right than the other one did, so she went to tell them that they were wrong.*

I: *It must have clicked with her, so that's why she thought it was right. Why did you think it was right?*

L: *'Cause if Mrs Burton thinks it's right, it probably is.*

> ***I(Interviewer with student K):*** *There she's going over to your group.*
>
> ***[videotape continues]*** *Yeah, so you seem pretty sure, you got the, you had answers for everything she said.*
>
> ***K:*** *Yeah, because, um don't say anything to her, but the girls said that she'd pick on me a bit because I'm new, so if I show her that I know what I'm talking about then she'll lay off.*
>
> ***I:*** *Oh, well that makes sense.*
>
> ***K:*** *Because I don't want to seem like I'm going, "Well, you're right."*
>
> ***I:*** *But you did know, didn't you?*
>
> ***K:*** *Yeah, but I just thought it, 'cause yeah.*
>
> ***I:*** *Yeah.*
>
> ***K:*** *So I just wanted to show her that I knew what I was talking about, because otherwise she'd keep on at me.*
>
> ***I:*** *Yeah.*
>
> ***K:*** *Admit that actually sort of think that she made a little bit of a mistake. Yeah. I knew she'd lay off if I sort of had an answer for everything, so that's why I just said, straightaway she'd ask me a question, I'd have an answer, and she'd go, um, think about it for a while and then straightaway say "You're right or you're wrong." Yeah, I just wanted to say everything quickly so she didn't have time to think of another question.*

In a study whose major focus was classroom negotiation, student K's account of her motives and her perception of the interaction offered some insight into what it was that was actually being negotiated in an exchange whose surface content was mathematical. Such examples strongly suggest that without the student's reconstruction, the researcher's account of the interaction would be unlikely to capture the student's motivations and construal of the particular social situation. Lacking this detail, any inferences the researcher might make regarding the student's participation in the classroom and her associated learnings would be extremely restricted.

Analysis by Exemplification

The key constructs employed in the articulation of our theories of classroom learning must be empirically well-founded. The following discussion illustrates the use of "Analysis by Exemplification" to identify pattern and structure within possible instances of the key construct "intersubjectivity" identified within the data set. In this account of classroom learning, intersubjectivity enters as a mediating agency, essential to the negotiative process, whereby uncertainty is resolved, and new knowings are constructed. The contribution of analysis by exemplification lies in the accumulation of empirical instances that conform to the theoretical characteristics of a particular construct. Given this correspondence, the

cumulative set of instances can be examined for transcendent elements or relationships by which the nature of the postulated construct can be grounded empirically. These theoretical definitions and hypothesised relationships can then be tested for consistency with the empirical data, and patterns within the identified instances can then serve to elaborate the construct.

The intended exemplification does not reside in the particular examples, but in the recurrent characteristics and relationships which transcend any particular instance and thereby exemplify the construct. General statements of principle, which define one construct in terms of another, or relate one construct to another, require empirical demonstration of the postulated relationship. This is especially obligatory when the proposed relationship is one of process and product. For the purpose of this discussion, both 'negotiation' and 'intersubjectivity', and the relationship between them require definition to provide a theoretical framework for the sample analysis which follows.

Negotiation has been characterised in some detail elsewhere as a cyclic process of refraction (construal), reflection, and representation, the goal of which is consensus and the matter of which is meaning (Clarke, 1996). Lave and Wenger associate learning with participation in practice and assert that "participation is always based on situated negotiation and renegotiation of meaning in the world" (Lave & Wenger, 1991, p. 52). Cobb and Bauersfeld define the negotiation of meaning succinctly as "the interactive accomplishment of intersubjectivity", where intersubjectivity is described as "a mutual or taken-as-shared understanding" (Cobb & Bauersfeld, 1995, p. 295). In this view, intersubjectivity is the product of a negotiative process. One contention of the research reported in this paper is that while one product of negotiation may be 'enhanced intersubjectivity', the nature of the negotiative process itself demands a form of intersubjectivity that enables and sustains negotiation.

Our argument is as follows: Negotiation depends on language (or at least on some form of communicative process), and language is constitutively intersubjective (Todarov, 1984, p. 30). Thus, a level of student-student and student-teacher intersubjectivity is prerequisite to the negotiative processes by which the resolution of uncertainty is attempted. A relationship between the constructs 'negotiation' and 'intersubjectivity' can be postulated in the following form: One pathway to knowing is via the resolution of uncertainty; the process of resolution is frequently negotiative; negotiation is mediated by language; language presumes intersubjectivity; and, the matter of intersubjectivity is meaning (Clarke & Helme, 1997, p. 117). Equipped with this theoretical association, the researcher is in a position to examine the data set for interactions which might serve as instances of the postulated relationship and thereby of the constructs under investigation. Consider the following transcript (All utterances are by students. K and L were subsequent interviewees, S19 and S20 were not):

Episode 1

Turn	Transcript
1	S19: It says how many sheets of graph paper would you need to show one million one millimetre squares.
2	L: To show one million, you know you don't divide it by one hundred, because there's more than a hundred one millimetre squares. I mean

3 you're going to find the area of this.

