A Less Partial Vision: Using Multi-theoretic Research Designs to Study Mathematics and Science Classrooms

David Clarke

University of Melbourne

d.clarke@unimelb.edu.au

This presentation reports the use of multi-theoretic research designs to study mathematics and science classrooms. The key consideration is comparison of the interpretive accounts generated by the application of two or more theories to a common representational record of the same classroom events. The compatibility of these interpretive accounts is contingent on particular conditions governing the application of the theories in a particular setting for a particular purpose. Multi-theoretic research designs such as those described in this presentation may help us to understand both setting and theory, and thereby facilitate the reflexive refinement of both.

Researching Classrooms: Data Source and Data

Mathematics and science classrooms offer rich educational environments, providing recordable instances of language use, a variety of classroom organizational groupings, varied instructional practices (demonstration, lecture, whole class discussion, and collaborative group work, both experimental and reflective), the utilization of a variety of artefacts (both physical and conceptual), the potential for ontological, epistemological, ethical and moral tensions to emerge, and, arguably, a highly diverse range of learning outcomes. It is this richness and complexity that offers the opportunity for the interrogation of current theory and that also poses the greatest methodological challenges.

In the projects discussed in this paper, multi-camera on-site video technology and post-lesson video stimulated interviews were used in a purposefully inclusive research design to generate a complex data source amenable to parallel analyses from several complementary theoretical perspectives. Data were generated and analysed from this data source using a variety of theories. Such parallel analyses of data generated from a shared data source afford insight into both the research setting and the theories on which the analyses were predicated.

In 2001, the book *Perspectives on Practice and Meaning in Mathematics and Science Classrooms* reported ten parallel analyses, undertaken from different theoretical perspectives, of a common body of classroom data drawn from eight mathematics and science lessons (Clarke, 2001). An emergent pragmatism within the education research community has seen a growing acceptance of multi-theoretic

inclusive designs, at least in principle (Cobb, 2007). The interdependence of theory and research findings has been explored in several studies. For example, the work by Even and Schwarz (2003) compared the two theoretical perspectives: Cognitivist Theory and Activity Theory in their investigation of a mathematics lesson. Their study demonstrated that the two approaches suggested different interpretations of the situation and suggested different origins for the learning difficulties identified. In the context of science education, Tsaparlis (1997) demonstrated that the use of various analytical perspectives led to identical conclusions with respect to the difficulties that students encounter in learning structural concepts in Chemistry, but provided different explanations for students' understanding of the concepts.

This paper draws its examples from two current studies: The Learner's Perspective Study (LPS) of well-taught mathematics classrooms in 16 countries, and The Causal Connections in Science Classrooms (CCSC) study. In each of these two projects, the focus of the analyses was a data source containing video records of classroom and interview interactions, supplemented by digitised student and teacher materials. In the Learner's Perspective Study, a three-camera approach was employed (Teacher camera, Student camera, Whole Class camera), including onsite mixing of camera images into split-screen video records used to stimulate participant reconstructive accounts of classroom events in post-lesson student and teacher interviews (Clarke, 2006). The CCSC study used a four-camera adaptation of the LPS research design.

The multiple, synchronised recordings of classroom interaction maximize the sensitivity of the anticipated parallel analyses to a wide range of classroom actions and learning outcomes, and facilitate a form of reciprocal interrogation, where the theories are employed to generate and analyse the data and the comparison of the parallel analyses facilitates the reflexive interrogation of the theories.

We have an obligation as researchers to accept responsibility for the constructed nature of our data – and, of course, to document the process of data generation, identifying the points at which decisions were made regarding inclusion and exclusion. This is not always easy – particularly when the acts of exclusion are made for us by the technology, the method, or a theoretical frame that attends to some aspects of the setting and ignores others. Further, as the discourse of the classroom acts to position participants in ways that afford and constrain certain practices, so the discourse of educational research acts to position participants (on both sides of the video camera) in ways that afford and constrain certain interpretations.

Parallel Analyses: The Reciprocal Interrogation of Setting/s and Theory/ies

In the Learner's Perspective Study, the aim is to employ a variety of theoretical and analytical approaches to explore data generated from a common data source. This approach was intended to realize two very specific aims:

- Understand the setting/s: To maximize the sensitivity of the combined analyses to a wide range of classroom actions and learning outcomes, and
- Understand the theory/ies: Through the combination of theoretical perspectives, to identify what is attended to by each and what is excluded, and

to consider the extent to which the interpretive accounts generated by use of the various theories are complementary, mutually informing, or, perhaps, incompatible.

Compare these four parallel analyses undertaken as part of the Learner's Perspective Study:

Variation Theory (Häggström & Emanuelsson, 2010)

Analysis was made of "question episodes" in grade eight mathematics classrooms from four countries in the LPS video dataset. *Variation theory* and the concept of *Responsiveness* were combined to capture two different aspects of classroom instruction – the *pattern of variation* and the *pattern of interaction* – which are analyzed and compared in relation to teachers' opportunities to learn about the students' conceptions. The findings suggest that both the character of the tasks used, as well as the ways in which teachers ask questions, and perhaps even more importantly how follow-up questions are phrased and aligned to student responses, influence how the students' knowledge becomes visible in interaction.

