

# The Mathematics Enhancement Project: The Pilot Phase

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This is the second 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 outlines the theoretical basis for the project, and describes the 2001 and 2002 Pilot Studies.

In 1999/2000 a project was designed to enhance the achievement and participation of senior secondary mathematics students in low socio-economic schools (Barton & Graham, 2000). The resulting Mathematics Enhancement Project (MEP) is in a pilot phase in 2001 and 2002. The Scoping Study, design of the project, and preliminary results from 2001 were reported in Alangui, Autagavaia, Barton & Poleki (2001). The overall theoretical basis is given in more detail in Barton, Autagavaia, Poleki, Alangui (2002).

The project proposal was for a comprehensive, 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 not reported here. 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. The team worked with three classes in each of two schools: the Yr 13 Mathematics with Calculus class, the Yr 13 Mathematics with Statistics class, and one Yr 12 Mathematics class. All classes had 15-20 students. Two teachers were involved from each school. The three team members each attached themselves to two similar classes – one from each school – visiting for one period per week during most of the year. Each researcher conducted a study at the same time as they helped students and contributed to teaching activities. The studies focussed on language issues, mathematical background, graphics calculators, and indigenous issues. The overall research question, however, was the ‘pilot’ question of whether this model of research and development was practical and likely to lead to successful outcomes.

In the 2002 Pilot Phase the main studies will focus on teacher development. In addition base-line descriptions of students and teachers, and two smaller studies on student motivation are being made. Two schools have been added, with a total of ten teachers now involved. Five team members will make regular visits during the year.

## A Critical Theoretical Approach

The research associated with this project has three distinctive characteristics. One of these, the politico-cultural dimension, is the subject of considerable literature within mathematics education, particularly in Australasia (see, for example, Atweh & Forgasz, 2001). The other two do not have such established theory, and thus provide interesting

arenas for investigation. We welcome ideas and critiques of our approaches.

### *Political Considerations*

Projects in low socio-economic or particular ethnic communities face issues of power, positioning and politics. On one level these issues are cast aside: a teacher faced with a mathematical query from a student rarely pauses to consider ethnic relationships or socio-economic background. At another level a teacher operates within a set of behaviours, values and attitudes with respect to particular ethnic and socio-economic contexts. This project does not seek to politicise classroom interactions, but to bring about an awareness of ethnic and socio-economic aspects of the habitual behaviour of students, teachers, researchers, the school, and the community alike. The underlying assumption is that awareness will lead to critical reflection, and any changes will be made by individuals themselves.

Issues of power, positioning, and politics also exist in the philosophical approach to the project, its documents, its aims, its methods, and its recommendations. We expect that our responses will evolve throughout the project. The most important of these issues is the positioning of Maori and Pacific Island students, or students from low socio-economic backgrounds, as “the problem”. Data showing under-achievement of these groups exists (e.g., Te Puni Kokiri, 2000), but the causes are widely debated. The creation of an under-achieving category immediately sets up expectations that make the statistics self-fulfilling. Zevenbergen (2001) places responsibility for under-achievement on the structural hegemony of educational institutions and their defining documents. In addition there is research which describes (Pacific Island) cultural characteristics which impact on school learning (Mara, Foliaki & Coxon, 1994; Pasikale, 1999; Silipa, 1999), including specific features which are likely to impact negatively on school mathematics (Manu’atu, 2000). Pasikale (1996) reminds us that the cause is not deficiency, but mismatch:

Success in learning is intricately linked to concepts of self-image and social image. Educational success for Pacific Islanders can only be assured if the cultural assets learners bring to the learning environment are not negated by the goals and practices of educational institutions. (p. ix)

This project turns Bishop’s concept of cultural conflict (Bishop, 1994) into a positive stimulus. This involves the steps: recognition, adaptation, and creation of opportunity. These steps need to take place on the community level as well as in the classroom.

Another major issue is the political basis of assessment. Senior mathematics is measured through a national examination. The usefulness and appropriateness of such a measure has long been questioned, but other methods fail to get recognition for vocational purposes or further education. “Whose knowledge?” and “Who sets the gates?” are important questions. The gate-keeping consequences for the participants in this project need to be addressed. Furthermore national examinations measure short-term learning, whereas this project is concerned with long-term participation and achievement.

