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ARTICLES

REVIEWS AND DEBATE

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Editorial Policy

The policy of the editors of *Perspectives in Education* is to promote rigorous critical discussion and debate about education (in the broadest sense of the word), particulary in the context of Southern Africa, through the publication of academic articles based on original theoretical and empirical research and analysis. *Perspectives in Education* attempts to reflect the variety of perspectives current in the field, and publishes both discipline-based and inter-disciplinary research. In order to ensure all articles are of the highest quality all contributions are submitted to at least two referees before acceptance for publication. Decision to publish is based on their recommendations.

The editors affirm their unequivocal rejection of all discriminatory principles and practices in education, and in particular their rejection of the racist and discriminatory features of the South African system. They furthermore express their commitment to a single non-racial education system to be established by the democratic participation of all South Africa's people which will provide for the development for their full potential.

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Editorial

In 1989, *Perspectives in Education* made a call for papers for a Special Issue on Mathematics Education. One of the most profoundly pernicious legacies of apartheid schooling has been the concentration of mathematical and scientific knowledge in the white community. The restriction on acquisition of knowledge by black students became policy in the 1950s. School curricula were structured in such a way that only a limited, practical mathematics was taught, if at all; teacher training, where it did include mathematics, trained teachers to teach a deadly subject barely understood; available courses on offer at universities created by the Extension of Universities Act of 1959 on the whole excluded areas which required mathematical and scientific knowledge. The consequences are reflected in the annually published matriculation results and in the racially skewed occupational structure of South Africa.

The democratic movement has always recognised that all should be educated equally, and that black people in particular have historically been denied and should have access to the "cultural treasures of mankind" - whether these be in the form of mathematics and science, or music and fine art. The teaching and understanding of mathematics and science have been at the heart of a wide conception of education whose concern has been with empowering people to take over and control what can be powerful instruments of oppression. A far narrower conception, of skilling people to meet the needs of the economy, has informed the thinking of South African government, commerce and industry. Alarmed at the incontrovertible evidence that economic growth will increasingly depend on development of the country's human resources, especially in the terrains of mathematics and science, the teaching of mathematics and science has amongst them also become a high priority. Mathematics, it is clear, will feature strongly in any new curriculum. How it is taught, however, will be critical. This Special Issue goes some way towards addressing key questions involved: curriculum construction, language and mathematics, racism in mathematics education, and skill versus political understanding.

Mathematics educators in South Africa, especially those committed to transformation of the system, are few and far between. Submissions to this Special issue of the journal did not roll in; some of those included here were indeed especially prepared for a Conference in London in April 1990. Very little work is being done in the area; this needs to change. The needs and the demands are enormous.

The papers that have been included are mainly by mathematics teacher trainers who confront the problems of apartheid schooling at the chalkface. Julie demonstrates in particularly graphic form how the authoritarianism of the system as a whole permeates curriculum construction, while both Julie and Breen show how, as teacher trainers, they attempt to teach students how to confront the racism and inequality with which mathematics as taught in South Africa is imbued. Both draw on the thinking of, amongst others, the Mozambican Gerdes, for inspiration. Jane Castle reminds us that innumeracy has to be considered alongside illiteracy; her examination of different approaches to numeracy education is well overdue. Jill Adler's thought-provoking piece probing some of the assumptions of progressive

mathematics pedagogy by contrast explores an experiment in "barefoot" mathematics education. Like Castle's paper, the value of that by Craig and Winter lies in the consideration of mathematical and language problems as intimately interconnected. Nick Taylor's essay review of Valerie Walkerdine's work will be of interest not only to mathematics educators, but to a range of others.

I would like to thank Yousuf Gabru, long-time mathematics teacher and Western Cape Teachers' Union (WECTU) activist, for inspiring this Special Issue.

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Equations of Inequality: Challenging the School Mathematics Curriculum

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This paper deals with the intended and implemented of the school mathematics curriculum. It discusses the production of the curriculum and strategies employed to incorporate political issues in the mathematics classroom during periods of intense political activity. It concludes that it is during the conception and interpretation stages of the curriculum development process that ideology is built into the curriculum and that within the mathematics classroom, strategies are developed to cope with both the bureaucratic demands of the state and the "immediatist" demands of the day-to-day struggles of the people.

Introduction

The 1954 Bantu Education Act formally legalized racially segregated educational facilities for all South Africans. It explicitly politicized education within narrow ruling party considerations by keeping tight control over who is taught, what is taught and for what purpose each is taught.

The students of 1976 had been schooled exclusively within the confines of Bantu Education. Yet they led an educational and social uprising which both continued the traditions of apartheid resistance of the 1950s, and laid the basis for the era of People's Education for People's Power as spearheaded by the National Education Co-ordinating Committee (NECC).

Apartheid ideologues and its adherents had no intention for black South Africans to dabble in mathematics or any of the sciences. Indeed they argued that black persons had no such capabilities. On the other hand these ideologues realized the importance of mathematics as a selector for social and economic empowerment.[1] Thus, although profound changes were made to subjects such as history, geography and languages to rid them of their primarily British character, mathematics was kept intact. Changes were however made to the context of the applications of mathematics as embedded in word problems. Adherents were urged to work for "excellence" in mathematics; thus the apartheid-supporting sector of the white community could establish themselves in the economic and technical fields. Academics at institutions which, through their philosophy and practices, supported the apartheid ideal worked fervently to establish and control associations to deal with mathematics education. One such association, the Mathematical Association of South Africa (MASA), stated categorically in its constitution that it was an exclusively white organisation.[2] This racially-based constitution was changed after the student revolts in 1976. A major factor contributing to this change was the refusal by some international academics to participate in racially-segregated mathematics education conferences in South Africa.

This paper looks at mathematics education in South Africa in its current context. It addresses the question of the school mathematics curriculum as an agency of discrimination in present-day South Africa. Furthermore, it gives some insight into how oppositional strategies can be developed and employed by mathematics educators in collaboration with teachers to cope on the one hand with the "immediatist" demand of the community for political relevance in the teaching of mathematics and on the other with the bureaucratic demand of the state to keep politics out of education.[3]

The production of the South African school mathematics curriculum

To speak of a South African school mathematics curriculum is to beg certain questions. Such a curriculum does not exist. A major reason for this is the racially-determined departments of education in South Africa. Each of these departments are supposedly responsible for their own curricula. However, in order to come to some understanding of the problematic of the mathematics curriculum in South Africa, it is necessary to give some background to how the curricula in the different education departments emerge. This section of the paper therefore addresses the production of the school mathematics curriculum and its close ally, mathematics curriculum materials development.

For mathematics teachers in South Africa, the school mathematics curriculum evolves in a mystical manner. This is understandable in the light of the dominant ideology which guides education and schooling in South Africa and has built into it the distancing of designers and implementers.

The mathematics curriculum process starts with an initial draft curriculum being drawn up by a group of experts decided upon by a para-statal board or syllabus revision committee. This syllabus revision committee is almost always chosen from the white education departments. The draft syllabus this committee constructs, is distributed to the different education departments, mathematics departments of universities and acknowledged (that is, state-approved) school mathematics associations for comments. The various departments set up mathematics syllabus committees whose brief is to review the draft and make recommendations. After further reviews and recommendations, the board and/or committee of experts will avail all departments of a syllabus which is now known as the core syllabus. Its function is to guide departmental syllabus committees in the construction of their syllabi. The core syllabus is described as the minimal set of mathematics that is to be covered within a given school year and it must thus be a subset of the content of the syllabi of all the departments. Minor additions to the syllabus are viewed by the state as "accommodating the needs of the different cultures". In reality, however, the syllabus that eventually reaches teachers is the same syllabus for different races - with state ideology built in via the core syllabus.

Mathematics teachers thus receive a syllabus describing goals and aims, some comment on methodological aspects, the content to be covered per year and the evaluation procedure to be followed. The intended curriculum reaches teachers after it has been designed elsewhere. Who designed the curriculum, the process that is being followed and the underlying motivations for the curriculum are unknown to those who must implement it.

State control and alienation of teachers from the process of curriculum development is further entrenched during implementation. During this phase,

syllabus interpretation is done for mathematics teachers by school inspectors and subject advisers who, like teachers, are employed by the state. These inspectors and subject advisers play prominent roles in the syllabus committees previously mentioned. Syllabus interpretation is sometimes carried to the point where detailed workplans, frequently describing what teachers must do during each mathematics period, are designed for teachers. They are expected to follow these workplans slavishly. Frequent inspections on whether teachers are executing the workplans in accordance with the goals - which in most cases are the improvement of examination achievement results - set out by the administrators are carried out by the same interpretors.

Covert interpreters of the intended curriculum are authors of textbooks and designers of curriculum materials. These persons are in many cases the same as those closely involved with the initial design of the core syllabus and/or persons serving on curriculum materials selection panels - persons selected by the education departments to evaluate and approve curriculum materials to be issued free to schools. Subjecting curriculum materials and its production to the process of critical analysis proposed by Lind-Brenkman,[4] it becomes evident that mainly the interests of the ruling class are served and propagated. Furthermore, the vested interest role of major textbook producers also comes to the fore through such an analysis. It appears that these businesses seek and appoint authors whom they think will best be able to get their product approved for the lucrative educational market. An interesting method they use is to commission "prominent" black educationists to co-author textbooks with their approved authors. The underlying motive for this co-option is to secure departmental approval of their products. These "prominent" educationists are in many instances closely involved with the approval of curricular materials.[5]

Textbook producers keep a close watch on the political climate and are quick to institute procedures to keep their products seemingly politically neutral. An interesting case in point is that in all South African mathematics textbooks, the institutional affiliation of authors disappeared from textbooks after the student revolts against the unjust and unequal educational system in 1976 and 1980.[6]

The above description of the coming-into-being of the South African school mathematics curriculum points to the fundamental role that conception and interpretation play in curriculum as an agency of discrimination. This separation of conception and interpretation from execution reduces teachers to mere technicians to implement others' ideas. Shipman asserts that "the maintenance of inequality through the curriculum is not only more subtle, but also more effective than depending on more obvious selection procedures".[7] I would argue that attempts to unravel the ideological intent of mathematics education must include the unpacking of the conception and interpretation of the mathematics curriculum. Basic issues that need to be addressed are posed by questions such as: Who conceived the curriculum and in whose interests was it conceived? Who were the participants in the design process? Who interprets the curriculum? What are the underlying motives for particular interpretations? Who should be the participants in the process? Should there be differences in the processes of conception and interpretation for different countries depending upon their stage of development towards democracy and their national needs? Should there be a period of "Dictatorship of the Proletariat" in curriculum conception and design in politically decolonized countries and those countries in the throes of political decolonization?

Strategies of resistance

Aronowitz and Giroux[8] make a strong case for the need to transcend the level of critique and for radical educators to move into the realm of the language of possibility. What they mean by this is that educators who are fundamentally opposed to authoritarian practices and convinced of their task to assist the oppressed to find their voice should search for space in curriculum design and practice to develop oppositional forms of knowledge. This section addresses the attempts by South African mathematics educators to develop just such oppositional forms of mathematical knowledge and places these efforts within their global perspective. An overview is given of the efforts by organisations, projects and agencies fundamentally opposed to status quo-preserving initiatives and agitating for the fundamental transformation of South African society to redress the educational impoverishment, especially school mathematics education.

Currently two such resistance strategies are being employed. At one level the syllabus content is appropriated and reinterpreted in terms of the reality of the students and the aspirations of the people in their quest for liberation. This strategy has much in common with the one employed by FRELIMO teachers in their liberated zones during the Mozambican revolution as reported by Gerdes.[9] In South Africa the term "liberated space" is used. The following is an illustration of this type of resistance action.

The topic being dealt with in the class is volume of rectangular prisms. The syllabus states the following: Construction of rectangular prisms in layers leading to the formula for volume of a rectangular prism.

The scenario of a procedure of classroom practice is as follows. After the concept of volume is developed through practical activities, a pamphlet which calls on the people to march to the educational offices to demonstrate their abhorrence of apartheid education and their demand for a non-racial unitary system of education is discussed. The focal point of the discussion is the sentence: We demand an end to overcrowded classrooms.

These discussions lead to the question: "How do we determine whether a room is overcrowded?" Discussion of this question through teacher hints leads to the conclusion that one way of addressing this problem is to find the volume of the classroom. Through actual measurement students find the dimensions of their classroom and calculate its volume. Information regarding the occupancy of a room is provided to students and they are now required to determine their specific situation with regard to the question of overcrowdedness. Their solutions bring about discussions of newspaper articles, the under- and non-utilization of classrooms in white schools and the campaigns around the opening of all schools for all South Africans. Furthermore, speculative discussions are held with respect to overcrowded classrooms in a post-apartheid South Africa with a democratic government.

Later, students do linear equations and problems leading to linear equations. During this topic they are encouraged to interrogate critically the reality situation of the textbook problems they are required to solve. The problem below appears in a textbook which is widely used in black schools.

In standards six and seven (eighth and ninth school year respectively) there are altogether 165 pupils. In standard six there are thirteen pupils more than in standard

seven. How many in each class? (Answer: eighty nine pupils in the standard six class and seventy six pupils in the standard seven class). The answers to this problem are discussed around questions such as: Is this classroom situation typical in all schools in our country? Whose interest is the author serving? Discussion around these issues is related to the discussion on volume and classroom occupancy.

Activities of this nature fall within the realm of what has been termed "political conscientization". In the process, students' mathematical work is related to the day-to-day struggles of the people. Within the constraints of the rigid South African school mathematics curriculum with its various control mechanisms there are possibilities for contestation. By doing it this way mathematics teachers are protected: they are "covering" the work that is expected of them and they can do political work in the classroom.

On a broader level, the question of whether such political conscientization through mathematics should only be done when authoritarian regimes are in control or whether this practice should be followed regardless of the government in control should be addressed.

A second strategy is the construction of topic-specific newsletters. After a topic or unit has been dealt with, students construct a newsletter in which all the articles and items deal with the specific mathematical topic. Advertisements, cartoons, letters to the editor, articles for lost and found columns, puzzles, editorial comment, and so forth are developed by students and used as the content of the newsletter. One such newsletter, *Quad News*,[10] developed by pre-service teachers, dealt with the theory of quadratics. Exerpts from some of the articles that appear in the newsletter are given below.

From the editorial comment:

> Explaining the reasons for the policy (of separate parliaments for separate "race" groups), the leader of the Quadratic Party, Mr P W Irrational-Roots said that the policy had a scriptural basis because the Danish mathematician, Niels Abel, had proven in 1823 (or 1828 according to some sources) that there exists no general formula for solving equations of degree 5 and higher. Mr Irrational-Roots said this proved conclusively that equations of degree 5 and higher are inferior to quadratics, cubics and biquadratics all of whom possessed a formula.....
>
> Mr Complete Square, the Minister of Foreign Affairs, justified the policy to foreign leaders by saying higher degree equations and polynomials were incapable of playing a role in the government and had to be guided by Quadratics. "The majority of them cannot even be trusted to factorize!" Mr Complete Square added.

(In this editorial the white parliament was termed the house of quadratics, the ruling party the Quadratic Party, and the parliaments for Indians and "coloureds" were termed house of cubics and house of biquadratics respectively. The Africans who, through this constitutional setup, had no parliamentary representation or house were termed quintics.)

From the news section:

> Yesterday, the Parabola brothers namely, $y = ax^2 + bx + c$ (a0) and $y = ax^2 + bx + c$ (a) escaped from prison. They are masters in disguise. Their standard form is ax2 + bx + c = 0, where x is the variable and a, b, c are constants. c is called the absolute term. Should they desire it, the Parabolas can quite easily get rid of the absolute term (c = 0) and appear in another form, for example, $y = ax^2 + bx$. People should be

> alerted to the possibilities....The Quadratic Equation-case made headlines a year ago when the Parabola-brothers stood trial. They have tortured some high school students over a period of 10 months. The police only discovered the offences after one of the students unsuccessfully tried to commit suicide - he has given up all hope after a long struggle with Quadratic Equations.

From the lost and found column:

> Recently my function, a quadratic, was lost in the immediate vicinity of the origin [0;0]. This function can easily be recognised by its real, rational roots...it can reach a minimum of -4. This function is alleged to have last been seen at the point [-0,5;-1,75] just before crossing the y-axis at -3. Anyone who finds this missing function should kindly return it the council of Quadratics, where it is desperately needed in the calculations department.

The construction of newsletters are preceded by discussions of excerpts from Flatland.[11] A direct result is that students do address socio-political issues. The Flatland exerpts are used to illustrate that mathematics can be applied in a variety of situations - even in writing about the stratification of society, class and gender discrimination and the difficulties experienced in getting new ideas accepted. These issues are brilliantly exposed in Flatland which, in addition to being a description of polygons, is a social satire describing english society in the late nineteenth century.

Writing in mathematics, other than the writing down of answers and answer-producing procedures, is currently emerging as a means of increasing students' engagement with mathematics and of providing teachers with feedback about students' level of understanding of mathematical topics. Hoffman and Powell argue that allowing students to construct problems is a useful way to empower students mathematically.[12] Although students can be empowered through problem construction, limiting writing to this does not address the problem of social relations among students within mathematics classrooms. Who takes the lead, even in groupwork situations, and in the construction of problems? The "good" mathematics students, or those believing that mathematics is not for them? The broadening of writing activities can, in different ways, contribute towards the breaking down of the "mathematically clever and dumb" notions amongst students within mathematics classrooms. By using mathematical terms and concepts as metaphors and allowing students to express themselves in forms with which they are comfortable -whether it is a poem, a suggestion for a headline, the drawing of a cartoon, the construction of a crossword puzzle - more students are offered the opportunity to explore their mathematical potential. Practices such as these help break down "mathematical elitism" amongst students.

Conclusion

The production of the South African school mathematics curriculum has been described above. I have argued that it is at the level of conception and interpretation that supremacist ideology is built into the curriculum. It is at these levels that considerations of "teachers as transformative intellectuals"[13] are excluded, resulting in their being treated as technocrats. This situation is further exacerbated by producers of textbook and curriculum materials; they are motivated by profit and therefore only consider the need to get their products approved for the education market. By exposing the process of curriculum development in South African school mathematics we can address the question of whether school mathematics

education is reformist and preserves the status quo or whether it is transformative and emancipatory.

At another level, however, there are attempts by mathematics educators in collaboration with teachers to address the immediate demands of students for relevance of the mathematics to which they are exposed. In order to satisfy this demand as well as the bureaucratic demands of the state, a strategy of incorporating the day-to-day struggles of the people, where appropriate, into the mathematical experiences of students, has been adopted. This incorporation not only includes conscientization of the evils of the state but also the sowing of seeds for consideration of what will be tenable during the period of reconstruction in a post-apartheid society. This strategy of building political considerations into the state-delivered mathematics curriculum is one which does not alienate teachers but strengthens them in their struggle for a just and democratic society. It is one with which they feel they can cope.

Acknowledgement

This article is based on a paper presented at the First International Conference on the Political Dimensions of Mathematics Education: Action and Critique, London, April 1990.

Notes and References

1 See the address given before the South African Senate, 1954, by HF Verwoerd in B. Rose and R. Tunmer(eds.), *Documents in South African Education* (Johannesburg: AD Donker, 1975). See also Verwoerd's statement about the black child and mathematics as cited in D. Harrison, *The White Tribe of Africa: South Africa in Perspective* (Los Angeles: University of California Press, 1981).

2. See the 1989/1990 presidential report of the MASA president in which he relates how MASA was founded as a whites-only organisation in 1969: *MASA News*, 5 (November 1991): 11.

3. "Immediatist " derives from "immediatism", described as "an impatient anticipation of imminent victory, a hubristic assessment of progress made, and a naive underestimation of the resourcefulness of the state", in C. Bundy, "Street Sociology and People's Politics: Some Aspects of the 1985 School Crisis in the Western Cape" (Paper presented to the Centre of African Studies, University of Cape Town, July 1986).

4. J. Lind-Brenkman, "Seeing Beyond the Interests of Industry: Teaching Critical Thinking", *Journal of Education*, 165, 3 (1983): 283-294.

5. See Monteith, who addresses the desirability or not of this with regard to history textbooks. M. Monteith, "The Making of School History Textbooks in South Africa" (unpublished paper for the History Math Materials, Education Faculty, University of the Western Cape, 1989). A perusal of authors of school mathematics textbooks series used in Western Cape schools, A. Gonin et al show that a former mathematics teacher and a current deputy director of the department of education and culture, house of representatives became a co-author of this series in 1989. The issue at stake is not the competence of subject advirsers, inspectors and other officials. Given the curriculum

construction process, it is rather to open up the issue of whether such a practice is desirable.

6. For the series A. Gonin et al, *Graded Mathematics for Junior Certificate* (Cape Town: Nasou), the 1962 editions contains institutional affiliation of the authors. A later edition, *Modern Graded Mathematics for Junior Certificate* (Cape Town: Nasou), is undated but can safely be assumed to be an early 1970s edition because the major author changes his affiliation from the University College of the Western Cape to the University of the Western Cape, and also contains the institutional affiliation of the authors. In later editions of this series, for example, the ones based on the 1985 syllabus, the institutional affiliation of the authors are not mentioned.
7. M. Shipman, "Curriculum for Inequality", in R. Hooper (ed.), *The Curriculum: Context, Design and Development* (Edinburgh: Oliver and Boyd, 1971).
8. S. Aronowitz and H. Giroux, *Education under Siege: The Conservative, Liberal and Radical Debate Over Schooling* (South Hadley, Massachusetts: Bergin and Carvey, 1985).
9. P. Gerdes, "Changing Mathematics Education in Mozambique", *Educational Studies in Mathematics*, 12, 5 (1981): 455-477.
10. *Quad News*, (A newsletter produced by the 1989 mathematics method students of the University of the Western Cape).
11. E. Abbott, *Flatland: A Romance of Many Dimensions* (New York: Harper and Row, 1963).
12. M. Hoffman and A. Powell, "Mathematical and Commentary Writing: Vehicles for Student Reflection and Empowerment", *Mathematics Teaching*, May (1989): 55-57.
13. Aronowitz and Giroux (1985).

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What Counts as Numeracy? Four Approaches to Numeracy Education for Adults in South Africa

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The provision of adult numeracy education has been largely neglected in South Africa, despite the large number of innumerate adults and the numeracy demands placed on people in times of economic hardship and technological change. Local efforts to explore the theoretical and practical contexts of adult numeracy have also been meager. This paper analyses four approaches to adult numeracy education in South Africa and highlights some of the implications of each approach for the practice of adult education. The paper argues against the prescriptive, highly structured, decontextualized, standardized approaches to numeracy education which prevail in traditional and functional programmes in South Africa. It advocates the development and implementation of a "social" approach to numeracy, in which mathematical skills are taught alongside literacy and critical thinking.

Introduction

Most people concerned with the basic education of adults would probably acknowledge that the term "numeracy" (like "literacy" and "adult basic education") is ambiguous and confusing. There is no universally accepted definition of it. Numeracy has been described in a number of ways, reflecting different philosophical positions in adult education.

This paper presents four different approaches to numeracy. The intention is to expose the assumptions underlying each approach to numeracy, to clarify different perceptions of the "problem" of innumeracy, and to explore some of the implications of each approach for the practice of adult education. The aim is not to treat numeracy comprehensively or definitively, but instead to stimulate discussion on an aspect of adult basic education which has been relatively neglected in South Africa, in the hope that such discussion will be useful for practitioners and policymakers.

Each approach to numeracy is presented under a heading. Two of the headings - the "Traditional" and "Functional" approaches to numeracy - are used in the literature for both literacy and numeracy.[1] The other headings, "Numeracy as an Aptitude" and "Social Numeracy" are not so accessible in the literature, although the latter concept emerges from discussions of literacy and numeracy taken in a social context.[2]

The Traditional approach to numeracy

The "Crowther" report of the Central Advisory Council of Education (in England) defined numeracy in 1959 as "the minimum knowledge of mathematics and

scientific subjects which any person should possess in order to be considered educated".[3] This definition suggests that numeracy is a product, though not necessarily an end-product, of schooling in a numerate discipline. It implies that a sophisticated level of mathematical and scientific understanding is required for numeracy,[4] and that the precise level of "minimum knowledge" will be determined by the numerate, or educated, members of society. The definition also implies that numeracy provides access to superior culture and information.

The problem with using the term numeracy to describe a minimum competence in mathematics lies with the vast continuum of mathematical knowledge and the equally vast range of contexts in which mathematical knowledge and skills are required. There simply is no agreement about what constitutes a minimum level of competence for adults. A mathematician at the Council for Scientific and Industrial Research might consider a person with matric level mathematics to be barely numerate, while a domestic worker who can take down a telephone number dictated to her over the telephone might be considered by her employer to have adequate number skills. While there are mathematical skills which are widely used by adults, in particular estimation and mental methods,[5] these general skills do not indicate any level of mathematical competence needed across a wide spectrum of occupational and lifestyle circumstances.

Learning mathematics "to be considered educated", as set out in the Crowther report, is a value-laden criterion for adult numeracy which says nothing about individual mathematical competence. Many people who are educated are also mathematically incompetent. One reason for this may be that in western society innumeracy, unlike illiteracy, has been socially acceptable for decades.[6] Swanson provides an explanation for this:

> Early in the history of education, mathematics was not a respectable school subject. It was a technical crutch leaned on by unschooled men who were interested in clockmaking and in navigation. Even in the twentieth century there is a good possibility that more mathematics has been learned in the bazaars of the world than in its classrooms and more mechanics has been learned on farms than in technical schools.[7]

Swanson's statement challenges several of the assumptions underlying the traditional approach to numeracy: that there is a normative standard for numeracy, and that this standard corresponds to a specific level of schooling; that standard educational approaches to teaching mathematics lead to numeracy; that mathematical knowledge and skill are valuable acquisitions in themselves, but also lend social status to the numerate.

The traditional approach to numeracy equates innumeracy with lack of opportunity in formal schooling. Innumeracy, like illiteracy, is perceived to be a debilitating national illness contributing to low productivity, unemployment and a self-perpetuating "culture of poverty". The way to eliminate innumeracy is therefore to provide adults who did not go to school with the same education in mathematics which schoolgoing children receive.

