Author: T. Meaney

Title: Ways and means to understand the linguistic choices of childrens mathematical explanations

Conference Name: Turning the kaleidoscope: NZARE National Conference 2004

Conference Location: Wellington, NZ

Publisher: NZARE

Year: 2004

Date: 24-26 November 2004

Abstract: This paper describes the issues involved in determining the methodology for exploring differences in the explanations and justifications that children give in primary mathematics classrooms. It begins by considering the reasons for wanting to know about these differences and then examines methodologies which have been used previously to explore the language of students.

Author Address: tmeaney@csu.edu.au

Ways and means to understand the linguistic choices of children's mathematical explanations

® Paper to be presented at the NZARE conference, Wellington, 2004

Tamsin Meaney
University of Otago
tamsin.meaney@stonebow.otago.ac.nz

This paper describes the issues involved in determining the methodology for exploring differences in the explanations and justifications that children give in primary mathematics classrooms. It begins by considering the reasons for wanting to know about these differences and then examines methodologies which have been used previously to explore the language of students.

This paper documents the decision making process in regard to methodology for researching language used in mathematics learning. The choice of methodology is an important issue but often the implications on the outcomes of research are not discussed. Doerr and Lesh (2003) summed up the present situation by stating:

> Current research on teaching mathematics … is plagued with a plethora of research designs and methodologies that tend to impede rather than promote the development of a shared knowledge base for teaching. ... We would argue that research designs need to be sufficiently open to allow for a multiplicity of perspectives and variability within areas of inquiry and at the same time sufficiently structured to allow for the sharing of models, metaphors, tools and principles. (p. 263)

By making more explicit the decision making process in regard to linking methodology to both the research question and the expected outcomes, it is anticipated that a contribution would be made to building this shared knowledge base. Therefore, this paper does not provide results from our research; some of these have been described elsewhere (Meaney & Irwin, 2003), with others to be published later. Instead it describes briefly the development of the research question and how it influenced the choice of methodology and this is followed by a discussion of the implications of this choice on the outcomes for the research.

Determining a research question

We began our research by thinking about how language use affected mathematics learning. This was because mathematics learning is enfolded within language. Without language, mathematics cannot be described or discussed and thus learnt. Chapman (1997) for example, stated that '[e]nculturation into school mathematics necessarily requires facility with its characteristic patterns of language use' (p. 157).

Although there has been significant amounts of research around this issue (see Ellerton & Clarkson, 1996), we became interested in the language used by different groups of students and its impact on their learning of mathematics. For example, Zevenbergen (2001) described the use in two different schools of the *triadic dialogue* sequence in which the teacher asks a question, the student or students respond and the teacher then provides feedback. Bernstein's (1990) work over many years consistently supported the idea that social class would have an effect on the language choices made by students because of their different perceptions of the context and of what were appropriate choices within that context. By drawing on this work and others to suggest that students from lower class backgrounds were less likely to be familiar with such a classroom interaction pattern, Zevenbergen hypothesised that these students would be at a disadvantage in learning mathematics. For teachers to be able to provide a range of experiences to support their students' learning and discussion of content, they need an in-depth description of the language that students use in the various aspects of their mathematics learning. Morgan (1998) in her research about students' writing about mathematics felt that there was a general lack of knowledge about language and language teaching to ensure that students could adequately express themselves mathematically. A clear sense of the language used in describing mathematical experiences would provide the starting point for understanding the interim steps that students should be encouraged to go through as they learn to talk and write more like mathematicians.

