The Mathematics Enhancement Project: Using the Concepts of Cultural Conflict, Critical Mathematics Education, and Didactic Contract

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This is the third report to MERGA of a project working with senior secondary mathematics in low socio-economic schools in Auckland, New Zealand. It is aimed at enhancing the achievement and participation of Year 12 & 13 mathematics students and promoting their transition into tertiary mathematical programmes. This paper focuses on three theoretical approaches used in the project, and describes the way that data is organised and analysed using them.

In 1999/2000 a project was designed to enhance the achievement and participation of senior mathematics students in low socio-economic schools. The resulting Mathematics Enhancement Project (MEP) is in a pilot phase in 2001 to 2003. The project has been reported twice at MERGA, most recently in Alangui, Autagavaia, Barton, Kensington-Miller, Lane, Paterson, Poleki, & Van Den Heuvel (2002). In the first of those papers the problems being addressed and issues arising in the project are discussed at length.

The project proposal is for a long-term approach to mathematical enhancement. It includes four components: teacher development, student support, community participation, and research. The community aspect is now regarded as a parallel project and is only just beginning in 2003. The project team is based in the Mathematics Education Unit in the Department of Mathematics at the University of Auckland. It includes both staff members and teacher/researchers on one-year Study Awards.

In its 2001 Pilot Phase the project focussed on student support. It is reported in detail in Alangui, Autagavaia, Barton, & Poleki (2001). In the 2002 Pilot Phase the main study focussed on teacher development, where four strategies of professional development were attempted, and their implementation and teacher reactions investigated (Kensington-Miller, 2003). Another study in this area is examining the use of high-level mathematics lectures and discussion as a means of involving senior secondary mathematics teachers in professional development. In addition, two smaller studies on student motivation and one on the cognitive quality of learning were made. Four schools, with a total of ten teachers, were involved. Six team members made regular school visits during the year. Some of the aspects of the 2002 Pilot Phase are reported in other MERGA papers at this conference.

The project is in a final year of the Pilot Phase in 2003. The focus is classroom organisation and planning for full implementation in 2004. The 2002 Pilot Phase identified systemic issues as of critical importance on several fronts. The investigations into the quality of learning, student motivation, and professional development are continuing through Masters and PhD studies.

This paper focuses on three theoretical approaches used in the project, and describes the way that data from the Pilot Phases is organised and analysed using them. This points the way to our future use of these frameworks in creating enhanced mathematics learning in the project schools. The several studies from which data is taken for use in this paper are all part of the MEP, but are written up separately. Details of their contexts, methods, and

results are available from the 2002 Report of the project (Barton, Kensington-Miller, Latu, Nathan, Paterson & Van Den Heuvel, 2003), available from the author.

Three Theoretical Frameworks

The overall theoretical basis is given in more detail in Alangui, et al., (2002) and Barton, Autagavaia, Poleki, and Alangui (2002). They describe the socio-political orientation, and the approach taken with respect to participating teachers. They also discussed the theoretical concepts of cultural conflict, and introduced the use of Skovsmose and Borda's (2000) Critical Mathematics Education theory.

The theoretical concepts associated with cultural conflict are being used within this project at the level of classroom activity. It is intended that Bishop's concept of cultural conflict (Bishop, 1994) be utilised for its positive potential. That is, mathematics learning environments and situations need to be examined, conflicts recognised and described, and then adapted into mathematics learning opportunities.

An example of this emerged from the 2001 Pilot Study in the work of Jessie Autagavaia (Alangui, et al., 2002, p. 5) with respect to language. She reported a conflict in the classroom where teachers perceived most of their students as having language problems, the students did not acknowledge this, and the classroom communication suffered as a result. The conflict was investigated and described in more detail, where it emerged that the mono-lingual English-speaking teacher perceived only one channel of communication (over 90% of the time students were linguistically passive), but the students were mostly bi- or tri-lingual (80% bi-lingual, of whom half were trilingual) and hence language-rich rather than language-poor, although their English literacy was not very high (over 60% of students had difficulties explaining in English the meaning of common mathematical symbols). The learning opportunity created from this situation both made use of the multi-lingual talents of the student by establishing opportunities to use their most fluent languages during mathematics learning, and also set up situations that supported the improvement of English-language communication in mathematics.

