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TOWARDS DEMOCRATIC MATHEMATICS EDUCATION IN SOUTH AFRICA

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More than a year has passed since the second national meeting of the National Education Crisis Committee (NECC) and its articulation of the slogan 'People's Education for People's Power' (1). Much has changed in this short time-span. The heady euphoria and fervour of last year, effectively nipped by severe state repression, has sobered into the realisation that not only is liberation not around the corner, but also that the NECCs proposed strategy of transformation from within state schools itself would need careful reconsideration. Students' return to school after prolonged boycotts was motivated by a vision of the schools being transformed into sites for education for liberation. Predictably, the state responded by passing and enforcing stringent legislation prohibiting the offering on any school or hostel premises of any syllabus, work programme, class or course which has not been approved in terms of the Education Act' (2).

Despite these restrictions, but with an acute awareness of changing conditions, those concerned with the democratisation of education in South Africa continue to develop 'people's education' not only as a total concept, but also in relation to what it can or might mean for different subject areas and practices. Commencing in the more 'obvious' subject areas of history and English, the re-development of education spread to include mathematics (3). This paper represents a contribution to this latter development.

Until recently the dominant view of mathematics was that it was neutral - comprising only universal truths. In part this view explains why even now mathematics is less easily placed

within the purview of 'people's education' than subjects such as history and English. There is, however, a growing awareness that mathematics does not function in a vacuum and that as part of a social institution (education) it should not be allowed to escape its social role. Let us now turn to explore that role.

It is well known that through schooling under apartheid in South Africa, thousands and thousands of adults remain innumerate or barely numerate (4), unable to calculate simple percentages and ratios; unable thus to calculate GST, UIF, tax contributions, etc., the disadvantaged position of the average production worker in any wage negotiation is obvious. It is perhaps one reason for poor wages in this country. This example underscores the urgent need to spread numeracy skills.

Further up the school ladder, while the extensive expansion of black secondary schooling over the past decade brought an increase in the absolute (though still relatively small) number passing matric with mathematics, this 'reform' is only quantitive. Material and human resources in the schools are abysmal. With only 12% of black secondary school teachers having a degree (5), mathematics teaching by and large is tackled bravely by teachers barely one step ahead of their students. As a result, authoritarianism and rote-learning methods predominate. Within the context of a larger school-going population, improvements in the quality of school knowledge are minimal.

The above represents a bleak picture indeed, and it is not yet the full picture of the relationship between mathematics education and relations of domination in South Africa. Enough has emerged through the sociology of education to convince us that unequal education is not simply a matter of unequal access and unequal resorces. Unequal education feeds and is fed by, produces and is produced by, an unequal society. We can thus only appreciate the extent and nature of inequality by looking firstly beyond the confines of black education and secondly beyond education into the broader social

structure.

Our society firmly associates social and economic growth with scientific expertise. Professions related to the sciences (and mathematics) accrue high social and economic status. Society assigns to the schools the role of producing the foundations for scientific expertise and mathematics has been constructed (expressing this rather simply) as the ultimate scholastic measure of potential for such expertise. One effect of this is a very formal, highly abstract secondary school syllabus that alienates the vast majority (6) and produces the widespread belief that mathematics is not for everyone: it is the many rather than the few (and more women than men) who emphatically say: 'I can't do maths'. Mathematics as it is taught in school focusses on the production of a professional elite, and functions to promote only a few to mathematics-related tertiary education.

Well known 'maths anxiety', feelings of failure and the inability to effectively use mathematical skills to interpret reality are also products of the consruction of school mathematics as a high status, inaccessible knowledge area. This is true of all schools and not simply 'bantu education' schools. My recent experience with pre- service teacher-trainees, most of whom have passed mathematics at the higher grade at 'white' schools, leaves me with little doubt that mathematics in all our schools is presented as a body of knowledge that must be absorbed: questions/problems have only one answer, and the object of study is to get each answer right. This technicist approach to scientific knowledge, produces students who are expert in memorising and applying rules, but who struggle to step out of this narrow frame to make meaning of their 'knowledge'. Two simple examples will illustrate this point.

Years of practising the division of common fractions only by the rule "turn upside down and multiply' has produced many students able to compute symbolically 1/2 1/4 = ?, using the division rule, but unable to explain WHY the answer 2 is meaningful. They were unable

to link the symbols to a meaningful physical embodiment. They were unable to translate or interpret 1/2 1/4 = ? as simply 'how many quarters are there in one half?'.