A third issue concerns teachers. This project regards teachers as professionals (not service providers). Our model of teacher development includes: building on the good from the past; gradual implementation tailored to the resources available; and depends on the active, voluntary participation of those involved. It is theory and research driven and assumes that there is no ‘ideal’ situation which can be implemented in isolation.

*Using Critical Theory*

Two uncommon aspects of this project are the linking of research and development, and the clustering of diverse research studies. When research and development go together the researchers become familiar with the classroom and the progress of the students. However, they have an investment in the effects of their research and hence objectivity in evaluation becomes problematic. A project of many studies must integrate several factors which are not simply additive, but interrelate in complex ways. Practically there needs to be focus on individual aspects, analytically there needs to be a holistic approach.

A framework has been adapted from the theory of Skovsmose and Borba (2000). Their triad of Current Situation, Imagined Situation and Arranged Situation can be enlarged from a single research study to a project of many studies taking place alongside development.

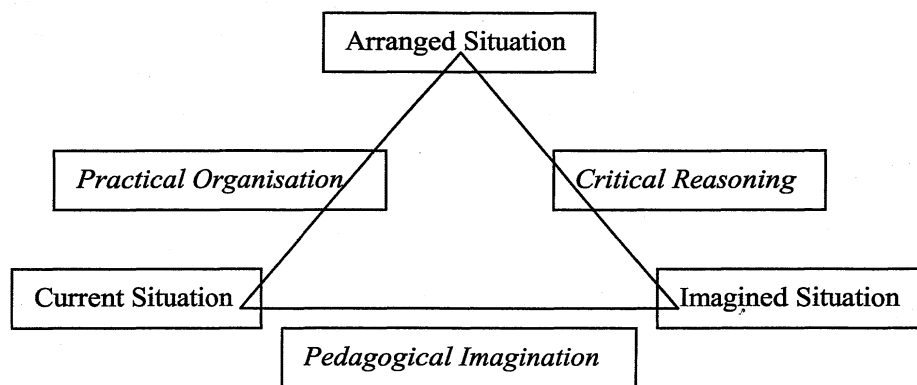


Figure 1. Triangular model of research in the classroom (adapted from Skovsmose & Borba, 2000, p. 12).

Skovsmose and Borba conceive development as the trajectories followed by each of the vertices of this triangle as it is repeated. To use this for a multi-faceted project, the triangle is conceived in three dimensions. Thus the Arranged Situation becomes the reality of what happens in the classroom as a result of all project activities. The reality of the classroom situation is the result of several Imagined Situations. Thus the vertices Current Situation and Arranged Situation should be taken to be a single trajectory (see Figure 2).

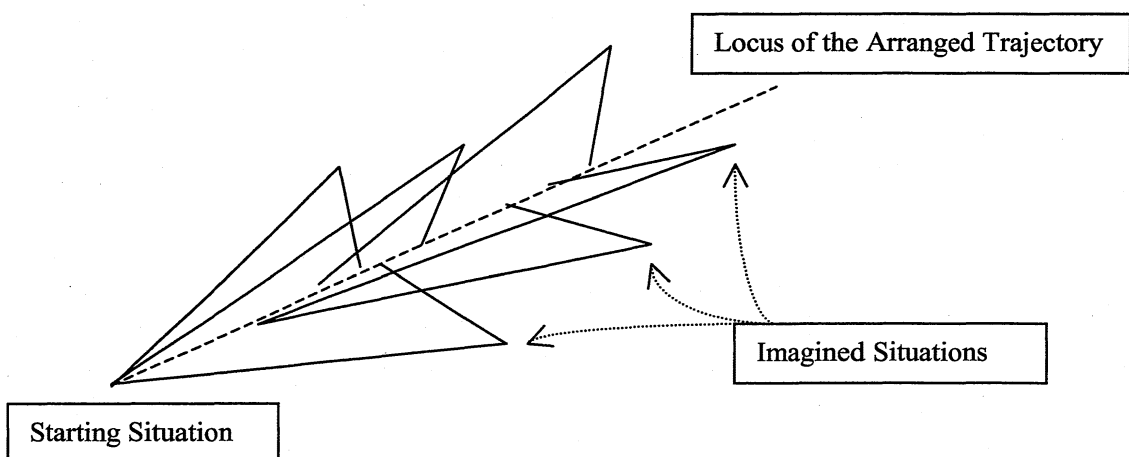


Figure 2. Model for a research & development project.