4 K: What?

5 L: You've got to find the area of this, there's more than one hundred one millimetres.

6 K: That's right. I was doing length by–oh screw that.

7 L: One hundred one millimetre squares.Take length–

8 K: Um, there's how many down here?

9 L: And along that side there is–

10 K: Ten, twenty, thirty, forty, fifty. How many are there down there?

11 L: There's a hundred one millimetres there.

12 L: No, there wouldn't be.

13 K: There wouldn't be, that's not right.

14 L: There'd be two hundred and fifty.

15 K: Yeah.

16 L: Yeah, there'd be two hundred and fifty.

17 K: And we just totally screwed it all–

18 L: Length of graph.

19 K: OK, so it would be length times width [inaudible]

20 L: And uh, two hundred and fifty millimetres. Width–

21 K: What's width?

22 L: That's–

23 K: That's ten, twenty, thirty, forty, fifty, etcetera.

24 L: eighteen, one hundred and eighty.

K: Times one hundred and eighty. OK here we go. Two hundred and fifty times one hundred and eighty equals forty-five thousand.

25 OK, that's forty-five thousand. We need a million. What's a million divided by forty-five thousand and times it by that?

26 L: Hang on, hang on, hang on, hang on. Don't go too fast. OK. Therefore there are forty-five thousand million mm squares.

27 S20: Forty-five thousand million?

28 L: Yeah.

29 S20: Forty-five thousand.

30 K: Twenty-two point two.

L: On one piece. Of graph paper.

The goal of Analysis by Exemplification, in this case, is the empirical grounding of intersubjectivity through the analysis of an accumulation of such examples. As Lerman (1996) has noted, "Intersubjectivity is a function of the time and place and the goals of the activity and the actors." Bruner, among others, has noted that the situatedness of intersubjectivity is ultimately cultural (Bruner, 1996, p. 11). Intersubjectivity, if it is to be understood at all, must be understood in context and in action. In the preceding transcript, there are several indicators suggestive of intersubjectivity. First, much of the recorded dialogue is incoherent as written text: That is, sentences are ungrammatical or incomplete; pronouns are used without textual clues as to their referrents; single word utterances are frequent. It is our contention that communication in this form is only sustainable because the participants share understandings of the referrents of the pronouns or key words, and of the processes, actions, or relationships suggested (but not stated) by the sentence fragments and the participants' gestures. Secondly, evidence of intersubjectivity can be seen in the manner in which one speaker will complete the sentence of the previous speaker, as occurs in 'turns' 8 and 9 ('turn' is defined below). The overt text in the form of the literal transcription is here being distinguished from the implicit text being co-constructed by the participants. The existence of an implicit text is inferred on the basis that the interaction appears to have been both purposeful and successful.

The findings of this form of analysis reside in the claim that the preceding episode, and others like it, constitute examples of intersubjectivity in practice in a classroom setting, conforming to theoretical conceptions of the construct. In particular, the various instances of intersubjectivity within this episode and others support the postulated function of intersubjectivity as enabling and sustaining negotiation. Evidence related to the enactment of the construct of intersubjectivity should assist us in theoretically locating intersubjectivity within the learning process as either agency or as outcome or as both.

Structural Analysis of Text

Another type of analysis of the integrated data sets involved the classification of the text into six stratified levels: the lesson, the activity, the episode, the negotiative event, the turn, and the utterance. In the example discussed below, the levels 'lesson' and 'activity' play no part. Episodes comprise the dialogue and actions that students engage in as they approach, work on and complete a particular classroom task, such as solving a mathematical problem. Thus, each episode is a coherent sequence or combination of behaviours unified by a single purpose. Each such episode may involve several negotiative events. A negotiative event is defined by an identifiable intermediate purpose; a purpose whose realization is an intermediate goal within the encompassing episode. Each negotiative event may be composed of several turns, each with its own immediate purpose. A turn comprises a communicative act by an individual, consisting of one or more utterances, intended in

combination to serve a single purpose. An utterance is the simplest meaningful communicative element. An utterance may be a sentence, a phrase, or a single word.

The significance of this particular form of structural analyis can be found in the consideration of patterns of association of a particular construct or practice with a particular level. The interpretation of the significance of a given episode requires an interpretation of each constituent level of negotiation: the negotiative event, the turn and the utterance. In

Episode 2, a sample of classroom dialogue, selected from Appendix A, has been analysed by partitioning the text according to the occurrence of "negotiative events" within an "episode" (Clarke & Helme, 1997). Again, K and L are student interviewees, S20 and S22 are other students, and T is the teacher.