Over the last year, we have become aware of further theoretical work in the area of cultural conflict by Alrø, Skovsmose, Valero, and Vithal. Both Vithal and Valero have completed PhD theses focussing on situations of conflict, although they deal with more macro-environments than our use of the concept (Valero, 2003; Vithal, 2000). They have also cooperated in a recent work (Vithal & Valero, in print). Skovsmose has reintroduced the idea of foreground and background when considering children's situations in the mathematics classroom (Skovsmose, 2002). Alrø, Skovsmose, and Valero (2003) are initiating a major project in the increasingly multicultural secondary schools in Denmark that intends to illuminate the classroom situation from communicative and socio-political perspectives, and that uses all these theoretical tools. The concept of foreground and background appears to be particularly useful for the MEP situation. Skovsmose describes the foreground as follows (Skovsmose, 2002, Abstract):

> By the "foreground" of a person I understand the opportunities, which the social, political and cultural situation provides for the person. However, not the opportunities as they might exist in any "objective" form, but the opportunities as a person actually perceives them. I see the foreground as an important element in understanding students' learning-actions. When a society has stolen the future of some group of students, then it has also stolen the incitements for learning.

He goes on to state that the most important sources of "stolen futures" are the socio-political processes of globalisation. He critiques the use of a student's background as a critical factor in mathematics education, claiming the more immediate effect of

foreground, or the way the student perceives his/her situation and opportunities. His main criticism is that a focus on the background "is a strategy by means of which the political nature of learning obstacles can be eliminated" (Skovsmose, 2002, p. 9). He also points out that a student's foreground may be different from cultural norms: "I do not see any contradictions in assuming, for example, that working with computers and playing with dynamic geometry can be meaningful when we have to do with marginalised students living close to the Fourth World" (Skovsmose, 2002, p. 15).

In the MEP there is an opportunity to interpret classroom conflict situations in terms of background and foreground, and to focus mathematics learning on the foreground. The benefit of such an approach is that the foreground is likely to be more amenable to change. Take the language conflict cited above. Another way of expressing this conflict is by noting that the foreground of the students included a perception of mathematics as monolingual English and hence they felt inevitably disadvantaged and less likely to succeed. The strategies adopted can be interpreted as empowering the students to see themselves as linguistically rich, and hence with extra mathematics learning resources rather than fewer. This was done both by putting them into mathematical situations in which they were more powerful (linguistically) than the mathematics teacher, and also by addressing directly those areas in which they perceived disadvantage.

As another example of the use of this concept in the 2002 Pilot Phase, a study by Arnold Van Den Heuvel on motivation revealed that there was poor attendance and low completion-rates of assigned work. The inevitable conflict between the teacher's curricular aims for the class (with the resultant negative interactions with students), and student's perception of themselves as working as best they could, was very evident. The perception was that students had very low general motivation to do school mathematics. The study set up weekly tutorials during lunchtimes and put in place a system of rewards and consequences for attendance and extra assignment completion. The nine students involved had eight tutorials. Only three absences occurred of students who were at school (a tutorial attendance rate of 95%), although 15 school absences occurred. There was only two-thirds completion of the assignments in Tutorials 1 and 2, but by Tutorial 6 this increased to 100% and remained at that level. Only once for one student did a consequence of no assignment completed get incurred. This was not evidence of low motivation. Further investigation of the student reactions to the various motivations was revealing. There was widespread and strong extrinsic mathematical motivation, that is, motivation to do well in national examinations. In terms of the theoretical constructs, the foregrounds of the students were not at all what had been inferred: they were strongly motivated and, what is more, expected to (just) pass the final year national examinations. The study revealed that most students responded to a regular and stable learning environment in which teacher encouragement was high. The issue of school absences was not related to mathematics.