To this model we have added an evaluative component. The locus of the Arranged

Trajectory is not controlled by any one research study nor by any developmental initiative, but must be evaluated as a whole. The final adaptation of this model then, is that it must take place within a Cone of Improvement. It is hoped that this construct will initiate discussion on what dimensions might be suitable as defining characteristics of this cone.

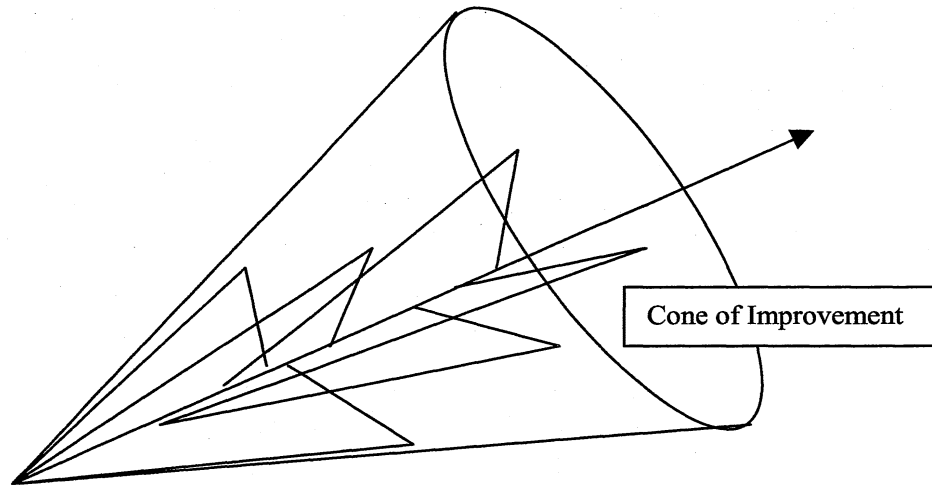


Figure 3. Evaluating the tTrajectory.

### The Pilot Process 2001

The prime questions of a pilot process are whether the project is worthwhile, practical and likely to be successful. The pilot has given an affirmative answer to these questions, with a few qualifications, and guidance as to how to continue.

#### *Pilot Questions*

The 2001 pilot confirmed that there is an issue to be addressed. There was no evidence that the problem had been overestimated in the Scoping Study. Two of the team were teachers and they reported that the organisation and quantity of mathematical work done in class was significantly below their experience. Although this pilot focussed on student learning, the team remained convinced that teacher professional development was likely to be the most important factor in initiating change in student achievement and participation, and noted that teachers were under more than normal stress. Testing this conviction has become the focus of the second pilot year. Thus the conclusions of the Scoping Study remain unchanged, and the project remains worthwhile.

Is it practicable? The model of using teacher-researchers on one-year study awards revealed some drawbacks and some unexpected positive spin-offs. The overall plan of conducting research in a classroom during regular visits, at the same time assisting with teaching and student support, proved both workable and satisfying. The budget proved realistic, and progress was made on an instrument to observe student learning in the classroom within the parameters of these visits. Treating students as successful mathematics students (having made it to Yrs 12 & 13) having further potential for success in mathematics was well-received. On the negative side, the lead-in time required for teachers inexperienced in classroom research was not properly anticipated, and future projects will be redesigned so that they are better supported as researchers early on in the

process. It was also harder than anticipated to maintain team meetings when everybody had significant other studies, teaching or research as well as MEP work. An unexpected outcome was the notable growth in the interest and research abilities of the teacher-researchers, and hence their potential to be used in future stages of the project.