Episode 2

	Turn	Transcript
E		L: [writing] Five hundred sheets. Height equals.
V	1	K: OK, question two [Find the height of a stack of one million sheets of paper].
E	2	L: Does everyone understand what we did with number one?
N	3	K: No, but. Anyway. Five hundred sheets.
T	4	L: And how many sheets do we need?
1	5	K: Five hundred sheets of what? Five hundred sheets.
	6	L: Their height equals five point eight.
	7	S20: We've done that.
	8	K: I know. But we've got to do it all together so.
	9	L: One point oh times ten to the power of six divided by five hundred.
	10	K: Oh yeah sure everyday what are you talking about? What are you talking about?
	11	L: Finding out how many five hundreds there are in a million.
	12	K: How many five hundreds there are in a million. That would make it one thousand. How many thousands are there in a million? That would make a thousand, two thousand. What? [to another S]. I have a lot to say.
	13	L: [uses calculator] Two thousand. Well done!
	14	K: This is called skill. This is what you do. Five hundred into a one hundred which is two. Then you do a hundred [correcting herself] which is a thousand.
	15	

	16	L: Times five point eight. Shush.
	17	K: Which is two. Then you do a thousand into a million which is a thousand, so one thousand times two is two thousand.
	18	L: Eleven thousand six hundred.
E	19	T: With your working out folks I want you to tell me what you are mult– Matthew– what you are multiplying by, and you simply put a little arrow telling me what and why.
V		K: What are we doing? Is it a million sheets of paper though?
E	20	L: Yeah. One point–
N	21	K: We're doing a million sheets of paper.
T	22	L: Yeah, you need–
2	23	K: Yes we do. We do, shut up.
	24	L: Therefore,
	25	K: Huh? I did that wrong.
	26	L: One [inaudible, working]
	27	K: Two thousand times five point eight is eleven, six, zero, zero.[ie 11,600]
	28	L: [sounding out letters] M-ms?
	29	K: Centimetres–which would make it eleven point six metres, right?
	30	

Episode 2 (continued)

	Turn	Transcript
E		
V	31	L: Or eleven–yeah. It'd be eleven point six metres, wouldn't it, 'cause you take off one to get the centimetres, and another one, yeah. [pause]
E	32	K: [looking up] That's quite high, isn't it?
N	33	L: All right. And you've got to point out what the units (?) are, right?
T	34	

3	35	K: You've got to point out what the what is?
	36	L: We have to show what we're multiplying by.
	37	[S22 says something to K, K laughs] S20: That's not how you know, you look like you know what you're doing and you just do it. K: Exactly, you go into a state of total concentration, it lasts about two seconds, that's when you get the answer, and then you don't know what you're doing, so it doesn't matter. Five hundred sheets equals, height equals five point eight centimetres. I don't even understand what I wrote. [pause as L, K write]
	38	
E	39	K: But why do we divide a million by five hundred to get that answer?
V	40	L: Because you know, if you know what the height is–
E	41	K: So what am I doing. Tell me what I'm doing here, tell me what I've done.
N	42	L: All right. You know that five hundred sheets equals fifty-eight–
T	43	L and K: five point eight centimetres.
4	44	K: There is a point there, it's up there.
	45	L: Oh, I can't see it.
	46	K: Get some other glasses.
	47	L: Now, we need to know–we need to know the height of a million sheets of paper. Therefore you must divide a million by five hundred and times that number by five point eight.
	48	K: [writing] Equals two thousand. Sheets of paper.
	49	L: OK. K: Two thousand times five point eight centimetres equals eleven thousand six hundred centimetres, equals eleven point six metres of paper. [bell rings]

As can be seen in the example above, the episode beginning when student K says "OK, question two" and concluding with the statement, "Two thousand times five point eight centimetres equals eleven thousand six hundred centimetres, equals eleven point six metres of paper" can be partitioned into four negotiative events:

Event 1 combines the refinement of intersubjectivity within the group with L's first solution attempt.

Event 2 revisits the procedure employed in Event 1.

Event 3 involves the negotiation of appropriate units of measurement.

Event 4 reviews the procedure again and links it to the task.

These structural elements within the text may reflect parallel structures within the process of learning. Alternatively, an analysis of the function of 'uncertainty' in the learning process can include the identification of the particular levels within the text with which uncertainty is most commonly associated or expressed. One structural characteristic, found in several episodes within the data set (including the Episode 2, above) and apparently typical of collaborative group problem solving, involves the repeated rehearsal of a successful problem solving attempt; that is, a sequence of negotiative events in which first the problem is solved, then the problem is solved, and then the problem is solved again. Each repetition of the problem solving process appears to serve a distinct purpose: to identify a possible solution, to establish a common understanding of the procedure, or to review the method of solution for viability, validity and/or completeness. In this case, it is the recognition of a pattern or structure, common to several episodes within the data set, that constitutes the outcome of this type of analysis, and contributes to an emergent model of classroom learning.