However, the range of mathematical language is broad and there was a need to limit our investigation so that it was manageable. Explanations and justifications is one area of mathematical language which has implications for how different groups of students are assessed (Meaney, 2002). A mathematical explanation is considered to be the description of *what* was undertaken to solve a problem (the solution strategy) whereas a justification would be *why* a certain strategy was adopted and its consequent result being accepted as appropriate. Moskal and Magone (2000) suggested that previous research had found that 'students' written explanations to well-designed tasks can provide robust accounts of their mathematical reasoning' (p. 313) and so can be used by teachers to assess students' knowledge. Mathematical explanations and justifications are of increasing importance in New Zealand with the introduction of the New Zealand National Certificate of Educational Achievement (Meaney, 2002). For students at the end of high school to achieve merit and excellence in mathematical assessments, they must be able to write mathematical explanations and justifications. In the Numeracy Project being run in New Zealand primary schools, children are slotted into particular levels based on their oral solutions to problems. By examining teachers' choice of assessment forms in determining student level, Young-Loveridge (2003) found that twice as many boys as girls were given the most challenging tasks to attempt. This had a direct impact on the number of boys compared to girls who were perceived as being at the higher levels of numeracy learning. Young-Loveridge related this result to teacher expectations. However, given the role that language plays in being the vehicle for exhibiting what students know, it is reasonable to assume that the linguistic choices made by students would affect teacher expectations. Research on teacher perceptions of students based on their speech showed that students who spoke non-standard versions of the language of instruction were more likely to be considered to have lower ability and behave inappropriately (Haig and Oliver, 2003). Research has also shown that teachers nominate and interact with boys more frequently (Wickett, 1997). The frequency of these interactions are believed to have an effect on the scaffolding and modelling of language that boys and girls receive and may promote boys' ability to gain academic language (Swann & Graddol, 1994). Our interest became concentrated on whether students from different backgrounds affected their language choices in giving mathematical explanations and justifications.

As no child arrives at school being able to talk like a mathematician, we were also aware that the acquisition of the mathematics register (or language to discuss mathematical ideas) occurs over time. Rowland (2000) found that the answers given by different aged pupils showed differences in how uncertainty was expressed. If we could gain information about the typical language used at a variety of educational stages, we could inform teachers how their students were likely to express themselves at different ages.

As well as looking for differences within variables such as whether younger children used different expressions to those of older children, it was also expected that combinations of variables would affect the choices of expressions. This is because no student is male or female without also being young or old and coming from a specific socio-economic background. For example, research has found that lower middle class women were more likely to imitate middle class language (Labov,1990) and that young men were subject to more peer pressure to use a less standard form of language (Milroy, 1980 and Milroy, 1981 cited in Wodak & Benke, 1997).

It was quite clear that we were not so much interested in mathematical correctness of the explanations and justifications but the forms in which they were couched (see Pimm & Wagner, 2003). This was because it seemed that form could have a significant impact on knowledge being considered correct and that there was a need to have a more complete description of how groups expressed themselves. Our research question thus evolved into: What are the typical linguistic choices of different groups of students when giving mathematical explanations and justifications? In particular we were interested in seeing if there were patterns of usage which were related to gender, socio-economic background, age and a combination of these. Having settled on a research question, we then had to consider what methodology would provide us with the most appropriate data and analysis tools to investigate it.

Matching methodology to the research questions

Methodology decisions were made in regard to collecting and then analysing data. How much data is collected, from what students, interacting in particular situations would immediately affect what we might be able to say about students' language choices. As well how we chose to interrogate the data would have an impact on the type of model of student language that could be described. Reviewing the literature suggested that we were likely to find differences between groups of students. Variables such as gender, age and socioeconomic background can be considered as socially constructed, with language use being one of the ways that individuals are positioned within a society (Wodak & Benke, 1997). In doing this research, it was important to recognise that specific features could not be considered as 'male' or 'female' but rather if there were differences these would occur along a continuum as 'linguistic differences are very often a matter of probabilities and tendencies' (Laver & Trugill, 1979, p. 23). As we were uncertain how differences in linguistic choices would manifest themselves, the data had to be analysed flexibly enough so that interesting things could be identified. As a quantitative approach to research requires the researcher to know what they are investigating before they begin, it was felt that a qualitative approach would be more appropriate. Qualitative research has been described as having the following 5 characteristics (Bogan & Biklen, 1982, p. 27-30):

1. Qualitative research has the natural setting as the direct source of data and the researcher is the key instrument
2. Qualitative research is descriptive
3. Qualitative researchers are concerned with process rather than simply with outcomes or products
4. Qualitative researchers tend to analyze their data inductively
5. "Meaning" is of essential concern to the qualitative approach

However, as we wanted to produce a description of students' language we anticipated that there would be particular features that required counting and so we did not discount the need to use some statistical techniques in our analysis. This combination of techniques from both approaches is not uncommon in research on language in educational settings (Swann, 1994). However, any combination of techniques results in compromises and some of the decisions made about the research and the related compromises are outlined below.

