ARE ALL STUDIES ON EQUITY IN SCHOOL MATHEMATICS EQUAL?

Stephen Lerman and Andri Marcou

London South Bank University

Researching what might lead to more equitable outcomes, across diverse social groups, especially since disadvantaged groups consistently achieve less than children from more advantaged backgrounds in many countries, has become quite common in recent years. In this paper we carry out a literature review of a selection of that body of research. We construct a model for analysis and place the selection on the model. We discuss our findings and conjecture what is important for future research in the domain.

INTRODUCTION

During the participation of the first author as a co-investigator on a research project funded by the Australian Research Council (Principal Investigators: R. Zevenbergen, P. Renshaw & S. Lerman) and as critical friend on a second such grant (Principal Investigators: P. Sullivan, J. Mousley & R. Zevenbergen) it became clear that there are very different orientations to research on achieving equity in mathematics teaching and learning. Looking beyond these two projects, we became interested in the following questions: how are researchers in the mathematics education community researching equity; what theoretical frameworks are being drawn upon and/or developed; what approaches to the issue are being adopted; and what do we know, at this stage? It is the intention of this paper to review and classify the research literature in the expectation that some critical insights into these questions will emerge from the analysis to inform future research and to enable a conversation between these different orientations.

Research on teaching and learning mathematics has traditionally drawn largely on either psychology or on mathematics itself as intellectual resources for framing that work (Kilpatrick, 1992). Student 'failure' to produce adequate levels of performance can then be ascribed to inadequacies of the pupil her or himself. Oversimplifying perhaps, one could say that these views see either the failing student's development as a deviation from a norm determined by psychological studies or that mathematical thinking is inherently difficult and accessible only to those with a propensity towards the subject, an assumption of innate mathematical ability. The leading research group in the field, formed in 1976, the International Group for the Psychology of Mathematics Education (PME) saw it as natural to locate its research within psychology, as the only field that seemed to offer the intellectual resources to investigate issues of learning. In 2005 the constitution was changed, although not the name, to recognise other theoretical resources as of equal value for research. One major argument put forward in support of the change was the recognition that issues

J.F. Matos, P. Valero & K. Yasukawa (Eds.) (2008). *Proceedings of the Fifth International Mathematics Education and Society Conference*. Lisbon: Centro de Investigação em Educação, Universidade de Lisboa – Department of Education, Learning and Philosophy, Aalborg University.

of equity cannot be adequately explained within mainstream psychology. The founding of the Mathematics Education and Society group was clearly a response to the domination of psychological paradigms in mainstream mathematics education.

With a growing recognition of the significance of the role of the teacher, along with the emergence of competence modes (Bernstein, 1990) in education in general, came a focus on forms of pedagogy, on the effects of stratification of pupils into classes based on levels of achievement, and on the recontextualisation of mathematics into the school mathematics curriculum as at least mediators, if not determinants, of students' experiences and hence of who fails and why (Lerman & Tsatsaroni, 1998). Sociological and socio-cultural theories have now become key intellectual resources in studies of pedagogy and classroom interactions and, in particular, analyses of success and failure in school mathematics (e.g. Dowling, 1998; Lerman & Tsatsaroni, 1998; Cooper & Dunne, 2000; Lerman, 2000; Tsatsaroni, Lerman & Xu, 2003; Watson & Mason, 2004).

As research on equity in mathematical achievement has developed and spread geographically, so too have the approaches researchers have taken. In analysing why some students succeed and others fail, and indeed why there is such a correlation between low socio-economic status and low mathematical achievement, researchers have focused on different aspects of the pedagogic relationship. On the one hand, many are convinced that the way mathematics *per se* is taught and the kinds of mathematical activities that are set up for students are the key to improving equity, whilst others see the social organisation of learning to be the key. At the same time, the research methods that researchers bring to their studies vary, from those that are focused on what works, often in a design and improve model, to those who find direction in particular theoretical orientations, either in the methodological design of their study or in the development of tools for analysis, most particularly from sociology.