Replicable Analysis of Text

Software packages such as *NUD•IST* (Qualitative Solutions and Research, 1994) can be employed to undertake a wide variety of forms of textual analysis. One of the most simple of these is the determination of the frequency of association of key terms or phrases employed in student classroom discourse or in student or teacher discussion of video-recorded classroom situations. Analysis of this type can reveal not just the frequency of use of such terms or phrases, but their frequency of association either with each other or with aspects of classroom practice or elements of the social situation. Further, software tools such as *NUD•IST* facilitate the identification of chains or networks of association that may reveal structures of theoretical significance, common across diverse bodies of text. Such software is in widespread use in studies in which text analysis is a key feature. The use of an indexing tool such as *NUD•IST* offers a form of replicability for textual analyses not previously associated with conventional content analysis; that is, a particular sequence of commands applied to one body of text, may reveal a network of associated clusters of text elements with a particular structure, and the robustness of the emergent structure can be tested by applying the same sequence of commands to a different body of text.

Indexing software packages can be used for textual analysis of transcripts of classroom dialogue or interviews in a multiplicity of ways. For example, it may be that a student recounts, in interview, a situation in which they came to "know" or to "understand" something related to the topic dealt with in the observed lesson. In particular, any student use of the verbs, "know", "understand" or "learn" can be analysed in detail with regard to the subject and object of each verb's use. That is, what sort of things can be "known", "understood" or "learned"; what sort of experiences, events, images, or people appear to be associated with "learning", "understanding" or "coming to know"; and, who is it that "knows", "understands" or "learns" things?

One such analysis undertaken as part of the Classroom Learning Project (Clarke & Kessel, 1995) suggested that when asked to reflect on the consequences of a lesson, students in the sample classrooms did not tend to employ terms such as "learn" or "know." Students in these classrooms, when reflecting on the consequences of their participation in a lesson, or in the course of classroom conversation, made frequent use of the term "right." Such a finding prompts us to conjecture what view of knowledge and classroom learning is held by

these students, such that their success in a mathematics or science lesson can be adequately (and consistently) described as "right." The restriction of the goals of mathematics instruction to only those things about which one can be "right" suggests an impoverished model of mathematical knowledge and a likely misconstrual of the teacher's classroom goals on the part of the students. Such a finding has clear implications for practical action to develop classroom situations that promote more sophisticated learning outcomes and a much less restrictive view of mathematical knowledge.

Complementary Researcher Accounts

Different perpectives, reflecting different objects of study within the encompassing goal of modeling classroom learning, can be used to analyze the same integrated data sets. For example, Clarke and Helme (1997) made use of the data in Appendix A to discuss the role of negotiation in the resolution of uncertainty in mathematics classrooms. This data is also amenable to analysis with respect to the several instances of student metacognition contained within the text and the function of these self-evaluative reflections within the learning process. These two accounts of the Appendix A data: one from the perspective of the resolution of uncertainty and one from the perspective of student use of metacognition, are not in competition; they represent complementary interpretations of the same integrated data set. Such complementary accounts have the potential to be mutually informing and to constitute in combination a richer portrayal of classroom learning than would be possible by the consideration of either account separately.

A key design element in this approach is the bringing together of a research team of sufficiently diverse expertise to adequately implement the Complementary Accounts Methodology. The research described here utilized an international team of over a dozen university academics with expertise in mathematics education, developmental psychology, sociology, epistemology, values analysis, motivation, mathematics, science education, children’s conceptual frameworks, metacognition, gender and a range of qualitative and quantitative research methodologies. Individual members of the research team, rather than seeking a consensus interpretation of an event, an episode, or an interaction, were encouraged to interpret the documented interaction from a distinct, carefully articulated, theoretical perspective. The goal of such a process is complementarity rather than consensus, and each researcher's interpretation is subject to the same criteria of coherence, consistency with the videotape data, and plausibility. As has been stated already, group consensus was sought in relation to the consistency of one account with the data, not with regard to the consistency of one account with another.

The integration of these complementary accounts into a rich portrayal of classroom learning can occur by a variety of means. The value of the example referred to above derived from contrasting interpretations of the same classroom episode. A different approach, recently employed by the research team, has been to identify particular constructs employed in several accounts and to contrast the function of the particular construct within each account. One example is 'uncertainty', which occurs in several complementary accounts and has been consistently associated with learning. Rowland, for example, has recently stated that "uncertainty is a productive state, and a necessary precondition for learning" (Rowland, 1995, p. 328). Several members of the research team have employed 'uncertainty' in interpreting the integrated data sets.