Data collection

In data collection, there were several issues which needed to be considered. These included in what setting should the data be gathered, from whom should it be gathered and by whom. The decisions in regard to these would have an impact on the description that we would be able to produce.

Qualitative research suggests the need for natural settings from which to gather data and context has an important effect on the production of linguistic data. Halliday (Halliday & Hasan, 1985) described the context of situation as being made up of what is going on, who is taking part and what role the language is playing. Changes to any of these affect perceptions of the context which then affect the language choices seen as appropriate. For example, how the teacher interacts with students will influence students' language choices (see Khisty and Chval, 2002). For a robust model of student language to be developed from this research, it was important to keep the situation as similar as possible for all students. Yet there was a need for a variety of students to participate so that we were not relying on one or two students to provide representative samples.

Studies into the language used by students in mathematics classrooms have in general had a fairly small number of participants. This has probably been because transcribing audiotapes of interactions takes large amounts of time (Swann, 1994) and produces huge amounts of data (Milroy, 1987 p. 22). Occasionally studies on language in mathematics education have been done with larger numbers of participants (Rowland, 2000, Bills & Gray, 2001 and Bills, 2002). As part of his study, Rowland (2000) interviewed the 230 students in one primary school to investigate their use of *hedges*. To do this he used a standardised set of questions and each interview took only five to ten minutes. The study by Bills (2002 and Bills & Gray, 2001) used 80 students who were interviewed at various times over two years. The transcribed interviews were then analysed to find the linguistic characteristics which accompanied correct calculations. Such studies constrained the language choices of students because they responded to a series of questions provided by an interviewer rather than being allowed more control over what was discussed (Rowland, 2000). However, the situations can be manipulated so that they are similar for every student and it was for this benefit that we decided to use data from the National Education Monitoring Project (NEMP). In NEMP, several hundred, randomly selected students in Year 4 and Year 8 from throughout New Zealand respond to the same set of tasks which are asked by about 100 teacher administrators. The responses that the students give provide a snapshot each four years of what these students know in mathematics. Many of these tasks are video recorded and therefore could be transcribed relatively easily.

Interviewing students for NEMP is not the same as recording naturally occurring interactions in their classrooms. However, the interactions between the students and the teacher administrators were similar to interactions that students would be expected to have with their own classroom teachers. Milroy (1987 p. 41) in discussing the collection of data for descriptive linguistic studies stated that the '[f]rom the interviewee's point of view, a co-operative response is often one which is maximally brief and relevant'. This could also describe the expected discourse patterns in teacher/child interactions in classrooms, except that the teacher administrators are told not to provide feedback on the correctness of the student's response which is a typical part of classroom discourse (see Edwards & Mercer, 1987). With NEMP assessments, the students work with the same pair of teacher administrators over the course of a week and therefore have some opportunity to interact before doing the mathematics tasks. We were aware that the interviewer's age, gender, ethnicity and personality could affect the language choice of students (Bogdan & Biklen, 1982). On the whole, the teacher administrators – mostly female from middle-class backgrounds – would not be unlike the teachers that students were likely to have in their own classrooms. Therefore we hoped that many students would interact in similar ways with the teacher administrators and so would use language which closely resembled what they would use in their own classrooms. The students did the tasks in their own schools although not generally in their own classrooms. NEMP assessment is low stakes as it has no impact on the child's academic programme nor is directly linked to school performance (Crooks & Flockton, 2001). Using the NEMP material was a compromise as it allowed us to gather material from a large number of students where the style and set of questions were the same for all. Although it was not a classroom setting, the data was gathered in a context which was familiar to students. However, it did mean that we would be able to say nothing about student-student interactions or even how students would use mathematics language when they had more control over the direction of the interview.