This is the approach to numeracy education taken by the Department of Education and Training (DET), the state body controlling education for blacks in South Africa. Since 1975 the DET's strategy has been to provide standardised primary schooling for adults at "Adult Education Centres" (located mainly in township schools but also in rural areas), and to promote the use of the school

syllabus in adult education programmes in industry. Adults enrolled in night schools are taught their numbers using the same personnel, syllabus, teaching methods and materials as those used in the day school. The cultural background and social contexts of adult learners are not considered relevant to the instructional process because numeracy is perceived to be the acquisition of a body of knowledge which is contained in books and taught by teachers at schools. The aim of such numeracy instruction is to prepare learners for entry to the lowest levels of the formal school system, and corresponds to what Phillips[8] has called the "educational" rather than the "social" meaning of adult education.

Numeracy as an aptitude

White[9] has described a widely held concept of numeracy: that number skills are a special gift or talent. Certain people are "good at figures" while others seem to have no aptitude for numbers at all. From this perspective, numeracy is not an educational attainment, as stipulated in the Crowther report, nor a response to the mathematical demands of the environment, as suggested by Swanson, but the development of a personal aptitude or predisposition.

One problem with this point of view is that it is often difficult to differentiate between aptitude and attitude. Striking ability in some areas is often accompanied by a "mental block" so far as mathematics is concerned. It has been argued[10] that unsatisfactory past experience of learning mathematics at school rather than any lack of aptitude in mathematics causes "maths anxiety" whose symptoms include "blocking out numbers", avoiding situations in which mathematics is required, forgetting simple computations and feelings of tension and anxiety when confronted with mathematical problems.

Mathematics instruction in school frequently stresses drill and memorisation of operations rather than an understanding of number. And mathematical concepts may well be taught before individuals have developed the necessary cognitive structures to accommodate them.[11] This may lead to failure and frustration, resulting in negative attitudes towards mathematics and diminished self-confidence. Many students report that they see no relation whatever between what is taught in mathematics class and the skills needed in everyday life situations.[12] So it appears that the "mental blocks" which inhibit mathematical competence (either scholastically or in everyday life) may be caused as much by lack of confidence and lack of knowledge as by lack of aptitude.

The confusion between aptitude and attitude extends beyond the classroom. Gender and cultural biases also influence attitudes towards mathematics. In western society mathematics is generally considered to be a male domain. It is also thought to be related to intelligence, which is why so much number material appears in intelligence tests.[13] There is a widespread belief that women are innately inferior to men in their capacity for mathematics. Yet numerous studies have been carried out which refute this notion.[14] It is apparent that sex role factors (steering girls towards doll houses and boys towards model airplanes) rather than innate ability account for gender related differences in mathematical performance. As British educationist Burton puts it, "...sex-differentiation in mathematics education reflects the distribution of power in our society".[15]

In South Africa race and culture have often been seen as determining mathematical capacity. "Western" mathematics[16] is claimed as evidence of the

white man's cultural superiority, while the mathematics generated in African cultures is considered inferior or negligible. Michau[17] suggests that the languages spoken in indigenous South African cultures may hinder the accessibility of mathematical concepts, while the transition from mother tongue to English as a medium of instruction in black schools complicates conceptual learning. The school curriculum for black children and adults, designed by conservative white educationists, ignores learners' enviroments, presenting mathematics as an alien cultural product. Mathematics is taught in isolation from social and political issues, divorced from the world of its applications. It is hardly surprising, then, that so many people experience mathematics as an abstract, meaningless and irrelevant school subject, unlikely to be useful in real life. Education which alienates learners from their own culture, without developing confidence and competence in the "new" one, leads to a sense of failure and dependency.[18] In this way the dominant group's view of mathematics education creates barriers to others' understanding and progress. These barriers in turn reinforce stereotypes and prejudices concerning ability in mathematics.

Fundamentally, proponents of the view that numeracy is an aptitude perceive mathematical facility to be a binary state - either you have it or you don't.[19] Biology is destiny. The criteria for numeracy are vague, but would seem to require abilities which extend beyond the practical demands of everyday life. These abilities are not all of the same type: for example a landscape artist and an airfreight dispatcher might share an aptitude for spatial relations (the mental ability to manipulate objects in three dimensions) although they may have less aptitude for mechanical reasoning (an understanding of how levers and gears work) than a construction worker, and less aptitude for abstract reasoning than a systems analyst.

A major problem with viewing numeracy as an aptitude or predisposition is the implication that there is equal opportunity to learn; that the same quantity and quality of mathematical experiences are available to everyone, even in culturally diverse societies. The emphasis is placed on individual intelligence or predisposition to make the most of these opportunities, while the socio-political and cultural forces which affect access to education and the quality of educational experiences are ignored.

Because neither the school system nor the social environment is held accountable for innumeracy, educational programmes are not seen to compensate for innumeracy, although they may provide an arena for the identification and development of mathematical aptitudes. In adult education the value of this concept lies in the recognition that individuals who have received little or no formal schooling, and whose language and literacy skills are very limited, may yet have striking mathematical aptitude. Illiteracy is not a reliable indicator of innumeracy, and educational programmes which rely heavily on paper and pencil work for the assessment and teaching of number skills may be missing the point.

A further implication of this approach to numeracy is that adult educators themselves may need a very broadly based background in mathematics in order to recognise and nurture learners' mathematical aptitudes. Gerdes, Bishop and Gay[20] are all convinced that it is necessary for teachers to investigate "indigenous mathematics" further in order to help learners make contact with the constructs of mathematics per se. It is also clear that teachers operating in multicultural settings need to be aware of the cultural and social values inherent in mathematics education, in order to clarify (for themselves and for learners) their role in cultural development.

Functional numeracy

Swanson's statement, quoted earlier in this paper, introduces the functional approach to numeracy. Here number skills are seen not as a product of formal education, as in the Crowther report, nor as a particular aptitude or predisposition, but as a requirement for participation, and particularly for economic self-reliance, in the society in which an individual or group lives.

Of course, different societies present different mathematical phenomena to be understood and interpreted, and place different demands on their members' number skills. People who live in cities, for example, use different number skills from people who live in rural villages.[21] Not only are the contexts in which people use number skills extremely varied, but these contexts are also subject to change. Quadling remarks that "It is a curious paradox that the world is becoming simultaneously both a more mathematical and a less mathematical place to live in. At the level of personal skill, the demands made on us are less than those made on our parents and grandparents".[22] Electronic banking, for example, has made the skill of balancing a chequebook redundant; the pocket calculator has made calculating with logarithms virtually obsolete; the decline of the purchasing power of the rand has made calculating the small change for purchases almost negligible.

The functional approach to numeracy recognises different kinds of numeracy, but maintains that there is some basic level of competence which is required for effective functioning in society - not only on the basis of individual survival, but also for overall community development.[23] Economic needs (the need to earn a living and manage money; the need for greater participation in the economic life of the country) take precedence over social needs (the need to establish oneself in a new and unfamiliar environment; the need to communicate ideas about number; the need to develop confidence as well as skill in manipulating numbers).

The criteria for "effective functioning" are usually described in terms of competencies, expressed either in mathematical terms (addition, subtraction, decimals, and fractions) or as functional skills (budgeting household expenses, costing goods or measuring weights). Competencies are related to specific contexts - usually the everyday activities of the workplace or market - which are often placed within the broader contexts of policies and programmes such as community development, economic upliftment, and functional literacy work.

Levine has observed that the term "functional" carries persuasive, positive connotations - "purposely active", "effective", "making a contribution to a whole" - which encourage optimistic assumptions about the effects of basic education on adults and society.[24] Indeed, the term seems to imply that relatively low levels of achievement will result in desirable outcomes such as employment, economic growth, job advancement and social integration. These inferences and implications need to be analysed carefully in relation to adult numeracy.

Functional numeracy links the teaching of mathematics to the context in which the mathematics will be used, as determined by practitioners and policymakers. There are several problems with this: first it tends to reduce numeracy to a checklist of measurable skills, restricting its meaning to a limited and limiting coping skill, while nurturing the perception that numeracy education is an apolitical, acurricular, essentially reactive process.[25] Secondly, it assumes that there is a commonly held set of values which permit the specification of content guidelines for numeracy

activities. This assumption is questionable in a volatile, multicultural society such as South Africa, and is undermined by the rapid rate of technological and social change affecting employment patterns and socio-cultural practices. Thirdly, it assumes that the locus of control should rest with practitioners, since the innumerate do not demonstrate functional competence to manage their affairs.

The essential problem with functional numeracy, then, is that the types of competencies which educators define for instructional purposes tend to be of the kind which promote behaviours and attitudes which conform to existing social arrangements (for example learning to read prices and labels of manufactured goods; filling in bank forms; following instructions).[26] Learners are taught "coping" and "survival" skills ostensibly to bring them into mainstream society, but which in fact serve to put them within reach of bureaucratic channels of communication and authority. The curriculum is often a predictable "package" of remedial, low status education which helps learners accommodate, or adjust to, prevailing social circumstances. The limited level and range of skills taught are unlikely to remedy structural inequalities such as unemployment, low pay or inadequate housing. Learners do not learn to question their circumstances or challenge the social arrangements made by employers, institutions and state agencies which contribute to their disadvantaged position in the first place. The emphasis is on adjusting and training, rather than on empowerment for social change.[27]

Functional numeracy instruction in South Africa tends to be orientated towards human resources development in the workplace. It teaches people to do specific jobs requiring number skills (for example in the banking, construction and mining industries) or to understand their payslips, rates of pay, wage negotiations, and financial commitments (as part of induction programmes in industry and commerce, or worker education provided by trade unions). Two examples of local functional numeracy programmes are the Building Federation of South Africa's "Entrepreneurial Course for Small Builders," which teaches adults basic arithmetic skills using a handheld electronic calculator, and the South African Committee for Higher Education's "Basic Arithmetic Course for Adults" which helps workers in industry to understand their rates of pay and printed payslips.

Social numeracy

The Advisory Council on Adult and Continuing Education in Britain has remarked that numeracy and literacy are not separate elements in basic education "to be learned like the kings and queens of England: they form the reality which the communication skill of words and numbers enable the student to grasp, and they will often be the subject-matter of literacy and numeracy practice".[28] In other words, numeracy, like literacy and language, is related to personal and social experience, and should form both the content and process of basic education.

The connection between language, literacy and social experience has long been recognised by sociolinguists such as Breen and Chandlin:

> If we present the learner with language only as an object, as if it were separable from the learner's relevant psychological and social experience, we are almost certainly postponing development of the learner's ability to communicate through language. We may be divorcing language learning from its essential interpersonal nature and offering it as a static object to learners who have themselves experienced the use of their first language as very much an interpersonal undertaking.[29]

The social concept of numeracy rejects traditional, subject-based approaches to mathematics as contrived and mechanistic, unlikely to be useful in real life. It also maintains that the functional concept of operative mathematical skills in prescribed contexts is too restrictive. It is concerned with a wider social frame of reference than work-related functional numeracy implies. Social numeracy programmes uphold the Freirian concepts of learner-centered and learner-directed curricula: the content and process of numeracy activities are founded in learners' personal circumstances, attitudes, ambitions and views of themselves.[30]

Proponents of social numeracy reject the notion of one "minimum" or broadly defined level of mathematical competence, believing that basic education should be responsive to a vast range of individual and group learning needs. Social numeracy sees the contexts in which adults use number skills as extremely varied. A professional photographer in Soweto, for example, needs different mathematics from a housewife who supplements her family's income by catering for wedding receptions. These social contexts are also subject to change: technological advances and the state of the national economy are obvious examples of forces which influence the broad social contexts of numeracy.

An important assumption underlying social numeracy work is that both the acquisition of number skills and the process of acquiring them lead to growth in self-esteem and confidence, enabling people to participate in and benefit from a wider range of activities than was hitherto the case. Social numeracy programmes therefore attempt to meet learners' personal needs to acquire a greater degree of control over their own lives, to be more autonomous in carrying out their adult duties and responsibilities, and to exercise more freedom of choice over their lives. The development of learners' social and political consciousness is an important aspect of social numeracy programmes. The process of individual empowerment is seen to be the basis for more far reaching social change.

One implication of this approach to numeracy for the practice of adult education is that teachers themselves may need extensive training and support to provide the envisaged kind of numeracy education to learners. Many literacy teachers seem to lack confidence in their own ability to handle everyday transactions requiring mathematics,[31] and it appears quite likely that their experience at school was of the very methods which cause blocks to understanding, failure and frustration.[32] In addition, most literacy teachers in South Africa are women, and women are most likely to have been underprivileged in mathematics education. It appears that teachers themselves may have to gain knowledge and confidence in mathematics before assisting others in the process of acquiring number skills.

An additional problem, until recently, has been the lack of a suitable social numeracy curriculum to give guidance to teachers on the development of syllabi, materials, teaching methods and evaluation strategies. Curricula developed abroad require extensive interpretation and adaptation to accommodate the specific socio-economic, language and literacy circumstances of adults in South Africa. Local organisations have been tardy in developing original materials and experimenting with teaching methods in numeracy.

A start has now been made towards teacher training and the development of a social numeracy curriculum by several Johannesburg-based literacy organisations including Use, Speak and Write English (USWE), English Literacy Project (ELP) and Learn and Teach. These organisations are developing materials and methods for social numeracy which complement their literacy work. Their orientation is towards

developing learners' confidence, problem-solving and communication skills while probing the political and social implications of mathematical problems and their solutions.

Conclusion

This paper has outlined four different approaches to numeracy in the basic education of adults in South Africa. Each approach presents a different view of the problems which numeracy education should address, the proper aims of numeracy education, and appropriate methods of delivery. Each approach envisages a different outcome of numeracy education. The paper also sets out some of the implications of each approach for educators involved, or about to be involved, in providing numeracy education to South African adults. Yet many important questions surrounding numeracy education remain unanswered: is there any relationship between numeracy and the economic development of rural and urban communities; between numeracy and the improvement of living conditions; between numeracy and self-realisation; between numeracy and social standing; between numeracy and the empowerment of people; between numeracy and the attainment of participatory structures? Are individual and community needs for number skills compatible with the aims of adult education providers? Perhaps these and other questions posed by literacy fieldworkers, organisers and theoreticians, will encourage adult educators to explore the field of numeracy education further. Hopefully "What counts in numeracy education" will become a topic for lively discussion and debate in adult education in South Africa.

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3. In Penny (1986), 24.
4. An advertisement placed by the Safmarine Corporation in the 31 July 1988 *Sunday Times Business Times* calls for "Numerate Graduates and MBA's for Cape Town to work on an inhouse management information and fleet development system". In this instance the term "numerate" is clearly linked to a high level of scholastic achievement rather than basic numerical proficiency.
5. A. Withnall, M. Osborn, and A. Charnley, "Numeracy and Mathematics for Adults", *Review of Existing Research in Adult and Continuing Education, Volume VII* (Leicester: National Institute of Adult Education, 1981), 4.
6. Withnall et al (1981), 46.
7. G. Swanson, "Non-formal Education - Preliminary Observations re: Current Status and Next Steps" (Conference paper, University of Natal, undated).
8. See H. Phillips, *Literacy and Development* (Paris: UNESCO, 1970).

9. Withnall et al (1981), 2.
10. See S. Tobias, *Overcoming Math Anxiety* (New York: W.W. Norton and Co., 1978); D. Robertson and J. Claesgens, "Maths Anxiety: Causes and Solutions" (paper presented at the Minnesota Vocational Summer Conference, Minneapolis, 1979); and L. Wilson and R. Wilson, "Mathematics anxiety and Adult Education", *Adult Literacy and Basic Education*, 8, 1 (1984): 26-33.
11. Wilson and Wilson (1984): 28.
12. Penny (1986), 23.
13. Researchers believe that mathematical prowess is influenced by the right hemisphere of the brain, the half which dominates in left handers. Biological explanations conclude that students who have high scores in advanced mathematical reasoning tests are more than twice as likely to be left-handed (and therefore "right-brained") as they are right-handed. According to one hypothesis, exposure to testosterone, the male hormone, may enhance development of the right brain: this would account for the persistently higher score which boys attain in mathematics aptitude tests in Britain and the USA.
14. See L. Fox, E. Fennema and J. Sherman, *Women and Mathematics, Research Perspectives for Change* (Washington: National Institute of Education, 1978); and L. Buxton, *Do You Panic about Maths?* (London: Heinemann Educational Books, 1981).
15. L. Burton (ed.), *Girls into Mathematics Can Go* (London: Cassell, 1986).
16. See A. Bishop (ed.), *Educational Studies in Mathematics* (Netherlands: Kluwer Academic Publishers, 1988), who points out that the label "Western" mathematics is inaccurate and properly resented by many mathematicians throughout the world. Mathematics is not the product of any one culture and no one should claim it as theirs exclusively.
17. See J. Michau, "Problem Areas in the Acquisition of Mathematical Concepts by Black Children in South Africa", *Journal of Education*, 10 (July 1978): 21-29.
18. U. D'Ambrosio, "Mathematics Education in a Cultural Setting", *International Journal for Mathematics, Science and Technology*, 16, 4 (1985): 469-477.
19. Clark (1984): 136.
20. See Bishop (1988), 187-9; P. Gerdes "On Culture, Geometrical Thinking and Mathematics Education", in Bishop (1988), 137-162; and J. Gay and M. Cole, *The New Mathematics and an Old Culture: A Study of Learning Among the Kpelle of Liberia* (New York: Holt, Rinehart and Winston, 1967).
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25. S. Brookfield, "A Critical Definition of Adult Education", *Adult Education Quarterly., 36, 1* (Fall 1985): 44-49.
26. Levine (1982): 261.

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28. Advisory Council for Adult and Continuing Education (ACACE), "A Strategy for the Basic Education of Adults" (Leicester 1979): 15.
29. M. Breen and C. Chandlin, "The Essentials of a Communicative Curriculum in Language Teaching", *Applied Linguistics*, 1, 2 (1980): 94.
30. See P. Freire, *Pedagogy of the Oppressed* (London: Penguin Books, 1970). Freire perceives that literacy can create changes in social patterns, in awareness, and in people's understanding of health, educational and social issues.
31. The problem appears to be one of confidence as much as competence. This has been expressed to the author in a number of ways: in interviews conducted in Johannesburg, February 1987, teachers said that they "had never been any good at maths," that they had "no idea about the maths taught at school," that they couldn't explain to someone else how they solved everyday mathematical problems because they themselves didn't solve them in the "right" way (that is, the way they had been taught at school).
32. Withnall et al (1981): 20.

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Politics and Practice in Mathematics Education in South Africa

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In the past decade a considerable literature, mounting pedagogic and political challenges to dominant conceptions of school mathematics, has emerged. Conspicuous by its absence, however, is a critical engagement with the obstacles to and unevenness in the implementation of mathematics programmes with progressive ideals. This paper describes and then reflects critically on the implementation of the mathematics component of the Community Based Education Project (CBEP). It argues that there is no smooth translation of "what" into educational practice. It is only through praxis, through constant reflection of ideas in action under concrete conditions, that we can shape both "what" might be empowering practice and "how" this can come about. As South Africa moves rather rapidly into a period of transition from opposition to reconstruction, questions of how to address the crisis in education become paramount. In particular, the development of school mathematics and science requires urgent attention.[1] It is in this context that this paper derives its meaning and makes its contribution. Hopefully, it will also contribute to the more general debates on critical pedagogy.

Recently, one of my post-graduate students attempted to implement ideas developed during a course on the politics of mathematics education in her standard seven class in a black township school. Drawing on the ideas of Fasheh, Mellin-Olsen and more particularly on the development of ethnomathematics by Gerdes in Mozambique, she attempted to explore the potential of a popular game called "Gaiza" for elaborating classroom mathematics.[2] In her attempt at mounting both pedagogic and political challenges to dominant conceptions of mathematical knowledge in schools, she was confronted by teacher resistance and pupil uncertainty. In addition, she had to cope with the extra time demanded by both the preparation and execution of the project.[3] Her experience highlights problems in the literature on alternative mathematics.

A return to the literature which inspired the project described above does not help to uncover why an attempt at "anthropological mathematics" for "cultural conscientialisation" as part of the "struggle against mathematical underdevelopment and the combat of racial and (neo)colonial prejudice" was such a struggle in the context of a democratising South Africa.[4] The obstacles to **implementing** Gerdes' "ethnomathematics", Mellin-Olsen's mathematics as "thinking tool" for social action (and more recently Brown and Dowling's "research-based" approach) or Fasheh's "education as praxis" for empowering people, are not developed in their writings.[5]

It is, of course, not surprising that new ideas and practices are taken up by practising teachers and their students with some difficulty. What is somewhat surprising is that a critical discussion of these issues is absent in the literature noted above. How do graduates of progressive pedagogy in teacher-training operate as

teachers once in school? Are there any struggles amongst teachers, between teachers and learners, and between teachers and the wider community? In the specific neo-colonial context, did teachers' histories in colonial education cease to ramify into their practices? How are classes as large as eighty in the lower grades with limited resources able to engage with new approaches? It is indeed interesting that a description and analysis of the power struggles which must inevitably arise in the context of implementation of progressive mathematics education is so limited in a literature which is, by definition, premised on the notion of politics.

Praxis is described by Fasheh as "the combination of concrete conditions (social, cultural and material), reflection and action in constant interplay".[6] It should therefore involve a constant analysis of and reflection on the **implementation** of progressive theory. An examination of this notion of praxis needs to inform a politics of mathematics education in any situation. The remainder of this paper analyses the formative stages and initial implementation of a "barefoot teacher" project in South Africa, the Community Based Education Project, within the framework of praxis as defined above. The CBEP will be examined within a consciousness of the struggle and dialectic in developing **both** the ideas for change and their translation and dissemination in practice. Such an examination will reveal that educational change, because encouraged and constrained by a historical context, is neither a simple substitution, nor a singular, uncontested process.

The CBEP: Its underlying assumptions and educational aims

The CBEP, a non-governmental, non-profit organisation, grew out of an initial request for a new school from parents in Alexandra township, near Johannesburg. The proposal was initiated in 1987, in the aftermath of the 1985 schools' crisis, and followed the call "Peoples Education for Peoples Power" (PEPP) in 1986.[7] At that time, the state of emergency had been in force for one year, and severe repression characterised education and the society at large. Numerous meetings were held involving both educationists from various progressive institutions and representatives from community organisations aligned with the broad democratic movement. In discussion, the model of a single school was rejected given that it is able to serve only a limited number of students. The project did not intend to set itself up as an alternative to state schooling. Rather, it intended establishing an effective bridging programme back into school, or into the workplace or into community life, for youth who, for politically complex and varied reasons, had dropped out of school.[8] It hoped to achieve this with pedagogic practices that would ultimately contribute to the development of a non-racial democratic South Africa. For the CBEP Steering Committee, democratising education meant more than consultative processes and opening up access to education: it included educational methods which would develop emancipatory practices.[9]

The project focus and fundamental principles that emerged from these discussions were:

- that the programme would offer training to community-sponsored facilitators on new and progressive methods of facilitating learning experiences. Such "barefoot" teachers would be provided with inexpensive, quality materials so that they would be in a position to teach in community-based classes;

- that it would set up an alternative education programme with communities so that the facilitators would be able to provide a bridge into school, community or work environments;
- that the programme would attempt to set up structures to be owned by the communities in which it operated and would have a greater generative effect in that it would meet the needs of more than one school.[10]

The core concept of the CBEP, the notion of a "facilitator", is innovative. At one level, it challenges traditional notions of selection into teacher education and so implicitly attempts to broaden access to education in a context characterised by grossly unequal and inadequate provision. At another level, it attempts to relocate ownership of education in communities. In this intention, and in the project's overall progressive framework, lay the seeds for a democratic and emancipatory educational intervention. The remainder of the paper will focus on the process of attempting to realise these aims during 1989 and 1990, specifically in the field of mathematics.[11]

Project structure[12]

A loose Steering Committee, comprised of a wide range of representatives from interested community organisations, was responsible for project policy. The Steering Committee set up a Curriculum Committee (CC) of a number of educators from different disciplines to conceptualise a skeleton curriculum that could guide the project in its development of the facilitators.

Two groups of project implementers were appointed during 1989: educationists and organisers/administrators. The educationists comprised two curriculum co-ordinators, who were both on the CC, and tutors who were initially appointed on the basis of subject expertise in mathematics, science, history, english, economics and geography. Their combined task was to implement the curriculum through developing learning materials to guide the training of the facilitators. The organisers/administrators of the project had the crucial task of both administering the project and consulting with community groups.

By the beginning of 1990, all these processes had come together. About forty facilitators, most of whom had a school leavers' certificate, but little more than that, had been elected by their community groups and were participating in the first training sessions.

The Curriculum Committee (CC) and the development of the skeleton curriculum

The approach during 1987 and 1988, both within and across committees, was "largely a discussion and workshop one with multi- racial, multi-disciplinary and multi-community consultation".[13] Feedback was generated from schools, teacher and student bodies, trade unions, youth groups, educational projects and others. This feedback was influential in initially shifting the curriculum from first a subject-based to an integrated one and then to an issue-driven spiral curriculum.[14]

It is not within the scope of this paper to analyse all the debates that informed this process. Here I merely try to sketch the emergence of the spiral curriculum and the debates involving mathematics.

In the discussions on an integrated curriculum during 1987 it was understood that mathematical elements would need to comprise a fundamental part of it. It became the task of the mathematics subgroup of the CC to:

(a) identify those concepts and skills that underpinned mathematics at each of two levels: (i) the primary - secondary school interface, that is, pre-standard six and (ii) pre-standard eight; and
(b) analyse how these might be merged into integrated curricula at these levels.

The point of departure for the mathematics group was the need to challenge the dominant absolutist view of mathematics in school, its elite status and the related pedagogic approach which promoted rote-learning and reinforced a narrow uncritical approach to knowledge. The result was a document that in the light of the above, (1) emphasised the importance of a problem-solving, process approach with group work, discussion and participatory assessment; (2) listed skills and concepts perceived to underpin mathematics at the pre-secondary school level and emphasised their development through the process approach above; (3) expressed concern that a totally integrated curriculum might restrict the development of mathematical skills by severing them from their mathematical context,[15] and (4) arising out of the previous point, advocated a two-pronged approach to allow for some specific mathematics studies alongside integrated studies.[16]

Activities that gave content to these points were discussed and documented and one example is described here for interest.