In this paper we present a model of those approaches with a view to mapping the field and enabling a conversation between different perspectives. Clearly equity is of serious concern to mathematics teachers and researchers, given the kudos that comes with a certificate in mathematics. The challenges to assumptions about mathematical ability have been many and varied, from projects aimed at specific groups disadvantaged by the education system (e.g. Bob Moses' Algebra Project) to critiques of the hegemony of academic mathematics and mathematicians (D'Ambrosio's ethnomathematics programme) and to post-modern analyses (Walshaw, 2004; Nolan & De Freitas, forthcoming). We suggest it is timely to examine how researchers approach their studies and identify some key questions.

CONSTRUCTING A MODEL

Based on the first author's engagement with the two research projects in Australia an initial model was formed as a working hypothesis by constructing two perpendicular

coordinate axes (Figure 1) drawing on the broad characterisation of the approaches researchers seem to have taken to the study of equitable achievement in school mathematics set out above. A vertical axis of 'Focus of Study' formed one element in the model, with the two extremes being 'Mathematics *per se*' and 'Mathematics in its social context'. 'Methodology' formed the horizontal axis of the model with the positions of theory-informed and pragmatic as the two extremes. At this stage it was by no means clear whether the axes, with an indication that distance along them might be of significance, would prove to be the most appropriate structure. The next stage was to carry out a literature search, with suitable limits set, and develop a structure for analysis enabling us to place the studies on the model, whilst at the same time allowing the model to change and develop as criteria for making decisions about the location of those studies were framed.

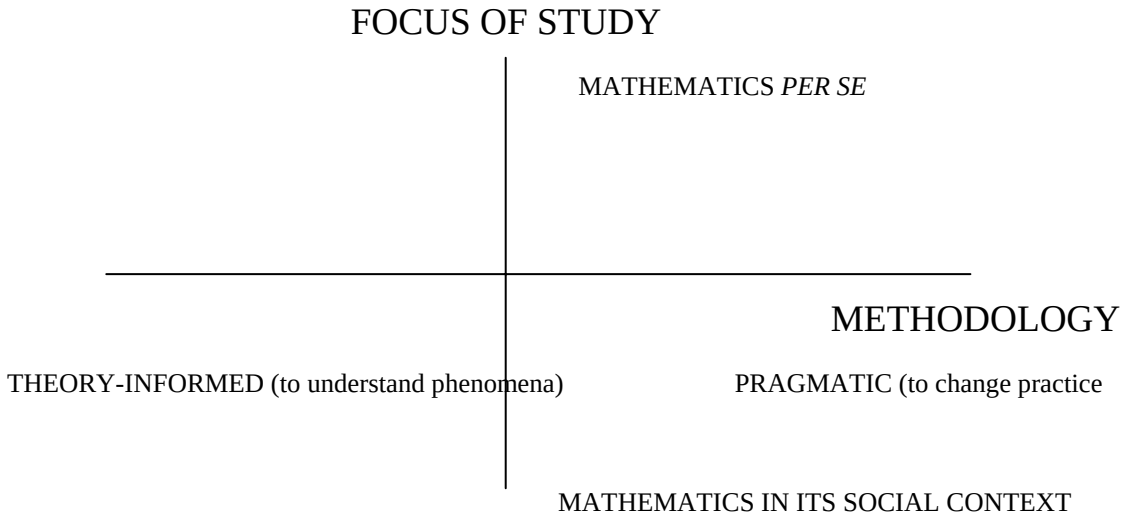

Figure 1. Initial model of research on equity

At this first stage of analysis we decided to restrict our study to those research projects that either initiated an intervention aimed at improving the equity of achievement in school mathematics or projects carried out to observe particular innovations or current situations in school mathematics and analyse them in equity terms, perhaps amongst other aspects. It may be appropriate at a later stage to look also at these theoretical studies on equity. We decided to work with articles rather than books and, since it is usual to find a number of articles from any one study, we restricted our choice to one on each study. We selected 11 articles (from a total of 27) that represented those studies and they form the empirical field for our analysis. We certainly do not claim to have exhausted the field. They are listed in Table 1, with full references at the end of the paper.