Critical Mathematics Education

The theoretical concepts associated with Critical Mathematics Education are being used within this project at the level of overall research design. It was noted in earlier papers (Alangui, et al., 2002; Barton, et al., 2002) that this study is a complex of development and research initiatives, and there are methodological problems associated with this structure. Those papers described the work of Skovsmose and Borba (2000), and showed how it may be adapted to provide a way of thinking about the project as a whole.

Figure 1 is a diagrammatic reminder of those descriptions. Their triad of research situations and the relationships between them—of which they regard Critical Reasoning as the most crucial—are repeated and laid on one trajectory to represent the different research and development projects that make up the whole MEP. An area of improvement is defined around this set of triads to represent the idea that we want the development as a whole to be evaluated and maintained within recognised positive change.

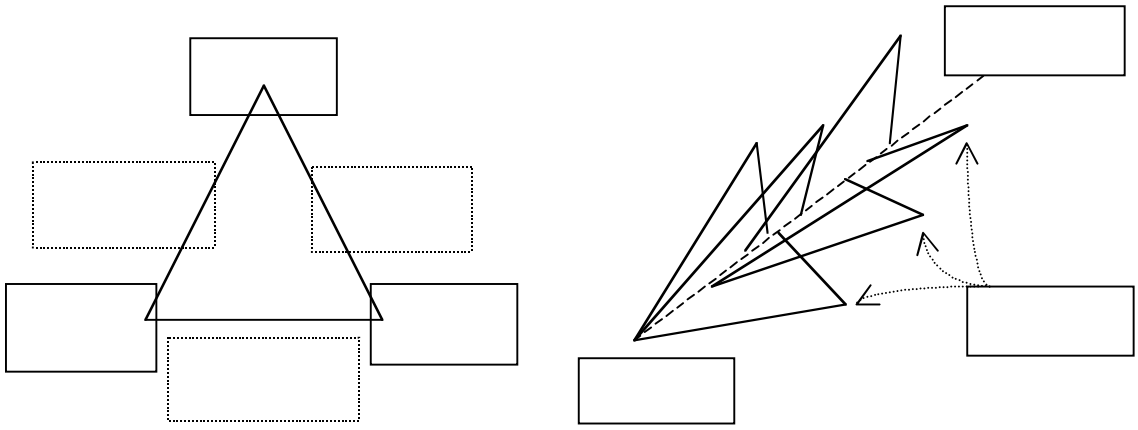

Figure 1. Skovsmose & Borba's triangular model and its adaptation.

An example of the use of this triad of Current, Arranged, and Imagined Situations is the professional development study undertaken in 2002 (Kensington-Miller, 2003). In the early stages of the design of this study, the teachers involved in this project were asked about the kinds of teacher development they wanted, and, early in the study, they were asked about their preferences and opinions on several professional development strategies. The most desired strategies were mutual peer visiting and organised meetings. This data represented the *Current Situation* for the study.

The three researchers then set about designing activities to be used during the year, based on their experience and the professional development literature. This process of *Pedagogical Imagination* was epitomised by one idea that was discussed at length. This was the idea that these senior mathematics teachers could be re-enthused in their profession by building on their fundamental interest in, and love of, their subject: mathematics. It was theorised that participation in a lecture by a mathematician about a new area of research mathematics would lead to a discussion of the mathematics, and that this may be able to be directed into discussions of their own learning and then into consideration of their students' learning. Several such discussions led to the researchers designing a set of professional development strategies that they felt would be successful (*Imagined Situation*).

The study then ran into considerable problems. It quickly transpired that the implementation of the four designed strategies was going to be difficult due to the lack of participation by the teachers. Teachers did not get around to making arrangements for peer visiting despite relief being available and each others' phone and email contacts being circulated; meetings were characterised by last minute withdrawals; teachers expected visiting mentors to take over their classes and demonstrate "perfect" teaching; and summary research digests were unread or unremembered. The *Practical Implementation* certainly headed in a direction different from the Imagined Situation! The lack of success in implementation despite the enthusiastic agreement and meeting of teachers' preferences in the design of strategies meant that the study changed from a comparison of the strategies

to an analysis of the implementation. The professional development strategies did go ahead eventually in some form or another. Several peer visits took place when the researchers took over responsibility for all aspects of organisation; two meetings took place, including two (very successful) mathematics lectures; mentoring continued (with some demonstration lessons); and two research summaries were circulated (*Arranged Situation*).