Is it likely to be successful? Each of the studies below demonstrated that a difference can be made relatively easily. We are confident this conclusion will extend to other areas.

### *Factor Study 1: Language Issues*

(It will be assumed that the reader is familiar with Alangui et al. (2001) from MERGA 2001 which details the aims and processes of each study. We note that the four studies in this pilot are on-going, so we remain tentative with respect to their conclusions.)

The study aimed to describe the language environment in the classroom and develop strategies to use available language skills and overcome language difficulties.

The overwhelming features of the observation phase were the richness of the students' language, and the paucity of the classroom language environment. Over 80% of students are bilingual, with more than half of those able to understand at least three languages. Nevertheless only English was acknowledged in the classroom. Nearly 90% of student time was linguistically passive. Over 60% of students had difficulties explaining in English the meaning of common mathematical symbols. Some classrooms display little mathematical language, and the seating organisation does not promote communication. Another observation was that problems are as much a matter of language confidence and speaking conventions as they are of English language ability.

Two main interventions were undertaken with the aim of creating opportunities for students to express themselves mathematically: situations for group and class mathematical discussions were created; and journal writing was instituted.

Students responded to language-use situations well, both participating in group discussions and being willing to give explanations to the whole class. Group work in particular was liked and valued by students. Students found journal writing to be a difficult mode, only half reporting it favourably, however, with teacher guidance, it became productive both mathematically and as way to communicate about the classroom. Further research needs to be done to evaluate the gains against the time consumed.

### *Factor Study 2: Mathematical Background*

The study aimed to describe the students' mathematical background and investigate strategies for using the knowledge they have and improving areas of need.

A recording mechanism was developed that allowed individual student and whole class profiles to be made. It was found difficult to do this comprehensively within the class time available to the researcher. The mathematical background of most students was adequate in the basic areas of number and algebraic manipulation, but poor in concepts such as Normal Distribution which should be understood at this level. What was known was of an isolated nature, requiring extensive prompting to retrieve. There were few connecting links between what was known, and most students experienced difficulties handling unfamiliar problems.

Three strategies were attempted to enhance background knowledge: the use of worksheets; explicit teacher instruction; and homework revision and testing. The worksheet intervention was not successful, possibly due to practical and affective causes rather than cognitive ones. Students failed to complete the worksheets and feedback

opportunities were restricted. The explicit teacher instruction during class time was successful as measured in post-tests. This was attributed to the very narrow domain targeted in the intervention. Whether this is practical in terms of class time for all areas needing attention, is still an open question. The revision and testing strategy targeted the problem of links between mathematical concepts, and no significant change was measured. Considerable difficulty was experienced in knowing how to approach this area, however, as it is regarded as crucial in the literature and was identified as a need with these students, it must be researched further. Overall students were positive about the interventions, the preferred mode being short tests, liked for their motivational effect and indication of progress.

Overall conclusions included the general finding that, in these classes, controlled in-class interventions are liable to be more successful than out-of-class activities needing independent student work. It was noted that the measuring instruments were probably inadequate and needed more work in future research.

### *Factor Study 3: Graphics Calculator Technology*

Texas Instruments TI-83s were made available to the Year 13 students and this study investigated the resulting community of practice.

Unsurprisingly, most students embraced the technology, and developed a better knowledge of it than their teachers, using features not mentioned in the mathematics classroom. The calculators quickly became part of their classroom lives, over 60% having them on their desks routinely, and virtually all students having them available every lesson. They discuss their use, and challenge each other with new uses. Only one student had any previous experience, but 75% of students used them in classes other than mathematics. This has happened despite the fact that teacher use is minimal. Over the year students developed from instrumental attitudes towards the calculators to an appreciation of their transforming capabilities. A large majority attributed improved performance to their use.

### *Factor Study 4: Indigenous Students*

The aims of this study were to describe issues to do with indigenous people through the eyes of the Maori students in the study. There were five such students who were interviewed about their views on: the relevance of mathematics to Maori; stereotyping; choice of school; language; their mathematics learning experiences and self-assessment; their expectations and aspirations; and their reflections on multi-ethnic classrooms.