A main advantage of NEMP was that it was possible to choose students who fitted particular demographic descriptions such as gender, age (year 4 or Year 8) and the decile ranking of the school attended. It is generally accepted in New Zealand that the decile ratings for schools do relate to the socio-economic background of students (see for example Crooks and Flockton, 2001). There are of course difficulties with such a categorisation as it is fraught with issues over who is making the decisions and what constitutes the factors which are relevant to such a decision (see Robinson, 1979). However, with few alternatives available, a decision was made to go with the accepted belief that children who came from high decile schools were from more affluent backgrounds. Tasks were also available whose responses could be related to ethnicity of students. These interested us as there had been studies to show that Pacific Islander students living in New Zealand do not achieve as well as their European or Asian peers (Young-Loveridge, 2000) and so we wanted to know whether ethnicity was reflected in the language choices of students. As a result videotapes of students were chosen based not only on gender, and age but also on their attendance at particular decile-rated schools and whether they were Pacific Islander or not.

To produce a rich description of students' mathematical explanations and justifications, it was necessary to look at responses to more than one task. This would enable us to see how the task itself as part of the context affected the language choices of students and so give us more insight into the process of making those choices. We therefore transcribed videos of children responding to four different tasks. From tasks done in 1997, we selected "Better Buy", "Weigh Up" (see Flockton and Crooks, 1997) and "Motorway" and "Bank Account" from 2001 (see Crooks and Flockton, 2001). The two tasks from 1997 were done by the same set of students whereas the ones from 2001 were done by separate groups. By using the 1997 tasks, we were thus able to see how the actual questions affected the same students' responses. Students attempting the 1997 tasks could be chosen based on age, gender and decile rating of school attended whereas students doing the 2001 tasks could also be grouped according to ethnicity.

In order to develop a robust model of the language that children used in giving mathematical explanations and justifications, we needed to ensure that we had a large enough sample size. Many descriptive linguistic studies used reasonably small sample sizes. Labov's well-known generalisations of the speech of New Yorkers was based on a sample size of only 88 speakers (Labov, 1966). Hawkins (1977) investigated the nominal groups used by five-year olds in London. Having decided on his variables of social class, IQ, gender and communication index of mothers (CI) he formed a matrix of 2 x 3 x 2 x 2 cells and assigned 5 children to each cell. However, as he did not have middle-class children who had both low IQ and low CI, two of the cells remained empty (one for boys and one for girls). This meant that he had a total of 110 samples of five-year old talk to analyse. Hawkins (1977) recommended using such a matrix by stating that '[i]ts advantage is that the effects of each variable may be estimated independently' (p. 8). Increasing the number of samples results in data handling issues which could make the research impractical. It was decided for this research that a matrix of the variables of interest to us would be drawn up and we would seek to have six children allocated to each cell. This is illustrated in Table 1 which shows the distribution for the first two task transcripts. For each of the four tasks, we would have a total of 72 transcripts of different children's mathematics language. A decision was made to include those students who remained mute when asked a question as we felt that there maybe be patterns in their distributions. This sampling method ensured that any group such as students from different decile schools would contain at least 24 samples. This number increased when results across all four tasks were compared. As the students doing the two 1997 tasks were the same, our total sample size was 216. We anticipated that with a sample size of 216 students with 288 transcripts to interrogate, that patterns in linguistic choices would become apparent.

Table 1.
Distribution of students chosen for analysis, six students per cell.

Year	High Decile Schools		Middle Decile School		Low Decile School	
4	Girls	Boys	Girls	Boys	Girls	Boys
8	Girls	Boys	Girls	Boys	Girls	Boys

Although we would have access to the videos of students, we had to limit what we would actually do with them. Much information such as eye signals and gestures is lost when transcriptions are made (Swann, 1994) but in order to keep the project manageable it was decided to concentrate on the linguistic expressions used by students. As a result, only student responses were transcribed as the NEMP procedure required the teacher administrators to ask set questions. It soon became apparent that this had not always happened but by only having the student responses we were forced to concentrate on their linguistic choices. It did mean that we missed opportunities to discuss the interactions between students and the teacher administrators.

One final advantage of using NEMP data was that ethics approval had already been granted. Obtaining consent from students and their parents and other interested parties such as the Ministry of Education is important in educational research to ensure that participants especially children are not exploited (Cameron, Frazer, Harvey, Rampton & Richardson, 1994). Yet 'going through the formal procedures that some educational systems require can be a long laborious process' (Bogdan & Biklen, 1982, p. 122) so it was useful to have this ethical approval already obtained. Cameron et al. (1994) also raised the ethical issue of how the results would be used which might be contrary to interests of the participants. In doing research where differences between groups could be highlighted, we needed to ensure that any findings were seen as being important only if they were causing teachers to underestimate the mathematical learning of students. Yet, it was not possible to discover this until we knew what some of these differences were.