Some of the skills underlying pre-secondary arithmetic and geometry could be reinforced and integrated from an initial activity that explored what happens to the product of two two-digit positive integers if you subtract an integer from the one and add it to the other. For example, if we take the integers 37 and 23, their product is 851. If we then subtract 3 from 37 and add 3 to 23, we get 34 and 26 with a product of 884. This product is larger. What happens if we subtract 4 or 5 or -4 or -5? This problem incorporates a fairly open exploration of number relations while simultaneously reinforcing the skill of multiplication. The effects on the numerical product can then also be given visual form through an exploration of the area of a rectangle with changing sides but constant perimeter. Continuing our example, a rectangle with sides 23 and 37 has a perimeter of 120 and area 851. With sides 26 and 34 we have a rectangle with perimeter maintained at 120, but with a larger area of 884. This activity can lead to conjectures and generalisations for a maximum product/area. This activity can be integrated into a theme/topic related to housing by exploring how and why housing has taken on different forms under different conditions. It can also be extended mathematically (beyond standard six level) into algebraic generalisations, volume and other polygons.[17]

Similar working documents as that produced by the mathematics subgroup in other subject areas were then combined by the CC co-ordinators into an extensive, detailed schedule which linked the wide range of suggested skills and concepts with (a) topics and themes and (b) methods. This schedule resulted in a heated debate in the CC over whether the progressive (emancipatory/empowering) intent of the curriculum could be realised by what was perceived as a technical, and thus acultural and ahistoric, skills-based curriculum, or whether it should be driven instead by relevant community issues which are both cultural and historical. To give

content to this debate, CC participants conducted in-house workshops using "shelter" (a concept to suggest both homelessness and housing) as an "issue".

Three crucial concerns emerged during these workshops, each of which will be discussed again later in the paper.

(1) In relation to the learner, what became clear was that knowing the "issue" (that is, knowing **that** more and better shelter was needed for more people) did not mean having the skills to explore it (that is, knowing **how**). Just as skills need to develop from and in meaningful, relevant issues/contexts so does an exploration of issues require skills to be developed. Skills and issues are thus inter-related. The questions thus become: when? and how?
(2) In relation to the teacher, the recognition and use of mathematics as a tool in problematising social reality was not an obvious process: it requires mathematical know-how. In the first "shelter"-driven workshop, which was mediated by the language specialists, it is worth noting that neither mathematics nor science-related activities or questions emerged.
(3) In relation to pedagogy, the translation of mathematics recognised in "social issues" (for example, shelter) into mathematics learning activities (for example, measurement techniques and problem-solving strategies for maximising space) required skillful mediation. In the second workshop, which examined settlement of a group of homeless people specifically to invoke space and cost dimensions, participants effectively debated "needs". Only with directives and intervention by someone with both mathematical and pedagogic experience (skillful mediation) was mathematics invoked and developed.

Underlying the CC's interpretation of educational practice for empowerment was a crucial, though hidden, assumption about teachers and facilitators: they appear to need both educational and mathematical know-how. Herein lies a tension in CBEP that I will examine later.

In order to address the points above, a spiral curriculum was conceived which endorsed the views that (a) "issues related to community needs" should determine the direction of the learning with emphasis on a questioning and critical approach to learning and knowledge; (b) related skills then needed to be determined, integrated, and developed in a generative way; (c) specific subject skills and concepts that needed separate study were also to be identified. For example, an issue like "shelter" could initiate a critical learning process. Skills relevant to exploring "shelter" would be identified and developed in the context of shelter. Methodology and resources would then be developed **with** the facilitators for their own teaching, in recognition that such teaching skills would need to be consciously developed. After evaluation, the process would begin again, building concepts, skills and understandings developed earlier.[18] In contrast to the earlier detailed skills-based schedule, here was a skeleton with no prescribed content, but with conceptual guidelines for a curriculum from which relevant, meaningful learning could develop with increasing complexity.

Implementation - From skeleton curriculum to course materials

During 1989, funds were raised and the process of implementation commenced. Subject tutors were employed. Co-ordinators took the tutors through a training programme and exposed them to the project, its intent and development to that point. This obviously included discussion of the spiral curriculum. Once employed, the task of the tutors, together with the Curriculum Co-ordinators, was to begin to develop materials for facilitator-training in early 1990.

In November 1989 potential participant community groups requested that CBEP explain its "alternative" educational character. A workshop followed where co-ordinators and tutors presented the project and the initial materials for discussion and consultation. The introductory sessions of the meetings were characterised by fiery political rhetoric. In the specific curriculum sessions which followed, the spiral, integrated curriculum, in contrast, was nowhere to be seen or heard. Materials were presented in subject-defined groups. A list of skills and concepts drove the mathematics materials. "Issues" were invoked to contextualise concepts. There was no hint of integration or dissolution of subject boundaries. The interpretation of "alternative" lay in an **approach** which encouraged participative and group learning, questioning and critical thinking **within** subject boundaries.[19m]

While the project was commended for its consultative processes, some potential facilitators expressed a real concern that they would not be able to switch easily from dominant educational practices (transmission from teacher to taught) to the "alternative" approach envisaged by the tutors. They believed they would be pressured to behave like "teachers", that is, as the bearers of relevant mathematical knowledge, where "relevant" also meant "what is needed to pass school examinations".[20]

Critical reflection

One obvious, visible reason for the disjuncture between the spiral curriculum and tutors' mathematics materials on the one hand, and between the tutors' methods and those of the facilitators on the other, may be the separation of conception from execution. While not wanting to diminish this as a cause, a more complex explanation is developed here. The work of the CC and the steps taken by the tutors in implementing the project must be understood in terms of the interaction between critical pedagogy and the social reality of education in South Africa. This affects not only the tutors but also, more crucially, the facilitators and their communities.

The emancipatory pedagogy envisaged in the spiral curriculum (as well as in many of the interesting examples discussed by Gerdes, Fasheh and Mellin-Olsen[21]) requires the teacher to think on her feet - to be, as the workshops described above revealed, an expert mathematics educator who can recognise and extract mathematics from situations and turn it into curriculum activities on the spot. Such practice is a far cry from the current dominant mathamatics teaching practices and acquired teaching skills in South African schools. While such "experts" might be available as tutors, the CC perhaps did not consider seriously enough the more crucial question as to what these practices implied for "novice" facilitators who were to develop their mathematical and pedagogic know-how in a thirty six week (108 hour) course. How were they to develop sufficient mathematical know-how in so

short a space of time such that they could be flexible in adopting different approaches in their own teaching? Time constraint is an important question for critical pedagogy in general.

The additional demand on tutors to integrate subjects seems also not to have been taken into consideration by the CC. Sociologically, the reclassification and reframing of knowledge in the move from subject-bounded to integrated curricula requires an abdication of dominant and "common sense" notions of what counts in teaching and learning mathematics as well as a redefinition of self as educator. The progressive potential in such a shift for forcing a rethinking of relevant and appropriate education stands in sharp contrast to its intensely threatening nature, particularly for tutors employed because they were successful mathematics teachers in a conventional sense. Practically and pedagogically, integrated curricula involving mathematics have proven enormously difficult,[22] often because of the time demanded. In addition, there is very little experience of integrated curricula in South African schools and, where there are such programmes, mathematics is often specifically excluded.[23] In this context, the tutors' move away from integration reflects both objective conditions and the hegemony of school mathematics.

More generally, the crisis in education necessitates both access to education and transformation of its inadequate oppressive forms. Conceptually CBEP aimed to provide both a bridge back into formal school and to forge a vision of emancipatory practice. The task of designing materials that would lay the ground for re-entry into subject-based formal school and simultaneously transform dominant practice was onerous. With only abstract, broad guidelines from the CC, and a concrete, well-known, school mathematics curriculum which is content-laden, the strength of the pull towards the latter - to that which was known and successfully experienced in the past by the tutors themselves - was underestimated.

The access/change tension was also reflected in the tension between the project's emphasis on materials for facilitators and the assumptions of the community-owned, issue-driven curriculum. Because some of the potential facilitators and all their students would be drawn from people forced out of formal education by the growing crisis, the project saw the necessity of providing materials which could be used in the training of the facilitators and thereafter assist them in their subsequent teaching. This task became the responsibility of the tutors. Were the tutors then to choose the community-based issues? How could this be done in a democratic way? How was a materials-development process to begin, particularly since the facilitators would all come from differently constituted community groups? On reflection then, in this contradictory context, it is understandable that the initial mathematics materials were concept and skills-based. Again, this raises a question not only for CBEP, but also for critical pedagogy in general. Can materials be non-prescriptive? How can materials be knowledge-producing? Are these contradictory or do learners (and CBEP facilitators in particular) not need both?

At a political level, the spiral curriculum as an authorising document became an object of contestation. Despite an expressed commitment to the aims and consequent methodology of the CBEP, both the tutors and the facilitators engaged in a power struggle around the interpretation and development of the curriculum. In part, these struggles occurred because of the commitment of the project to internal democracy. They also mirrored the struggles which occurred around the development of the spiral curriculum itself. Its own development began with subject

boundaries, concepts and skills, and only after a process of consultation and intense debate did it achieve its final abstracted form. As with all policy documents, this form masked the process and struggle of its own production. In the light of the above, it becomes clear that the document did not have the clarity and authority required of a policy document. Such legitimacy, and with it a lessening of the power struggles thus far experienced, will only come with a more widespread and fundamental social acceptance of not only the aims, but also the practices required of radical pedagogy.

Where does this take us?

The tensions, conflicts and problems raised in this paper reinforce, once again, the constant reflection and development required in the praxis of critical pedagogy. Political mobilisation and democratic decision-making are necessary but not sufficient elements to start an emancipatory learning process from concrete conditions. These concrete conditions, and in particular the tenacity of its cultural forms and practices, must be understood in order to be contested. In CBEP's formative years (1987 - 1990), political mobilization was at a high level as education continued to be a site of struggle and resistance. As such, it is perhaps understandable that the CC underestimated the hegemony of existing social practices and the strength of apartheid education which for decades has consciously and systematically de-skilled the oppressed majority. Such de-skilling occurs not only at the level of denying citizens access to education, but also of institutionalising authoritarian teaching methods. At the same time, the CC possibly misjudged the nature of resistance by its expectation that alternative teaching methodologies would automatically be embraced.

This brings into focus important pedagogical questions which, while they emerge in an examination of the CBEP, have a general application. Firstly, how do we engage critically with prospective teachers who need to learn mathematics, and learn to teach it simultaneously? As mentioned earlier, the CC understood that while it was crucial that the facilitators be taught in the way it was hoped they would then teach, there is no necessary connection between their learning and their subsequent teaching. How can the connections and processes of learning be made explicit? What this requires is that the facilitators work at two levels: as participative and active mathematics learners, which is in itself probably a different approach to learning and knowledge, and as teacher trainee. This is complex. Gerdes briefly tells us how he works with his teacher trainees, but not how he makes conscious and explicit his mediation processes.[24] What we catch sight of is the empowerment of trainees as learners of mathematics. What remains obscured is whether and how they are enabled and empowered as teachers.

Secondly, in shifting the emphasis from mathematical content to mathematical processes, we submerge challenging questions like: can we learn any mathematics at any time, in any order? For example, can the development of another proof for Pythagoras' Theorem through ethnomathamatics or statistical skills be inserted at any moment?[25] Does a politics of mathematics education inform primary and secondary mathematics in the same way? Are there such things as basic skills and conceptual frameworks without which further, more complex or abstract learning is denied? In short, the "learnability" of concepts and skills and their appropriate integration into an emancipatory curriculum as a whole needs serious consideration.

In starting the learning process from concrete conditions, that is, inserting culture, we need to confront such mathematical questions.

Finally, we need to consider again the notion of praxis. This examination has rendered the contests between various participants in the CBEP visible. The co-ordinators and tutors have had to face, work through and adapt the programme of critical pedagogy to the material and social constraints of the South African situation. What is at stake is the development of a negotiation process between conceptions of and experience in progressive pedagogy rather than a narrow response that allows dominant relations to remain intact. It is essential that this process ultimately be an empowering one for all in CBEP. In such praxis lies the strength of CBEP and its possibilities for developing a rooted emancipatory project - a project ultimately "owned" by its participant community groups.[26]

Conclusion

Through reflection on an attempt at educational innovation and change, this paper has argued and shown that a politics of mathematics education is more than a struggle over what counts and who decides. As with my student's experience, there is no smooth translation of the "what" into educational practice. It is only through praxis, through constant examination of ideas in action under concrete conditions, that we can shape both what **might** be empowering practice and **how** this can come about.

The description and comment on CBEP is but a glimpse at a project in process in a difficult but dynamic context. It contains snapshots rather than a complete motion picture. In addition, it should be borne in mind that implementation is a process that occurs in a context, and contexts are rarely undifferentiated and unproblematic. Invariably pedagogical and political struggles and contests will take place despite common intent. A politics of mathematics education needs, through praxis, to develop this consciousness of struggle in process.

Notes and References

1. Of 10 000 children that enter school, only one is likely to emerge after twelve years with an exemption in mathematics and science. Figures given by the Director of Protec and quoted in *The Star*, 26 April 1990, 21.
2. M. Fasheh, "Mathematics, Culture and Authority", *For the Learning of Mathematics*, 3, 2 (1982); M. Fasheh, "Mathematics in a Social Conext: Math within Education as Praxis vs within Education as Hegemony" (Paper presented at ICME-6, Budapest, July-August 1988); P. Gerdes, "Conditions and Strategies for Emancipatory Mathematics Education in Underdeveloped Countries", *For the Learning of Mathematics*, 5, 1 (1985).
3. This paper is described in full in C. Bilankulu, "Ethnomathematics" (B. Ed long essay, University of the Witwatersrand, 1989).
4. Gerdes (1988).
5. A. Brown and P. Dowling, "Towards a Critical Alternative to Internationalism and Monoculturalism in Mathematics Education" (Working Paper No 10, Centre for Multicultural Education, Institute of Education, University of London, 1989).

6. This notion of praxis is similar to that developed by R. Smal, "Educational Praxis", *Education Theory*, 28, 3 (1978), who emphasised critical and conscious human activity that is not one-sided: praxis involves change of both object and agent.
7. See Z. Sisulu, "People's Education for People's Power", *Transformation*, 1 (1985): 107.
8. The large number of students out of school is a result of intermittent school boycotts, state-enforced age limits, denial of re-entry to matric failures (particularly in 1989), increasing demotivation and the destruction of a learning culture in black schools.
9. CBEP Curriculum Seminar, 24 April 1989 and CBEP Community Workshop, 18 November 1989; See also P. Gerdes, "On Culture, Mathematics and Curriculum Development in Mozambique" (Paper presented to siminar on Mathematics and Culture, Bergen, September 1985) for a discussion of democratic pedegogy in the Mozambican context; J. Adler, "Towards Democratic Mathematics Education in South Africa", *Lengwitch*, 5, 1 (1988); C. Breen, "Alternative Mathematics Worksheets" (University of Cape Town, mimeo, 1986); N. Taylor et al, "People's Education and the Role of Mathematics: A Workshop" in J. Muller (ed.), *Critique-Vision-Strategy: Proceedings of the Kenton Conference 1986* (Johannesburg: University of the Witwatersrand, 1987), have tried to give some content to the role of mathematics in developing PEPP in South Africa, while M. Gardiner, "Liberating Language: People's English for the Future", *Lengwitch*, 4, 1 (1987) and C. Kros,"History for Democracy", *Lengwitch*, 4, 1 (1987) have discussed these issues in relation to english and history respectively.
10. See the intitial project proposal (undated); "Note for Curriculum Development Seminar", April 21, 1989 and papers presented to the Community seminar, November 1989.
11. My purpose is not to evaluate the project, but rather to draw on its experience at various stages to highlight, even at this early stage of the project's life, both the possibilities for and obstacles to a transformative agenda specfically in the context of South Africa.
12. This section, and the one that follows, offer brief descriptions. In so doing they unavoidably freeze and diminish the dynamism of a developing project. More detailed documents on the development of CBEP can be obtained from the project.
13. CBEP, 21 April 1989. In a racial society it is extremely difficult to avoid racial descriptors. "Multi-racial" attempts to reflect an aspect of the consultative process.
14. "Spiral" is used here in the Brunerian sense of increasing and expanding levels of complexity.
15. For example, decimal fractions developed only in the context of money or measurement with no reference to place value would be limiting. See CBEP Maths Curriculum Group Report, 12 September 1987.
16. *Ibid.*
17. See minutes CBEP Maths Group Report, 15 October 1987.

18. CBEP minutes, May 1988.
19. See documents presented at CBEP workshop, 18 November 1989.
20. What is embedded here is the question of certification. Credentialism remains rife and was a critical issue for CBEP at this juncture.
21. P. Gerdes, September 1985; M. Fasheh, "Mathematics, Culture and Authority", *For the Learning of Mathematics*, 3, 2 (1982); S. Mellin-Olsen, *The Poltics of Mathematics Education* (Dordrecht: D. Reidel, 1987).
22. See G. Howsen et al, *Curriculum Development in Mathematics* (Cambridge: Cambridge University Press, 1981), 227-236 for illumination of unsuccessful attempts at integrated curriculum innovations involving mathematics. In addition, the provision of tertiary academic support through integrated programmes has been criticised for creating extra pressure on students by removing familiar subject markers and requiring that they work with different areas simultaneously. (Discussion with Academic Support Tutor, university of the Witwatersrand, January 1990).
23. Sacred Heart College in Johannesburg, one of the more prominent progressive non-racial schools, is a case in point.
24. Gerdes (1988).
25. R. Noss, "Review of Mellin-Olsen's Mathematics Education", *Educational Studies in Mathematics* 19, 3 (1988) makes a similar point in his review.
26. During the latter half of 1990, following critical reflection on its development, the project negotiated a serious redirection with its steering committee and constituent communities. Part of its struggle was an identified need to pull the project away from the overpowering pressure for formal education towards its intent for broader, community-owned education.

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Teacher Education and Mathematics: Confronting Preconceptions

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This paper is a personal account of an attempt to develop a reflective model for teacher training. The model is aimed at challenging students' present conceptions of themselves as teachers, learners and mathematicians. It does this through the creation of an environment of self- and mutual-acceptance where students are encouraged to reflect critically on their reality. Initial responses to the model are discussed by using extracts taken from student diaries.

Introduction and background

After an initial university training period of four years, secondary mathematics teachers in South Africa return to teach in a racially defined education system where they are met with many different realities.

One such reality focuses on black schools and the achievement of black pupils in their end of school examinations. For example, one aspect of the enormity of the problem of failure in mathematics can be seen by studying the 1990 national examination results for the Department of Education and Training (DET). 7 882 students wrote the mathematics highter grade paper and 7 021 of them failed (an 89% failure rate). The results of mathematics standard grade were just as distressing. There were 9 995 candidates, of whom 8 899 failed (also an 89% failure rate).[1]

Another reality centres around the call for People's Education for People's Power initiated and spearheaded by the National Education Crisis Committee (NECC).[2] The increased contestation of the education arena which began in 1976 with the Soweto school boycotts, placed educational issues in a wider political context. Unlike some school subjects such as languages and history, mathematics education has only recently started to be closely examined for its political dimensions.[3] Julie[4] provides an overview of the context in which mathematics education takes place in South Africa.

An important result of this examination has been the debate about an alternative curriculum for mathematics education in a future non-racial South Africa. The possibilities which have emerged from this debate have generally focused on three main areas.[5] One aspect centres around the need to place the development of mathematics in a more balanced historical context so that the present Euro-centric vision of mathematics is challenged by acknowledging the major contributions made by other communities.[6] A second concern stresses the social aspect of the development of mathematics and acknowledges the inherent mathematical abilities

of all people.[7] Here use can be made of worksheets which aim to use mathematics to demonstrate some of the political realities. The worksheets could focus on a mathematical aspect such as statistics in the classroom.[8]

A third area deals with the methodology being used to teach mathematics and sets about challenging the picture of mathematics classrooms described by Fasheh:

> The classroom is highly organised; the syllabus is rigid; and the textbooks are fixed. Maths is considered as a science that does not make mistakes .... There is one correct answer to every question and one meaning for every word and that meaning is fixed for all people and for all times. "Wrong" answers are not tolerated; students are usually punished if they make "mistakes". Teachers ... are also expected to perform according to a certain set of rigid expectations and they are punished if they don't.[9]

In an attempt to provide a different mathematics learning experience, attention has been paid to the possibilities of a more investigative approach, wherever possible, with the social context of the learners being considered.[10] Mellin-Olsen[11] stresses that the success of this approach depends on teachers being familiar with their students' reality.

The importance of these three areas has been generally accepted. Continued political pressure for structural change in education is regarded as an essential first step in addressing the crisis in black education. The urgent need for further work on a possible alternative mathematics curriculum is being addressed by the Southern Transvaal branch of the NECC's Mathematics Commission.

As a university mathematics education lecturer, my concern has been with the third area - the task of creating a different classroom atmosphere from that described by Fasheh. The challenge is to confront the fact that student teachers will almost certainly end up using methods used by their own teachers. In South Africa these methods are likely to be highly authoritarian and restrictive.

This paper will describe my ongoing attempts to intervene in this process and to facilitate a change in teaching methodology in a class of about fifty pre-service graduates. They attend an annual four-and-a-half hour mathematics method session each week for about twenty weeks throughout the year.

First attempts and second thoughts

My initial attempt at developing a new "progressive" method was to set aside specific lecture sessions in order to cover the priority topics described above. For example, I covered the politics of mathematics education in one full session of four and a half hours. In this time I described the liberation process in Mozambique and how it affected the teaching of mathematics in schools.[12] I quoted obviously biased textbook examples[13] as well as a few selected examples from South African textbooks, in order to illustrate the existence of a social context being described in existing textbooks. I then handed out copies of the book of alternative mathematics worksheets which had been prepared by students,[14] and asked the students to work through and evaluate these worksheets in groups for the rest of the session.

In another session I tried to illustrate the level of institutional violence in schools by focusing on the dehumanising aspects of the school. I tried to bring out the need for teachers to be more humane by telling stories of my own teaching experiences where children, who were coping with nightmarish home conditions, were subjected to rigid and harsh school discipline.

In a similar way, I introduced sessions (with appropriate readings and examples) on different topics such as african and arabic mathematics, girls and mathematics, ethnomathematics and mathematical investigations in the classroom - all areas usually omitted from traditional method of mathematics lecture courses.

Although these additions to the curriculum were based on current research into mathematics education and seemed to be generally well received by the students, events during the lectures gave me reason to feel some doubt. For example, when we covered the important topic of the politics of mathematics education, there was an immediate response. Some students nodded their heads wisely and enthusiastically, while others allowed their eyes to glaze over as they turned off.

During the session on the need for humanising mathematics education, I noticed what seemed to be sneers amongst some members of the class. On reflection I concluded that I was experiencing the successful products of apartheid education - a system designed to "produce students who are passive, rigid, timid and alienated".[15]

The students in my class had been educated separately without access to each other, generally by authoritarian teachers using rote-learning methods. In their own way, each student had had to build up his/her own defence mechanisms in order to live with the daily brutality and injustices of life in South Africa. I was offering them yet another lecture which allowed the material to remain "out there" - something to be observed, defended against or commented on from a so-called "objective" distance!

My disquiet grew into a stronger sense of unease during teaching practice, when I saw how difficult students found it to transform an intellectual belief into classroom practice. Very few of even the most radical students were prepared to use the alternative worksheets in "normal" classes.

A reflection model

Perhaps the most important insight to come out of the above first attempt, was a realisation that it was impossible to get people to reach out to a new understanding of the issues involved if they were closed to themselves and to me. This meant that, if I was serious in my commitment to change, my major task was to create an environment in my class where it would be safe for students to be open to themselves and to each other. If the topic was to cease to remain "out there", it would have to involve the student. The best way to do this would be to ensure that a high level of critical self-assessment took place. Given the realities of the daily experiences of South Africans it would be essential for this critique to take place in an atmosphere of mutual- and self-acceptance.

Any new model for change would then be based on the belief that change in practice does not come from a lecture or any other outside experience - it can only come from an inner transformation. This reflects Gattegno's statement that "only awareness is educable".[16] If my main aim as lecturer is to deal with awareness, I am relieved of the burden of forcing material on students. Instead I have the challenge of placing more trust in the learner, both in what s/he brings and in his/her ability to know what is appropriate and how to work with the material presented. Powell and Hoffman[17] use these ideas of Gattegno and incorporate them with the work of Freire to construct their own model for use in teaching underprivileged students in New York.

In structuring the presentation of material, I have been guided by the belief that learning is a social activity. Mellin-Olsen expands on this theme, based on the work of Vygotsky in his book on the political dimensions of mathematics education.[18]

Finally, in designing a model for action, I took the concept of "teaching as story-telling" from Kieran Egan.[19] In particular I found it valuable when he described "the need to be more conscious of the importance of beginning with a conflict or problem whose resolution at the end sets the rhythm in motion".[20] This led me to recognise the power of tension and energy as a means of ensuring involvement and discussion.

In trying to move towards a reflective model for future engagement with the class, I identified the following crucial ingredients:

i) The new course should be about learning rather than teaching - learning about ourselves as teachers, mathematicians and human beings;
ii) Wherever possible we should engage with each other in social situations - playing games, learning names, working in constantly shifting groups - so that we try to build up trust;
iii) An increase in energy is welcomed and indeed actively sought. Activities are selected to engage students in some form of conflict so that different realities can be explored;
iv) We should try to refine the ability to observe ourselves in different situations, to consider the possibility of acting differently and of creating opportunities to test these possibilities in a supportive environment; Most activities/discussions should return to the self. What do I think? How did I react? Why? What else is possible?