These students were interested in mathematics and felt at home at these schools. They had so far enjoyed mathematics but were finding it difficult this year. They felt high expectations upon them, but most of them still believed in their ability to succeed. They particularly appreciated one-on-one learning opportunities, and teachers who made them work hard. They found the multi-ethnic classroom a learning experience, and expressed apprehension about being treated differently because they were Maori.

## The Pilot Process 2002

Some of this year's activities will be reported in more depth at the July conference.

The focus of this year's pilot is to understand more about teacher development in the project schools. We plan to trial five professional development strategies, and to initiate a sixth in more depth, however the main aim is to understand more about the parameters of

professional development in the environment exhibited in these schools. There are four objectives for the year in the area of teacher development.

The first is to report on the existing state of teachers' well-being and attitudes, and the factors in these schools environments which impinge upon their teaching. It will involve teacher questionnaires and interviews, both of which will use classroom observations as stimuli for some questions. The teachers will participate as researchers and subjects.

The second objective is to establish a monitoring process to measure change. It will use the base-line data from the first, and will develop of instruments to measure classroom variables, in particular the three criteria that have always been part of the project proposal: on-task time, mathematical quality of tasks, and classroom relationships.

The third objective is to evaluate teacher development strategies. It will compare five strategies with consideration for the particular situation of these teachers and the extensive literature on mathematics professional development. They are: organising teachers' meetings on mathematics education issues; organising mutual peer observations and reflection; mentoring teachers in their own classroom; supporting teachers doing action research; and providing readable digests of mathematics education research literature.

The strategies will be evaluated with: pre- and post-interviews and questionnaires; teacher reports of classroom behaviour changes attributed to these initiatives; teacher attitude changes as measured by standard instruments; observed classroom learning behaviour changes attributable to these initiatives; and analysis with respect to theories and other research reported in the literature.

The final objective is to begin to investigate in depth the use of mathematics itself as a stimulus in teacher professional development. This particular strategy is indicated in the literature, and by our experience, to be particularly effective as a means to initiate professional development amongst teachers who have little time or motivation. It is hypothesised that teachers' own learning of mathematics will be effective in engaging them in discussion of learning and teaching, and thereby in reflecting on their classes. There is evidence that mathematics teachers in particular are deeply motivated by their subject matter. Two Saturday workshops will be mounted and evaluated, one focussing on an advanced mathematical topic, the other on extensions of a Yr 13 mathematical topic.

A second theme for the 2002 pilot is student motivation. Two studies will be mounted, one aimed at researching a strategy to increase classroom motivation, and one aimed at investigating the underlying causes of the phenomenon of mathematical "turn-off".

In the context of final year national assessments, finding the time and appropriate resources for classroom interventions to motivate students to study and to continue mathematical studies is always difficult. One researcher will initiate a motivational programme with one class. This will be evaluated by: gathering student responses through questionnaires; observing student reactions in the classroom; and gathering teacher responses through interviews. As well as evaluating this programme, we expect to draw general conclusions about the potential for increasing these students' motivation.

A second study will investigate the phenomenon of students who have shown early promise in mathematics and who have suddenly abandoned all effort in the subject. It will coordinate recent research on Pacific Island and Maori students with mathematics at Yrs 12 and 13. Students who have not fulfilled their potential in mathematics will be identified by comparing results from national examinations in Yr 11 and Yr 13, and will be interviewed. We hope to comment on relationships or discrepancies between these two sources of data.

Also this year we aim to develop the theoretical base. We expect to work with Ole

Skovsmose and colleagues in Denmark to develop the model described above. In addition, further theoretical work needs to be done in collaboration with others working in the area of Pacific Island and Maori perspectives.

## Conclusion

The Mathematics Enhancement Project is aimed at developing a model intervention for implementation in low decile schools at reasonable cost. The Pilot programme presently underway has already given us good information about the planned project, and some information as a result of particular studies. The present focus on teacher development does not imply a change in our view that development is multi-faceted. We seek critiques and comment from other researchers.

## Acknowledgment

The project reported in this paper has been made possible thanks to the generous support of Texas Instruments and research funding from the Woolf Fisher Research Centre.

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