Cognitive Reductionism in Interactional Analysis (Ohtani, 2010)

This study investigated how Japanese linguistic conventions are performed in classrooms in ways that may privilege certain participation structures in classroom practice. Japanese value implicit communication, requiring speaker and listener to supply the context without explicit utterances and cues. In Japanese discourse, agency or action are often hidden and left ambiguous. In English, when introducing a definition, the teacher might employ a do-verb: "We define". In Japanese classrooms, the teacher often introduces a definition in the intransitive sense as if it is beyond one's concern. Such differences in the location of agency, embedded in language use, constitute a different participation structure in classroom practice.

Conversation Analysis (Epistemic Stance) (Sahlström & Melander, 2010)

This analysis contributes to the growing body of work within Conversation Analysis (CA) on learning, knowing and remembering, by investigating the ways in which participants display their epistemic stance. A comparative analysis was undertaken of 15 lessons and post-lesson interviews in eighth-grade Mathematics classrooms in Sweden, USA and Australia. The results show an abundance of epistemic stance markers (such as "think", "know", "say") in both teacher and student talk. There are substantial possibilities in this approach. We can study changes in "participation" in a systematic, practical and concrete way, pursuing the analysis of learning in interaction on the basis of the evidence participants themselves offer as evidence for their ways of knowing.

Discursive Practice and Learning (Clarke & Xu, 2010)

Mathematics learning can be conceptualised in terms of the participation in forms of social practice, where discourses form key components of that practice. Classroom discourse is a form of social performance undertaken within affordances and constraints that can be both cultural and linguistic. If we conceptualize mathematics as a special form of communication, the term

> "learning mathematics" becomes tantamount to developing mathematical discourse (Sfard, 2008). Analysis of classroom practices in Shanghai, Seoul, Hong Kong, Tokyo, Singapore, Berlin, San Diego and Melbourne suggest that discursive practices are culturally-situated to a profound extent and that differences in these practices can be associated with distinctive learning outcomes. In particular, comparative analysis reveals the cultural specificity of conceptions of accomplished practice for both teachers and students.

Each of the researchers applied their own analytical perspective in order to select elements within the data source, thereby generating a distinct data set for each of the intended analyses. Each data set, so constructed, was then analysed using the same theoretical framework that guided the construction of the data set. In this respect, each analysis resembles any mono-theoretic research design in that the constructs privileged by the chosen theory were matched to data types and a research design constructed that employed methods suitable to the generation of the targeted data. Each independent analysis remained vulnerable to the same accusation of circularity or pre-determination that can be levelled at any mono-theoretic research design. Once available, however, the results of the parallel analyses can serve several purposes:

- By addressing different facets of the setting/s and thereby providing a richer, more complex, more multi-perspectival portrayal of actors and actions, situations and settings;
- By offering differently-situated explanations for documented phenomena and differently-situated answers to common research questions;
- By increasing the authority of claims, where findings in relation to the same question or the same phenomenon were coincident;
- By qualifying the nature of claims, where findings in relation to the same question or the same phenomenon were inconsistent or contradictory;
- By providing a critical perspective on the capacity of any particular theory to accommodate and/or explain particular phenomena, in comparison with other theories employed to conduct analyses related to the same events in the same setting.

The derivation of all findings from the same data source and the application of all analytical approaches (and therefore all findings) to the same setting/s (the mathematics classroom) greatly strengthens the project's capacity to realise these five purposes. In relation to the first of the two stated goals of multi-theoretic research design (above), all four analyses relate to the one data source generated through implementation in the classrooms of many different countries of a common research design, but they address different aspects of that data source.

In the case of the CCSC study, multiple analyses were conducted in relation to a single setting (an Australian Year 7 science classroom), but each analysis addressed different aspects of that setting. For example, analyses employing Distributed Cognition and Variation Theory suggested the lack of connection between macroscopic and microscopic domains as a source of student difficulty. Despite the identification from the perspectives of both Distributed Cognition and Variation Theory of the macroscopic-microscopic relationship as a source of student difficulty,

there were significant differences in the explanations provided by the two theoretical perspectives regarding the nature and the origins of this difficulty (Xu, 2009).

The use of parallel analyses informed by multiple theoretical frameworks offers a form of safeguard against the possibility that a single analytical framework might render the study insensitive to potentially salient considerations and significantly reduce its explanatory potential. It is not the compatibility of the theories that is being considered, but of the interpretive accounts generated by their application to a common representational record of the same classroom events. This compatibility is contingent on particular conditions governing the application of the theories in a particular setting for a particular purpose. Theoretically inclusive research designs help us to understand both setting and theory, and thereby facilitate the reflexive refinement of both.

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