In order to ensure that the process of reflection is taken seriously, students at the start of the course are told that this is a process course with the aim of enabling them to think about themselves as person, teacher, learner and mathematician. They are required to keep a diary in which they reflect on any aspect of the day's experience which excited them. If nothing excited them - why not? Hoffman and Powell[21] describe a similar use of diaries as a "vehicle for student reflection and empowerment". This is a personal diary and will only be seen by me and them. As an added inducement to reflect seriously, the diary is used as a source of marks for the end of year assessment. Apart from acting as a means of engaging students in reflection, this diary also gives the lecturer valuable feedback. It is taken in at different stages during the year so that early communication between students and lecturer can be encouraged. For example, one student writes:

> Having to write a diary is entirely new to me. It is very painful to reflect on one's experiences, weaknesses and strengths. Yet it is an effective way of getting in touch with and evaluating your personal growth. The overall effect is that of not only making one sensitive to one's own thoughts and feelings, but also those of others.[22]

Some examples

I have used the above model for the past three years. In this section I will give examples of some of the activities undertaken and illustrate their impact with

extracts from student diaries. It is important to stress that time was allocated after each activity for feedback.

a) Social interaction

These are the most crucial sessions in that they allow students to connect with themselves and each other. Initially this is done through a variety of warm-up games involving physical interaction. The physical contact appears to have improved relationships amongst the class. Learning each others' names and changing groups regularly is also stressed so that artificial barriers and assumptions can be challenged. Because of the relaxed atmosphere in the class and the fact that every week one is forced to work with new people, one gets to know a new person each week. "I am always amazed at how the personalities of people influence dynamics of groups and group work. I have been in different groups every week and I think I have acted differently in all of them because of others in the group".

One of the most adventurous additions in the past year has been the introduction of movement to music into these sessions. On several days the class has participated in circle dancing where the students join hands and perform some basic steps to music.

This was a good exercise in getting people used to each other - seeing each other struggle, helping each other and laughing with each other. These apparently disjointed activities provided an important opportunity for coming together in a new experience as well as a base from which one could move more confidently into more challenging mathematical activities.

b) Socialised fear

The activity around socialised fear was created mainly as a response to the complacency of students to the dehumanising nature of schools and to allow students to see how passive, unassertive and easily controllable they may have been socialised into becoming.

Mr Smith (myself in an academic gown) is an authoritarian teacher who arrives as a guest lecturer and for five minutes terrorises the class by making the students experience the tension of writing a test under constant time and teacher pressure. The results of his visit are devastating for many. No student to date has refused to participate, yet all have recounted the feelings of extreme tension, fear and anxiety that his presence elicited. They were transported back into previous school experiences. The discussion after this activity allowed students to question their own freedom of choice and also highlighted an important source of mathaphobia. The telling comment that "I recognise part of Mr Smith in my own teaching" helped underline the importance of teaching method in a way that is more urgent and accessible than any lecture. The following diary from students extracts give an indication of the powerful emotions raised by the activity:

> Looking back at what happened in the class, it is amazing to think what power a person with a booming voice and an authoritarian approach, wields. We, the students, are all intelligent (supposedly) graduates, with at least four years' out-of-school experience, and yet we were all taken in, or rather, we all toe'd the line, just to keep the peace.

> In that short space of time, not only did I re-live my early school days (long-forgotten in order to survive), that is, re-live every emotion that I ever felt in the mathamatics class and at school in general but was also able to isolate why I had come to hate school, exams and rules and had come to fear maths. Chris Breen's playing was a re-enaction of the typical teacher (and more particularly my mathematics, science and accounting teachers) I had experienced at school. I felt anger, fear, humiliation even when remarks weren't directed at me personally.
>
> But, most of all, a feeling of fear for the consequences of what I as a teacher can cause in the future, for as we were acting out this whole show, memories from my schooldays flashed past me. Exactly the way we were experiencing it now. This incident "opened my eyes", it made me aware of the powers I as teacher can exercise one day, of the traumatic effects I may have on children, and I pray that God will help me not to become such a "moron".

Mr Smith stays with us throughout the year as a sobering metaphor and caricature of a particular teaching style. It is most useful during teaching practice times.

c) What is mathematics?

This activity was designed to introduce the possibility of a political dimension present in mathematics education. The topic was broached by presenting students with three two page essays, which are responses given by previous students to an examination question. The question asked them to write a speech outlining why standard seven pupils (fourteen year olds) should continue with mathematics the next year. The three extracts each present a different view of the value of school mathematics. The first, B, presents a technicist view which only addresses the applications of mathematics in a modern first world situation. The second, C, gives an esoteric view which describes the numerous joys of mathematics but denigrates school mathematics to a rote-learnt subject of little value and advises pupils against continuing with school mathematics. The third, D, exhorts pupils to learn mathematics so that they can understand the extent of their oppression and be sufficiently skilled to contribute to the revolution and the fight against the oppressors. Students were asked to work in groups of six with people with whom they have not yet worked, and to rank the extracts according to their personal view.

The activity started in a comfortable silence as the students read the extracts. The silence became more tense and extended as they reach D, and the students needed to be reminded of the task. The different beliefs and assumptions were soon evident. These were some of the students' comments:

> Found B intrinsically repelling not only because it seemed to worship the ground technology flies over, but because of a subtle attitude that comes through which smacks of all-boys schools and prefects detention. Particularly enjoyed C because of its sincerity and D because of its different perspective. Refreshing.
>
> Essays B and C were fine - pretty neutral. D however was rather difficult to know how to respond to especially with four out of six of the group being black. D spoke about maths as a necessary tool to overcome the oppression of the African and "coloured" people. Whether or not they were real I sensed a bit of tension in the group mainly because of the nature of the essay. However we talked about these feelings and put things in the open. I was astonished at the outcome. The black students did not all choose the most radical/political one whereas some of the whites did.

After an initial tentative exploration of positions, serious negotiating took place and alliances were formed. Some students took the opportunity to reflect on some of the causes of these different beliefs:

> It is significant that the extract on mathematics and the socio-political issues affecting the oppressed and exploited gave rise to a great deal of debate. Some members in the group could not appreciate why politics should enter a discussion or be used as motivation for getting pupils to take mathematics at school. Others stressed the importance of mathematics as a component of general education in a modern, technological society. What is significant to me is the fact that the social backgrounds of the students apparently have a decisive influence on their thinking.

Several students showed that they welcomed this opportunity to talk and saw the need for more such opportunities, although they acknowledged some of the difficulty involved:

> To me the whole purpose of the exercise was to show us that talking face to face, by people from different areas of segregation was a sensitive issue but necessary and fulfilling also. I also felt that we, the students need to talk more for further understanding of each other.

The next extract gives an insight into the success of apartheid in separating people and forcing them to be defensive :

> This didn't take much time so we had a chance to "chat" for a while. This meant so much to me because for the first time I was able to speak openly to people of different races without feeling threatened. I am not a racist by any means, but I am against violence, and I am white - I didn't ask to be born this way - I just was. Love me for being me - the person - not the colour my skin is (or hate me for that matter).

Finally, the dilemma of confrontation between people from opposite sides of the political spectrum was highlighted in the following diary extract. The student shows a healthy awareness of herself and ends with a promising statement of openness:

> This was difficult because it was clear that they had been written by three different people with different political backgrounds and in my group we were a combination of all three different backgrounds. This led to a lot of dispute among us to the extent that at some point it became a personal confrontation between one group member and myself. This person comes from a political background which he described as conservative and I come from the opposite side of the political sphere and as a result we could not find any common ground, instead we were constantly stepping on each others toes. In the end though we rated the papers, unfortunately the person with who I argued had to compromise his position.
>
> This part of the session was very interesting in the sense that I never thought there could ever be a political debate arising from anything pertaining to mathematics. Also I realised how fanatical and unaccommodating I can be sometimes. As soon as the person who argued with me mentioned that he came from a conservative background, my whole attitude towards him changed. He tried to talk calmly about his political stand but I would not listen to anything he said - to me any person I associate with the Witwolwe and the Afrikaans Weerstand Beweging (AWB) (rightwing movements in South Africa: ed.) is not worth listening to, let alone talking to him. Hopefully I will in future take him for the person he is and not judge him by his background.

Not all debates remained unresolved. Some recorded the joy of an apparent change in belief:

> The best part was actually seeing how one member of our group "saw the light" and moved away from his narrow and technicist view of mathematics.

d) Personal conflict exercises

At the other end of the spectrum from the co-operative circle dancing, we also engaged in activities which encouraged inter-personal conflict. These activities were only offered towards the end of the year when the students had been able to build up a degree of trust in themselves and in me.

One such activity is the rejection exercise where the class is divided into groups of four. Each person is given their own instruction which tells them to focus on one particular person and try to expel that person from the group for whatever reason they can think of. The task is structured in such a way that each person has a different target and that no two students are given oppositional roles. The degree of discomfort caused by this activity supports the seemingly contradictory assertion that students in this conflict-torn country do not readily accept opportunities to experience and resolve conflict:

> The rejection exercise was terrible because we had to be unnecessarily nasty to each other. I ended up being the nastiest in the group in an attempt to protect myself from leaving the group.

One particular experience of this rejection exercise is worth recounting as it illustrates the way important issues can be raised by students as a by-product of the activity. In this way the issue is a natural extension of the students' reality rather than an artificially introduced topic for lecturing.

When we came to the time for the report back after the rejection exercise, one group proudly said they had refused to participate and had decided instead to have a discussion over tea. Other groups recalled the reasons they had used to try and reject people and how alliances had often been formed in contravention of the rules.

The spokesperson of one group stood up and could not stop laughing. "It's obvious who we got rid of", he said. "Just look at our group. We just decided to get rid of 'whitey'". Sure enough, there was only one "whitey" in the group. We spent a bit of time checking out how the "whitey" and the others in the group had felt about his being singled out and excluded. Then a sheepish hand went up from the spokesperson of the "tea group". He wanted to confess that he had been the one to suggest that the group should be unco-operative and that they talk about having tea instead. He asked us to look at the composition of his group. He was also the only "whitey" in his group and had hurriedly taken action in self-defence to pre-empt racial discrimination. When the laughter had died down, we managed to find out that he had in fact manipulated the group to get one person evicted from it in order to make the tea - the only woman in the group!

Understanding the reflection model

This last example shows the contrast between the initial model and the present reflective model. Using my initial model I would have planned a lecture on racism or sexism in mathematics education with appropriate readings followed by class discussion. Using the reflective model, I engaged the students in a group "energy

activity". They felt sufficiently confident in each others' company to reflect, both humorously and seriously, on the racist and sexist issues which were raised in the process of their interaction.

There thus does appear to be value in this reflective model. But how does this model relate to existing theories of learning? At this stage I will limit myself to a few comments and observations.

The first observation to be made about the reflective model described in this article is that it leans heavily on humanistic psychology for its understanding of learning. This approach regards the goal of education as being "the facilitation of change and learning",[23] and sees authentic learning as being self-initiated and involving the whole person. The teacher acts as a facilitator who provides the resources for students' self-directed learning. This role of the teacher as facilitator has led to a practice of group work where learners are randomly assigned to groups to discuss an issue amongst themselves with no identifiable teacher. Flanagan and Sayed[24] have criticised this popular conception of group work, maintaining that it does not promote learning, at least learning of an intended kind.

However, the example of "What is Mathematics?" quoted in a previous section seems to present a situation in which the lecturer has carefully set a framework in which learning can take place, but has left the nature of that learning to the participants of the randomly constructed group. The sample of responses suggests that in fact considerable learning has taken place, and that the nature of the activity has been present during the actual discussion.

The reflection model does not however take its framework from humanistic psychology alone. The aspect of the model which introduces energy activities takes its guidance from the work of Vygotsky.[25] For Vygotsky the transition from inter- to intra-psychological functioning is possible through the creation of a zone of proximal development. He describes this zone as the distance between a learner's "actual developmental level as determined by independent problem solving" and the higher level of "potential development as determined through problem solving under adult guidance or in collaboration with more capable peers".[26]

In this model it is important to create cognitive conflict in learners' understanding if they are to move from their actual level of development to their potential level of development. The energy activities seem to find more favour with this model than with humanistic models.

Yet there is another dimension to this conflict which transcends Vygotsky's emphasis on cognitive conflict. The presentation of energy activities here and the emphasis on self-reflection mean that it is not only cognitive conflict which is encouraged in this model, but also conative and emotional conflict. For example, the appearance of Mr Smith is an activity which produces conflict but does not remain a cognitive experience.

This inclusion of conative and emotional conflict together with the more common cognitive conflict returns to the humanistic emphasis on the development of the whole person. Yet again there is a contradiction as the dominant theoretical orientation in group work, coming from humanistic psychology, stresses the achievement of harmony and consensus as a basis for successful learning.[27]

It was also suggested above that the work of Freire had been influential in designing the model. With respect to encouraging conflict, Ellsworth[28] has also highlighted the striking silencing of conflict in the discourse of critical pedagogy, where the assumption is that all learners are opposed to the same oppressors.

This split in theoretical orientation is also to be found in the emphasis on individual activities as reported here. This is partly due to the chosen emphasis of the report. Other activities focus on the structural imperatives of mathematics education. For example, students shared their involvement in political issues such as the campaign to support temporary teachers. Throughout the course students were encouraged to discuss ways of implementing change to the present system of teaching mathematics, and come to the realisation of the need for structural change and collective action.

A further contradiction appears in the supposedly empowering role of the lecturer. As Lazarus[29] points out, an inherent contradiction arises from a person structurally situated in an unequal power relationship attempting to empower others. In addition, the lecturer here is assigning marks based on the development of each student's self-reflection process - fertile ground for the creation of a hidden pedagogy. If marks are given in a humanistic way for the amount of openness and growth which takes place in the course, should students not also be allowed to grow and be open?

This article has been about the teaching of mathematics and yet it contains little mathematics. This does not reflect the true account of the class. Energy is introduced into the content of mathematics by using open-ended investigations, body mathematics where students are used as apparatus, and the simple strategy of using wrong answers as a means of starting conversations.[30]

And Now?

I believe that the exciting willingness shown by students to participate in activities and to reflect honestly on the insights gained from new experiences as shown in students' diaries, gives sufficient encouragement to continue exploring this reflective model. While this model owed a great deal to Egan's metaphor of teaching as story-telling, perhaps it would be appropriate to extend it by saying that at the end of the course, it is hoped that the students will have the confidence and the vision to "choose their own adventure".[31]

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The Cognitive and Epistemological Constraints on Praxis: The Learning – Teaching Dialectic in Mathematics

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The purpose of this paper is to focus attention on two interrelated sets of constraints on praxis, the cognitive and the epistemic. The cognitive constraints refer to those enabling and limiting conditions which are **intrinsic** to the knower, while the epistemological constraints refer to the public-collective and **extrinsic** framework(s) for task execution. We argue that both these sets of constraints must be confronted in the teaching-learning situation, through the development of **meta- and epistemic cognitive controls** if we wish to successfully bridge that which an underprepared learner brings to a teaching-learning situation and that which is required for him/her to master the tasks confronted in this teaching-learning situation. A crucial aspect of the work reported on is the transition between everyday thought, action and use of (natural) language, and the demands of mathematical tasks and this "language".

Introduction

In this paper we will sketch the parameters of an ongoing project in mathematics education at tertiary level. The title of this paper is an attempt to focus attention on two interrelated sets of constraints or enabling and limiting conditions on all praxis. These also occur when engaging in those tasks typical of formal studies at university level, mathematics included.

The cognitive constraints refer to those enabling and limiting conditions which are **intrinsic** to the knower, while the epistemological constraints refer to the public-collective and **extrinsic** framework(s) for task execution. In other words, all problem-solving is possible given certain capacities of the knowing subject, and occurs within the constraints posed by the history of tasks and task execution, and the social, educational, scientific and so forth demands on problem-solving. We argue that both these sets of constraints must be confronted if we are to address any specific transaction between the knower and a task.

The purpose of this paper is not a detailed review of relevant cognitive theories or appropriate epistemologies.[1] Our aim is rather to engage colleagues in a debate about what learning-teaching mathematics is and has become, and what this task must confront if we are serious about contributing to the, at present, small number of (especially African) matriculants interested in, and capable of, engaging in mathematics at university level. More particularly, we focus on empirical work which emphasises the problematic relationship between everyday thought, action and use of (natural) language, and the demands of mathematical tasks and this "language".

At the core of what we will discuss below, is the following observation by Piaget:

> As for the logico-mathematical structures in general, it would be inconceivable to attribute to them, as regulators, the physical nature of objects, since they extend beyond them everywhere. If a harmony exists between mathematics and reality, it is because of the subject's operations.[2]

Given certain capacities of the knower, mathematics will, therefore, be invented and imposed on reality. This is a statement regarding the possibility of mathematics, and the nature of cognitive capacities. What is also important is that any specific individual must confront what "learning-teaching mathematics" has become and the demands of this history on any actor (for example, university student) engaging in mathematical problem-solving.

Constraints on praxis

The problem-solving situations or tasks encountered in goal-directed activities have essential natures which place certain demands (and limits) on transaction. Each task has a historical trajectory which may be conceived of as falling within the intersection of the psychological and social "life-lines of development".[3] The tasks we come to take for granted as being part of what the developing person must or will confront from birth to death, as well as those "novel and truly novel"[4] transformations which characterize development and life, have their origin at some historical moment when circumstances and/or actors place new demands on habitual ways of acting and/or on the familiar frameworks containing praxis. The origin and development of mathematics, as a way of ordering reality and later as a disciplinary domain could also be regarded as a historical product of mind's engagement in reality. Mathematics as an invention (and imposition) of mind is certainly remarkable in one sense, but also bears testimony to those capacities of which all minds are potentially capable.[5]

The learning-teaching of mathematics, as typical of formal education in modern industrial societies, is one task among many, and cognitively speaking, no more or less interesting than the task of choosing a life partner, even though the epistemological constraints on these two tasks may be very different. The question this begs is why so many secondary school students fail to become equipped for or interested in mathematics at tertiary level. Common sense has it (with the consent of many experts) that mathematics is "difficult" and that those able and interested to engage in this task are "clever"; this "difficultness" and requirement for "cleverness" seems (therefore) to limit - almost naturally - the pool of matriculants from which to draw for mathematics at tertiary level. We would like to propose that the learning-teaching of mathematics in higher education, like all other disciplines at this level, may beg special resolution of the learning-teaching dialectic. Mathematics does not present a case which cannot be submitted to an analysis in terms of the cognitive and epistemological constraints on tasks. Such analyses are important in all disciplines, if we are to improve on the learning-teaching situation. In fact, we would suggest that this kind of analysis may open mathematics, which too often seems a mystified discipline, to sound educational practices.

Elsewhere[6] we have examined why, despite the fact that from adolescence onwards the human mind is potentially capable of logico-mathematical thought, so many learners at university level still fail to engage independently and effectively in

mathematical tasks. In terms of sound educational practices, we proposed certain teaching strategies to overcome learners' **incorrect tacit rules for task engagement.**[7] We now want to turn attention to another aspect of the learning-teaching of mathematics, that is, the objects of knowledge confronted in this discipline. We argue that the nature of the objects of knowledge confronted in mathematics learning-teaching poses particular problems regarding the relationship between the "real" world and the world of mathematics, and between natural language and mathematical language.

Cognitive constraints

It seems important to attempt to find links between the functioning of mind or the cognitive system, and the essential nature and demands of the learning-teaching dialectic in mathematics if our aim is the development of sound educational practices. In this regard we propose Piaget's model for the development of knowledge as a useful entry to the task of establishing links between the functioning of mind and the learning-teaching situation.

Piaget[8] discusses the origin and growth of knowledge in terms of the process of "equilibration" with the twin components of assimilation and accommodation. He proposes three kinds of "equilibration": (1) between the schemes of the subject, and the exterior objects; (2) co-ordination between schemes and subsystems of the same rank; and (3) between "the partial systems with their differentiations and the total scheme with its integration".[9] We will briefly clarify each of these, as far as possible by direct reference to Piaget's writing, in order to lay the foundations for our own argument.

Piaget writes on the three kinds of "equilibration". The first kind is expressed best by Piaget:

> At the beginning of the fundamental interaction of the subject and the objects, there is the equilibration between the assimilation of schemes of action and the accommodation of these to the objects. Let us note that here there is the beginning of mutual conservation, for the object is necessary to the development of action and vice versa; it is the scheme of assimilation which confers its significance to the object and transforms it by displacement, use, or other action.[10]

The second kind of equilibration refers to the co-ordination of subsystems. The interaction of the subsystems demands resolution of non balance, and the achievement of equilibration.

The third form of equilibration does not merge with the second, since it involves a hierarchy and not only the simple relationships between collaterals. In fact, a totality is characterized by its particular laws of composition which determine a cycle of interdependent operations and are superior in rank to the special characteristics of subsystems.[11]

The three kinds of equilibration involve both affirmations and negations:

> The three kinds of equilibrations as the products of progressive assimilation and accommodation ... can be accomplished in a spontaneous and intuitive manner by successive groupings, which eliminate failures and retain success; but in so far as the subject seeks an adjustment - tends to obtain a coherent stability - he must use the exclusions in a systematic manner. Only an exact relationship between affirmations and negations ensures the equilibrium.[12]

The resultant changes from equilibration can be "exogenous or endogenous".[13] The subject's relationship to exterior objects or the organization of schemes and subsystems can change. Piaget states that "with any action or operation, including a teleonomy, the new means to be used should involve the first two kinds of equilibration and the new goals the last".[14]

This very brief reference to Piaget's ideas regarding the functioning of the cognitive system is given here to emphasize the following two areas in the empirical work reported on:

(1) The nature of the objects of knowledge in mathematics; and
(2) The metacognitive demands on the learning-teaching task.

These two areas are suggested by the thesis, assessed in Winter's two research projects, that the adult learner will perform better on mathematical tasks if they are given explicit frameworks/guides for their cognitive operations. These frameworks are focused on these two areas (1) and (2), and entail cognitive and epistemic guides or cues which boost their "equilibration".[15]

The nature of the objects of knowledge

The objects confronted in the mathematics learning-teaching situation are not usually or even typically physical or "real world" objects which submit to empirical scrutiny. This imposes a particular set of cognitive constraints on the learning-teaching dialectic. It is necessary in this regard to distinguish between the originator or original development of mathematics and the learner who confronts a "ready-made" formal system. For the latter, "mathematics" is both historically and in the actual learning situation, removed from the "real world" and any resistances real (physical) objects may impose by way of "application difficulties and the effects of the (subject's) operations on the objects".[16]

The metacognitive demands of the learning-teaching task

In the case of adult-learners, it seemed justifiable to attempt a metacognitive analysis of the task demands in order to make the learning-teaching process more effective and open to conscious control by the learner. Or, in the terms of Niaz,[17] to boost the functional M(mental) power and to **reduce** the M **demand** of the task(s).[18]

We therefore attempt to make explicit what is often spontaneous. In other words, we argue that if learning-teaching could boost the three kinds of equilibration: (1) between the schemes of the subject, and the exterior objects (2) co-ordination between schemes and subsystems of the same rank, and (3) between "the partial systems with their differentiations and the total scheme with its integration", we would create an efficient and productive "fit" between the cognitive system and the learning-teaching situation. Given the functioning of the cognitive system, throughout life but more particularly from late adolescence onwards, it seems important to make the teaching of mathematics more appropriate to the functional demands of mind through a metacognitive approach to the necessary operations which the learners must perform for effective task engagement.[19]

The cognitive constraints on tasks, especially in terms of the nature of the objects confronted, is interesting in a number of ways. By way of summarizing what is to follow in this regard, consider the following:

1. Underprepared learners tend to muddle the meaning of symbols in the (natural language) alphabet, and the use of these symbols (as variables) in mathematics. They also tend to confuse a symbol with its different rules within different mathematical domains. In addition, those with poor control over English find it difficult, if not impossible at times, to access instructions and other operational cues embedded in mathematical problems;
2. "Real world" experiences interfere with engagement in "story problems" in mathematics. In particular, the rules used for natural language and ordinary tasks are confounded with the rules used for mathematics.

Both these sets of problems could be explained in terms of "overlearning", that is, operational rules, learned through schooling and other past experiences, having become part of the spontaneous operations applied or part of the habitual ways of acting. Our proposals regarding the "fit" between the functioning of the cognitive system and the structuring or ordering of the learning-teaching task relates, therefore, to dislodging these taken-for-granted or automatic operations, and replacing them with appropriate rules; these too must be overlearned in order to become automatic. In this regard, the frameworks/guides/cues (or meta- and epistemic cognitive controls), provided as a "bridge" between what students do know and can do, and what the tasks demand, are meant to both dislodge their spontaneous operations and provide them with new and appropriate operations.

Our data come from the following two research projects:

A. The first was a masters project and involved approximately twenty students from the Engineering Bridging Unit of the University of Natal.[20] The students' use of incorrect tacit rules when engaging in mathematics was the main focus. Appropriate mediational strategies necessary to dislodge such rules were devised, and assessed.
B. The second project, begun in 1989, involved approximately forty five students from the Engineering Bridging Unit of the University of Natal. Research included the investigation of learners' attempts to solve calculus story problems (disguised calculus optimization problems or dcop's). Students' attempts at six different tests are currently subjected to in depth analysis.[21]

One of the major obstacles that prevents the proper reading of mathematics is that it is an abstract subject, with a high density of concepts.[22] It is, however, in "story problems", where the concepts of the two worlds, the mathematical and the "real" are forced to coexist, that an additional cognitive strain is placed on the resolution of the task. Analysis of learners' engagement in "story problems" was the main focus of research project B, as these tasks present major problems to, especially underprepared, learners engaging in mathematical tasks at university level. "Story problems" also occur frequently in undergraduate mathematics courses.

Employment of the natural language is taken for granted when operating in the "real world," but this domain for action and natural language as conveyed in "story problems" often obscure the demands of mathematical language on solving a problem.[23] Certain "story problems" are difficult because they employ linguistic forms that do not readily map onto learners' existing conceptual mathematical knowledge structures. For example, a learner may understand part-whole set relations (logico-mathematical knowledge) and yet be uncertain as to how the comparative verbal form (for example, how many more X's than Y's) maps onto them.