The analysis of the implementation of the professional development strategies (*Critical Reasoning*) became the main focus of the Masters thesis of the main researcher (Kensington-Miller, 2003). Post implementation questionnaires and interviews revealed that the teachers remained enthusiastic about professional development and wanted more—in apparent contradiction of their actions. Closer analysis revealed that the problems were systemic rather than personal, that is, they resulted from the school environment of the teachers rather than from actions that were under their individual control. This has contributed to the design of future professional development.

The *Cone of Improvement* is represented by the data we now hold on the participation and perceived effectiveness of the strategies that were implemented, moderated by the analysis of the literature on teacher development undertaken during the study.

It was noted in Alangui et al. (2002, p. 3) that, in a development and research project, researchers have difficulty standing back sufficiently from their work since they are also involved as participants or stake-holders in developments they have designed. It can be seen above that the use of the Skovsmose and Borba triad enables this situation to be overcome by explicitly requiring critical analysis of the distance between the Imagined and Arranged Situations.

A second example of the use of this theoretical framework to describe research activity can be seen in the end of year meeting of MEP teachers. They were asked to describe those features of the *Current Situation* that they regard as most getting in the way of them doing the kind of teaching they want to do, or of students learning effectively. This is to become the basis of the planning (*Pedagogical Imagination*) of Pilot Year 3 this year.

The unanimously agreed, and vociferously voiced, feature was the way in which students were called upon to do things that took them out of class. Sport, choir, culture groups, prefect/School Council/leadership duties, family commitments, and church were all mentioned. Particularly important were week-long school trips that fundamentally interrupted the progress of mathematics learning. It was noted that these commitments called on the same students, who were often the best Yr 13 students academically.

A second major feature was the poor English of a large group of students. Third, with respect to the teachers themselves, the factor of available time was dominant. They also mentioned lack of resources; inappropriate national curriculum design; students' employment commitments; poor generic study skills; student movement between schools; school changes such as a new principal; and teacher and student morale. They did not mention the classroom or school physical learning environment. These teachers' perceptions of the Current Situation will be the building block for our planning in 2003/4.

The linking of the multiple facets of the MEP within a Critical Mathematics Education framework has proven useful in overcoming anticipated problems of this project. It is expected that the model will be developed as the project moves into full implementation.

Didactic Contract

During 2002 the MEP was fortunate to receive a visit from Prof. Colette Laborde who became interested in the theoretical issues within the project and also involved herself in some classroom activity. She observed the difficulty within the mentoring aspect of the

project of communication between teachers and mentors about what was going on in the classroom. There seemed to be misunderstandings between these groups about what could happen during the regular classroom visits of the mentors, what was useful for mentors and teachers to focus on and to talk about, and how research could be undertaken in such situations. A particular aspect of this relationship was the concern of mentors that they would be seen as judgemental of the teacher, and the fear of teachers that this was indeed happening. Prof. Laborde suggested that the project could adopt the idea of Didactic Contract from the writing of Brousseau (1997).

Brousseau's theory of situations is based on the idea that "a concept will never develop if the subject never has a need for it" (Sierpinska & Lerman, 1996, p. 860). That is, learning occurs when it is too difficult, or too much effort, for a student to adapt to the situation confronting them with existing knowledge. The teacher, therefore, has the task of organising situations for the concepts to be taught so that the new concept becomes the best and easiest cognitive path to follow. Within the theory of situations, an important concept is that of didactic contract. This is the (usually unspoken and mostly implicit) set of reciprocal agreements and expectations between the teacher and the student about what is happening in the classroom: its aims; its methods; its behaviours; its content; and the criteria for success. Each of these implies certain assumptions about mathematical knowledge. The power in the idea is that there exists such a contract and that it is often very different from the espoused descriptions of what is happening in a classroom and of the nature of mathematical knowledge. Margolinas (1995) develops this concept, further discussing a series of layered knowledge-games each within its own situation that are played out by teachers and students: the 'onion model'.