In a less abstract setting, faced with the following:

Ring the CALCULATION you would need to find the answer:

If one kg of bananas cost 0,88c, how much would 0,58 kg of bananas cost?

0,88 + 0,58 0,58 x 0,88 0,88 - 0,58

0,58 - 0,88 0,88 0,58 0,58 0,88

Over 90% of this group of 130 students chose a division calculation. What was striking was that given time to reflect and use a calculator to explore whether 0,88 0,58 (or even 0,58 0,88) gave a sensible answer, many quickly saw that each result was ludicrous but could not easily unravel why.

The picture emerging therefore is of students with pieces of paper vouching for a level of academic attainment, but rigid in their thinking, rule-seeking in their behaviour and passive in their approach to knowledge. Given the dominant authoritarianism in our social structure and the consequent authoritarian practices that pervade our schools and maths classrooms, passivity and rigidity of thought are not surprising.

Thus we see yet another side to the functioning of mathematics schooling in South Africa. In its political role, mathematics contributes to the production of students unprepared for critical participation in society. Combining this with the ideology that maths is only for some and with the discriminatory access to mathematical knowledge in South Africa, we get a complex interplay of factors which clearly indicate that the democratisation of

mathematics requires more than equalising access. Democratisation includes attacking authoritarianism and implies questioning the curriculum, i.e. what is taught (valued as mathematical knowledge), how this is taught and then assessed.

This conclusion is similar to that cited by a noted Jordanian mathematician, Fasheh. Through his experience as a scholar and then mathematics educator attempting curriculum innovation on the West Bank of Jordan, Fasheh (8)

> ... came to believe that the teaching of maths, like the teaching of any other subject in school is a 'political' activity. It either helps to create attitudes and intellectual models that will in their turn help students to grow, develop, be critical, more aware and more involved, and thus more confident and able to go beyond the existing structure: or it produces students who are passive, rigid, timid and alienated. There seems to be no neutral point in between.

With current classroom practices in South Africa producing the latter students described by Fasheh, mathematics education for 'people's power' needs to pose the question: how can the teaching of mathematics contribute to education for democracy, to the development of Fasheh's critical and aware students? How can we develop, in Gramsci's terms, 'the mature scholar', able to participate creatively and critically in his or her social world?

As noted earlier, these issues have begun to be addressed in the South African context. I'd like to now look specifically at classroom practice (and this does not imply that People's Education begins and ends in classroom practice) and discuss some additional ways of addressing this question.

Fasheh was quoted by Breen in the introduction to a booklet of alternative worksheets produced by teacher trainees at UCT (9). Within the broad framework of seeing the maths classroom as contributing to an understanding of social relations, the worksheets

collectively attempt to introduce into the maths classroom, challenges to (i) eurocentrism, (ii) racist myth and stereotyping, (iii) decontextualised problem-solving, and (iv) methods and practices that perpetuate teacher-dominated chalk and talk followed by repetitive drill and practice exercises.

For Breen, attempts to change this last point lie at the core of any alternative programme. He sees the work of British humanistic mathematics educators as 'providing an exciting basis for teaching in a way that will combat elitism, racism and sexism as a by-product while focussing on the "deep-structure" of mathematics'. He does not provide examples of this work but is clearly referring to developments in the field of 'investigational maths' that is more and more the current orthodoxy in British maths education circles. The proponents of the 'new' orthodoxy argue that it shifts classroom emphasis from the absorption of mathematical thought to the development of mathematical thinking (10).

The extracts further on, are examples of open-ended mathematical investigations. They can be done at varying educational levels in that few specific content skills are necessary for involvement. The social organisation of the classroom is seen as a fundamental part of this work and involves small groups who work together on the task at hand. The skills developed through this kind of practice are: specialising, pattern-seeking, generalising, conjecturing, and, importantly, communicating. Children are encouraged to develop ways of communicating their findings verbally and symbolically, so that they are intelligible to those not involved in the task. It is argued that these involve learners in mathematical thinking. In addition, because the work is done in groups, and because there is no single way of progressing through the task, children can learn to co-operate, share ideas and discuss amongst themselves what they think and why. Experience has further shown that children of ranging 'ability' can become effectively and constructively involved in an investigation and so develop positive attitudes to themselves and their ability to 'do maths'. Gender domination is also undermined since research suggests that girls function positively

in co-operative learning situations (11). The social reality so constructed is non-authoritarian and non- elitist. It is a far cry from the passivity and alienation currently produced in South Africa.

