MATHEMATICS THROUGH/FOR UNDERSTANDING SOCIAL LIFE: PRODUCTIVE PEDAGOGIES MEETS CRITICAL MATHEMATICS[1]

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This paper discusses how the involvement of young people in "real" research activities can be an effective pedagogy for learning for mathematics as well other life skills. However, such collaboration with young people presents dilemmas to their teachers. The concepts of productive pedagogy developed by one school reform movement in Australia are used to reflect on the SARUA project that works for students from underrepresented backgrounds in higher education.

In many countries, mathematics enjoys a special role in school curricula and is seen by many teachers and parents as particularly important for the education of their children. In many curriculum documents, mathematics is seen as essential for the economic well-being of the nation based on its contribution to science and technology. Students often grow to believe that studying mathematics is important for their future lives and that it opens the door to better jobs. However, many students fail to see any relevance of the specific content studied. In spite of being seen as highly important, and probably partly because of it, mathematics is the cause of considerable levels of anxiety for many students who struggle to make sense of it and for many school teachers who have to teach it. Further, as many international comparative studies such as TIMSS and PISA have demonstrated, mathematics achievement and participation remain inaccessible to students based on their gender, cultural and ethnic background, and country of origin.

During the past 50 years, there have been many reforms in mathematics education as well as an escalating body of research on its teaching and learning. Atweh (2004) commented that the effect of research and reform programs in changing actual school practice is still open to debate. Perhaps, the limitation of research and reform to affect classroom practice can be attributed to three causes. First, the gaps amongst research, classroom practice and policy – gaps in time (generate knowledge now and apply it later), in personnel (demarcation between academics, bureaucrats and teachers) and in dissemination (academic vs. teacher journals and conferences) – limit the interaction between these three areas in the discipline. Second, some educational reforms may lead to a demoralising and disempowering of teachers (Hargreaves & Evans, 1997) and may be seen by teachers as external demands on them, hence they are resisted (Sprinthall, Reiman and Thies-Sprinthall, 1996). Third, in a book with the provocative title of "The Predictable Failure of Educational Reform" (Seymore 1990 cited in Hargreaves, 1994), the author identifies the piecemeal approach that many of these reforms take as contributing to their failure; e.g., separate agendas for reforms for the curriculum, assessment, teacher professional development, school structures

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and organisations, and so on. The first aim of this paper is to discuss one reform in Australia that avoids some of the pitfalls of earlier reforms affecting mathematics education pointed to in the above comments. One corner stone of this reform is what is called "the New Basics" including the Productive Pedagogies.

Here we argue that reforms in schools should also include young people themselves who have been referred to as "the missing voice" in educational research (Cook-Sather, 2002, p. 5). In the fast-changing climate of the early twenty-first century, Cook-Sather said, "students must be included among those with the authority to participate both in the critique and in the reform of education" (p. 3). There are a few instances of projects involving students as key participants and researchers in educational reform processes, particularly in the United Kingdom (Cook-Sather, 2002; Fielding, 2001; Kirshner Thomas, 2000). Kirshner and O'Donoghue (2001) noted, "while great advances have been made in theorizing researcher-practitioner partnerships, research collaborations with youth remain under-theorized and under-utilized" (p. 4). Using late modernity theorisation according to writers such as Habermas and Kemmis, and other writers within the action research literature, Bland and Atweh (2004) theorised the concept of young people as researchers. They discussed potential benefits and limitations of such involvement and identified some issues that need to be considered in planning and reflecting on collaboration with young people as researchers, such as voice, i.e., insider/outsider, expert/novice, and the question of empowerment. The second aim of this paper is to briefly discuss one such project where high school students from underrepresented backgrounds in higher education have been involved in action research studies that led to the development of mathematics knowledge in a real world context. Finally, this paper attempts to demonstrate how students' research can parallel the principles of Productive Pedagogies elaborated in the Australian reform noted above.