An example of research based on this idea can be found in Perrin-Glorian (1999), who interviewed and observed five teachers at senior secondary level. These data were used initially to reconstruct some didactic situations, and then the didactic contracts were analysed by asking questions such as: How does the student know whether they are right or wrong? What are the teachers' 'rules'? Does the teacher change the situation? The discourse was also analysed to identify the relationships within the lesson between previous work, the students' own work, text exercises, and so on. The results of analysis were categorised as institutional constraints, regularities, and differences. The outcome was a rich and organised description of teaching/learning activity.

Critiques of the model also exist, for example Mercier, Sensevy, & Schubauer-Leoni (1999) point out that didactic contracts refers to a class as a whole, and do little to help us understand the actions of individuals—nor do they explain how such a contract is individually agreed. They draw on research to reinforce this point.

Within the MEP the idea of didactic contract was seen to hold potential for the discussions between teachers and mentors/researchers because it would both focus attention on the classroom situation rather than upon the behaviour or ability of the teacher, and it would also set up a series of questions about what was going on, its learning effect, and what changes could be made.

As a start to trying to use this idea with teachers, the concept was discussed during the final teacher meeting of 2002, and a short time was spent listening to the teachers put forward what they felt were key elements of their "agreement" with students. This data should be regarded as the rough outer layer of the 'onion'. For example, with respect to homework, teachers described the contract as one in which the mutual expectation on the student to do the work set varied from optional, to one where students would make an attempt but stop when it got difficult, to a situation in which it was necessary for teachers

to "stand over" the students to get work done. On the teachers' side, it was generally agreed that any work done would be marked.

The classroom behaviour contract was described in comparison to that for students:

- Punctuality is permitted to be more lax (both for students and for teachers);
- Behavioural standards (for example, calling out, playing around) are agreed to be higher;
- Students help each other more often, more productively, and without being asked;
- Attention spans, tasks, and work periods are longer;
- Teachers have work on the board and students begin it on entering the class without being directed to do so;
- Students expect greater expertise and mathematical confidence from the teachers.

These descriptions provide a basis for the planning of future classroom activities and research involving both teachers and researchers. On the evidence of this one meeting, the aim of promoting judgement-free discussions of classroom situations is being met, and the idea of didactic contract will continue to be used.

Conclusion

The Mathematics Enhancement Project is a long-term attempt to significantly improve senior mathematics education in schools in low socio-economic areas. It is an assumption of the project that there is no single, or easy answer to the problems that exist in these classrooms. The consequence of this is that many initiatives and studies need to be brought together over a period of years. The key to such an integration is a coherent and consistent theoretical approach that enables links to be made between studies, and generates a complete picture of the project.

A danger of adopting a particular framework is that its epistemology and assumptions limit what happens, and the MEP is concerned to maintain an open mind on several such issues, particularly as it is working in a culturally and politically sensitive area. However it must move forward. The concepts of Cultural Conflict and Critical Mathematics Education theory have politically radical roots, and Brousseau's work is close to a constructivist perspective. To some extent these overtones exist in the current work of the MEP.

However, the adaptation of these frameworks for the specific situations faced within the project means that researchers are not limited by these approaches. This paper is an illustration of the way the theoretical constructs are being used—and it is through use that they become adapted and reformed to our particular context. Thus the MEP is developing its own framework by building on the work of others. We know that there are other situations similar to ours, and put forward our movement towards theoretical coherence for possible use in those projects.

We look forward to continuing this theoretical development as much as we anticipate classroom initiatives and empirical research. We are especially pleased to welcome to the project some of the international theorists in these areas over the next year so that they can contribute their insights and experience.

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