I have tried to present some detail here because investigational practices do seem to offer light in a dark tunnel. It is also important that they are understood as the influence on mathematics education by general trends in education away from content-bound curricula to process-oriented curricula. The construction of process- type mathematics in the British context seem to offer a positive contribution to mathematics education for democracy - particularly in the light of the growing emphasis on 'process' as the 'intrinsic mode of people's education' (12).

Most new strategies bring with them a new set of questions. Here we have to raise the crucial question of the complex relationship between process and content learning in mathematics. Does the ability to approach and solve problems depend on some (mathematical) content knowledge or does the meaningful internalisation of mathematical content depend on a problem-solving/process approach to learning? And further, where does social reflection fit in to process-orientated mathematics education? What about questions of number and power?

These questions suggest that it is important to move on from process- oriented, open-ended strategies to advocate, in addition, more teacher directed strategies (e.g. structured worksheets) that specifically problematise world relations and numbers in context, and aim to develop in learners (i) a critical approach to number and (ii) an appreciation of how mathematics enables us to question and understand our complex world. For (i) learners need to understand (for example) the interests reflected in two different headlines reporting on the first day of the current miner's strike: one leading with 'two thirds of miners still at work, and the other leading with '230 000 miners out on strike'. For (ii) the

alternative worksheets mentioned above and the kinds of materials being produced by the Association for Curriculum Development (ACD) in London, are useful starting blocks. An interesting worksheet from ACD guides learners in comparing numbers of workers involved in agriculture in first and third world countries with food consumption in these countries. Using both percentages and graphical representation to affect comparisons, issues of global poverty and undernourishment emerge for discussion.

The emphasis in the ACDE worksheet and the UCT students collection is on using mathematics to understand relations of domination, to encourage reflection on the social. They should be extended to include reflection on the mathematics used to that end. For example, how, why, when (and for whom) does the translation of absolute numbers into percentages facilitate reflection? Why, how and when does graphical representation facilitate understanding of different situations? In short, learners need to relate the abstract world of mathematical knowledge to the real world in which it functions. We thus need to develop ways of embedding progressive practice in social reality.

An example that I have used to this end a few times relates to area and perimeter, concepts in the current syllabus. For any fixed perimeter, the shape that gives the maximum area is the circle. Learners at different levels can arrive at this conclusion through practical investigation. What is useful about this kind of question is that while the circle is the mathematical solution, it is more (or less) appropriate for different social and physical contexts. Learners can discuss how they would maximise space for a play area for toddlers or for a dam: the circle might, for example, be appropriate for a dam, but not unequivocally so for a play area. They can also be directed to reflect on the issues that influence their decisions. By relating abstract maths to decision-making and negotiated meaning learners can appreciate Einstein's popular remark: 'As far as the laws of maths refer to reality, they are not certain, and as far as they are certain, they do not refer to reality'. A more graphic example of this is the relationship between the certain, but abstract mathematical equation

1 = 1, and the contested real world equation, 1 woman = 1 man (13).

Teachers bogged down by the created need to 'finish the syllabus' cannot see the time (nor possibly the need) for such reflective practices. But the result of this is students who are able to calculate area and perimeter from formulae learnt off-by-heart, but unable to see the relationship between area and perimeter nor appreciate the context into which it may fit.

The examples above are not intended to convey an alternative curriculum for mathematics and people's education. They rather indicate some of the kinds of issues and questions that I feel are essential to confront if mathematics is to be democratised in the classroom. They leave unasked further questions, the most pertinent for this paper being: how can changes in classroom practice be effected? What will be the role of present and future teachers and of students/learners in such social transformation? In short, discussion of change in classroom practice cannot conclude without confronting how a vision of emancipation is translated into progressive action.

In thinking about action, it is appropriate to start with a reminder that while interventions into curricula can, through the different classroom practices they demand, contribute to challenging racism, sexism, and elitism, they cannot in themselves, as Breen seems to suggest, combat the social ills so deeply embedded in the fabric of our society.