1	Boaler, J. (2002). Paying the price for "sugar and spice": Shifting the analytical lens in equity research.
2	Boaler, J. (2002). Learning from teaching: Exploring the relationship between reform curriculum and equity.

3	Lubienski, S. (2002). Research, reform, and equity in U.S. mathematics education.
4	White, D. Y. (2003). Promoting productive mathematical classroom discourse with diverse students.
5	Kitchen, R. (2003). Getting real about mathematics education reform in high-poverty communities.
6	Sztajn, P. (2003). Adapting reform ideas in different mathematics classrooms: Beliefs beyond mathematics.
7	Zevenbergen, R. (2005). The construction of a mathematical *habitus*: implications of ability grouping in the middle years
8	Zevenbergen, R. & Lerman, S. (2006) Using ICTs to support numeracy learning across diverse settings.
9	Forgasz, H. (2006). Teachers, equity, and computers for secondary mathematics.
10	Sullivan, P., Mousley, J., & Zevenbergen, R. (2006). Teacher actions to maximize mathematics learning opportunities in heterogeneous classrooms.
11	Clements, D., H., & Sarama, J. (2007). Effects of a preschool mathematics curriculum: Summative research on the Building Blocks Project.

Table 1. Studies on Equity

The next diagram (Figure 2) presents the final version of the decision tree that we used to classify the studies in terms of the two axes. In our view, as researchers, the criteria we used for decisions (recognition and realisation rules) should be made as explicit as possible within the constraints of a paper, in order both for our peers to evaluate and critique those decisions and to facilitate the extension of studies such as these to other intellectual domains.