PRODUCTIVE PEDAGOGIES

One reform movement in the state of Queensland, Australia, called the New Basics, that went on trial in 2000, attempts to provide an integrated approach to public school reform based on a) an examination of directions that education should take to prepare students for an ever changing society, b) our knowledge of effectiveness of teaching methods, and c) associated assessment practices. The three basic components of the reform are illustrated in Figure 1 below.

While not discarding traditional subject areas in the curriculum, New Basics presents new ways of coordinating, focusing and integrating teaching programs in schools. It is a reform that is centred around the teacher as a professional in that it "provides teachers and schools with ways of renewing knowledge of fields in light of dynamic changes and blending of disciplinary knowledge that have occurred since their initial training" (Education Queensland, 2000; p. 37).

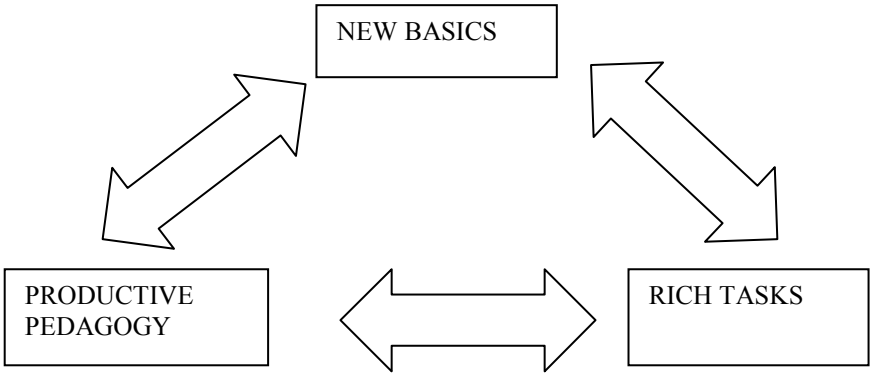

Figure 1: the components of New Basics

New Basics refers to four basic themes and practices that are seen as essential for students' present and future work and life. They do not represent new topics or content but rather organisers for all content areas studied. The four organisers are: i) *Who am I and where am I going?* - Life pathways and social futures; ii) *How do I make sense of and communicate with the world?* Multiliteracies and communications media; iii) *What are my rights and responsibilities in communities, cultures and economies?* Active citizenship; iv) *How do I describe, analyse and shape the world around me?* Environments and technologies.

The Rich Tasks, on the other hand, are interdisciplinary assessment points, covering Years 1-3; 4-6; 7-9, that "legitimate and underscore the New Basics and Productive Pedagogies by making available assessable activities that are intellectually challenging and have real-world value, two characteristics which research identifies as necessary for improved student performance". Typically they are big projects on which students collaborate for several months during the assessment year.

Finally, Productive Pedagogies are classroom principles that teachers can use to critique their teaching methods to improve educational outcomes. Productive pedagogies are critical in nature, empowering students to create their own history and to become agents for democratic, social change (Zyngier, 2003). By moving away from notions of education as preparation for a possibly non-existent world of work, schools can enable students to connect to their own realities. The productive pedagogies concept, as the term implies, is pluralistic and does not propose any single model of classroom practice. There are 20 Productive Pedagogies in the New Basics Framework, grouped under four categories: intellectual quality, supportive classroom environment, connectedness, and recognition of difference.

Intellectual quality: This dimension includes higher-order thinking, deep knowledge, and deep understanding. It includes "substantive conversation", or "talk leading to sustained conversational dialogue between students, and between teachers and students, to create or negotiate understanding of subject matter" (Education Queensland, 2001, p. 6). There is evidence that high expectations of intellectual quality benefit all students and reduce equity gaps (Education Queensland, 2004). An example of how higher order thinking might be experienced in a mathematics

classroom is provided in the "Classroom Reflection Manual" (Education Queensland, 2004) in which Year 2 students grouped and regrouped objects according to criteria they determined themselves. The students had to articulate reasons for their classifications and justify placing some in overlapping sets.