This research set out to develop a robust model of student language in giving mathematical explanations and justifications. As a result, it was felt that a qualitative approach was the most suitable in order to achieve this. However in determining how to implement such an approach, compromises had to be made between the aims of being as descriptive as possible whilst also using naturalistic settings and keeping the project manageable.

Analysing the data

Once the decisions had been made about what data to collect, we then had to consider how it was to be analysed so that we could ensure that meaning was our focus. As we were unsure what aspects of students' language were most useful in producing a robust description, it was necessary to consider how others had approached their analysis of students' mathematical language. For example, Chapman (1997) examined her transcripts to discover the ways that the teacher rephrased students' utterances and how these rephrasing were then picked up by the students. In other studies such as that by Gooding and Stacey (1993), transcripts were coded so that specific types of responses (asking questions, responses to requests for clarification) were highlighted and their use related to common attributes of the groups of students who used them. For our research, neither methods of analysis seemed appropriate as we were not focussing on the exchanges between students and the teacher administrators, rather we were comparing different students' responses.

We were also aware of the potential difficulties associated with a coding system which simply reflected what researchers expected to see (see Edwards, 1976) and how this did not support a qualitative approach to the research to be undertaken. Originally, we started by looking for particular features that we felt were more mathematical in student responses, such as the use of nominalisations or noun phrases as agents of actions rather than people, following the example of Hawkins (1977). These features were based on work described in Meaney (forthcoming). The results from this survey were reported in Meaney and Irwin (2003) and were quite confusing. We had to reconsider how to examine the data so that the patterns within it became clearer. In the end a coding system was used, but one which looked at *text structure* rather than discourse analysis. We began by making an intuitive analysis of which students used clear language and which students gave accurate and reasonable explanations and justifications. We then discussed what it was that contributed to some students responses being classified as clear.

It was at this point that the work by Hasan became valuable in our search for analysis tools. This was because her beliefs about text structure enabled us to code students' responses but in ways that support the illumination of patterns. It also enabled us to keep the context of the responses as an integral part of the description. Hasan's (Halliday and Hasan 1985, p. 56) described contextual configuration as the significant attributes of a social environment in which a text is constructed and it can be used to predict the text structure. In this study, students' explanations were given in responding to questions on a mathematics task asked by a teacher administrator in a school environment. Hasan (Halliday and Hasan 1985) stated that the contextual configuration 'can predict the OBLIGATORY and the OPTIONAL elements of a text's structure as well as their SEQUENCE *vis-á-vis* each other and the possibility of their ITERATION' (p. 56 capitals and italics in original text). However as Hasan (Halliday and Hasan 1985) also pointed out, the relationship between language and situation is bi-directional and some elements of the text structure will in fact help to construct the situation. For example, when a student provided a minimal response and the teacher administrator kept asking further questions, sometimes this probing became more about teaching the student than about assessing their current understanding. If these further questions become an obligatory element of the situation, then the situation has changed from one of assessment to one of teaching. By looking for the patterns of obligatory and optional elements and how they are sequenced and repeated across different students' responses, we have begun to describe different children's perceptions of the situation. As there had been no previous similar work in this area, our coding was inductive rather than looking for expected elements, thus we hoped to limit the problems identified by Edwards (1977) in regard to coding.

A qualitative analysis needs analytical tools which do not to constrain the data but do support the uncovering of patterns within it so that a rich description of students' language choices can be made. Although we have also now begun to look at the data through other lenses, Hasan's ideas about contextual configuration has enabled us to reveal subtle differences in the way that different groups of students put together their justifications and explanations in mathematics. This has come through the identification of the different elements in the texts and then looking at how they are sequenced. We are aware that this choice of analysis tools means that our description of students' language choices will be limited to the existence and ordering of elements within their texts.