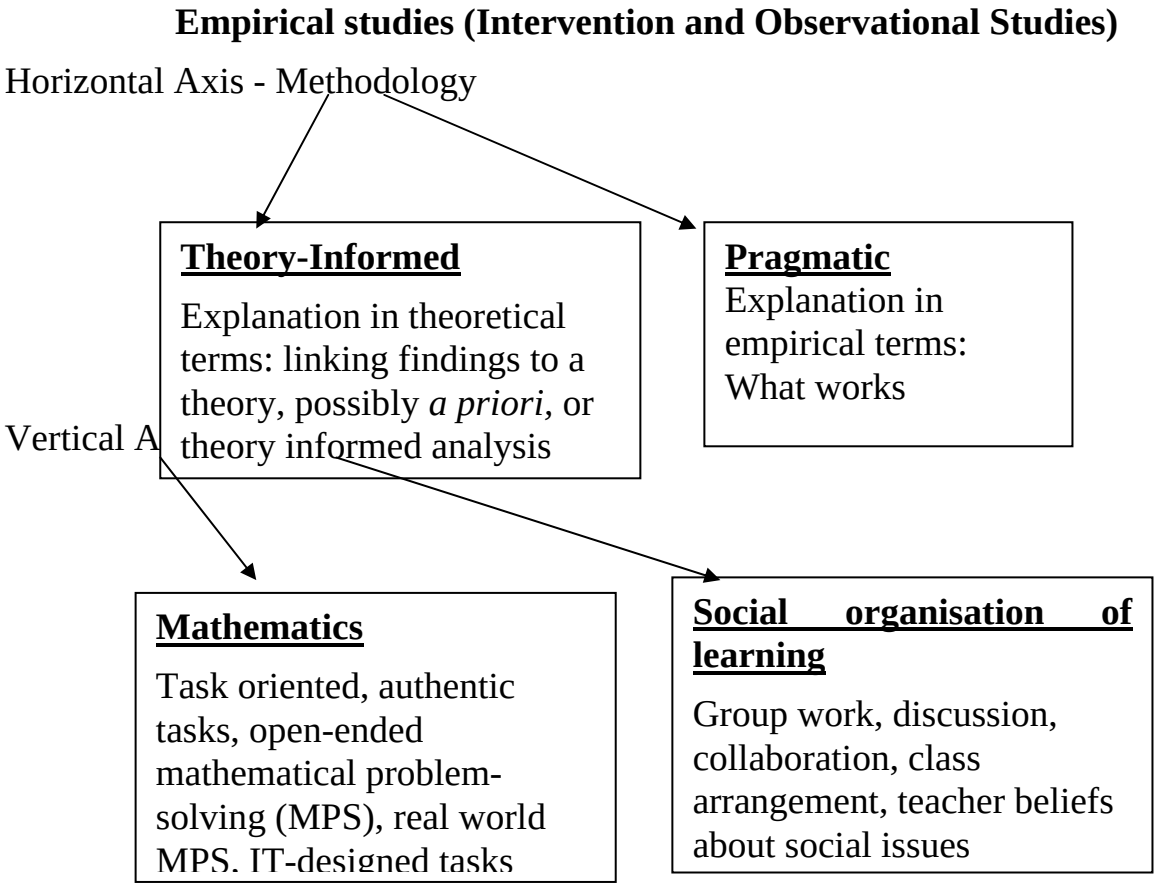

Figure 2. Decision tree

We now give two examples of the analysis and hence the decisions we made regarding the selected papers. The first (Sullivan et al., 2006, number 10 in Table 1) is an intervention and the second (Zevenbergen, 2005, number 7 in Table 1) is a study of an existing situation, what we have called an observation. We offer selective quotes from the articles and the conclusions we have drawn.

(i) Sullivan, P., Mousley, J., & Zevenbergen, R. (2006). Teacher actions to maximize mathematics learning opportunities in heterogeneous classrooms

- Lesson focused
- "We examine three teacher actions that address the mathematical goals: using open-ended tasks, preparing prompts to support students experiencing difficulty, and posing extension tasks to students who finish the set tasks quickly; as well as actions that address the socio-mathematical goals by making classroom processes explicit" (p. 117)
- The article contains a deep description of an observed lesson planned by researchers and teacher. "…the intent was to stimulate engagement in the mathematical ideas inherent in the tasks, including creating opportunities for visualisation and for identifying

patterns, and recognising the possibility of transfer or extension to other spatial or design situations." (p. 128)

• "In the lesson the students undertook tasks that were substantial and that involved engagement with significant mathematical ideas. The students worked actively, creatively, and individually in drawing the shapes or buildings using isometric representations, rather than listening to explanations by the teachers. The engagement seemed directly due to the open-ended nature of the task, and the opportunities for the students to respond creatively. It also seems to us that the prompts that the teacher used scaffolded students so that they could engage with the task and the mathematics." (p. 138)

• Focus on the mathematics, together with an awareness of social factors

• Pragmatic explanation of outcomes

(ii) Zevenbergen, R. (2005). The construction of a mathematical *habitus*: implications of ability grouping in the middle years

• "Using the theoretical tools offered through the writings of the French sociologist, Pierre Bourdieu, I propose, drawing on the notions of field and *habitus*, that the practice of ability grouping helps to reproduce the status quo, and can be detrimental to goals of social justice." (p. 608) Theoretically driven.

• 96 students of years 9 and 10, high through to low achieving students in secondary schools from six Australian schools were interviewed

• "Through the practices within the field, ability-grouping constructs a *habitus* that either includes or excludes students from the subject. The higherstreamed students made it clear that they have a greater sense of belonging to their classrooms than their peers in the lower streams. They are more positive about mathematics, and have a greater sense of being able to achieve in the subject. Their peers in the lower streams recognize the more restrictive experiences of schools mathematics in terms of pedagogy, assessment, and classroom ethos, and this comes to constitute a predisposition to think in particular ways in relation to school mathematics." (p. 617)

• Focus on ability grouping, i.e. social organization of the classroom

Finally, we present the location of the articles selected onto the model, in Figure 3.