In "story problems", especially dcop's, there are concepts common to both language games but which have different meanings in each of the two. For example, students in project B indicated two **adjacent** sides of a rectangle as being **opposite**, as their ordinary understanding of adjacent involved the concept "next to," and not necessarily touching. Their three dimensional experience of objects which are "above" others, created a sense of "above" as meaning "over". This confusion resulted in the incorrect presentation of a two-dimensional diagram, of a triangle "above" a rectangle: The triangle was **superimposed** or placed "over" the rectangle; they actually drew the triangle inside the rectangle.

Certain concepts (for example, "capped" and "surmounted") are not part of mathematical language but occur in dcop's (for example, "the rectangle is capped by a triangle"; "the cylinder is surmounted by a hemisphere"). Many of the students in project B had never encountered these words/concepts before. This made their access to the mathematical task difficult, if not impossible.[24]

Another dcop presented to the students involved a **hemisphere**, with the volume of a **sphere** provided. They are, however, more familiar with the use of a sphere encountered at an earlier stage (such as school story problems or in the "real world"). They, therefore, used the volume of a sphere instead of a hemisphere in their attempts to solve the problem. In a similar problem, their frequent use of ! for circle calculations prevented them from using π for describing length.[25] The constant π is regarded as "belonging" only to circles by some students. They could not understand how a piece of string in the shape of a circle with radius r could be "cut" to obtain a piece of string of **length** $2\pi r$, as π (according to their taken-for-granted rules) cannot be associated with length, only circles. Students also had a problem with the word "circumference" and believed that circumference was a word used only when dealing with circles. The word perimeter was regarded as only belonging to mathematical figures such as triangles, rectangles and circles.

"Story problems" are artificial representations of the "real world" and this may result in a false mathematical model of the problem being construed. The rules used in natural language are different from the rules required in mathematics and their confusion may result in errors.[26] For example, the sentence "there are six times as many students as professors at university" is often incorrectly translated into mathematics as 6.S = P, where S denotes the number of students and P the number of professors. In this way, the cognitive operations performed by the learner prevents successful equilibration.[27] Furthermore, students' "real world" experiences may interfere with the proper translation of the "story problem" into mathematics. Some students translated the sentence, "shed with a flat roof", into a diagram of a box with a pyramid lid as they had an existing conception of a house (or hut) with a sloping roof and forced the sentence to match this ordinary or "real world" knowledge scheme.

Another dcop problem given to the students involved enclosing a rectangular region with a fence and many students could not solve the problem as they believed that the height of the fence should be provided. They failed to obtain a two-dimensional view of the problem (looking at the rectangular region from above) and viewed the rectangular region from the side so that the height of the fence became relevant.

A "floating net" occurred in another dcop given to the students. In this case the absence of the depth of the net posed a problem for some students. The students "real world" or three dimensional experience of the height of a fence and the depth of a net prevented the successful resolution of the mathematical task.

Errors such as these, illustrate the difficulty of translating from the "real world" and natural language to the mathematical, revealing the problematic relationship between everyday thought, action and use of (natural) language, and the demands of mathematical tasks, especially dcop's.

Students must have a correct mental conception of the problem at hand if they are to solve the problem efficiently and correctly.[28] Such a "correct" conception must involve not only appropriate "real world" experiences but also familiarity with the move from natural language to an artificial language, and from "real world" operations to mathematical operations. Many underprepared students, because of socio-economic and educational disadvantage, do not have experiences consistent with modern, industrial society. Furthermore, their educational experiences also lack appropriate and adequate opportunities for familiarizing themselves with the demands of mathematics.

The cognitive constraints on tasks, as briefly outlined above, and illustrated in terms of the typical problems students have in this regard, have a "public face". This means that those teaching strategies devised to overcome these limiting conditions on task execution, may be overcome with the explication and use of the epistemic constraints on tasks. These are the conventions which regulate the learner's operations during problem-solving.

Epistemological constraints

In adult life, from late adolescence onwards, and when confronting the typical problem-solving situations inherent in this part of development in modern societies, the learner of mathematics must confront the implicit or explicit rules regarding that which constitute the task or that aspect of knowledge or reality engaged in during praxis. What may count as appropriate operations, legitimate methods or procedures, facts or theories, and criteria for evaluating the knowledge or solution produced, underlie all problem-solving situations; whether the actor knows it or not or is accustomed to making these explicit or not, and whether the task engaged in is obviously related to knowledge production (for example, solving a mathematical problem) or not (for example, choosing a suitable life partner). In other words, each task is saturated with a history which constrains action directed or generated by it. These epistemological constraints are, however, rarely used to inform and structure the learning-teaching situation. In the case of mathematics education, this lack of attention to "knowing about knowing" is even more glaring.

Strohm Kitchener proposes "a three-level model of cognitive processing"[29] which seems useful for addressing these lacunae in all tertiary education, and mathematics in particular. Of importance to the present argument is her analysis of

"puzzles versus ill-structured problems"[30] and their respective epistemic natures. Her work develops the older and less useful (due to a strong behaviourist bent) models of Churchman[31] and Mitroff and Sagasti.[32] The latter authors discuss problem-solving in terms of the actor as an inquiry system, a term which fits in well with the present analysis of the learner operating within two sets of constraints - the cognitive and the epistemic - and consciously so:

> Puzzles have a single, right or wrong answer which is available to the individual. The task, therefore, is to apply a particular, mechanical decision-making procedure to find, compute, or remember the answer. Puzzles may be simple or complex deductive ones (for example, 2 + 2 = 4 in base 10...) or inductive ones whose solution is guaranteed by convention (for example, a problem in a statistical textbook for which the inference is determined by scientific rules. In both cases, puzzles have two distinguishing characteristics: (a) there is only one correct final solution and (b) the solution is guaranteed by using a specific procedure (for example, following a mathematical formula...).[33]

Kitchener goes on to write that the richer problems of everyday life, those most often encountered, are not puzzles but ill-structured problems. It is in this sense that we mean that choosing a life partner is as interesting a task, cognitively, as learning mathematics.

Mathematics learning-teaching as a domain, especially at the undergraduate level, makes epistemic demands which are relatively simple. The frameworks for action or the operational guides we suggest,[34] function as our "knowing about knowing" converted into appropriate epistemic guides or procedural steps for the learner. Once these operations become part of the cognitive repertoires of learners, they are in a position not only to act appropriately when solving mathematical problems, but are also in a position to exercise meta- and epistemic cognitive control over their task engagement and thus to boost the success of their (inherent) equilibratory mechanisms.

Through work with under-prepared African students in the faculties of Arts & Social Science, University of Natal, the following (common sense) rules used by them for engaging in tasks, have been delineated:

1. There is a "right" and "true" and "proper" because God (or the Bible or some other unquestionable Authority) made it so, or because Nature constitutes it as such and in no other way;
2. The "I" of being or living or daily interaction has one direct access to this "true," and that is through "...on the spot reporting" or personal, immediate, first person accounts of experience;
3. If the experience of "I" has any revelation (or conversion ?) to the truth, then that revelation has (of necessity) a linear narrative line where the events which are presented sequentially produce the last event as the obvious "truth"; and
4. The revealed "truth" (or last event) begs no resolution of paradoxes (horizontally or vertically) or an appreciation that this claim may beg evidence, or an appreciation of logical, epistemic and moral consequences following on from it.[35]

The students' work from which these tenets were constructed were not engaging in mathematical tasks but we have no reason to assume that their common sense epistemology would be any different in another setting. It also seems safe to assume that other students like these who come from educationally and socio-economically disadvantaged backgrounds, may come to the learning-teaching situation at university with very similar epistemic assumptions. If this were true, such students should find puzzle-like tasks such as mathematics at undergraduate level at least more consistent with their epistemic assumptions than ill-structured problems. Tenet (1) easily translates into "there is (in puzzles) one correct final solution"; tenet (2) into an algorithm or mathematical formula or procedure for solving the puzzle, and tenet (4) into "Puzzles do not require considering alternative arguments".[36] The one jarring disjunction between the common sense epistemology and the task demands of mathematics relates to tenet (3) above, the role of experience in knowledge production.

As was elaborated above, the relationship between the "real world" and mathematics is full of pitfalls for the learner. In fact, there may well be grounds for arguing that any attempt to relate mathematics more directly or concretely to "real world" experiences during teaching may be counterproductive especially in the case of underprepared students. If anything, students must acquire a familiarity with non-tangible operations or mental action or **mind**-on "experience" for mathematics learning to be effective. Rather than attempt to make mathematics education "relevant" it should provide the meta- and epistemic cognitive scaffolding for engaging in the "unreal" or "irrelevant" world of mathematics.

Students are underprepared in the following senses: first, their common sense epistemology at odds with modern assumptions in this regard; and second is, their habitual ways of acting inappropriate for problem-solving at the tertiary level of studies.

The greatest task for teachers of mathematics seems focused on first, dislodging their taken-for-granted reliance on "**hands**-on experience" as some direct access to the "true" or "right" or "proper," or direct contact with the "real world" through personal experience; and second, in providing them with those frameworks or operational guides which are demanded by the tasks typical of tertiary studies in general, and mathematics, in particular.

The public conventions related to the use and meaning and substitutability of letters in the alphabet, are very different to those conventions in mathematics. This conflict between two sets of conventions is an example, of epistemic constraints on the learning-teaching of mathematics. For example, learners are taught the alphabet at an early stage and are drilled to believe each letter has unique properties and uses. If the "x" in the word "fix" is substituted with a "y", for example, the two words would not be equivalent. However, in mathematics the rule $f(x) = 3x + 4$ is equivalent to the rule $f(y) = 3y + 4$ (x can be replaced with y) or $f(1+x) = 3(1+x) + 4$, but many students write $f(1+x)$ as $1 + 3x + 4$ as they believe the x in $f(x)$ is exactly the same as the x in $f(1+x)$. To dislodge this overlearned rule students are encouraged to use contentless forms (such as 'blob') and write $f(blob) = 3(blob) + 1$. Replacing "blob" with $(x+1)$ on both sides of the equation results in the correct equation.[37] This contentless cue focuses learners' attention away from natural language conventions, and onto the conventions in mathematical language.

In order to prevent the incorrect application of overlearned rules, such as illustrated above, a conceptual glossary was provided for students.[38] This

conceptual glossary provided the meanings of concepts frequently occurring in mathematics, especially in dcop's, in each language game. This conceptual glossary is an attempt to create a framework to overcome problems regarding the learning-teaching of mathematics. As such it is a necessary step in the creation of enabling conditions for mathematics learning-teaching. This conceptual glossary was provided together with a comprehensive set of metacognitive rules (teach steps) necessary to solve dcop's. These steps were obtained from an analysis of expert and novice mathematical learners' engagement in dcop problem solving, as part of project B.[39] Students were given these teach steps in order that they may engage in the problem in a manner which recognizes the problem's essential demands. They rote-learned these in an attempt to make the application of these rules spontaneous or automatic, thereby freeing that mental capacity which they would have had to use for constructing the demands of the tasks in terms of the necessary operations to apply. We attempted to make our "thinking about thinking" and "knowing about knowing" explicit as guides for their action or operations, thereby freeing their mental capacity from "thinking about thinking" while also having to solve a particular problem..

The pass rate of the Engineering Bridging Unit students, solving dcop's, increased from 24% to 62% after this exercise involving the teach steps. This success rate emphasizes the importance of analyzing the nature of the objects of knowledge confronted in mathematics in order to formulate learning-teaching strategies necessary for the successful resolution of mathematical tasks; this rate also emphasizes that the teach steps need some refinement if it is to increase to 100%!

Conclusion

We stated in the introduction to this paper that the work presented is part of an ongoing project. The overarching aim of this project is an analysis of the learning-teaching dialectic in mathematics. Important in this regard is our purpose to refine our "knowing about knowing (mathematics)" to such a degree that we could enable those, currently excluded from mathematics studies at tertiary level to participate successfully and autonomously in this area of studies.

Mathematics as an invention (and imposition) of mind is certainly remarkable in one sense, but also bears testimony to those capacities which all minds are potentially capable of.[40] Our work is aimed at making this potential an actual achievement of real actors in education at tertiary level. In this regard we are confident that the small inroads we have made into those teaching strategies and operational guides which could achieve this, has been successful.[41]

Acknowledgments

The authors wish to acknowledge the Human Sciences Research Council, the FRD of the Council of Scientific and Industrial Research and the University of Natal Research Fund for financial assistance towards this project.

Notes and References

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of Higher Education, 2, 1 (1988): 3-8; A. Craig, "The Conflict Between the Familiar and the Unfamiliar", *South African Journal of Higher Education*, 3, 1 (1989): 166-172; and A. Craig and P. Winter, "An Analysis of Learners' Engagement in Mathematical Tasks", *South African Journal of Higher Education*, 4, 1 (1990): 59-68, for discussions of the theoretical background to our work, and particular empirical projects in this regard; also M. Niaz, "Manipulation of M Demand of Chemistry Problems and its Effect on Student Performance: A Neo-Piagetan study", *Journal of Research in Science Teaching*, 25, 8 (1988): 643-657, for related work.

2. J. Piaget, *The Development of Thought* (Oxford: Basil Blackwell, 1977), 22.
3. A. Craig, "Mothers and Children: An Analysis of Change" (PhD thesis, University of Natal, 1985), 16.
4. J. Pascual-Leone and D. Goodman, "Intelligence and Experience: A Neo-Piagetian Approach", *Instructional Science*, 8 (1979): 301-367.
5. See Piaget (1977) and Craig (1988).
6. Craig & Winter (1990).
7. See P. Winter, "An Analysis of Learners' Engagement in Mathematical Tasks" (MEd thesis, University of Natal, Durban, South Africa, 1988).
8. Piaget (1977).
9. *Ibid.*, 40.
10. *Ibid.*, 9
11. *Ibid.*
12. *Ibid.*, 11-12.
13. *Ibid.*, 8.
14. *Ibid.*, 40.
15. See Craig & Winter (1990) for guides for resolving complex puzzles through a classification procedure; and appendices 1 & 2 of P. Winter, "The Cognitive and Epistemological Constraints on Mathematics Teaching-Learning" (Research in progress towards a PhD thesis) for guides regarding the nature of the objects of knowledge confronted in "story problems".
16. Piaget (1977), 40. See Winter (in progress) for an empirical project specifically focussed on the nature of the objects of knowledge in mathematics learning-teaching.
17. Niaz (1988).
18. See aslo Winter (1988) for a review of Pascual-Leone's theory of M power and M demand.
19. See L. Vygotsky, *Mind in Society* (Cambridge, Massachusettes: Harvard University Press, 1978), and J. Wertsch in B. Rogoff, and J. Wertsch (eds.), *Children's Learning in the "Zone of Proximal Development"* (Washington: Jossey-Bass Inc, 1984), for an explanation of the zone of proximal development. This paradigm for learning-teaching suggests a "bridge" between what the learner does know and can do, and what the task demands in terms of knowledge and operations. We propose certain guides or procedural steps as providing this "bridge".
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21. See Winter (in progress).

22. See C. Collier and L. Redmond, "Are You Teaching Kids to Read Mathematics?", *Reading Teacher,* 27 (1974): 804-809; C. Smith and H. Kepner, "Reading in the Mathematics Classroom" (Educational Resources Information Center, ED 207863, National Education Association, Washington, D.C., 1981) and V. Schnell, "Learning Partners: Reading and Mathematics", *Reading Teacher*, 35 (1982): 544-548.
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30. *Ibid.*, 222, 223.
31. C. Churchman, *The Design of Inquiring Systems: Basic Concepts of Systems and Organizations* (New York: Basic Books, 1971).
32. I. Mitroff and F. Sagasti, "Epistemology as General Systems Theory: An Approach to the Design of Complex Decision Making Experiments", *Philosophy of Social Science*, 3 (1973): 117-134.
33. Kitchener (1983), 224.
34. See Craig & Winter (1990); Appendices 1 & 2 of Winter (in progress).
35. See A. Craig, "Adult Cognition and Tertiary Studies", *South African Journal of Higher Education* .
36. Kitchener (1983), 224.
37. See Winter (1988).
38. This appendix can be obtained from Winter, Department of Maths and Applied Maths, University of Natal, Durban as appendix 1.
39. *Ibid.*, as appendix 2.
40. See Piaget (1977) and Craig (1988).
41. See Winter (in progress).

APPENDIX A : Conceptual Glossary

Note: There are words which belong exclusively to the real world (e.g. feeling), words which only seem to make sense in the world of mathematics (such as flat object), words which belong to both worlds (such as box) and words which have a different meaning in each world (such as function).

	REAL WORLD	ARTIFICIAL (MATHEMATICAL WORLD)
Above	This refers to an object which is over another three dimension object. The swing is above the ground in the figure 1.	If a triangle is above a rectangle, then it is mounted on top of its upper edge. See figure 2: the triangle is above the rectangle and one side of the triangle coincides with one side of the rectangle.
Adjacent	Next to or sharing a common boundary. Counties can be adjacent while two people can sit next to each other and not touch and yet be adjacent to each other.	Two sides are adjacent if they touch. They need not be at 90 degrees to each other.
At the bottom	See the word "below".	Same as "below". See the word "below": the triangle is at the bottom of the rectangle.
Below	This refers to an object which is underneath a three dimensional object. The ground is below the swing in the figure 3.	If a triangle is below a rectangle, then it is underneath its bottom edge. See figure 3: The triangle is below the rectangle and one side of the triangle coincides with one side of the rectangle.
Box	A three dimensional object having a base. It may or may not have a top. See the hat box in the figure 4.	A three dimensional object with six sides having a rectangular base and rectangular sides perpendicular to the base, and a rectangular top. See figure 5. The box may or may not have a top. Unless stated otherwise, one assumes that it has a top. A box is not always a cube (see cube below).

Capped	Capped means to be on top. e.g. the mountain was capped with snow. See figure 6.	Capped is not a word which is used in mathematical language but may be used in dcop's. See the word above: the rectangle is capped by a triangle.
Circumference	The dictionary definition of circumference is "enclosing boundary" or "distance around".	The length of a curve which encloses a boundary. Same as the word perimeter. See perimeter.
Cone	A rough object with a circular base and sides converging to a point directly above the centre of the circle. An ice-cream cone is an example. See figure 7	An object with a circular base and sides converging at a point above the base. Volume is area of base circle times the height times (1/3).
Cube	An obejct in the shape of a rough box in which all edges are approximately the same length. For example, ice cubes. See figure 8.	This is a box in which all edges have the same length, i.e. square base and height same length as width of base. See figure 9.
Cylinder	Coke cans are in the shape of a cylinder — a uniform object with a circular base and top. See figure 10.	A uniform object with the top and base having the same shape. A right cylinder is a cylinder in which the top lies directly above the base. See figure 11 for a (non-right) cylinder.
Disc	A three dimensional object which has almost no thickness. e.g. a floppy disc. See figure 12.	A disc is a cylinder with a small thickness or height. See figure 13.
Extreme	Refers to great or excessive. e.g. the water excerts extreme pressure on the dam wall.	Extreme values refer to the maximum or minimum values of a function. Plural: extrema.
Felt	Material	Not a mathematical term but may be used in a dcop.

Fencing	Used for designating a border or for enclosing regions.	Not used in mathematical language but in dcop's. Fencing used in the problem is to be represented on paper and is thus viewed from the top with the width of the fencing being irrelevant to the dcop.
Flat object	A three dimensional object whose thickness is negligible. e.g. a disc.	Represented as a two dimensional object which has NO thickness. e.g. a diagram of a flat piece of metal in the shape of a rectangle will be represented as a two dimensional rectangle.
Floating net	Used in the sea or in lakes or in rivers. Net may enclose a region.	Not used in mathematics, but may occur in dcop's. To represent the problem on paper the floating net is to be viewed from the top and the width of the net is thus irrelevant to the dcop.
Function	This refers to the working property/role of people or objects. e.g. the function of teachers in society is to transmit knowledge to students.	A function in mathematics refers to a rule which associates the elements in one set with exactly one element in another, not necessarily different, set.
Maximize	To increase to its greatest possible size. For example one may maximize the number of people who can be seated in hall. This is not an exact value. It could mean to add.	To increase to its greatest possible size. Maximize refers to an exact value. Maximize does not mean to add. The following "est" words mean to maximize: Biggest, largest, greatest, longest, toughest, most ect. Special 'est' words tell us immediatley what has to be maximized: e.g. heaviest which refers to mass.

Minimize	To reduce to its least possible size. May mean to take something away. e.g., to minimize the amount of material used in cutting out patterns. Does not refer to an exact value.	To reduce to its smallest possible size. Does not mean to subtract. Refers to an exact value. The following "est" words imply to minimize: shortest, quickest, least, closest, nearest, most (economical).
Mounted	Mounted refers to being on top: e.g. The rider mounted the horse.	Mounted is not a word used in the language of mathematics but may be used in dcop's. See the word 'above': the triangle is mounted above the rectangle.
On top of	See the word "above".	Same as the word "above". See the word "above": The triangle is on top of the rectangle.
Per	Short hand for 'for each'. If a carpet costs 10 rands per metre, then it costs 10 rands for each metre.	Suppose that we have 7 metres of the carpet costing 10 rands per metre then the 7 metres of carpet will Cost 7m (10 rands/m)=7 rands. Note that the metres divide into each other. Per is used to keep the units consistent when dealing with equations such as the cost given above.
Perimeter	Refers to the length around the outside of an object, the object being viewed from above. e.g. perimeter of a country, pool, box or table.	Refers to the length around the outside of a given figure. See figure. Dotted lines are not part of the perimeter but are used to construct the figure.

Pi	Pi rarely used in the real world.	Refers to the ratio of a circumference of a circle to its diameter. It is a NUMBER. It is not 22/7. It is an irrational number which is APPROXIMATELY 22/7. Since it is a number, lengths, areas, volumes can be expressed in terms of pi.
Pyramid	The pyramids of Egypt, for example.	A three dimensional object with a rectangular base and sides converging at a point above the base. Volume is area of base times the height times (1/3). See figure 16.
Quarter	Quarter is used to designate a small amount of a whole part. It is approximately one part of four parts. See a quarter of a cake in figure 17.	A quarter is denoted by the fraction1/4. A quarter of a SEMI-circle is depicted in the figure 18.
Rectangle	An oblong object usually implies that its base is rectangular with the width different from the length. Not necessarily a precise designation.	A rectangle refers to a two dimensional figure which has 4 adjoining sides, opposite sides being equal and parallel, adjacent sides perpendicular. See figure 18.
Right circular cylinder	See 'cylinder' above	This is a right cylinder with the base and top being a circle. Volume is area of base times height, surface area is twice the area of the base circle plus the circumference of the base circle times the height. If it has no top then the surface area is as above less the area of the base circle. See Figure 20

Right cone	See 'cone' above	A cone in which the sides converge to a point directly above the centre of the circular base. Volume is area of the base times the height times (1/3). See figure 21.
Right cylinder	See "cylinder"	This is a cylinder in which the base is directly below the top (see cylinder above).
Right pyramid	See "pyramid". See figure 22.	This is a pyramid in which the sides converge to a point directly above the centre of the rectangular base. See pyramid above.
Square	A square is a rough mathematical rectangle with all sides approximately equal. See figure 23	A square is a rectangle with all sides having equal length.
Underneath	See the word 'below'.	See the word 'below': in the figure the triangle is underneath the rectangle.
Variable	Refers to changing. e.g. the Temperature in a room without airconditioning is variable.	Variables are used to denote the specific and the general. e.g. the variable x for the function $f(x) = x + 1$ can be replaced with t or with the number 2, or 'blob'.
Washer	A washer can be in the shape of a disc or a disc with a hole in the middle. Washers are made of different kinds of materials and are to be used in machinery and in plumbing. See figure 24.	A washer is a disc with a hole in the middle. See figure. Washers do not belong to the world of mathematics but may be used in dcop's and are used to find volumes of solids of revolution in calculus.

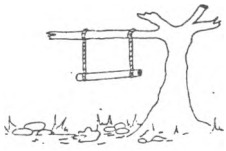
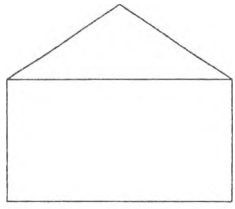


FIGURE 1



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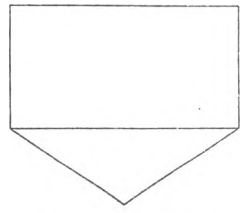

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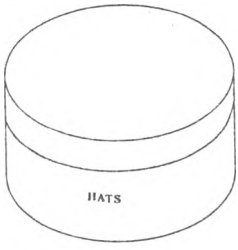

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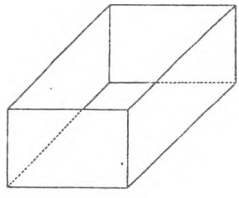

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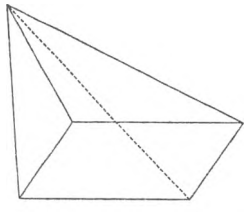

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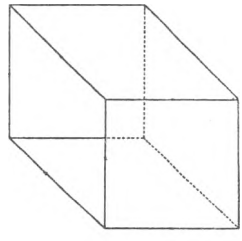

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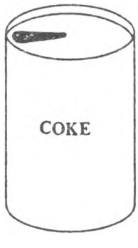

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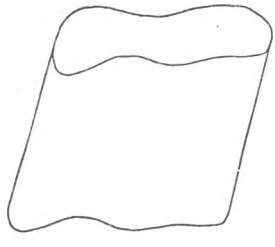

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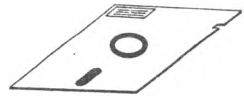

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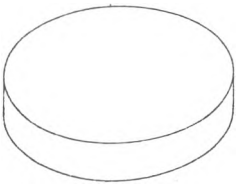

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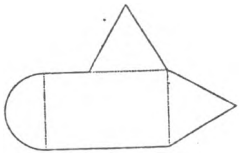
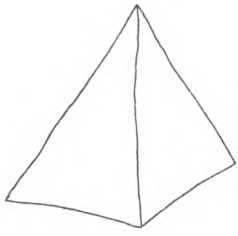


FIGURE 14



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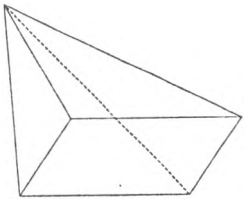

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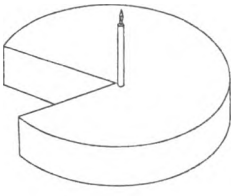

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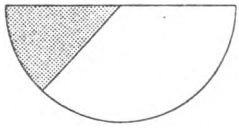

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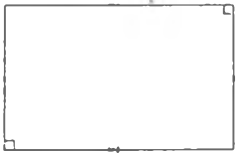

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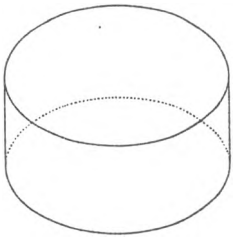

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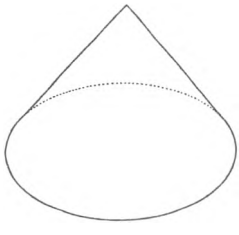

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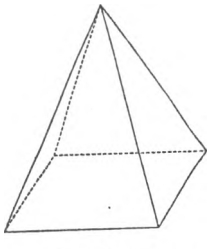

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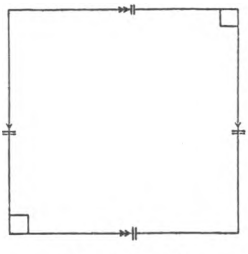

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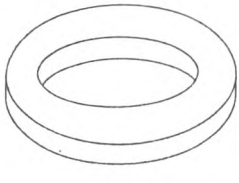

FIGURE 24

APPENDIX B

The term dcop refers to "disguised calculus optimization problem".