Impact on the research findings

Our research question was one which interested us and which looked from the previous research on this area as being one which was significant. In examining ways that it could be investigated, we were aware that these would have an impact on what we would ultimately be able to present as our findings. A quantitative approach might have produced a more systematic description showing how often terms and expressions were present in students' speech. However, it would not necessarily have enabled context in which the students' response were made to be an integral part of that description. We were aware that we had compromised the qualitative requirement of a natural setting for our data gathering. However, it would not have been possible to make any comparisons between the language of different groups if the settings were not the same for all students. As our ultimate goal was to support teachers understanding of how students' language use affected their perceptions of their students' knowledge about mathematics, it seemed valuable to produce a model which was as broad as possible and still placed importance on the context. Yet we were also aware that by looking at student-student or student-teacher interactions during learning experiences the model that we would have been able to produce would have been significantly different. To ensure that our project remained manageable we were forced to narrow our research question and then chose data gathering and data analysis methods which would provide us with a robust model of students' language in giving mathematical explanations and justifications.

Conclusion

Choosing and using a research methodology has significant impact on what can be said about a particular research question. No methodology is perfect and the compromises that have to be made will affect the outcomes. Yet in reporting the findings, the methodology can often be only cursorily described which does not contribute to the development of a shared knowledge base for researchers. This paper has contributed to this sharing process by describing some of the decision making in regard to the major research that we are undertaking presently.

Acknowledgements

This project was undertaken with Dr K. Irwin from the University of Auckland and funded as a NEMP Probe Study which is administered through Canterbury University.

References

Bernstein, B. (1990). *The structuring of pedagogic discourse, Volume 4: Class, codes and control*. London: Routledge.

Bills, C. (2002). Linguistic pointers in young children's descriptions of mental calculations. In A Cockburn & E. Nardi (Eds), *Proceedings of the 26th annual conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 97-104). Norwich: PME.

Bills, C. & Gray, E. (2001). 'Particular', 'Generic' and 'General' in young children's mental calculations. In M. van den Heuval-Panhuizen (Ed) *Proceedings of the 25th annual conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 153-160). Utretch: PME.

Bogdan, R. C. & Biklen, S. K. (1982). *Qualitative research for education: An introduction to theory and methods* Boston: Allyn and Bacon Inc.

Cameron, D., Frazer, E., Harvey, P., Rampton, M. B. H. & Richardson, K. (1994). The relations between researcher and researched: Ethics, advocacy and empowerment. In D. Graddol, J. Maybin & B. Stierer (Eds), *Researching language and literacy in social contexts,* (pp. 18-25) Clevedon: Multilingual Matters.

Chapman, A. (1997). Towards a model of language shifts in mathematics learning. *Mathematics Education Research Journal*, 9(2), 152-172.

Crooks, T. and Flockton, L. (2001). *Mathematics: Assessment Results* Dunedin: Educational Assessment Research Unit.

Doerr, H. & Lesh, R. (2003). Designing research on teacher's knowledge development. In L. Bragg, C. Campbell; G. Herbert & J. Mousley (Eds.), *Mathematics Education Research: Innovation, networking, opportunities* (pp. 262-269). Melbourne: Deakin University.

Edwards, A. D. (1976). *Language in culture and class* London: Heinemann Educational Books.

Ellerton, N. & Clarkson, P. (1996). Language factors in mathematics teaching and learning. In A. Bishop, M. A. Clements, C. Keitel, J. Kilpatrick & C. Laborde (Eds), *International handbook of mathematics education* (pp. 987-1023). Dordrecht: Kluwer Academic Publishers.

Flockton, L. & Crooks, T. (1997). *Mathematics: Assessment Results* Dunedin: Educational Assessment Research Unit.

Gooding, A. & Stacey, K. (1993). Characteristics of small group discussion reducing misconceptions. *Mathematics Education Research Journal* 5(1), 60-73.

Haig, Y. and Oliver, R. (2003). Language variation and education: Teachers' perceptions. *Language and Education* 17 (4), 266-280.

Halliday, M. & Hasan, R. (1985). *Language, Context and Text: Aspects of Language in a Social-semiotic Perspective*. Melbourne: Deakin University Press.

Hawkins, P. R. (1977). *Social class, the nominal group and verbal strategies*. London: Routledge & Kegan Paul.

Khisty, L. L. & Chval, K. B. (2002). Pedagogic discourse and equity in mathematics: When teachers' talk matters. *Mathematics Education Research Journal*, 14(3), 154-168.