Ainley, for example, employed the student's response to uncertainty as an indicator of student interest. In discussing student interest in the context of a science lesson on "fibres", Ainley stated, "The certainty which went with the exclamation had been challenged, generating uncertainty. The experience of uncertainty prompted an information-seeking question to an 'authoritative' source and the uncertainty was resolved with Jodie now

knowing that paper did in fact have fibres in it" (Ainley, 1998, p. 5). Baird's analysis centred on cognitive ignorance and metacognitive awareness. Baird utilised the classroom data to demonstrate "the powerful influence of acknowledged cognitive ignorance (and the confusion [or uncertainty] with which it was associated) on decisions made and opportunities to effect metacognitive control over learning" (Baird, 1998, p. 21). Clarke and Helme (1997), as discussed earlier, located uncertainty in relation to other key constructs within one model of classroom learning. Reynolds and Reeve, in exploring the functional contribution of gesture to classroom discourse, have suggested that gesture can serve to compensate for inadequacy or uncertainty with regard to appropriate language (Reynolds, 1998). Rodrigues (1998) contrasted the productive "pondering" arising from one student's uncertainty prompted by the uncertainty of a classmate with the less problematic and arguably less productive communications of the teacher. Pursuing a related point, Holton and Thomas (1998) have argued that the most productive teacher questioning occurred in a situation where the teacher, herself, was uncertain of her knowledge of the mathematical content.

In combination, these complementary accounts locate uncertainty in relation to several of the constructs central to the emergent model of classroom learning that is the goal of the Classroom Learning Project. The researchers' various perspectives employ intersecting sets of constructs and their interpretive accounts provide a form of empirically-founded 'cross-referencing' for the recurrent components of a model of classroom learning.

An analogous, but distinct, approach involves the utilisation of patterns or structures arising from one analysis as analytical tools or explanatory devices in another analysis. For example, Clarke and Helme (1997) utilised negotiative events, within a stratified partitioning of classroom dialogue and interactions, as a key structural element in their analysis of the function of uncertainty in classroom learning. This structure has been exploited by other researchers in the Classroom Learning Project team in their analyses of classroom data, notably in an analysis of power relations within student collaborative groups.

> Negotiative events appear to be a key unit for analysis, because the transitions from one to the next mark the progress of a group's work on an activity. A student who enacts closure of one negotiative event and intiates the next does to a very large extent control the discourse (Barnes, 1998).

It is in their capacity to be mutually informing that much of the value of complementary accounts resides. This is particularly true where one analysis suggests an explanation for the outcomes of another. For example, it is not surprising that an analysis of the values underlying classroom interactions should inform an analysis of student interest and motivation. Educational researchers have always appropriated, adapted and applied each other's analytical tools. Within a team employing a complementary accounts approach, this process of appropriation and adaptation is facilitated by a common focus on the same complex data set, coupled with the regular opportunity for comparison and negotiation of meanings and accounts afforded by the group interpretive process.

CONCLUSION

In the research discussed in this paper, an attempt was made to optimize the use of currently available technology through the synthesis of classroom videotape and interview data in an integrated video and text document. An important, possibly essential, perspective on the classroom can be obtained from the students themselves in interview situations, where the significance of classroom events and their associated thought processes can be reconstructed by the participants themselves with the assisting prompt of the classroom

video record. The resultant data set is amenable to a variety of forms of analysis and some of these have been illustrated. In the Classroom Learning Project, we have taken a critical approach to constructivism. An empirical grounding has been sought for key elements such as negotiation and intersubjectivity and for their interrelationship. The contribution that constructivism might make to a theory of situated learning in classrooms will depend on the extent to which the elements and relationships employed in that theory prove useful in the construction of viable models of classroom learning.

Recent developments in educational research (and in learning theory) have led to acceptance of the idiosyncratic and legitimate subjectivity of both the research subjects and the researcher, and to the consideration of what can be learned from the comparison of the multiple stories compiled from the accounts of the various participants in the social setting, and from the constructed accounts of the research team. Judgements regarding the relative merit of one account over another will relate to the purpose for which the comparison is being made and do not call into question the value of either account with regard to any other purpose. It is through the accumulation of such complementary accounts in relation to a common integrated data set, that our portrayal of classroom learning will approach the complexity of the process we seek to model. The meaning that emerges from this research will be our meaning; commensurate with our methods, our theories and the purposes which motivated our research. The interpretive process from which such meanings are derived must be subject to the same scrutiny and conform to the same theoretical considerations as the classroom interpretive processes that are the focus of our research.