Supportive classroom environment: A supportive classroom environment is an essential component of productive pedagogies, especially for students from educationally disadvantaged backgrounds (Education Queensland, 2004). This includes opportunities for students determining their activities in the lesson. The Classroom Reflection Manual (Education Queensland, 2004) provides a cross-disciplinary example in which Year 8 students discussed what they wanted to learn about themselves and the world. These questions formed the basis of their curriculum for that year with the students involved in determining curriculum content and activities. Again, high expectations of students play an important role in establishing a supportive social environment, in which it is possible to take risks and attempt challenging work. Academic engagement in such an environment can be assessed through student self-regulation, enthusiasm and contributing to group activities.

Connectedness: The concept of connectedness includes linking new knowledge with students' background knowledge as well as connectedness to the world outside the classroom through a focus on identifying and solving intellectual and/or real-world problems (Education Queensland, 2004) thus allowing learning to occur more easily and meaningfully (Moulds, 1998). Creating connections may present a particular problem for mathematics teachers where the applications can be complex to the level of mathematics available, but integrated, thematic, and interdisciplinary approaches can provide creative possibilities to enhance learning and transcend subject matter bounds (Lonning, DeFranco & Weinland, 1998).

Recognition of difference: The valuing of non-dominant cultural knowledges is a key aspect of recognition of difference which would include deliberate attempts to increase the participation of the diversity of students. This enhances the building of a sense of community and identity and encourages active citizenship within the classroom (Education Queensland, 2004) and avoids the disengagement of those from otherwise unvalued backgrounds and cultures. In an example of classroom practice provided in the Classroom Reflection Manual (Education Queensland, 2004), year 7 students gathered comparative statistics on global issues relating to poverty. This study led to the students creating a library display and making recommendations for the school to become involved with human rights agencies.

THE SARUA PROJECT

The Student Action Research for University Access (SARUA) project (Atweh, 2003) consists of groups of senior high school students, working in collaboration with their teachers and staff from the university to a) conduct research activities on the barriers to higher education for students from social backgrounds underrepresented at universities, and b) plan, implement, and evaluate school-based projects to overcome the problems identified. The project was conceived as an equity and access project

rather than as a pedagogical project to develop school-subject learning. SARUA is committed to promoting "students' knowledge and interest about university at the same time as they are developing some of the skills required at tertiary level" (Atweh & Dornan, 1999, p. 7). Examples of student-produced research through the SARUA project for their high schools include:

- An inquiry into the low tertiary entrance rate of students from the school, leading to the development of a homework centre, a tertiary shadowing program, a school-university buddy system and positive publicity about the school through local media and school publications (Bajar, Brennan, Deen, James, Nguyen, Nguyen, Owens, Peace, Rice, Rilatt, Strachan, & Tran, 1993)
- An investigation into tertiary aspirations of years 8 - 12 students leading to the implementation of school-based projects on self-esteem and year 10 assistance in subject choice (Bevan, Fawke, Gladman, Tuigamala, & Fidow, 1996).
- An inquiry into factors affecting the participation of Aboriginal and Torres Strait Islander females in secondary and tertiary education, which noted a strong desire but lack of role models and information (Allberry, Borey, Morris, Cobb, & Jarrett, 1996).

In a typical year, students are invited to participate by their teachers based on a combination of criteria including their motivation to participate, their social and ethnic background, and academic achievement. Students receive two days of training on social issues, project management and introduction to research methods. The training session concludes with plans for projects for the rest of the year. Students and their teachers work on a weekly basis on their projects at the school. At times, this may be possible during the school timetable –mostly, however, students work on the project in their own free time. Close to the end of the year, they return to the university for at least two days to analyse their data and write their reports. All through the year, staff from the university provide assistance, advice and specialised training as requested by the school.

STUDENTS' RESEARCH AS A PRODUCTIVE PEDAGOGY

While the SARUA project described above is not conceived as an activity to teach mathematics directly, students in the project have utilised a significant amount of mathematical content such as percentages, decimals, fractions, and graphs. In this project, these were used implicitly in meaningful real world contexts. This is in keeping with critical literacy and critical mathematics. The mathematics used in writing up the student reports was arguably already known to the majority of the students. However, an argument can be raised that similar contexts could be used with lower age students that may be more useful in developing these concepts and skills. Using contexts such as real research to develop the mathematics not only provides a way of giving meaning to these concepts, but also allows for the development of higher order thinking strategies not possible while using meaningless numbers. For example, in making decisions on the most appropriate graphs to

represent the data, students engaged in elaborated conversations with each other about the advantages and limitations of each type of graph in conveying the specific message that they want to communicate. Hence, through students' involvement in authentic research activities, mathematics can be developed *through* attempts to understand the social reality of the students.