Labov, W. (1966). *The social stratification of English in New York City*. Washington, DC: Centre for Applied Linguistics.

Labov, W. (1990). The intersection of sex and social class in the course of linguistic change. *Language variation and change* 2, 205-254.

Laver, J. & Trugill, P. (1979). Phonetic and linguistic markers in speech. In K. R. Scherer & H. Giles (Eds) *Social markers in speech* (pp. 1-32) Cambridge: Cambridge University Press.

Meaney, T. (2002). Aspects of written performance in mathematics learning. In K. Irwin, B. Barton, M. Pfannkuch and M. Thomas (Eds), *Mathematics in the South Pacific: Proceedings of the 25th Mathematics Education Research Group of Australasia Conference*, (pp. 481-488) University of Auckland: Auckland.

Meaney, T. (forthcoming, 2004). Mathematics as Text. In A. Chronaki & I. M. Christiansen (Eds), *Challenging Ways of Viewing Maths Classroom Communication* Westport, CT: Information Age.

Meaney, T. & Irwin, K. (2003). How does changing the question result in students changing their answers? *NZARE/AARE Joint Conference Proceedings*, University of Auckland 30th November – 3rd December, 2003. Retrieved from : http://www.aare.edu.au/03pap/alpha.htm#l on 25th March, 2004.

Milroy, L. (1987). *Observing and analysing natural language: A critical account of sociolinguistic method* Oxford: Basil Blackwell.

Morgan, C. (1998). *Writing Mathematically: The Discourse of Investigation*. London: Falmer Press.

Moskal, B. M. & Magone, M. E. (2000). Making sense of what students know: Examining the referents, relationships and modes students displayed in response to a decimal task. *Educational Studies in Mathematics* 43, 311-335.

Pimm, D. & Wagner, D. (2003). Investigation, mathematics education and genre: An essay review of Candia Morgan's "Writing mathematically: The discourse of investigation". *Educational studies in mathematics*, 55, 159-178.

Robinson, W. P. (1979). Speech markers and social class. In K. R. Scherer & H. Giles (Eds) *Social markers in speech* (pp. 211-249) Cambridge: Cambridge University Press.

Rowland, T. (2000). *The pragmatics of mathematics education: Vagueness in mathematical discourse* London: Falmer Press.

Swann, J. (1994). Observing and recording talk in educational settings. In D. Graddol, J. Maybin & B. Stierer (Eds), *Researching language and literacy in social contexts,* (pp. 26-48) Clevedon: Multilingual Matters.

Swann, J. & Graddol, D. (1994). Gender inequalities in classroom talk. In D. Graddol, J. Maybin & B. Stierer (Eds), *Researching language and literacy in social contexts,* (pp. 151-167) Clevedon: Multilingual Matters.

Wickett, M. (1997). Uncovering bias in the classroom – a personal journey. In J. Trentacosta & M. J. Kenney (Eds), *Multicultural and gender equity in the mathematics classroom: 1997 Yearbook* Reston, VZ: The National Council of Teachers of Mathematics.

Wodak, R. & Benke, G. (1997). Gender as a sociolinguistic variable: New perspectives on variation studies. In F. Coulmas (Ed.) *The handbook of sociolinguistics* (pp. 127-150) Oxford: Blackwell Publishers.

Young-Loveridge, J. (2000). How children's understanding of the number system varies as a function of ethnicity and socio-economic status. In J. M. Bana, J. & A. Chapman (Eds), *Mathematics Education beyond 2000: Proceedings of the Twenty-Third Annual Conference of the Mathematics Education Research Group of Australasia* (pp. 672-679). Fremantle: MERGA.

Young-Loveridge, J. (2003). The impact of using strategy windows to select an appropriate form of assessment for students' numeracy learning. *NZARE/AARE Joint Conference Proceedings*, University of Auckland 30th November – 3rd December, 2003. Retrieved from : http://www.aare.edu.au/03pap/alpha.htm#l on 25th March, 2004.

Zevenbergen, R. (2001). Mathematics, social class and linguistic capital: An analysis of mathematics classroom interactions. In B. Atweh, H. Forgasz & B. Nebres (Eds), *Sociocultural research on mathematics education: An international perspective*, (pp. 201-216) Mahwah, NJ: Lawrence Erlbaum Associates.