A brief look at research into girls and mathematics in Britain illustrates the complexity of gender discrimination and implies the ineffectiveness of simplistic strategies to effect change. In seeking to explain why there is discontinuity in girls' performance in mathematics in secondary school, Walden and Walkerdine (14) move beyond explanations related to gender stereotyping in school classrooms, playgrounds and mathematics texts. They argue that the performance differences between boys and girls at sixteen is produced

Extract from: Points of Departure 1 An Association of Teachers of Mathematics (ATM) Activity Book. Derby 1986.

43. BRAILLE

Louis Braille, a Frenchman living in the 19th Century, invented an alphabet for use by blind people.

The alphabet consisted of raised dots in rectangular patterns. Each pattern of dots was based on a 3x2 rectangle.



Some patterns used are given below:



How many different patterns can be made using this system?

Investigate for different sized rectangles.

44. PASCAL VARIATIONS

In Pascal's triangle, each number is produced by adding the two numbers above: 3 and 1 give 4.

```
        1
      1 1
    1 2 1
  1 3 3 1
1 4 6 4 1
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Investigate other rules for producing triangles of numbers.

45. CONSTRUCTIONS

Investigate constructions which are possible using

a) straight edge and compass

b) straight edge and fixed compass

c) straight edge only

d) straight edge marked with 2 points

e) ruler with 2 parallel straight edges

f) movable compass only

by a complex interplay of factors relating to conceptions of mathematics, theories of learning and development, gender, and to practices in the classroom, all of which need to be understood. Through in-depth research into primary and secondary classroom practices, and drawing on critiques of learning theory, cognitive development and their relation to mathematics they reveal that it is not that girls underperform, but rather that their performance, for complex reasons, is devalued. Interviews revealed that teachers often attributed girls performance to 'hard work': in contrast boys' good performance was attributed to natural mathematical ability. In the Assessment Performance Unit tests girls' performance was significantly higher than boys' on all computation items, but then these items are described as 'lower order' concepts and/or skills. These attributes are themselves linked to the contradiction between the social construction of feminity as caring, co-operative and non-challenging, and the social construction of mathematical ability as evidenced by inquiry and challenges to the teacher. Girls are thus positioned in an unconscious double-bind: they cannot be both feminine and 'good' at mathematics.

It does not take too much imagination to extend some of these insights into racially perceived differences in performance and leaves us with perhaps a more sober understanding that changing these deeply embedded social perceptions and actions requires more than enthusiasm and belief. The process of change is long term. It includes, but extends beyond, classroom practices.

Thinking specifically now about how changes in classroom practice come about, these depend in the first instance, on teachers and learners believing (and the reasons for their beliefs might be contradictory) that such changes are necessary. The evils of inequality in South Africa are experientially profoundly understood by most teachers and learners. But does this mean that social practices such as passive learning through teacher chalk-and-talk are necessarily questioned? Does student militancy necessarily imply progressive learning styles? One wonders if the phrase 'old habits die hard' is out of place here.

If real change is to emerge in mathematics classrooms, then the process by which it comes about is as important as the change itself and this necessarily implies full participation by teachers and learners.

Focussing briefly on teachers, this last assertion was clearly brought home to me through discussion with, and observations of, teachers following the SMILE (secondary mathematics individualised learning experiment) in London inner-city schools. The programme interested me because it appeared to be a semi-flexible materials / resource-based scheme, and one which mathematics teachers initiated, continue to develop and control.

While there is a lot to say about the academic and social effects of the scheme and how it is perceived by teachers, learners and the wider community, the greatest insight for our purposes here was recognising that those teachers who perceived the programme positively and executed it with openness and progressive creativity were those involved in its development and control. Those teachers who were critical of the programme and also felt then that it could not be used creatively were those who felt the scheme had been imposed on them. This simple fact of work alienation is so well-known and yet so easily forgotten. I learnt again that if changes in classroom practice are to come about successfully, then teachers themselves need to participate fully in their development and control. Imposed strategies, however well motivated, are quite likely to meet with resistance.

There is a long and challenging road ahead if mathematics education is to become a progressive force for change in favour of the majority of the people of South Africa. The challenge involves on one level the extension of basic skills and on a different level, a redirection of content and pedagogy as part of the process of the democratic development of all the actors on the education stage.