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Classroom Learning Project
Website:http://www.edfac.unimelb.edu.au/DSME/research/clp/index.htm

Appendix A: Sample Integrated Text

Year 8 Mathematics Class (videotaped 19/10/94 - classroom dialogue indicated by times plain font, researcher's field notes indicated by **times bold font**) with student comments (interviewed 19/10/94 - indicated by*times italicised font*), and teacher's comments (account recorded 22/9/97 - indicated by helvetica plain font)

The transcription of classroom dialogue from videotape:

All audible utterances by focus students are transcribed. Utterances by other students audible to focus students are transcribed. Teacher utterances audible to focus students are transcribed. Additional annotations are also included indicating emphasis, inflexion, or gestures that appeared significant for an understanding of the particular exchange. All transcribed classroom dialogue is in plain font.

The inclusion of researcher field notes:

Researcher field notes are included in **bold font** exactly as they were recorded in the course of videotaping the lesson. The field notes accompany the time-tagging markers generated by the CVideo software, linking the text to the videotape record.

The transcription of student comments:

Inserted in the transcript at the point in the videotape transcription to which they refer. *Italicised font*.

The transcription of teacher comments:

Inserted in the transcript at the point at which T paused the videotape to make comments. They are typed in helvetica.

General transcription conventions

1. Emphasis denoted by underlining: I was <u>very</u> concerned

2. Inaudible words or utterances less than one second denoted thus: [inaudible]

3. Inaudible utterances longer than one second denoted thus: [next 5 sec inaudible]

4. Where a word is unclear, suggested word is followed by (?)

5. A slight pause in speech denoted thus: It was...a good idea

6. Self-interruptions denoted thus: She was–I thought she was

7. Interviewer's comments or questions denoted thus: [I: Year 8 last year?]

8. Researcher's comments to clarify meaning denoted thus: [referring to previous lesson]

Additional Explanatory Notes

Study students [L and K] are sitting together. The following is an edited selection of the integrated text incorporating those sections discussed in the paper.]

Teacher recorded account at commencement of viewing the videotape (note: the teacher had access to the transcript of the classroom dialogue, but not to the student interview transcripts).

I love this lesson. I still do it years later. It'll be very interesting for me to see how effectively it comes across to the kids. I've often have them work for the whole lesson on just one or two problems and Ifeel that they get a lot out of it, and uh sometimes the trivia in mathematics and the finer points can quite often be useful. I think they like the idea of working out the height of a thousand sheets of paper and the estimation and the methodology I see as veryimportant and far too often in maths we tend to go ahead and just, you know, the tendency is to give them textbooks and nothing to really work out and talk and negotiate and problem solve. So I particularly chose this because it's a wonderful problem solving exercise and um it's fun, and I love doing it as well.

00:29:36 to 00:30:07 L does something metacognitive

S19: It says how many sheets of graph paper would you need to show one million one millimetre squares.

L: To show one million, you don't divide it by a hundred, because there's more than a hundred one millimetre squares. I mean you're going to find the area of this.

K: What?

L: You've got to find the area of this, there's more than one hundred one millimetres.

K: That's right. I was doing length by–oh screw that.

L: One hundred one millimetre squares. Take length–

K: Um, there's how many down here?

L: And along that side there is–

K: Ten, twenty, thirty, forty, fifty. How many are there down there?

L: There's a hundred one millimetres there.

I really wonder how K would have coped with the task if L wasn't there. I mean she seems to be fairly competent at her work and she's like a little mini teacher in the room. [I: L you mean?] Yes L. And um, yeah, so I just wondered how much K really would have understood by herself. At least, you know, she tried a couple of ways and then said, "oh no that's not going to work'" so that was part of the aim, what I was onto. But if the class was busy and L wasn't there to help K I wonder how far she would have gone ahead.

00:30:12 to 00:30:51 that's not right, it'd be 250, length times width

L: No, there wouldn't be.

K: There wouldn't be, that's not right.

L: There'd be two-fifty.

K: Yeah.

L: Yeah, there'd be two-fifty,

K: And we just totally screwed it all–

L: Length of graph.

K: OK, so it would be length times width [inaudible]

L: And uh, two-fifty millimetres. Width–

K: What's width?

It’s interesting that K says, "What’s width?" Is she just relying on L to give her the data or does she really know what’s going on?

L: That's–

K: That's ten, twenty, thirty, forty, fifty, etcetera

L: Eighteen, one hundred and eighty.

K: Times a hundred and eighty. OK here we go. Two hundred and fifty times one hundred and eighty equals forty-five thousand.

00:30:58 to 00:31:23 45,000 meant

K: [L answers question from another student]. OK, that's 45 thousand. We need a million. What's a million divided by 45 thousand and times it by that?

00:31:24 to 00:31:33 L says hang on.

L: Hang on hang on hang on hang on. Don't go too fast. OK. Therefore there are forty-five thousand million mm squares.

S20: Forty-five thousand million?

L: Yeah..

S20: Forty-five thousand.

K: Twenty-two point two.

L: On one piece. Of graph paper.

K: OK, question two.

L: Does everyone understand what we did with number one?

K: No, but anyway.