Further, developing the mathematics within this real context allowed students to reflect on the real world and reasons for their disadvantage. Mathematics was shown to be a powerful tool to understand their social reality and to change it (Mellin Olsen, 1987). Very rarely do students have the opportunity to develop meaningful data from their classroom activities in mathematics, and even less frequently would they act on the knowledge to improve aspects of their world. Hence through students' involvement in authentic research activities, mathematics can be developed for understanding their social reality and empowering them to act on it. This development of mathematics for and through understanding the social reality of the students establishes essential connections with the world outside mathematics. It also connects mathematics with literacies developed in other school subjects.

Mathematics teaching has been critiqued for being detached from the interest of the learner and society (Frankenstein, 1994). Often, the applications of mathematics to real world problems that are used are taken from the natural world and, at times, from business. Often, these are taken as non-problematic, perhaps reflecting the widespread belief that mathematics is value free (Bishop, Seah & Chin, 2003). Frankenstein (1994) proposes that "[c]riticalmathematics literacy … involves the ability to ask basic statistical questions in order to deepen one's appreciation of particular issues, and the ability to present data to change people's perceptions of those issues. A critical understanding … prompts one to question 'taken-for-granted' assumptions about how a society is structured and enabling us to act from a more informed position on societal structures and processes" (p. 23). Kellermeier asserts that "a criticalmathematics curriculum would then weave a discussion of social issues into the learning of functional and mechanical mathematics thus preparing students to better participate as global citizens" (1996, p. 9).

Atweh (2003) point out how the students involved in the SARUA project demonstrated considerable "research sense" and a critical appreciation of the research process itself. This was clearly illustrated in the research reports they produced. For example, they were able to identify the strengths of using questionnaires for data collection in order to "question a large anonymous audience, within a minimal amount of time" (Borowicz et al, 1993; p 2). They also identified that the attitude of the data collector towards the respondents was a major factor in obtaining valid information. They concluded "one must commit oneself to the task, taking a professional outlook and reflecting this image toward the respondents" (p. 3). Similarly, they were not afraid to go beyond the data and raise hypotheses about its causes. For example, in noting that 71% of the young men and 29% of the young women surveyed have university aspirations in spite of the fact that girls indicated that they enjoy school more than boys, the young researchers were able to offer the

explanation that: "Possibly this may be due to a lack of female role models who have completed university other than teachers, as well as early motherhood which is common in [this suburb], rather than women concentrating on careers" (p.21).

Here, we have demonstrated that when students are involved in "real" research activities not only do they have a chance to develop learning of high intellectual quality, but that learning is necessarily interdisciplinary and connected to their real world concerns. However, from our involvement in SARUA we also have learnt the importance and, we should add, the dilemmas, of providing students with support and recognise issues related to their differences.

Atweh (2003) argues how through students' engagement in authentic research activities, they are developing collaborative learning skills in a supportive and trusting environment. Working with students in this mode is not without its problems (Atweh, Cobb & Dornan, 1997) and requires continual self critique and reflection. It challenges the normal demarcations of power between teachers and students. It also opens the door for challenges and new opportunities to work in productive ways. Successful collaboration between students and researchers demonstrates a parity of esteem (Grundy, 1998), whereby the participants work to develop a reciprocal sense of trust and respect, and a common commitment towards the content of research shared by all parties involved - students, teachers, and university staff.