(1) Read dcop carefully.
   (a) Extract real world terms and mathematical terms to form two separate lists.
   (b) Ensure that you understand the implications of each word/term. See conceptual glossary.

(2) Construct a diagram, mainly using the terms from the list of mathematical terms.
   (a)
   This diagram becomes an artificial representation of the 'real world' problem and loses its 'realness'. Note that certain three dimensional shapes are represented as two dimensional objects on paper (such as a window, 'flat object' — see conceptual glossary) while other three dimensional objects are represented on paper as three dimensional (see 'box' in conceptual glossary).
   (b) Decide which lines are to be broken or continuous. Broken lines refer to those lines which are only used to construct the diagram and are not actually part of the problem. See concept perimeter, for example.

(3) Attach variables to diagram.

(4) Decide what has to be maximized or minimized (this will be called P) as follows:
   (a) Find that SENTENCE which contains the word maximize (maximum, maximal) or minimize (minimum, minimal) (see conceptual glossary for definition of these terms). If the dcop does not contain these words then look for the sentence which contains the 'est' words such as least, smallest, shortest, closest, nearest, biggest, longest, greatest, toughest, stiffest, most, lightest (look under maximum and minimum in conceptual glossary). These 'est' words imply either maximize or minimize.
   example, lightest means weight (mass) is therefore the P one seeks!
   The word 'most' can imply minimize (as in the most economical) or maximize (as in the most amount of area). THERE WILL BE ONLY ONE SUCH SENTENCE. The appropriate sentence will be denoted by S.
   (b) If we have a special 'est' word then we have our desired P. Otherwise look in S for one of the terms: Area, volume, distance, length, cost, profit, income, capacity (volume), time, toughness, thickness, amount of light (area), weight. Amount of fencing refers to length, while amount of material generally refers to area.
   Dimensions cannot be maximized or minimized, nor can a container. Only ONE of the terms area, volume, distance, length etc., will be contained in the sentence S. This term (word) will give us our P.

(5) Use the diagram constructed in (2) to write P in terms of the variables used in (3). This P will be in terms of more than one variable, usually two.

(6) Write P in terms of exactly one variable say x. This can be done by writing one variable in terms of the others using information provided in the dcop. Note that x will belong to an interval I.

(7) Once P is in terms of one variable, we can differentiate P with respect to this variable (say x). Solve P'=0 to get x=a, or b or c, etc (roots of p"=0).

(9) Find the value of P and the other variables using x=a or d.

(8) Evaluate P" at x=a (and other roots). If P"(a)>0, then x=a will result in P being a minimum. If P"(a)<0, then x=a will result in P being a maximum. If no root gives a minimum and the problem requires P to be minimized (or visa versa), then the minimum (maximum) will occur at one of the end points if I, say d.

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REVIEW ESSAY

Difference and Discourse: Valerie Walkerdine and the Sociology of Mathematical Knowledge

V. WALKERDINE, *The Mastery of Reason,* Routledge, London and New York (1988) ISBN 0-414-00696-1, 230 pages

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Introduction

Attempts to get to grips with the idea of a People's Mathematics in South Africa[1] are premised on the assumption that mathematics education as currently practised serves the interests of the dominant groups in society. The view that mathematics represents *a priori* truth serves to perpetuate this hegemony. A firmly founded sociology of mathematical knowledge, therefore, is a prerequisite for reconstructing the mathematics curriculum so as to "place maths and science at the service of the people rather than at the service of big business and the state".[2]

Over the last three decades an increasing number of studies has attempted to problematise the contested nature of mathematical knowledge. This corpus includes the works of White,[3] Struik,[4] Gay and Cole,[5] Zaslavsky,[6] Fasheh,[7] Gerdes,[8] Lave,[9] Mellin-Olsen,[10] and the Brazilian School.[11] This work is largely descriptive and, where individual studies do attempt any theorisation, they are unable to provide a general explanation which transcends the data and context of the respective analyses.[12] The work of Valerie Walkerdine represents by far the most comprehensively realised theorisation of the sociology of mathematical knowledge attempted to date.

Walkerdine's project may be summarised briefly as consisting of three steps. One: a critique of cognitive psychology, and in particular the work of Piaget.[13] Two: the development of a new conception of the human subject.[14] This step involves the rejection of the notion that the subject is driven largely by rational processes, is relatively autonomous of his/her historical origins and class and gender location, and behaves in a generally consistent manner under most circumstances. Three: with the "fragmented subject" as her starting point, Walkerdine then develops a new perspective on how mathematical learning occurs.[15]

The remainder of the present review is divided into five sections. The first three contain a largely descriptive account of Walkerdine's work to date. This is followed by an analysis of the main shortcomings in this corpus. A concluding section sketches some possible steps towards providing a foundation for the development of a People's Mathematics.

From dualism to discourse

The enterprise of Walkerdine and her colleagues is part of the revolt against structuralism which, at its most mechanical, privileges economic, linguistic or cultural structures as the determinant elements in the explanation of individual behaviour and social phenomena. Structuralism views the individual subject as a victim of the forces of the economy and history. Cognitive psychology, on the other hand, places the locus of decision making and action firmly in the individual. It is the contention of the English poststructuralist school[16] that Piaget assumes a disjuncture between the individual and his social milieu: the latter is viewed as a relatively remote context which, at its strongest, merely modifies the behaviour of the self-sufficient subject. *Changing the Subject*[17] sets out to dissolve this individual/society dualism by reconceptualising the field in such a way as to stress the dialectic relationship between the two poles. This task involves the search for links between "a diverse and contradictory social domain and the multiple and contradictory subject".[18]

The first step in this enterprise is the sketching of a genealogy of modern psychology in order to understand how and why it functions as it does. Hendriques et al draw heavily on the work of Foucault in describing the conditions of possibility of psychology. These have their origins in the rise of capitalism in the seventeenth century and the need to discipline the population, inculcate good work habits and the skills required by the industrial mode of production, and elicit consent for the new form of government. These developments intensified during the ensuing centuries, and the emergence of mass schooling in the nineteenth century represented a quantum leap in efforts to regulate the population through consent rather than coercion.

Central to these developments was the emergence during the Enlightenment of rationality as an organising principle for viewing the workings of both the individual and society: reason, as manifested, for example, in Newton's laws of motion, began to be championed as the only "true" way of understanding the world. Secular wisdom, based on logic and justice, replaced the absolutism of the church. Crucial to the functioning of these principles was the logocentric subject of Descartes. The individual began to be seen as independent, unitary and non-contradictory. It is this notion of the cogito - of the mind guaranteeing its own rationality, irrespective of social conditions - that is the primary foundation of psychology.

Psychology, in turn, became one of the principal "technologies of the social", developed to regulate the social order through the relegation of moral questions to the domain of the scientific.[19] Measurement and categorisation evolved as the two mechanisms for this regulation. But the very qualities which psychology chooses to calibrate, and indeed the way in which it chooses to view the individual, in an essential sense predetermines its findings and consequently the direction taken by its regulative practices. Chief amongst these regulative practices, from our present perspective, is the Piagetian child-centred pedagogy:

> It is the empirical apparatus of stages of development which of all Piaget's work has been most utilised in education. It is precisely this, and its insertion into a framework of biological capacities, which ensures that the child is produced as an object of the scientific and pedagogical gaze by means of the very mechanisms which were intended to produce its liberation.[20]

In the same way, Piagetian pedagogy produces both what it means to learn, and the content and nature of this knowledge. The self-sufficient individual, using his innate faculties, which develop inexorably toward an ever more rational ideal, abstracts the unchanging truths from his surroundings, irrespective of his historical trajectory, social position or emotional climate.

When viewed against the rise of the rational capitalist state, which regulates its citizenry through the inculcation of reason, the central role of mathematics in the curriculum becomes transparent. Formal mathematics represents the ideal of:

> ... a rationality devoid of any content which can describe and therefore explain anything. Mathematics has for centuries held this position as queen of the sciences, when nature became the book written in the language of mathematics and when mathematics held out the dream of a possibility of perfect control in a perfectly rational and ordered universe.[21]

Pedagogy and psychology are in perfect harmony in propagating this view. Mathematics is reasoning, and the aim of school mathematics is to teach children the joy of discovering mathematical principles, of seeking pleasure in order, in attaining the correct answer.

> The rational dream sought to produce children who would become adults without perverse pleasures. These are the hopes invested in the power of reason and in mathematics teaching.[22]

This "normal" model of development idealises and universalises the path followed by certain white, bourgeois males, and presents it as if it were an unfolding of nature.[23] Any children who do not exhibit this pattern of development are pathologised as "abnormal". Mathematics thus plays a key role in marginalising "The Other": women, blacks, the working class and those who do not exhibit an aptitude for the subject.

The next step in Walkerdine's delineation of a sociology of mathematical knowledge involves an exploration of discourse, the mechanism through which subjects engage in social practices. Discourse is a complex notion which ranges in scale from a micro-level encounter between two individuals to a macro-level organising concept such as Marxism. In pratice any discourse limits what can be said, whilst at the same time providing the spaces - the concepts, models, metaphors and analogies - for making new statements within that discourse.[24] In other words, discourse both constrains and enables.

The essence of discourse theory is to provide a new perspective on the relationship between "the real world" and the perceptions, statements and actions within a particular discourse. On the one hand, it denies that real processes, such as the economy or nature, determine what may or may not be asserted in discourse. On the other hand, it refutes the position that what counts as knowledge and how it is produced is a purely scientific process removed from politics. For example, Piaget's stages of development are not independent of children's learning, but Piagetian discourse sets up a specific set of relations between learning and a scientific theory; it establishes what can and cannot be said about learning. While it may provide certain insights into how children learn, it constrains teachers to view their pupils in a particular way, and inhibits other insights.

There is a close relationship, in turn, between teachers' perceptions and expectations, and the behaviour of their pupils. Thus:

> .... the subject itself is the effect of a production, caught in the mutually constitutive web of social practices, discourses and subjectivity; its reality is the tissue of social relations.[25]

Since the subject does not exist outside of specific positions made available in specific discourses, and since a number of subject positions are offered by any discourse, it follows that an individual personality cannot exhibit a perfectly consistent set of subjectivities across a variety of discourses. This necessitates the notion of the contradictory subject. For example, certain girls may be in a position of power when the discursive relations are amenable to their giving vent to their nurturing capacities, but these same individuals could be marginalised when, in the very next moment, the classroom discourse turns to one in which competitiveness and aggression become the dominant features.[26]

Signification, discourse and desire

It is within these discursive frameworks that specific acts of signification, or knowledge production, occur. Signification is to Walkerdine's psychosemiotic approach to learning[27] what representation is to cognitive psychology. For psychology, the relationship between external reality and what the learner comes to know is mediated by the information processing faculty of the brain: reality is represented through the processes of perception and cognition. Signification, on the other hand, is not a representation but a production:

> ... significations are produced and lived in everyday practices and social relations and
> ... subjects are constituted and located as part of these same practices.[28]

From this perspective, what the learner comes to know is shaped by the discursive web within which the learning occurs.

Another element crucially implicated in the shaping of knowledge is the history of the subject. Class, gender and cultural positions, together with individual neuroses and proclivities, can be traced back to earliest childhood. Jacques Lacan's psychoanalytic semiotic theory provides the framework for these considerations.

It is during Lacan's mirror stage, in the recognition of a distinction between herself and an other that conscious subjectivity is born. At the same time, in the realisation that the mother, the source of the only satisfaction ever attained, is separate from the self, an irrevocable loss is discovered. At this stage the subject enters the realm of the symbolic order as language emerges:

> ... the child uses his or her first words to establish, in fantasy, control over the loss of the object which gave satisfaction.[29]

But, at the same time, the use of the signifier to control the signified increasingly confirms the gap between the subject and the object of her desire. Meaning is carried by the sign, which embodies the unity of the signified and the signifier. Thus semiotics, the theory of signs, bridges the psychic and social domains. It also provides a system which recognises the complex intertwining of cognition and affect, and the ways in which conscious, rational agency is subverted to the irrational desires of the unconscious.

Walkerdine's work contains numerous examples of ways in which these theoretical concepts manifest themselves in mathematics learning.[30] The formation

of a mathematical sign, such as "more", does not merely involve the representation of an object, operation or relation by a symbol, but occurs within a specific signifying practice. The opposite of "more" in home-based eating practices, for example, is more likely to be "no more" rather than "less". In school-based mathematical practices, on the other hand, "less" is the opposite of "more". From this perspective, the folly for pedagogy of assuming that the former provides a contextualisation of the latter, is obvious. Furthermore, the term "no more food" might have quite different meanings for working class and middle class children. The same signifier constructed in different discourses may denote a variety of signs. On this issue, Walkerdine concurs with the main conclusion of the ethnomathematicians such as Gay and Cole, Lave, Gerdes, Fasheh, Mellin-Olsen, and Carraher et al: school mathematics differs from that of the marketplace, the craftsman's shop or the kitchen. All the more surprising, therefore, that Walkerdine alludes to the work of these authors only belatedly, and then in passing.[31]

Transfer between out-of-school signifying practices and the discourse of school mathematics

One of the potential pitfalls of the micro-analysis of signification practices is that, through privileging discourse, such an account easily slides into relativism, in which all discourses are equivalent with regard to their status as truth, and where there is no basis for establishing the superiority of any particular account. Walkerdine takes particularly seriously the pedagogical problem of transfer from out-of-school practices to school mathematical activities. In her investigation into how to forge associative links between signs constructed in one set of practices and those formed under different discursive relations, she confronts the issue of discourse relativism.

Central to her semiotic description of the transfer process is an elaboration of the difference between the two kinds of mathematical practices.

> Formal academic mathematics, as an axiomatic system, is built precisely on a bounded discourse, in which the practice operates by means of suppression of all aspects of multiple signification. The forms are stripped of meaning, and the mathematical signifiers become empty. This is central to its power as a system or discourse which may be superimposed onto and read into all others.[32]

In out-of-school discourses, on the other hand, meaning and method are specific to familiar practices. Some of the latter discourses may provide articulation points which lead to a fruitful overlap with school mathematics, thus facilitating transfer, while "other points of intersection (namely the inclusion of the same signifiers, forming different signs within the two practices) will produce possibilities for error in this misunderstanding".[33].

The pedagogical task, therefore, is to identify areas where out-of-school practices might usefully overlap with school mathematics and to structure the school discourse so as to work systematically through the process of transfer. The shift from one practice to another involves the prising apart of one set of relations of signification and rearticulating them to produce new signs. This, in turn, is achieved through the construction of complex signifying chains, "which facilitate the move into new relations of signification which operate with written symbols in which the referential content of the discourse is suppressed".[34]

One example of a discourse containing such a signifying chain which Walkerdine quotes is set in the home: a mother and her four year old daughter are discussing how many friends the latter will have to play, and how many glasses of juice and biscuits will be required. Firstly, the daughter names the seven children she wants to invite. Secondly, the mother helps her to raise one finger to correspond with each name. In the first step, the names are signifiers of the children, but in the second step, they drop to the level of signified in relation to the new signifiers, the fingers. In the third step, the fingers in turn become the signified for the next level of signifiers, the spoken numbers which are counted off the fingers. This process is represented schematically in Figure 1.

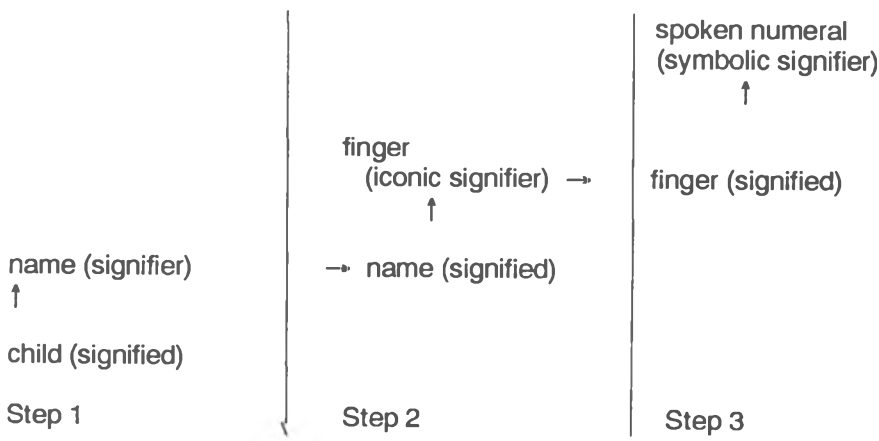

Figure 1 The construction of mathematical knowledge as signifying chain

Another example described by Walkerdine involves a similar mother-daughter conversation around the topic of cake baking.[35] The first three steps are almost identical to those described above, after which the mother begins posing questions about counting and simple addition. At first she relates her discussion about the quantities to the names of familiar children. During the course of the conversation, she gradually shifts the focus of referential attention to her fingers, first establishing a one-to-one correspondence between the children and her fingers, and then later omitting the names and referring the mathematical operations only to her fingers. The mother achieves a move out of a discourse in which number relations are part of a home-based practice into a discourse concerned with the internal relations of the number system. The external reference (or metaphoric content) is suppressed in favour of a focus on the properties of the numbers themselves (the metonymic content).

But out-of-school practices can only become mathematics if certain transformations are accomplished. The above examples illustrate successful transformations from a non-mathematical to a mathematical discourse. This sophisticated treatment stands in stark contrast to cognitive psychology in which the cultural lineaments of activity are unproblematised, and where *any* situational referent is assumed to engage the attention of the learner.[36]

Some problems with Walkerdine's account

In her earlier work,[37] Walkerdine's subjects appear as captives of practice. We see little conscious agency in the form of domination, resistance or negotiation, while both cultural specificity and desire are almost entirely absent. Her later work,[38] however, contains a number of examples which begin to address these issues, thus promising a move out of the grip of discourse determinism.

The most striking example shows a teacher involved in a simulated series of money transactions with a group of six- to seven-year olds.[39] Walkerdine prefaces the scene with a series of discursive excerpts in which the children exhibit a sophisticated understanding of the exchange value of money in negotiations with their parents. This understanding is in sharp contrast to the assumptions made by the teacher when setting up the school practices, that is, that children's understanding of money comes through the manipulation of coins representing very small amounts, and that it is some time before they come to grasp the highly abstract notion of exchange value. Thus, the school transactions are not only unhelpful in fostering the understanding which the teacher hopes to facilitate, but downright misleading. However, this is not the main point which Walkerdine makes by means of this example. The teacher has constructed a game in which shopping is used as a foil to give the children "concrete" practice in the subtraction of small numbers inserted into a "real" situation. But it is precisely the mathematical task which makes it unlike real shopping. Each child has 10p with which she can make purchases and calculate the change due. Since this bears little relation to actual shopping practices, the children treat the game as a fantasy, and it is here that class, culture and desire enter the school signification practices. In these and other shopping fantasies described by Walkerdine the children "become" what is not possible in real life: rich, arrogant and able to indulge expensive tastes. They buy luxury foods, take exotic holidays and behave badly toward shop assistants. In one sequence, the girls playing the role of shop assistants caricature their own London accents, while the "customers" affect middle-class accents.

Walkerdine does not back these latter assertions by means of hard evidence, since they were gleaned from field notes rather than interview transcripts. This somewhat weakens her case because conclusions drawn from interviews or the analysis of other discursive practices may be open to divergent interpretations.[40] This gap in Walkerdine's methodological rigour is emphasised by the alternate readings she provides to research carried out within a Piagetian paradigm. Thus, Walkerdine has not yet given a convincing demonstration as to how class and culture give direction to children's fantasies. That they do indulge in fantasies sparked off by school mathematical practices is closely argued and amply illustrated with excerpts from the 10p game described above. We are convinced that desire provides the mainspring for the appropriation of discourse by individuals and groups. Walkerdine claims that it is the class positioning of the children in the 10p game which causes them to go off on tangential fantasies rather than engaging with the subtraction task. Thus, the terms of the discourse disempower them mathematically. This explanation is not very satisfactory (would middle class children behave differently?), nor does it point a way out of the morass of discourse determinism.

Attempts to specify ways in which girls are excluded from holding power in the discourse of school mathematics are more successful.[41] Girls' success is dismissively attributed by their teachers to rule-following, rote-learning or mere hard work. The more competitive and aggressive behaviour of boys, on the other hand, is hailed as "brilliant" and indicative of "real understanding". In both cases, these "subjectifications"[42] have little empirical foundation in relation to actual performance.

A far more problematic matter arising out of Walkerdine's work concerns the relationship between political goals and classroom practices. Many teachers would have felt most uncomfortable by her critique of Piagetian pedagogy and the role played by mathematics in constructing rational subjects and regulating the social order. For this reason, Walkerdine's descriptions of successful instances of transfer from out-of-school discourses to school mathematics signals a welcome move from critique to alternative practice. But it leaves enormous questions unanswered. Walkerdine recommends ways of facilitating transfer without telling us why it has suddenly become acceptable to teach mathematics. Is it merely an oversimplified notion of transfer which makes current practices repressive? Will a closer focus on the mediation of organic cultural discourses and school mathematics ensure the emergence of an emancipatory mathematics? Could the pedagogical practices prescribed by Walkerdine not be used to further conservative political goals?

Conclusion

Walkerdine's insistence that all mathematical activities occur within specific signifying practices allows for the consideration of factors other than individual rationality in the sense-making process. She has begun to show how class, culture and gender location, under the motive force of unconscious desire, give shape to mathematical meaning. Although launched from within an impressive theoretical edifice, these demonstrations are, at this stage, too few and in some instances too problematic to present an entirely convincing account. For this reason, dialogue between Walkerdine and the ethnomathematicians would certainly prove mutually fruitful.

In particular, the ethnomathematical case studies, which detail the disjuncture between school mathematics and out-of-school mathematical practices across a range of geographical, class and cultural boundaries and across a variety of mathematical task situations need to be analysed within Walkerdine's psychoanalytic/sociological framework.

Ethnomathematics would thus benefit from considering the descriptions of Lave, Fasheh, Gerdes, Mellin-Olsen and Carraher within a theory capable of integrating these context-specific accounts. At the same time, these case studies offer the possibility of fleshing out, through exemplification, the bones of Walkerdine's framework.

However, Walkerdine's theory begs a more fundamental elaboration. Having discredited psychology by means of a most convincing political analysis, she leaps into an equally convincing description of novel pedagogical practices which offer the possibility of integrating out-of-school problems and school mathematics. But Walkerdine leaves a gaping chasm between her political analysis and pedagogical prescriptions. We need a mechanism for linking politics and pedagogy; for ensuring that progressive political ideals find expression in the classroom so as to mobilise mathematics as an instrument of liberation rather than oppression.

Such a mechanism will need to be placed within a comprehensive theory of the curriculum, which takes account of all the processes of knowledge constructions and reconstruction, and both provides a place for the exercise of the interests and expertise of politicians, academics, workers, captains of industry, scientists, bureaucrats, students and teachers, and builds in structures whereby these contributions are made accountable to each other and to a set of common ideals.

Notes and References

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REVIEW

Apartheid Education and Popular Struggles

By ELAINE UNTERHALTER, HAROLD WOLPE, THOZAMILE BOTHA, SALEEM BADAT, THULISILE DLAMINI, BENITO KHOTSENG (eds.), Ravan Press, Johannesburg, (1991) ISBN

Reviewed by Mokubung Nkomo
University of North Caroline, Charlotte

It is common knowledge now that the struggle over educational inequity and maldistribution of resources on account of race antedates 1948. Opposition to educational inequity escalated with the passage of the Bantu Education Act in 1953. The response was brutal repression that quashed the protests and the nascent alternative structures initiated in the 1950s, and drove scores of educationists into exile or other fields. The 1980s witnessed a revival of resistance which displayed greater vehemence, protraction, organization and yet barely survived the onslaught of the two states of emergency that ended with the now-historic February 1990. While the state's reaction to resistance in the education domain was characteristically savage, the impact of this resistance on the state's self-confidence and well-being cannot be minimized.

During the latter period, opposition to apartheid education took a variety of forms: grassroots activities by students; a handful of conferences both internal and external; and the publication of numerous articles and books grappling with various aspects or perspectives on the education crisis. The latest contribution in this last category is an anthology of papers resulting from conferences convened by Research in Education in South Africa (RESA) entitled *Apartheid Education and Popular Struggles*. The thirteen-chapter collection consists of two sections: the first is a critique of state and corporate reform initiatives; the second offers a critical assessment of the various facets of reform and transformation on the ground during the 1980s. This is where the volume seems to have carved its effective title, Popular Struggles.