Yes K I'm not surprised [inaudible] that she doesn't understand what's going on, 'but anyway'. It's interesting how her main contribution was [3 sec inaudible] so maybe that was her way of saying [2 sec inaudible]. So yes I always find that the difficulty with a lesson like this is to go over it clearly so that people like K can understand but I don't bore the socks off L. If I go through and um say, "those people who got the question right go onto the next thing", how do I go back and um make certain that they really dounderstand it, so I always find that's the hardest thing, how do I help the really weak people, allow the faster ones to go on and then you get that grey area where you're not quite sure who understands and who doesn't. So uh, you know one day hopefully I'll get a bit closer than I do at other times.

K: Five hundred sheets.

L: And how many sheets do we need?

K: Five hundred sheets of what? Five hundred sheets.

L: Their height equals five point eight.

S20: We've done that.

K: I know. But we've got to do it all together so.

L: One point oh times ten to the power of six divided by five hundred.

K: Oh yeah sure everyday what are you talking about? What are you talking about?

L: I'm finding out how many five hundreds there are in a million.

K: How many five hundreds there are in a million. That would make it one thousand. How many thousands are there in a million?

I: What's that?

K: Um, what were we up to? Did she say borrow? We were doing sheets of paper, um, that's right, L was just saying, I think she was saying something really fast: Five hundred sheets equals five point eight centimetres. I think it was when she did 'cause we needed the height of a million sheets of paper. I think she said, "A million divided by five hundred", something like that, and I didn't know what she meant.

I: Uh huh. And?

K: Then I figured it out.

I: So how did you figure it out?

K: I just heard her and I'm trying to do my own work, and she's talking, and it's like I'm - yeah, I agree with you . . . . I didn't understand what she was talking about so I just did it on my own, I think.

I: Yeah, so then when you went through it on your own.

K: I work better when there's no-one else around anyway, but.

00:36:45 to 00:37:07 K argues with L?

K: That would make a thousand, two thousand. What? [to another S]. I have a lot to say.

L: [checks result on calculator] Two thousand, well done!

K: This is called skill. This is what you do. Five hundred into a hundred which is two. Then you do a hundred [correcting herself] which is a thousand.

L: Times five point eight. Shush.

K: Which is two. Then you do a thousand into a million, which is a thousand, so a thousand times two is two thousand.

L: Eleven thousand six hundred.

Yes I was thinking to myself how would I help people like K learn and maybe what I need to do is to actually prioritise those tasks into those that may be more concrete for some kids, and leave like the graph paper one, which is quite tricky, leave that one maybe for later on. I might even say, 'look if you're having a little bit of trouble this might be the easier place to start, and you might like to talk with some friends more about this particular question, rather than that particular question.' But once K gets it, then suddenly, 'Oh yes, I can actually handle some of this'. But she sounded very discouraged about the graph paper one. So at least this one here seems to [inaudible]. I guess even if I get–it's very hard when you're teaching. You often have to think about where you start from and maybe it's not where you finish it's where you start from, it's where you move to. That maybe a little bit of success–she may not understand the whole five but even if she understands one of them. Sometimes problem solving helps(?) and the techniques will actually come, be of use for you, a little bit later down the track. And maybe the next time she sees a stack of graph paper she might think, 'now how did I solve that?' and, 'oh yes, I know that there is a technique that I can work out how many sheets of graph paper to make a million.' So if it doesn't cotton on then, it may actually, hopefully stay in their mind and they may actually use it later. Because one of the beauties of this sort of problem–I'm hoping that may occur for some students.

00:37:08 to 00:37:19 T asks question

T: With your working out folks I want you to tell me what you are mult– Matthew– what you are multiplying by, and you simply put a little arrow telling me what and why.

K: What are we doing? Is it a million sheets of paper though?

L: Yeah. One point–

K: We're doing a million sheets of paper.

L: Yeah, you need–

00:37:20 to 00:37:33 K says I did that wrong

K: Yes we do. We do, shut up.

L: Therefore.

K: Huh? I did that wrong.

L: One [inaudible, working]

00:37:36 to 00:38:04 S asks L something

00:38:06 to 00:38:46 K says something to neighbour about not understanding

K: Two thousand times five point eight centimetres is eleven, six, zero, zero.[i.e. eleven thousand six hundred]

L: Mms?

K: Centimetres–which would make it eleven point six metres, right?

L: Or eleven–yeah. It'd be eleven point six metres wouldn't it, 'cause you take off one to get to centimetres, and another one, yeah.[pause]

K: [looking up] That's quite high, isn't it?

That's what I'm after. That's what I'm after. For them to actually visualise it and see, say, 'Hey, that's really quite high.' That makes the whole activity worthwhile in my eyes, from my point of view.

L: All right. And you've got to point out what the [inaudible] are right?

K: You've got to point out the what is?

L: We have to show what we're multiplying by.