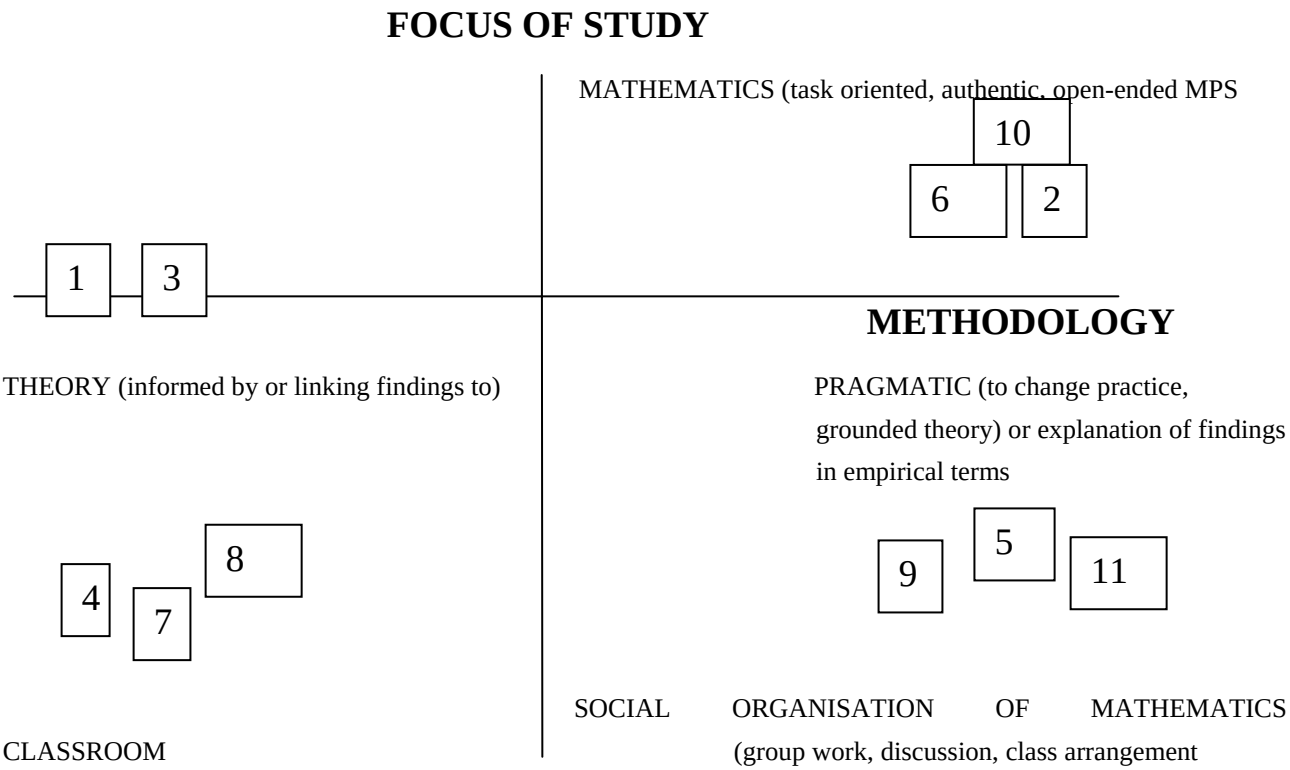

Figure 3. Locating the studies on the model

DISCUSSION

We first make a few comments on the location of the articles on the model. We subsequently conjecture what the features of the particular arrangement might suggest, within the constraints of the sample size and the selection of research studies.

We find that we have placed articles in each of the quadrants and that they are evenly spread, with a small preference for what we have termed a pragmatic approach to the analysis and the same slight tendency towards a focus on the social organisation of the mathematics classroom. But these differences are too small, especially when taking into account the sample size, to be significant.