In the lead essay we are told that the aim is to dispel the notion that education is central to social transformation. "Our contention", the authors declare, "is that education is accorded immense weight as a mechanism either of social reproduction or social transformation ... for example, in the reproduction of the racial order and relations of production, or in the transformation of the stratification system and the redistribution of occupational opportunities".[1] Distilled, their argument is that "education may be a necessary condition for certain social processes, but is not a sufficient condition, and hence cannot be analyzed as an autonomous social force".[2]

These are valid points, and there is an effort in some of the essays to substantiate them. To make the case, the authors of the introduction (Unterhalter and Wolpe) periodise the apartheid education regime into five segments: education for reproduction of the racial order; Bantu education and the reproduction of South African capitalism; education as an instrument of transformation; and education as a mechanism of social transformation. In each period they critique the conservative/orthodox (that is, state intellectuals and civil servants), and the liberal and national liberation perspectives. The division of the entire apartheid era into five segments within which three ideological perspectives (conservative, liberal and "liberation movement") are assessed and affords an opportunity for comparative evaluation of the assumptions, policy intentions and policy alterations initiated by state and capital; and of the critical reactions of the opposition to these initiatives in each period.

It is useful to observe that throughout the entire period, structural functionalism was the dominant theoretical paradigm, among both apartheid proponents and critics. In the 1950s and the 1960s the proponents of this paradigm, especially state intellectuals and civil servants, promoted the notion of social homeostasis defined within the parameters of apartheid social relations. Equilibrium or stability was the ideal, and education the mechanism for socialization employed to achieve or restore stability should disequilibrium - economic, political, or otherwise - occur. Paradoxically, orthodoxy has its own trenchant dynamic with its exigencies of the moment. This is amply demonstrated by the authors' discussion of state's education reform initiatives throughout the entire period. In recent years the adoption of "total strategy" suggests a realization that a multiplicity of devices were necessary in order to maintain stability.

Early critics of apartheid education (for example, Horrell) although providing definitive empirical evidence refuting official claims, did not directly challenge the paradigm or its assumptions. However, a discernible but gradual detachment of the paradigm becomes obvious as alternative modes of analysis emerged. The shift is clearly delineated by the authors' periodization. Over time the critique of apartheid education has been refined; moving, for example, from structural functionalism to conflict, marxist, neo-marxist formulations and other eclectic forms. It is in fact a dialectical development that accordingly embraces elements from receding paradigms that are relevant to the present conjuncture and casts aside those that are not.

Since the critique that is offered in *Apartheid Education and Popular Struggles* has a spatial and temporal advantage that reflects this development, one would have anticipated a more carefully-crafted critique of the different criticisms from the broad range of the liberation movement in each period, with cognizance of the prevailing consciousness and the intellectual tools or paradigms of the period. Taking *Aparthied Education and Popular Struggles* as an illustration, while it possesses a more wholesome critical capacity (an advantage it has by virtue of its temporal location), it nevertheless leaves many areas untouched because of its own understandable limitations: shortcomings which will be unfurled from the vantage point of future hindsight.

The vehement assaults of apartheid on civil society have created a tradition of protest that is reactive rather than proactive. The project of progressive education critics was that of specifying the assaults in education and their deleterious impact - a necessary function despite its limitations. The urgency of the crises in each period

and the delimitations imposed by the form in which such criticism was made - journal articles for instance - precluded full exposition of all the intricate relationships between education and other social processes. (There are works where these connections are made which are not cited by the authors of the lead essay). But this is not a blanket apologia for all, as there are clearly some who have been insular.

It is indeed a parochial progressive educationist who would consider education as an "autonomous force" with the exclusive mandate and privilege to transform society. That education is a specific sphere within a larger context with specific interrelated spheres is implicit, rather than explicit, in most of the informed progressive works. It would be myopic for any progressive critic of apartheid education to accord education a central role in transformation.

On the other hand, it would be foolhardy to relegate education to the periphery in the transformative project. While education and other social processes may be independent of each other, there is a mutual dependency suggesting a dynamic and dialectical interaction among all. By and large, the education sphere does provide the proper and reasonably reliable forum to sustain and move the boundaries of public consciousness and consensus. In this sense, education must be accorded an important co-partner status in the project of transformation. People's Education, as recognized by the authors of the lead essay and by Levin in chapter 5, is an acknowledgment of this role. Further confirmation of this is offered in the concluding chapter of the volume by R Levin, I Moll and Y Narsing. They state that People's Education "can lay the necessary basis of a socialist transition in education".[3] Of course, this is properly situated within the context of the overall democratic struggle.

As with other anthologies, this volume (alas!) is afflicted with the common virus of unevenness and inconsistency. For example, the most glaring inconsistency is the strong critique of "reproduction theory" in the introduction and the acknowledgment of its role by some contributors.[4] One gets the feeling that this criticism was aimed at a particular strain but, unfortunately, cast such a broad net as to appear to generalize what is otherwise a restricted phenomenon. The response then seems to be an exaggerated reaction. There is no compelling evidence that the "reproduction" and "autonomous, central role of education in social transformation" views are as pervasive as the authors claim.

Apartheid Education and Popular Struggles, despite the problems mentioned, is a significant contribution to the current debate on education in South Africa. The introduction illuminates particularities in the general education discourse whose assumptions are highly arguable, if not mistaken. Valuable insights emerge from individual chapters dealing with specific concrete issues that should inform overall or specific policy formulation on education. The volume should be read along with a number of other relevant works that have been published recently to get a handle on the massive scope of reconstruction and transformation of education and the requisite systemic articulation of the whole. Of course, particular attention will have to focus on emergent, mutating neo-apartheid structures that, as with the old apartheid social order, will continue to undermine whatever changes may occur in the education domain.

Notes and References

1.

E. Unterhalter and H. Wolpe, et al, *Apartheid Education and Popular Struggles* (Johannesburg: Ravan Press 1991), 3.

2. *Ibid.*
3. *Ibid.*, 232.
4. *Ibid.*, 28, 32, 33, 100, 122, 126, 127.

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REVIEW

The Blackboard Debate: Hurdles, Options and Opportunities in School Integration

By MONICA BOT, South African Institute of Race Relations, Johannesburg, (1991) ISBN 0-86982-385-X, 150 pages

Reviewed by Mary Metcalfe
University of the Witwatersrand, Johannesburg

This is a useful and informative book which reviews policy alternatives for racial integration in South African schools. Much of the research informing the work was conducted in 1989, but references are also made to material from late 1990. The book has five chapters. The first examines changing government policy - in all Department of National Education (DNE) departments - regarding integrated schooling particularly in relation to Free Settlement Areas (FSA's). The legal opening of some areas to all races in 1989 is presented by Bot as being the significant factor in extracting this concession from the House of Assembly.

In the second chapter she examines some of the economic pressures for policy change, arguing that there are powerful economic reasons for integration. These include under-utilisation of white resources and the consequent need for rationalisation in a climate of commitment to educational parity.

The third chapter focuses on attitudes to integration. Acceptance of this development by the white population is of particular significance to Bot. In examining the substance of these attitudes she identifies some "underlying concerns", in particular the question of standards which, she argues, has a close relationship with socio-economic status. To cope with the "problem of standards", options are considered regarding the following: selection tests, providing for gradual integration by allowing children "in" only from the first year of school, providing bridging or supplementary education and streaming. The multi-racial assumptions of Bot's approach are evident in her discussion of quotas. In this section, she begins to gather fuel for her developing argument that, in the light of differences in opinion, more user-choice will have to be permitted rather than a "centrally determined policy".[1]

In the fourth chapter, Bot develops her main thesis: that non-racial schooling should be developed through the expansion of private schooling. State initiatives are again understood as relating to FSA's, and private or community responses to apartheid education are construed as possible models for the future. Integrated private schools are presented as having a major role to play in curriculum development, but this development is seen as having to be acceptable to the business community. In summarising this chapter Bot gives a revealing list of

options for the expansion of integrated schooling. This includes the notion that the right for a non-racial education belongs in the realm of the private; and that integration should continue at "indian and coloured schools" but that (white) parental choice should determine admission at white schools.[2]

In the final chapter, Bot examines the role of different interest groups. These are identified as teacher associations, provincial education councils, private schools and associations, the private sector, universities, parents and community organisations. Bot acknowledges differences in the strategies employed by these groups and argues that compromises need to be made to achieve alliances focused on the achievement of long-term goals. It is clear from her analysis that she perceives certain of these groupings to have more power in influencing the evolution of education policy.

The text is rich with information. The "databank" approach, typical of the *Institute of Race Relations' Surveys,* is the major contribution of this work, whose value is reduced by the absence of an index. However, this collation tends to be rather uncritical and mechanical. Bot seldom explicitly argues her position but rather presents a smorgasbord of information. While she does present an explicit defence of privatisation, the merits of this are unproblematised. There is no serious effort to defend this position against competing challenges. Other implied assumptions reflect conservative tendencies, including a shallow understanding of probems of legitimacy.

The chief sources of information are newspaper articles and interviews with various educationists, the majority of whom are at private schools or in government departments. In reporting on interviews conducted in the private sector, Bot makes no attempt to locate it as a specific interest group. The comments of this group are unproblematically reported along with a range of other sources. Her unquestioning use of newspaper reports results in a failure to weigh the significance of the evidence derived from this source.

The only interviews conducted with "community groupings" took place between March and August 1989 when a single interview was conducted with a representative of each of the following organisations: African Teacher's Association of South Africa (ATASA), ACTSTOP, Soweto Civic Association, The South African Council of Churches (SACC), Funda Centre, The Sowetan, and The South African Council for Higher Education (SACHED). There is no evidence of interviews conducted post-February 1990, or post-August 1990 (when the "Clase Models" were instituted). Despite Bot's exhortations to the National Education Co-ordinating Committee (NECC) to enter this terrain ("rather than focusing merely on crisis issues",[3] no interview was conducted with any NECC representative at any stage, nor is there any analysis of NECC documents which refer to desegregation.

Bot's analysis is puzzling in its failure to acknowledge historic moments. While the work includes developments from as late as October 1990, she makes no mention of the significant events of that year which must surely mark it as a seperate period with markedly different constitutional possibilities than the years immediately prior to it. It is as if Bot embarked on the project with FSA's in mind and refused to reconsider broader possibilities once the terrain had shifted. Analyses offered before February 1990 must be understood in that historic context and cannot be simply juxtaposed with remarks offered in the period after this. An example of this error is her reference to Molobi's acknowledgement in 1989, during the repressive period of the State of Emergency, that "alternative" schools might have

the potential to explore "fundamental change" despite the inherent dangers of loss of solidarity and elitism. Bot uses this, in 1990, to imply "community" support for private schools as a model for the future.[4]

Bot argues for privatisation in several forms. There is a strong commitment to decentralisation of choice. Popular support for increased decison-making at local level is misrepresented as being equivalent to privatisation by localising decision-making.[5] The latter form could be criticised for reducing redistributive possibilities and allowing historically formed pockets of privilege to make choices in their own interests, to the exclusion of others. Bot's preference for localisation of decison-making is reflected in her summary of available options, one of which is white parental choice regarding black admission.[6] This conservatism is unusual in 1990. Bot's strong commitment to this position is evident in her comment that "admission policies should as much as possible be left up to schools, as parents and school staff can best determine their local needs in this regard".[7]

In addition to the privatisation of decision-making regarding desegregation, Bot is quite clear in her support of private ownership of schools. In fact, such is her commitment to the privatisation path that she exceeds even the government in her enthusiasm for this option. Rather than making empty House of Assembly schools available for the use of children in other apartheid departments, as was the 1990 procedural priority in state policy, her preference would be for these schools to be sold to "educationally sound private schools".[8]

Bot's belief in private community schools as a solution leads her to romanticise community initiatives while neglecting the material context which gives rise to, and limits the value of, these initiatives. Weilers Farm School, which serves a large and "illegal" informal settlement south of Johannesburg, is indeed a brave attempt to provide schooling where the government refuses to do so. Bot, however, portrays it as an example of community involvement that should be emulated. She neglects to observe that the initiative takes place in spite of the historically determined circumstances which at the same time flaw it. The "committed teachers" are unqualified, unemployed and unpaid, and this is of concern both to the teachers and the community. She ignores the fact that this school, to which parents "encourage children to go", had, at the time of her writing, one informally (and inadequately) constructed classroom for over 400 children ranging from pre-school to standard eight.

A major weakness of this analysis is that questions of legitimacy are not significant for Bot. This is expressed in her dismissal, and lack of understanding, of resistance politics. Having quoted Dlamlenze as saying that, "Black education will continue to be in crisis for some time, until African people are represented in parliament", she immediately proceeds to urge that they "could become more influential if they could see their way clear to take advantage of Dr Van der Merwe's invitation in July 1990 to become more involved in education".[9] Mass Democratic Movement (MDM) initiatives such as the All Schools for All People Campaign (ASAP) are portrayed as unrealistic politicking which is counterproductive to the actual process of change which occurs, in her view, at a structural level only through dialogue with the government. Thus the NECC is reproached for its failure to participate in such dialogue.

Some of the limitations of this analysis are due to simplistic notions of class and culture. Bot appears to believe that "rich" blacks will attend "rich" white schools and "poorer" blacks will attend "poorer" white schools.[10] Apart from her assumption that

access to education will be related to the means of purchasing property in the vicinity of the school, this represents a limited understanding of indicators of socio-economic class. In addition, it fails to take into account the willingness of those without easy access to adequate resources to commute to schools that are perceived to be good. The worst features of "multiculturalism" are evident in her recommendation that universities should provide teachers-in-training with "a knowledge of different cultures".[11]

Amongst the more conservative attitudes expressed is her view that desegregation necessarily contributes to a drop in standards.[12] She uses a questionable and problematic justification for the exclusion of blacks from white state schools: "one problem that remains is that black pupils admitted to white state schools are going to be advantaged compared to other black pupils",[13] and quotes Minister Clase in support of this view. Another problem is her comparison of desegregation of education in South Africa with international trends of provision for education of "immigrants".[14] One of the comments most revealing of her conservative bias is that she chooses to make a connection between the "propagandistic" tendencies of People's Education with the Chinese cultural revolution which "all but destroyed China's education system".[15] While "propaganda" should always be rooted out - for example in many of the sources she herself has used - it is hardly fair to portray People's Education in this way. The development of a critical understanding of the world is precisely the commitment of People's Education.

While this book is recommended as a valuable resource because of the richness of its data, its assumptions need to be critically analysed by the reader who, in addition, must problematise Bot's failure to recognise the current process of broadening participation in the arena of educational decision making. By so doing she has neglected, or at least underestimated, the role of the previously disempowered.

Notes and References

1. M. Bot, T*he Blackboard Debate: Hurdles, Options and Opportunities in School Integration* (Johannesburg: South African Institute of Race Relations, 1991), 51.
2. *Ibid.*, 115.
3. *Ibid.*, 10.
4. *Ibid.*, 57.
5. *Ibid.*, 7.
6. *Ibid.*, 15.
7. *Ibid.*, 121.
8. *Ibid.*, 105.
9. *Ibid.*, 123.
10. *Ibid.*, 50.
11. *Ibid.*, 119.
12. *Ibid.*, 43.
13. *Ibid.*, 11
14. *Ibid.*, 51.
15. *Ibid.*, 75

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REVIEW

Trends Transforming South Africa: Insights Information and Ideas

Edited by TONY MANNING, Juta and Co. Ltd, Cape (1991)
ISBN 0 7021 2543 1, 188 pages

Reviewed by Leon Tikly
Glasgow University, United Kingdom

As South Africa moves towards the formation of a new historical bloc, the contributions to *Trends Transforming South Africa* can be interpreted as an attempt to forge a new hegemonic project for a new political order. It is perhaps both a sign of the times and intrinsic to that hegemonic project that a business conference organised by the Building Industries Federation of South Africa (BIFSA) should apparently provide "the ideal platform to get the views of a number of leading experts in a wide range of fields" on the question of what the future holds in store. Perhaps also a sign of the times that the rather superficial set of observations and assertions that constitute the content of the book should have been neatly packaged by the ex-Marketing Director of Coca-Cola.

Although a BIFSA conference is not the major forum through which the views of the various interest groups represented are expressed, the contributors to the book do give voice to what may be described as the reforming tendency in South African politics - an alliance of business interests, verligte Afrikanerdom and a small dose of "English liberalism" in the form of a contribution by John Kane-Berman. Other contributors include Conrad Strauss of the Standard Bank, Mervyn King, Azar Jammine and Tony Manning (the editor) who collectively represent the economic and political views of the business community.The reforming tendency within white politics is represented by Wynand Malan (ex-Nationalist Party and Democratic Party politician), and by Rusty Evans (Department of Foreign Affairs). They provide analysis and comment on the contemporary national and international political scene respectively. Besides Kane-Berman's contribution on the youth, Johan van Zijl, Christo Viljoen, Fanyana Mazibuko and Geoff Garrett collectively take up educational themes. Dennis Sifris and Ian Player, on the other hand, deal respectively with "the devastating impact of aids" and environmental issues. One lone voice represents the views of the democratic movement in the form of a short contribution by Lawrence Maduma who presents Congress of South African Trade Union's (COSATU) economic position organised around "wealth through redistribution" themes. This contribution is tagged on, tokenistically, right at the end of the book, and does not accord with the views represented elsewhere. Given the

nature of the forum, the contributions are weighted more towards explicitly business interests within the reforming tendency.

It is the aim of this review to analyse how the rather disparate elements articulate the formation of a new hegemonic project in complementary and contradictory ways. A critical understanding of this project is important for the oppositional democratic movement in the current phase of negotiations. As the African National Congress (ANC) and its allies move closer to those spheres of the state and civil society in which struggles for hegemony are played out (the education system(s), health service, company board rooms, and so on) there is surely a strong case for knowing what views they will be up against.

As with the state bureaucrats who have authored the Educational Renewal Strategy (ERS), the book attempts to use a technicist approach to the issues raised, in the form of strategic management techniques. Do not expect, therefore, any elaborate historical understanding of current educational or other issues. Managers, we are told, start from a "stock-taking" of the current situation and move, conservatively, towards a vision of the future that is informed by individual assumptions and values. What then, one may ask, are the issues of importance to the contributors, and what are their fears? What is the nature of their vision, and what assumptions and values underpin that vision?

Most of the authors are informed by a sense of the inevitability of fundamental political change in South Africa, and by the prospect of an ANC-led government. It is this sense of inevitability rather than any profound abhorrence of past and present injustices that leads to a rejection of apartheid practices. It is also true, however, that apartheid is considered by many of the contributors (in true liberal style) to have failed the economy by breeding political instability, encouraging stifling state bureaucracies, and inspiring sanctions. The bedrock of the hegemonic project outlined in the book is a profound sense of economic crisis.

Neo-liberalism, as an aspect of New Right thought internationally, has permeated verligte Afrikaner as well as business thought quite profoundly. There is in the book a persistent fear of nationalisation and of any kind of strong role for the state in a future dispensation. As demonstrated both by current government policies, and by the paper on education by Christo Viljoen, however, neo-liberal ideas provide a source of contradiction for verligte Afrikaners. The fears associated with complete integration within one education system, and the expressed desire to limit the scope of that integration must inevitably involve the perpetuation of a strong state hand. The current proliferation of models for the "opening" of schools is a good example here.

Interestingly, anxieties around the issue of integration of schools, as well as explanations given to account for the educational problems encountered by black people, focus on "deficit" cultural models (although lip-service is paid to structural inequalities). Seemingly "culture", as opposed to race, is increasingly becoming the basis for differential educational practices on the part of reformers.

As with capitalist modernisers around the world, there is a deep fear of mass action of any kind. Although there is much celebration about the "failure of socialism", and although anxieties persist about socialist thought within the ANC, concerns about mass action most strongly crystallise around "the angry youth". In his paper of this title, John Kane-Berman goes a long way towards constructing the youth as perhaps the major threat to hegemony. The ANC, we are told, must get the

youth under control. Various ideas presented in the book, including educational ones, are explicitly or implicitly aimed at the curtailment of collective action.

In response to the fear of mass action, there is an ideological effort, most notable in the editor's paper, to redefine us not as workers or members of oppressed groups, but as consumers. This, once again, is typical of the New Right internationally. In a particularly naive and glib example of the above we are informed that:

> People everywhere wear Levi jeans, Ray Bans, and Giorgi Armani suits; they listen to music on Sony Walkmans - or a discman if they're into CD's; they drive on Michelin tyres; and they pay for all that with an American Express card.[1]

Clearly, if this aspect of the New Right project is going to succeed in South Africa, a more thorough grounding in current realities will be required on the part of right-wing ideologues.

Perhaps for the reasons alluded to above, neo-liberal consumerist rhetoric about "choice" in the educational sphere is not so well developed in South Africa as it is in Britain for example. It is implicit, however, in ERS proposals to decentralise and deregulate, and in proposals for community colleges and schools contained in the book. The argument for community-based education is that it will give communities greater control over institutions. Community colleges are also presented in the book as a possible solution to the problem of the "lost generation", and as such, bear an uncanny resemblance to the Edukon idea contained in the ERS. The "hidden agenda" behind community-based strategies is of course that they provide an opportunity for the state to further abdicate responsibility, not only for the control, but also for the financing of education. The sting in the tail of the whole community college/school idea will be the varying degrees to which different communities will be able to resource their institutions. The biggest problem with redefining us as a population of consumers is that it does not take into account our differing abilities to buy goods and services.

One "big idea" presented in the book in terms of keeping costs down within a new deregulated education system is the introduction of more technology (videos, televisions, radios and computers) to replace teachers. The ERS is, rightly, more cautious on the matter, and contends that such technology should only be used to support rather than replace teachers. However, the ERS's proposal to limit the distribution of videos and computers to middle class and advantaged learners only, is both divisive and riddled with contradictions.

The need to pay more attention to technical and scientific education is a theme that runs throughout the book. It stems from the identification on the part of many of the contributors of what they consider to be the cause of causes for South Africa's economic malaise, namely, the mismatch between education and the "manpower needs" of the country. The cry is for more skills training and a vocational, as opposed to an academic, approach for the majority who will not go into further education. The concomitant suggestion in the book that education must be made to fit manpower needs provides a further source of contradiction between neo-liberal rhetoric and the strong role of the state that would be necessary in any such endeavour.

The ideological effects of the "skills" and "manpower" rhetoric in practice in South Africa have been described before, both in relation to producing "good" workers,[2] and to further limit worker control over production processes.[3] If one accepts the

above arguments, then the direct relationship being drawn in the book between the need for skills training and the problems of the disaffected "lost generation" is informative. Given the existence of mass youth unemployment, current suggestions within, for example, the National Training Strategy for the adoption of schemes similar to Britain's Youth Training Scheme (YTS) is also informative. YTS was criticised in Britain as little more than an attempt to "launder" the unemployment statistics, and, in the context of inner city uprisings, to ameliorate the grievances of youth. YTS, as experienced, amounted to little more than cheap labour, and the skills acquired by youth were often negligible.

There is evidence, however, that the "manpower" issue is real in that there is a shortage of skills required by specific industries, and that skills required by industry change over time.[4] One solution presented in the book is for the provision of "magnet schools" attached to local industries. Besides inculcating basic skills, these schools could also cater for the specific needs of an industry at a particular time, and create "career education" opportunities for workers as demands for specific skills change. (The theme of "career education" is also one that has been taken up by the DET of late). The potentially divisive outcomes of creating an elite of workers in the context of continued unemployment is an issue that would have to be addressed by educationalists, COSATU and others if the "magnet school" idea became popularised.

A further aspect of the hegemonic task of containing mass resistance is evident in Viljoen's paper on education, which amounts to an appropriation of radical discourses around People's Education. Of relevance to the "manpower" debate is the distortion of the demand that workers should be educated so as to be able to resist exploitation in their workplace. According to Engelbrecht, who is quoted in the book, this demand now reads that People's Education "should be in the interests of the people - relevant to work". Such a redefinition allows for even the narrowest forms of vocational education to appear to have legitimacy amongst the people. For those concerned to broaden the whole conception of vocationalism in South Africa beyond narrow skills training, the above misappropriation is especially dangerous in a context in which COSATU and the government appear to be reaching a certain rapprochement on the "skills" issue.

The hegemonic project represented in *Trends* is weak in terms of theoretical elaboration, and remains largely at the level of "common sense" assumptions. The picture on the front cover, which shows a white man leading a group of also predominantly white men along a one way street, serves to demonstrate the need on the part of the authors to broaden their constituency if they really intend to lead us all to a "new South Africa"(Ltd).

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REVIEW

Ethnomathematics – A Multicultural View of Mathematical Ideas

By MARCIA ASCHER, Brooks/Cole Publishing Company, California, (1991) ISBN 0 534 14880 8, 203 pages

Reviewed by Annemarie Martinson
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In teaching a course on the history of mathematics which follows in outline one of the well known texts (for example, Boyer[1]), the focus tends to be on mainstream western mathematical development. The course starts with the solution of practical problems by the Egyptians, then moves on to the development of axiomatic proof by the Greeks, the contribution of the Arabians, and then the transfer of this combined body of mathematical knowledge to Europe after the Middle Ages, where mathematics developed with a flourish during the Renaissance and continued to do so up to the present. This approach emphasises that the mathematics we learn and teach is the result of man's intellectual efforts over thousands of years; that mathematics is not a finite body of knowledge but is constantly being expanded by the creative work of professional mathematicians. Student teachers attending such a course would be able to "enrich their teaching by including snippets of history".[2] But mathematics teachers in southern Africa need to do more than this - they need to ensure that their students, from whatever background or culture, do not feel alienated from or foreign to mathematics, as this may increase learning difficulties. Teachers should strive to let each student recognise that his or her own society has also contributed to the growing body of mathematical knowledge.