INVESTIGATING AREA AND PERIMETER

Work in groups of 3 - 4 people. You need: quad paper and two pipe- cleaners joined to form a closed flexible frame.

PROBLEM 1. Your community has acquired an amount of fencing and decides to use it at the creche to enclose a safe play area for toddlers. What shape should the play area be?

You need to present your suggestion and reasons for it to the next community meeting. So, record in whatever way you feel is appropriate, the steps you take to reach your conclusion.

SOME HELP - the fencing is a fixed amount. It becomes the perimeter of the play area. Use your flexible frame to investigate how area changes as you change the shape of the fixed frame.

PROBLEM 2. If your community wishes to construct a water reservoir, what shape would you suggest this to be?

REFLECTIONS AND DISCUSSION

1. Maximising space and area might have a fixed mathematical solution, i.e. in the abstract, but what happens in real socio- economic situations?

2. Read the following extract from AFRICA COUNTS by Claudia Zaslavsky (1979) pp. 155-6:

> The African adapts his home admirably to his means of subsistence, to the available materials, and to the requirements of the climate. The circular house in its many versions is found throughout the continent. The circle, of all closed geometric shapes in the plane, encompasses the greatest area within a given perimeter. Confronted by a scarcity of building materials and by the urgency to erect a shelter without professional assistance and in the shortest possible time, the African chooses the circle as the most

economical form. He is not unique; round houses are constructed in the Arctic as well as at the Equator, ... Labelle Prussin has studied the architecture of West Africa, and has this to say: "I did a simplfied 'engineering analysis' comparing the round and square houses in the savannah, with equal volume, for bending, shear, bearing, etc., given similar vertical and horizontal loading, assuming constants in humidity, temperature, and soils, vegetation and technology. Of course, the round house won by a landslide."

(a) Why do you think that in some communities housing has remained circular but in others housing changed to become largely rectangular?

(b) How would you find out more about changing housing styles and shapes across the world?

NOTES

1. The second Education Crisis Conference was held in Durban in March 1986. The resolutions passed there are available in Perspectives in Education, 9 (1), July 1986, pp.60-70.

2. Govt. Gazette 10563. Proclamation R235, 29 December 1986.

3. The NECC recently appointed a mathematics and science commission. However, debate on mathematics education for democracy in South Africa took root some time ago. Elements contained in this paper were first presented at the 1986 Kenton education conference collectively with Nick Taylor, Lizo Magadla and Siza Shongwe. I am indebted to them for the development of the ideas here. We conducted a related workshop for the Maths and Science Teachers Association (MASTA) - whose membership is largely Soweto teachers - and gave a similar presentation, though in three separate sessions, to the 12th Convention of Teachers of Mathematics, Science and Biology in Grahamstown in July 1987. See also Breen, C (1986) Alternative Mathematics Worksheets Dept. of Education, UCT. His

introduction to this booklet of worksheets while not under the title 'people's mathematics' raises relevant questions.

4. There are no projections for adult innumeracy in South Africa, but illiteracy statistics, based on the completion of five years of schooling and suggesting that 55% of the population, or five million people, are illiterate, form at least an indication of innumeracy.

5. See Carstens, P.D., Du Plessis, A. and Vorster, C. (1986) Education and Manpower Production (blacks) No. 7, Research Institute for Education Planning, University of Orange Free State.

6. The current matric syllabus is geared to the demands of academic tertiary-level maths-related study.

7. We could speculate here that some of the reasons for these 'inabilities' lie in the de-emphasis on arithmetic (on function) and the increased emphasis on structure that came with the 'new maths'. This issue needs exploration beyond the scope of this paper.

8. See Fasheh, M (1982) 'Mathematics, Culture and Authority' in For the Learning of Mathematics. 3(2) November, pp.1-8.

9. See Breen, op cit.

10. There is a proliferation of investigational mathematics materials in Britain, all of which emphasise this shift. A resource that I have found particularly illuminating is a pack for teachers by Pirie, S. (undated) Mathematical Investigations in YOUR Classrooms. University of Oxford, Dept. of Educational Studies.

11. Competitive learning environments are anxiety producing, and have negative effects on many girls, and some boys. Research discussed in the Open University course PM645 Girls into Maths (1986) suggests that pupils (boys and girls) generally prefer co-operative learning styles and they therefore perform better too.

12. This is discussed by Michael Gardiner in his paper 'Liberating language: People's English for the future' in Lengwich. Vol. 4(1), March 1987.

13. See Fasheh, op cit.

14. See Walden, R. and Walkerdine, V. (1985) Girls and Mathematics: from primary to secondary schooling Bedford Way Papers 24, University of London, Institute of Education.

See also OUP PM645, op cit., for additional debates on girls and mathematics.