We found relevance in where the articles were placed in the quadrants in relation to the axes with the two articles numbered 1 and 3 that were to be placed in the quadrant 'Theory/Mathematics *per se*'. All the articles except these two were relatively strongly categorised as representing the approach of both axes. Our reasoning was different in each of these cases. Article 1 was rich in empirical data and the analysis drew on a number of theoretical resources, including sociology (both Bernstein and Bourdieu) and communities of practice theory. The author argued both for the kinds

of mathematical activities that were used by the teachers and for the forms of social organisation of the classroom as being factors that distinguished the two settings being examined. We therefore placed it in the theory section but neutrally between mathematics *per se* and social organisation of the mathematics classroom. Article 3 examined national data on performance in mathematics in the USA to identify possible links between enquiry-based mathematics and disadvantaged groups. The focus here was on the curriculum and associated forms of pedagogy and not on either mathematics *per se* nor the social organisation of the mathematics classroom. At the same time the analysis drew on Bernstein's theories and hence was clearly in the theoretical domain.

We have not found it possible, nor useful, to rank the articles along the axes in any other instances.

In relation to the horizontal axis it is not surprising to find a range of research methods, and indeed philosophies of research methods, in education and its sub-fields; in our case in mathematics education. In a previous study (Tsatsaroni et al., 2003) we examined the state of the research community of mathematics education through an analysis of research publications over a 12 year period in the two leading mathematics education journals (*Journal for Research in Mathematics Education* (JRME) and *Educational Studies in Mathematics* (ESM)) and the Proceedings of the International Group for the Psychology of Mathematics Education (PME). We wrote:

> It is… clear that reference to some theory is a feature that the researcher has explicitly and perhaps routinely demonstrated in the process of empirical investigation. In particular, theory appears to be informing the empirical in the majority of papers (65.5% in ESM, 71.7% in JRME, 79.1% in PME…). Our data also suggests that 76.3%, 73.9% and 76.4% for ESM, JRME & PME respectively are content with applying the theory rather than engaging with it in any other way... Here it is also interesting to observe that this feature appears to be constant, as we have not observed in the data any change of pattern. One can hypothesise that we have a case of a research field/community where *to be seen to be doing research using and applying theory* seems to be the main pattern. In terms of the methods of inquiry used, if our initial interpretations are sound, the drive towards balancing qualitative and quantitative types of inquiry in the three examined sites of research publication might indicate the adoption of a pragmatic attitude towards research, consistent with the overall tendency in the social sciences towards a new positivity in the '90s and beyond, as described in the relevant literature. (p. 32)

In that study we found also that the theories upon which researchers drew for their analyses ranged widely with an increasing tendency towards what we might call the social turn (Lerman, 2000).

The present study places a higher percentage of papers in the category of those research productions that do not draw explicitly on a theory. We conjecture that this might be because of an increasing tendency towards positivity within all educational research communities in the years since we carried out the above research. Certainly

the political pressure to focus on ‘what works’ in educational research in the USA will have had an influence. Furthermore, within the community we are seeing an increasing application of design science (e.g. Cobb, 2006) which is, at heart, a pragmatic approach to analysing why things happen as they do in education. These two points may be connected.

In relation to the vertical axis, researchers are evenly divided between, on the one hand, a conviction that mathematical activities other than those most often found in textbooks and classrooms can provide opportunities for all students to successfully learn mathematics and, on the other hand, those who look to the way the classroom is socially organised, or perhaps we might better say how the interactions between students and between students and the teacher are organised, for features that make a difference in who succeeds.

For our part, we are concerned that we in the community have explanations for why particular interventions seem to be successful in improving equity, or why particular features of classrooms lead to more equitable outcomes. That is, we are concerned with both what works and why it works. Social science research in general and educational research in particular recognises that what works in one place, with one teacher or department, at one time, is unlikely to transfer to another situation in a reliable manner. We are convinced that if we have some good explanations for why a specific intervention or feature works it may be translatable into different circumstances by different teachers at different times, as it may be adaptable in its application to those circumstances. Some theories provide a rich explanatory tool; in research reported above, we have found Bernstein’s theories to be just such a framework (see also Morgan, Tsatsaroni & Lerman, 2002). In other approaches explanations are perhaps harder to come by.

REFERENCES

Bernstein, B. (1990). *The Structuring of Pedagogic Discourse*. London: Routledge.

Boaler, J. (2002a). Learning from teaching: Exploring the relationship between reform curriculum and equity. *Journal for Research in Mathematics Education, 33*(4), 239-258.