All the university participants approached researching with school students with a great sense of ethical responsibility. As much as possible, we dealt with the students as equal partners and dealt with them with the same respect that we did each other. We respected and attempted to promote students' freedom in their decision-making. However, the students were also aware of the "duty of care" responsibilities. We were in a more privileged position as we had more experience in the planning and conduct of research as well as our knowledge of theoretical issues. The boundary lines between the authority that we had and the freedom that we advocated for the students were sometimes confusing to them as well as to us. At times, students and their schoolteachers were hesitant to proceed on a decision without checking if it was what university staff wanted them to do. However, these requests for "permission" became less frequent as the project progressed each year.

The university researchers learnt two means to deal with these confusions about our roles. First was the process of open negotiation with the students and teachers about each partner's roles. This negotiation started when the university staff were explaining the project to the schools, the volunteering teachers and the students themselves. The advertising material sent to the schools about the project specifically outlined lists of responsibilities of the various partners. Further, this negotiation was continuous throughout the life of the project. Whenever possible, decisions that we made were explained to the students. Likewise, the students were invited to evaluate the sessions and the processes of the project.

Further, at various times in the deliberations with students, it became clear that the students need some assistance in considering the options of what is possible before they can decide on an appropriate action. For example, in helping them decide what

type of data collection tool to use, we discussed with them various data collection methods with their advantages and disadvantages. Naturally, in choosing the list of methods discussed, we selected methods based on our assessment of what was appropriate and what was achievable by the students. From the discussed options, the students had to make their own decisions on which instrument they used.

At the initial stages of the project, students worked in homogenous groups based on gender and cultural background. This was done in response to demands from certain schools themselves. Atweh, Cobb and Dornan (1997) identified several benefits of organizing the groups this way. These included,

- an increase in the participation of students from certain backgrounds who were hesitant to join the project as a minority group working within mixed groups;
- an opportunity to consider aspects of their culture that may not have arisen in culturally mixed groups;
- an opportunity to address issues of race and prejudice in their discussion and research;
- the avoidance of the possible tension that can arise between students from both genders about equal participation; and
- the development of leadership potential within the various groups.

However, the grouping of students in homogeneous cultural backgrounds and gender was not without its dilemmas. One of the indirect aims of the project design was for the participants to become aware of social disadvantage and oppression as widespread phenomena that affect different people according to their gender, race, socio-economic or other source of disadvantage. The university team believed that such awareness is best achieved in groups of students from different backgrounds working collaboratively where they have a chance to develop mutual respect and understanding. On the other hand, the project was also founded on the belief that research into the factors affecting underrepresentation should be contextualized in terms of the various factors of disadvantage. The experience of disadvantage varies in different communities. Such contextualization could be best achieved in homogeneous gender and cultural groups. This presented a dilemma for the project.

To satisfy both these conflicting considerations, the project in 1996 was planned so that students with similar backgrounds worked in homogenous groups yet shared their plans and results with other groups. For example, during the training workshop at the university in 1996, eight school groups were represented: four consisted of Aboriginal students and Torres Strait Islander students, one was an all Pacific Islander group and three were mixed gender students from low socio-economic backgrounds (including non-English speaking backgrounds, Aboriginal students and Pacific Islander students). During the training sessions the students participated in joint sessions and worked in their school groups. This meant that there were regular opportunities for sharing the issues discussed in the small groups with the whole project. During the year, attempts were made to issue a regular newsletter informing the groups of the activities at other schools. These arrangements gave all students a

sense of belonging to a local group while, at the same time, functioning within a larger project that included students from diverse backgrounds.

The second dilemma encountered was the match between the schoolteachers' backgrounds and those of the students. The selection of the school liaison people is a crucial component in the success of such projects with students (Atweh, Christensen, & Dornan, 1998). The university team believed that the deeper the understanding the liaison teacher had of the culture of the student the more successful the project would be in achieving its aims. Arguably, this was important with respect to both gender and cultural background. Not only would a person from the "inside" be more able to understand the issues faced by the students, but they would also be able to provide a better role model to the students. This has not always been possible. In many cases there were no Aboriginal, Torres Strait Islander or Pacific Islander teachers in the respective schools. Further, in some cases where there were teachers within the school from the targeted backgrounds they were already overburdened by their heavy involvement in a variety of other school activities and projects.

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