[S22 says something to K, K laughs]

S20: That's not how you know, you look like you know what you're doing and you just do it.

K: Exactly, you go through a total state of concentration, it lasts about two seconds, that's when you get the answer, and then you don't know what you're doing, so it doesn't matter. five hundred sheets equals, height equals five point eight centimetres. I don't even understand what I wrote.[pause as L, K write, sound of other students discussing problem]

'Exactly' says K. 'You go through a total state of concentration, it lasts about two seconds, that's when you get the answer and then you don't know what you're doing. So it doesn't matter' (laughs) Aha! That's her idea of learning.

00:38:48 to 00:39:25 K asks L q to explain, L's explanation*

K: But why do we divide a million by five hundred to get that answer?

L: Because you know, if you know what the height is–

K: So what am I doing. Tell me what I'm doing here, tell me what I've done.

L: All right. You know that five hundred sheets equals fifty-eight –

L and K: Five point eight centimetres.

K: There is a point there, it's up there.

L: Oh, I can't see it.

K: Get some other glasses.

L: OK. Now, we need to know – we need to know the height of a million sheets of paper. Therefore you must divide a million by five hundred and times that number by five point eight.

K: [writing] Equals two thousand. Sheets of paper.

L: OK.

K: That would make it two thousand times five point eight centimetres equals eleven thousand six hundred centimetres, equals eleven point six metres of paper.[bell rings]

L: She didn't understand why you would times, this is what I think, she didn't understand why you'd times the two thousand by five point eight, because you have to find the height of a million sheets of paper.

I: Yeah,

L: And we knew that the height of five hundred sheets of paper was five point eight. I think she didn't understand what the two thousand was from.

I: Um hm.

L: And that was because you divide a million by five hundred sheets, and that gave the two thousand and then you had to times that by five point eight to give you, 'cause there's two thousand lots of five point eight sheets and she didn't understand where the two thousand came from, I think.

00:39:27 to 00:41:30 T asks students K and L what they've done. K explains, T is dubious, then says I think you're right, L explains, says we're right.

T: Where'd you get a hundred and eighty from?

K: Width. Equals forty–

T: Why did you multiply them together? Why not add?

K: To get the area. I know that much.

T: [to L] You've been tutoring her?

K: Equals forty-five thousand, therefore you'd need–oh, how'd I get that?

T: Forty-five thousand?

K: Forty-five thousand. That's what we got.

T: Forty-five thousand? Can you press that– can you press that– can you do that again? Two hundred and fifty times a hundred and eighty? Oh, hang on, hang on, I think you're right. Hang on. I think they're wrong.

K: Yup, they're wrong, we're right.

(L holds up calculator)

I(Interviewer with student L): *Uh huh. So why were you so sure your answer was right? Or were you sure your answer was right?*

L: *Um, because when she asked us what it was, she thought it was right too.*

I: *I'd like you to tell me this last bit. So say that again for me.*

L: *She came and asked us to do the answer that we found and we had a different answer to the one that another group had given her and when she heard our answer it must have clicked that, um, it sounded more right than the other one did, so she went to tell them that they were wrong.*

I: *It must have clicked with her, so that's why she thought it was right. Why did you think it was right?*

L: *'Cause if Mrs Burton thinks it's right, it probably is.*

I(Interviewer with student K): *There she's going over to your group.*

[videotape continues] *Yeah, so you seem pretty sure, you got the, you had answers for everything she said.*

K: *Yeah, because, um don't say anything to her, but the girls said that she'd pick on me a bit because I'm new, so if I show her that I know what I'm talking about then she'll lay off.*

I: *Oh, well that makes sense.*

K: *Because I don't want to seem like I'm going, "Well, you're right."*

I: *But you did know, didn't you?*

K: *Yeah, but I just thought it, 'cause yeah.*

I: *Yeah.*

K: *So I just wanted to show her that I know what I was talking about, because otherwise she'd keep on at me.*

I:*Yeah.*

K:*Admit that actually sort of think that she made a little bit of a mistake. Yeah. I knew she'd lay off if I sort of had an answer for everything, so that's why I just said, straightaway she'd ask me a question, I'd have an answer, and she'd go, um, think about it for a while and then*

straightaway say "You're right or you're wrong." Yeah, I just wanted to say everything quickly so she didn't have time to think of another question.

[It is noteworthy that the teacher did not comment on this exchange at all.]

[I: That was quite an interesting class] Mm, yes. Science is so much more straightforward. But the understanding of maths concepts when you've got so much dependent on previous years and kids have splinter gaps in their knowledge, or wide gaps in their knowledge, it's (?) quite difficult. It's one of the reasons I like teaching maths but it's also my biggest frustration. Is that really, I feel like I'm painting over wood that needs to be replaced at times, because the wood is damaged and all I'm doing is putting a glossy paint over the top.