Boaler, J. (2002b). Paying the price for "sugar and spice":Shifting the analytical lens in equity research. *Mathematical Thinking and Learning, 4*(2&3), 127-144.

Clements, D., H., & Sarama, J. (2007). Effects of a preschool mathematics curriculum: Summative research on the building blocks project. *Journal for Research in Mathematics Education, 38*(2), 136-162.

Cobb, P. (2006). Design Perspectives in Mathematics Education: A Commentary on Sfard’s and Lerman’s Chapter. . In J. Maaß & W. Schlöglmann (Eds.) *New mathematics education research and practice* (pp. 189-202) Rotterdam: Sense Publishers.

Cooper, B., & Dunne, M. (2000). *Assessing Children's Mathematical Knowledge* Buckingham, UK: Open University Press.

Dowling, P. (1998). *The sociology of mathematics education: Mathematical myths/ pedagogic texts*, London, Falmer Press.

Forgasz, H. (2006). Teachers, equity and computers for secondary mathematics learning. *Journal of Mathematics Teacher Education, 9*, 437-469.

Kilpatrick, J. (1992). A history of research in mathematics education. In D. A. Grouws (Ed.) *Handbook of research on mathematics teaching and learning* (pp. 3-38). New York: MacMillan.

Kitchen, R. (2003). Getting real about mathematics education reform in high-poverty communities. *For the Learning of Mathematics, 23*(3), 16-22.

Lerman, S. & Tsatsaroni, A. (1998). Why children fail and what mathematics education studies can do about it: The role of sociology. In P. Gates (Ed.) *Proceedings of the First International Conference on Mathematics, Education and Society (MEAS1)* (pp. 26-33). Centre for the Study of Mathematics Education, University of Nottingham.

Lerman, S. (2000). The social turn in mathematics education research. In J. Boaler (Ed.) *Multiple perspectives on mathematics teaching and learning* (pp. 19-44), Westport, CT: Ablex.

Lubienski, S. T. (2002). Research, reform, and equity in u.S. Mathematics education. *Mathematical Thinking and Learning, 4*(2&3), 103-125.

Morgan, C.; Tsatsaroni, A.; Lerman, S. (2002). Mathematics teachers' positions and practices in discourses of assessment. *British Journal of Sociology of Education, 23.3*, 445-461.

Sullivan, P., Mousley, J. & Zevenbergen, R. (2006). Teacher actions to maximize mathematics learning opportunities in heterogeneous classrooms. *International Journal of Science and Mathematics Education*. 4, 117-143.

Sullivan, P., Mousley, J., & Zevenbergen, R. (2006). Teacher actions to maximize mathematics learning opportunities in heterogenous classrooms. *International Journal of Science and Mathematics Education, 4*, 117-143.

Sztajn, P. (2003). Adapting reform ideas in different mathematics classrooms: Beliefs beyond mathematics. *Journal of Mathematics Teacher Education, 6*, 53-75.

Tsatsaroni, A., Lerman, S. & Xu, G. (2003). A sociological description of changes in the intellectual field of mathematics education research: Implications for the identities of academics. ERIC# ED482512.

Walshaw, M. (2004). *Mathematics Education within the Postmodern*. Information Age Publishing.

Watson, A. & Mason, J. (2005). *Mathematics as a Constructive Activity: Learners generating examples.* Mahwah, NJ: Lawrence Erlbaum.

White, D. Y. (2003). Promoting productive mathematical classroom discourse with diverse students. *Journal of Mathematical Behavior, 22*(1), 37-53.

Zevenbergen, R. (2005). The construction of a mathematical *habitus*: implications of ability grouping in the middle years. *Journal of Curriculum Studies 37*(5), 607-619.

Zevenbergen, R. & Lerman, S. (2006) Using ICTs to support numeracy learning across diverse settings. In P. Grootenboer, R. Zevenbergen & M. Chinnapan (Eds). *Proceedings of the 29th Annual Conference of the Mathematics Education Research Group of Australasia*. (pp. 591-598). Canberra: MERGA.