This is where ethnomathematics can play a part. Ethnomathematics has been variously defined and widely debated. In 1989 D'Ambrosia wrote:

> We use the term ethnomathematics for the art or technique of understanding, explaining, learning about, coping with, and managing the natural, social, and political environment through processes like counting, measuring, sorting, ordering, and inferring-processes that result from well-defined cultural groups.[3]

In the introduction to her seminal book, now under review, Ascher states that "the study of the mathematical ideas of traditional peoples is part of a new endeavour called ethnomathematics".4 In 1986, in an earlier paper, Ascher and Ascher gave a narrower definition: "... ethnomathematics is the study of mathematical ideas of non-literate peoples".5 In the same paper they also pointed out that all people, whether literate or not, have always practised mathematics implicitly in their daily

lives, and that by learning about the mathematical ideas of other cultures we learn to appreciate the intellectual endeavours of others.[6]

In her very clearly written new book, Ascher provides examples of mathematical ideas as found in the cultures of various peoples. The Incas of South America, the Navajo of North America, the Tshokwe and Kpelle of Africa are some. She examines the mathematical ideas of space, number and logic and presents them in their specific cultural contexts. Then to help us understand the ideas she interprets them in the western mode of mathematical expression.

Many histories of mathematics assume that non-literate people are incapable of abstraction and that without a written system can have no recorded numerical system. In chapter one, Numbers - Words and Symbols, Ascher introduces the reader to the code of the quipu, which serves as the logical numerical system of the Incas, a non-literate people. Her research on the quipu, an assemblage of coloured knotted chords, was the start of her interest and research in ethnomathematics.[7]

In chapter two Ascher explains how the western mathematical ideas of graph theory can be recognised in the sand tracings of other cultures - the Bushoong of Zaire, the Tshokwe of Angola, and the Malekula of Vanuatu in the South Pacific. For each example she describes the cultural context, and then analyses the mathematical ideas to clarify the similarities to and differences from the western mathematical ideas, but stresses that one should not expect them to be the same across different cultures.

Other subjects that she investigates are kin relations, games, symmetry, and organisation of space. Each chapter ends with a list of references and useful explanatory notes with suggestions for further reading for those who would like more detail in either mathematics or anthropology.

In the final chapter Ascher discusses ethnomathematics generally, and comes to the conclusion that "a broader global ongoing history (of mathematics) must acknowledge and include the ideas of other cultures".[8] She also mentions that other educators have other aims for ethnomathematics. According to Frankenstein and Powell, Ascher's approach "can help to counter the Eurocentric view of mathematics development"[9] and thus can provide cultural affirmation for students of racially and culturally diverse backgrounds. According to Gerdes, this affirmation can help to stimulate confidence in the capacity of every person "to understand, develop, and use mathematics" and enables "mathematics to become emancipatory".[10]

Ascher's approach consistently supports her belief that "all mathematical ideas, in traditional cultures or not, need to be viewed in cultural context".[11] If this were so then there would no longer be a need to distinguish between ethnomathematics and history of mathematics.

In this attractively presented and easy to read book Ascher has provided much stimulating and thought-provoking material which can be used and adapted for both university and school teaching, helping mathematics educators to recognise how ethnomathematics and western academic mathematics can be merged to form a more effective teaching approach.

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REVIEW

Foundations of the New South Africa[1]

by JOHN PAMPALLIS, Maskew Miller Longman, Cape Town, (1991) ISBN 0 636 01494 0. 327 pages

Reviewed by Ismail Vadi
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It has often been said that historical re-interpretation is the lifeblood of history. Yet in our country the various racially-divided departments of education remain blind to this basic principle of historical study. More disturbing is the fact that thousands of history teachers have accepted complacently a history curriculum designed, without consultation, by bureaucrats in various educational administrations. Many of them have slavishly followed prescribed history textbooks which often distort and falsify the history of all our people, black and white. Many more have worked hard in their classrooms to meet a pre-ordained set of history teaching objectives drawn up years ago, irrespective of the world-wide changes in the socio-political spheres. Such a pedagogic approach reduces history teaching to an exercise in sterility and makes our students the dead reservoirs of dry historical facts.

The developing concepts of people's education and people's history reject this approach to teaching. People's history aims to restore to the study of history a critical perspective which would enable the student to arrive at independent judgements of the past. Following Carr's advice, it calls upon students and teachers to study the historian as much as the history.[2] People's history places people - as agents of historical development - at the centre stage of historical inquiry and study. It takes as its starting point that all people make history, not just great men - and in the South African context, not just great, white men. People's history draws more heavily on the radical school of historical interpretation that has emerged in the last two decades in South Africa. Finally, it places greater emphasis on national and class concepts to analyse the past, rather than the categories of race or volk.

John Pampallis' book, *Foundations of the New South Africa*, is a good example of a People's History textbook that could be used effectively in South African schools in the near future. Published in 1991, it serves as the history textbook for ANC exiles studying at the Solomon Mahlangu Freedom College (SOMAFCO) in Tanzania. Its explicit aim is to prepare students at SOMAFCO to "serve the national liberation struggle of the people of South Africa".[3] It has twenty chapters on South African history which cover course work for standards nine and ten.

Colin Bundy, in his review of the book, has asserted that, "Pampallis, while teaching history to forms four and five at SOMAFCO, "found the need for a general textbook to cover the South African history section of our syllabus. His endeavour to fill the gap has produced a solid, informative history of South Africa since 1870. And academic historians, chewing through it, will vouch for the nutritional value and balance of the product".[4]

The book begins with a chapter, entitled "Prelude to Industrial Capitalism", which provides a broad description of South African society before the mineral discoveries. It traces the nature of the conflict between latent Boer nationalism and British imperialism prior to 1870, and examines the degree of class stratification within white settler communities. The text then goes on to discuss the Anglo-Boer War by analysing the underlying class basis of this violent conflict between British imperialism and Boer nationalism. It is against this background that developments relating to the "Uitlander Question", the Jameson Raid, the Anglo-Boer War and the Peace of Vereeniging are discussed. The reasons for African, "Coloured" and Indian participation in this war, either on the side of the Afrikaners or the British, are analysed and make interesting reading. The steps towards Union are also analysed in the context of a deepening economic crisis confronting the self-governing colonies in South Africa and the significance of the armed rebellion led by Chief Bambatha in Natal. The Act of Union is seen as an extension of colonial rule in South Africa, where political power is transferred by the British to a white minority settled in South Africa, and not to the indigenous majority.

The next four chapters make fascinating reading. They trace the birth and development of African nationalism and a national consciousness among black South Africans. Details are provided about the growth of the independent African church movement (such as the Ethiopian Church and the African Methodist Episcopal), the emergence of African newspapers articulating African grievances (such as Jabavu's *Imvo Zabantsundu*, Peregrino's *South African Spectator*, Plaatje's *Koranta ea Becoana*, Dube's *Llanga Lasi Natal*), and the birth of African political formations and educational associations in the late 19th and early 20th centuries. These developments serve as a foundation for the formation of the African National Congress on 8 January 1912 and the emergence of a new concept of nationhood rooted in the dynamism of African nationalism.

There are two excellent chapters tracing the emergence and development of a culture of resistance both in the Indian and "Coloured" communities; the former initiated by Mahatma Gandhi based on the concept of "Satyagraha" and the latter by Dr Adbul Abdurahman of the African People's Organisation. Finally, the reasons why these various political initiatives in opposition to white minority rule did not merge into a single movement are analysed, as are the strengths and weaknesses of these political forces. These are constantly related to the class composition of the leadership and membership of these organisations and movements. For example, in assessing the work of Gandhi, Pampallis argues:

> The leaders of the Satyagraha campaigns also mobilised thousands of ordinary people - workers, peasants, the poor self-employed - to participate actively in the struggles for their rights. It was the first time that this type of struggle had taken place in South Africa and it sowed the seeds of the passive resistance campaign of 1946 and the Defiance Campaign of 1952.[5]

At the same time he has correctly identified an essential weakness of Gandhi's movement. He states:

> Its most glaring weakness was that it was a lone struggle by a small section of the population. There was no attempt to link the struggle of the Indians with that of the African and Coloured people. The Indian people seemed to regard themselves firstly as Indians, rather than South Africans who needed to join with other oppressed South Africans in the struggle against white supremacy. They saw their own problems in isolation, and even Gandhi never raised a voice of protest against the oppression of Africans at a time when African rights were under sustained attack.[6]

Finally, there is a short but informative chapter on developments that affected the rural population. The impact of land shortages and of the 1913 Land Act on African tenants, labourers and share-croppers are examined, and the plight of those dispossesed of land are brought to the fore, as is the resistance they had offered.

The book continues with an investigation into the tensions that the First World War had introduced among Afrikaners and English-speaking whites. In particular, it examines the economic recession in the immediate post-war period, leading to the outbreak of the 1922 white miners' strike, and the political consequences of the partial insurrection of the miners. The rise to power of the Pact Ministry is analysed, with emphasis on the class character of its support base. The negative impact on the African people of laws such as the Wage Act of 1925, the Mines and Works Amendment Act of 1926, the Native Administration Act of 1927, and the "civilised labour" policy of the Nationalist-Labour Alliance are discussed in some detail.

This helps one to understand why the ANC had become more radical in its approach to politics in the 1920s, why the newly-formed Communist Party of South Africa (CPSA) adopted the "Black Republic" slogan and had begun recruiting a larger number of blacks into its ranks, and why the Industrial and Commercial Workers Union (ICU) had developed into a mass-based, urban-cum-rural movement in the early 1920s.

The next few chapters examine the forces which promoted the formation of a coalition government between the National and the South African Parties in the early 1930s, resulting eventually in the creation of the Fusion Government. The causes of the split in the Fusion Government on the eve of the Second World War are carefully analysed. These are discussed against the background of a weakening ANC that had come to be controlled by a moderate leadership and the sectarian and ideological divisions that had crippled both the ICU and the Communist Party.

But the most exciting chapters are those which deal with the political stresses and strains that followed the outbreak of World War Two. These relate to the growing splits within the established parliamentary political parties, the radicalisation of the ANC, the formation of the ANC Youth League espousing a brand of militant African nationalism, and the ideological re-orientation of the Communist Party which now sought to work much more closely with the ANC, the Indian Congresses and the rapidly expanding black trade union movement.

One chapter deals specifically, and sensitively, with the 1946 African mine workers' strike and the Indian Passive Resistance Campaign of 1946-48. Pampallis lucidly describes the growing unity of the African and Indian peoples in the 1940s, despite the isolated incident of Afro-Indian conflict in Durban in 1949. Finally, the section on the 1940s ends with an excellent chapter on the unanticipated electoral victory of Malan in 1948 and the systematic introduction of apartheid in the 1950s.

The remaining chapters deal with South African history from 1950 to 1986. The emphasis here is placed on the responses of the ANC to the intensification of national oppression and apartheid. The major campaigns of the ANC and its allies such as the Defiance Campaign (1952), the Campaign for the Congress of the People and the Freedom Charter (1953-55) and the Women's Anti-Pass Campaign of 1956 are fully described. In addition, local struggles in urban and rural areas, such as the Evaton bus boycott and the Pondoland uprising, are analysed in detail which gives one a feel for the intensity of the South African conflict. Finally, the reasons why the ANC and the Pan Africanist Congress (PAC) opted for the armed struggle after their bannings are explained.

This is followed by a discussion which traces the re-emergence of resistance to white rule in South Africa in the 1970s and 1980s against the background of a deepening economic and political crisis confronting the National Party. In this context the rise of the black trade union movement, the causes of the 1976 Soweto revolt, the birth of the United Democratic Front and the general upsurge in resistance activity are sensitively analysed. The final chapters examine the imposition of the state of emergency, the emergence Mass Democratic Movement (MDM) and the beginning of the de Klerk era.

Pampallis' book invites history teachers to make a more fundamental assessment of history teaching. It forces us to give more weight to the concepts of "class" and "nationalism" in the study and teaching of South African history. In doing so it re-creates a picture of our past that places people (workers, capitalists, peasants, women, intellectuals, the various national groups), rather than great white men, at the centre of the historical stage. In this sense Pampallis has come a long way in producing a comprehensive text for history teaching at the senior secondary phase.

A key problem, however, is his presentation of history in the post-1948 period. His class analysis of pre-1948 history evaporates into an uncritical, nationalist historiography with a bland chronicle of the ANC and its allies, and their programmes of action and methods of resistance. There is virtually nothing said about other black political movements such as the Pan Africanist Congress or the Black Consciousess Movement. What is certainly needed in schools today is not a glorified presentation of the history of the ANC and its allies since the 1950s, but a critical and consistently-radical perspective and analysis of that history. Despite this significant analytical shortcoming, this is an excellent school history textbook. Each chapter is followed by essay and discussion topics based on extracts and quotations from widely-used textbooks such as Lategan and de Kock, Joubert and Davenport, as well as from speeches by Nelson Mandela, Joe Slovo and other political leaders. These invite student comment, not only on the historical content, but also on the biases, prejudices and assumptions of the writers.

In the words of Bundy, Pampallis' book is a "well-researched and meaty history, (that) puts to shame the tepid texts approved by the multiple educational authorities inside the country".[6] In my opinion, it is an essential handbook for any history teacher in this turbulent period of social and political transition.

Notes and References

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REPORT

Kenton – at – Katberg, October 1991

John Pampallis
EPU, Durban

Between 25 and 28 October, almost 150 participants from across South Africa and Namibia gathered at the Katberg Protea Hotel for the 1991 Kenton Conference. The conference, South Africa's largest annual gathering of (mainly) left-wing academics in the field of education, was opened officially by Professor Sibuzise Benghu, Vice-Chancellor of the host institution. The University of Fort Hare hosted the conference as part of its 75th anniversary celebrations which are being held at a time when it is trying to throw off the legacy of thirty years of Broederbond control, and to re-establish the proud reputation it had in days gone by. The Kenton Conference was preceded by a smaller one-day meeting at which the South African Comparative and History of Education Society (SACHES) was formed.

As a first-time participant in such a conference, I was struck by the self-consciousness of Kenton. Participants seemed always aware that they were at Kenton and not just at any conference. Speakers hardly ever referred to the gathering as "this meeting" or "this conference", but rather to "Kenton" or "this Kenton". People presenting a paper for the first time invariably referred to the Kenton Conference reputation for ruthless criticism and hoped that they would somehow manage to come through relatively unscathed. In fact, I found that, with one exception discussed below, the inexperienced were generally treated rather gently although without condescension. With the more experienced participants, though, Kenton's reputation seemed quite justified.

During the three days of the conference, twenty seven papers were presented. The Kenton tradition that anyone who wanted to could present a paper resulted in a large number of presentations, and necessitated a number of parallel sessions. The papers covered a wide range of topics under the unifying theme of education: teacher training, adult education, worker education, education for children with special needs, the universities and tertiary education, as well as more general papers on the politics, philosophy and sociology of education. Surprisingly, perhaps, not a single paper dealt specifically with any aspect of primary or secondary education.

Space, and the impossibility of attending all sessions, only allows the specific mention of a few of the papers here.

The academic session of the conference opened on a somewhat embarrassing note, with three academics from the University of the Orange Free State (UOFS) presenting a paper entitled "Meeting the challenges in the new South Africa within the framework of an Afrikaans-medium university". The paper, which I guessed was informed by some type of OFS National Party vision of "the new South Africa", was not very warmly received. We were told how the UOFS was adjusting to new

realities by admitting "non-white" students to its ranks. The assertion regarding sports that, "Even on (sic) this important sphere of life, UOFS did not hesitate in meeting the demands of a new South Africa", and that the university soccer team included ten blacks and only five whites, provoked giggles from the audience. (No mention was made of the rugby team.) The paper, as Saleem Badat of the University of the Western Cape pointed out, sounded like a presentation from the UOFS public relations department. He probably spoke for most of the audience when he expressed disappointment with the paper's failure to examine issues such as the constraints and possibilities for change and to explore challenges like the democratisation of university structures, student input, affirmative action and the sensitive issues surrounding admissions policy.

These and other issues facing universities were dealt with in a number of other papers, including those by Benito Khotseng, Nico Cloete and Nadia Pandor, Caroline Suransky and Lawrence Singh. The last-mentioned precipitated something of a storm when the truth of the author's accusations of racism in the Department of Education at the University of the Witwatersrand were challenged by the head of the department.

Quite a large number of papers dealt with the larger question of transforming the education system (or parts of it) within the context of a changing and democratising South Africa. One of the first papers of this kind to be presented and discussed was entitled, "Educational Challenges for the 1990s: Transition to What?". In his presentation, Peter Kallaway raised the question of the role of international agencies in transforming the South African education system. This became one of the ongoing themes of discussion - both in the academic sessions and in informal conversations outside the conference hall; the desperate need for funds being weighed against the fear of having our education system restructured in the interests of foreign donors, with no decisive input from the democratic movement. While some derided the fear of a "foreign conspiracy", others stressed the need for progressive South Africans to try to present a united front in dealing with agencies of imperialist countries.

This whole discussion was made more pertinent by the presence of USAID's South African Tertiary Education Sector Assessment (TESA) programme. TESA's plan for assessing within two months how millions of USAID dollars should be spent in the tertiary sector, was briefly explained at the beginning of the conference by Peter Hunter of the University of the Witwatersrand, one of the South African participants in the programme. The TESA team was scheduled to make a more detailed presentation about their programme later in the conference, but, for reasons which were not explained, did not do so.

Three papers dealt with the problems of ethnicity, culture and nation-building in a future South Africa. Benito Khotseng spoke about the important role of the universities in creating a South African nation. Joe Muller and Michael Cross, on the other hand, problematised the notion of nationhood and the aims of nation-building. The former drew on US experiences to discuss multi-culturalism in the curriculum (as well as more generally) and the problems of cultural unity versus differentiation. The latter, drawing on a number of international examples, discussed different models of ethnic relations on the "melting pot" - "salad bowl" continuum.

Unfortunately, discussion on the Muller and Cross papers was somewhat stifled by the fact that they were presented at the same session as David Bensusan and

Yael Shalem's paper on "Civil Society and Privilege". This paper which was deeply immersed in deconstructionist jargon, excited considerable agitation from a section of the audience and tended to monopolise most of the discussion period. Unfortunately for me, the discussion did not really help to dispel my perplexity about the paper, and I found myself concurring completely with Pandor's comment that though she understood the questions, the answers were incomprehensible. It was with some relief that I learned after the session that my mystification was shared by a considerable number of others. As the conference went on, Bensusan seemed keen to clarify his position in a number of interventions, and to some extent was successful in doing so. One couldn't help wondering, though, what the point was in making the paper so inaccessible in the first place.

The only paper to discuss directly the political and organisational problems of the democratic movement in education was Nazir Carrim and Yusuf Sayed's offering on social movements and the NECC. In it they examined the NECC's shift from "critical struggles" (the politics of protest) to "positive struggles" (the politics of reconstruction). They saw the NECC's future role *vis-a-vis* both the ANC and a future democratic state as being best served by distancing itself from both, and by ensuring "that its articulations do not project an alternative political project on the historicity level". Unfortunately, the conference discussion on the paper did not have time to really get into this issue which is likely to loom ever larger in the ranks of the democratic movement in the months and years to come.

The major problems with the conference, in my opinion, were problems of omission. At a time when the reconstruction of the entire education system is at issue, it was disappointing that there were no papers dealing with the organisation, control and management of education. This, I fear, is a reflection of a more general neglect by the left in this country. If the democratic forces continue to neglect those vital areas - areas where much power inevitably lies - then they will remain the domain of conservatives, even in a South Africa with a popularly elected government.

Even more disturbing, was the almost complete lack of any mention at Kenton of the crisis in the African schooling system. The near-complete breakdown of schooling in some areas, the effects of violence (both political and criminal) on students and teachers, the inability of thousands of young people to find places in school, and the appalling matriculation results were all but ignored by Kenton 1991. A representative of USAID remarked to the convenor of the organising committee that he felt the issue of black empowerment had not been addressed by the conference. He was, I'm afraid, spot on, embarrassing as it is for us on the left to have to admit to the veracity of criticism from this quarter.

The problems were exacerbated by the low attendance at Kenton of black, and particularly African participants. If Kenton is to remain relevant, let alone a major forum of the academic left, this is something that will have to be remedied. Surely there must be some way of overcoming the rather anarchic traditions which result in simply putting out a blanket invitation to all to attend and, if they wish, to present papers. Perhaps the organising committee in any given year could make a special effort to invite participants from the predominantly African universities and, if necessary, to try to make arrangements to help defray the costs of at least those who present papers.

Its weakness notwithstanding, Kenton-at-Katberg was worth attending. Important issues were discussed, it gave researchers an idea of the work being

done by others the same or similar areas to their own, and provided a valuable and rare opportunity for people from all over the country to share experiences and make useful contacts.

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REPORT

Department of Education and Training Mathematics Education: A Preparation for Failure

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Much has been said and written about the results that matriculants of the DET obtain for mathematics. *The Argus* correspondent, summarising the DET report tabled in Parliament on 2 April 1990, wrote: "Last year's (that is, 1989) 'shocking' black matric pass rate was partly the result of change in national educational policy ... the freedom to adjust marks was restricted ...".[1]

But obviously learners do not do this badly because of a failure of the DET to "adjust" marks or because of a few months of bad teaching. The cause must be rooted in the entire system of teaching and learning. Seven years (often more for many learners) of the schooling experience are spent in primary school. This is more than half the years that a matriculant will have spent in school. Many of the problems start in these primary years.

For many learners in primary schools this will be the only experience of schooling that they will receive. Figures published by the Institute of Race Relations show that during 1989 alone 63% of all school leavers in the DET were in the primary phase.[2] During 1989, 454 300 primary school children left school. This makes it vital that the education they do receive is the very best possible.

In a system which is so deficient change has to occur. The change has to start with the teacher in his/her classroom.[3] Organisations, teacher unions and tertiary institutions are recognising the need to support teachers wishing to bring about change in the schools.

The Mathematics Education Project (MEP) is one of these initiatives. It is based at the School of Education, University of Cape Town. MEP has three components : primary formal mathematics education, secondary formal mathematics education and adult non-formal mathematics education. A fellowship holder has been appointed for each of the sections. MEP (primary) works closely with about six DET primary schools in Khayelitsha and Old Crossroads, Cape Town. This means that work is carried out with about twenty five primary mathematics teachers on a very regular basis.

This report will attempt to reflect and describe some of the difficulties experienced in mathematics teaching in DET schools. It will do so by attempting to examine the teachers' qualifications, preparations and perceptions. Finally, this report will explore how mathematics teachers can be empowered in their classrooms.

The teachers

Most primary school teachers of mathematics in South Africa are non-specialists. Some are very interested and drawn to mathematics, others are mildly interested and there are those who dislike the subject (but, who nevertheless have to teach it). Most of the teachers who work with MEP (primary) have been disappointed by their own mathematical education. One teacher related how exciting mathematics was, but, when he attempted to complete a university-based correspondence course, found it to be difficult and mystifying. He lost some of the confidence he had in himself as a mathematician. The MEP teachers have all been college trained. They fall into the following categories:

1. standard six plus three years of training at a college (lower primary teaching certificate);
2. standard eight plus two years at college (higher primary teaching certificate);
3. standard ten plus three years at college (senior primary teaching diploma).

Those teachers who started teaching with the qualifications mentioned in 1 and 2 were informed during the years 1977-1979 that they were underqualified and that they would have to complete their matric. The teachers near Cape Town had to study part-time at St Francis Adult Education Centre. A number have done this but there are still quite a number of teachers who have not.

In 1984 the issue of salary parity with other departments became a possibility, provided suitable qualifications had been obtained. This made it desirable to have matric and three years of training at a college of education. With this qualification a teacher would be considered fully qualified to teach and could expect the same salary as his/her colleagues in other departments of education. However, "more than a third of teachers in black schools in South Africa do not have matric".[4] Out of a total of 54 000 teachers 18 500 do not have a standard ten certificate. This represents 34,4% of black teachers.

According to the DET regional office in Port Elizabeth there are still **many** teachers in the primary schools who are considered to be unqualified, some without any college training whatsoever. DET are attemptimg to "phase them out".[5]

Until 1989 the students at colleges were offered instruction in the content and methodology of all the primary school subjects and they also completed courses in "education". These courses are called "teaching science" and provide a solid grounding in fundamental pedagogics.

The college syllabus for mathematics is in the process of being changed. The present second and third year students are the last to complete the old syllabus. This old syllabus completed by the teachers already in the field is referred to as the "old structure". Within this old structure students could complete the mathematics course whether they had matriculation mathematics or not. Some students had their last contact with mathematics in standard six at school.

The mathematics course at a DET training college is divided into two sections: content and didactics.

a. The content section

During the first year of study at college the students essentially cover standard five work. The content of the first year syllabus includes : sets, the number system, fractions and decimals. The second year covers topics such as : graphs (pie charts, linear and column graphs), percentages, ratio, simple interest and profit and loss. The third year course covers some standard six and seven algebra and geometry.

b. The didactics section

In the mathematics didactics section students are instructed on how to teach mathematics: "how to explain concepts, how to write out lesson plans and how to set tests".[6]

Students write an internal examination at the end of the first and second years but are required to write an external examination at the end of the third year. It is interesting to note the high failure rate of the students at the end of the third year. In one school that is involved with MEP(primary), no less than three of the newly appointed teachers are unable to be appointed permanently as they have to write and pass a sumplementary exam in mathematics so as to be awarded their Senior Primary Teaching Diploma.

It seems that very little, if any, attention is paid to such crucial issues as:

i. the psychology of learning mathematics;
ii. the role of language in learning mathematics;
iii. the social nature of learning;
iv. socio-political issues concerning mathematics and mathematics education;
v. mathematics and culture.

Indeed, most of the teachers with whom I work have been unaware of any of the current debate and discussion on these issues.

Many students come to college already having had a very negative experience of learning mathematics. At college the student teachers are seldom encouraged to look at the reasons behind their experience and hardly any attempt has been made to expose them to a different vision of what mathematics and learning mathematics could be. It is very important to add that most of the lecturers teaching the course in mathematics (didactics and content) have been high school teachers. It seems that these lecturers are not required to familiarise themselves with the primary classroom at all. Indeed, many of the teachers who were frank about their college experience have spoken bitterly about their mathematical learning experience at the colleges.

Because the teachers have had a negative experience of mathematics, it is quite obvious that they take this to the classroom, as well as their accompanying fears and anxieties. Because of their previous experience, most of the teachers see mathematics merely as a set of basic skills and algorithms that have to be taught, drilled and examined.

These teachers work in an educational system that operates in a top-down mode. They know that they have seldom been consulted about changes to the syllabus or about matters concerning teaching administration. Even teaching methodologies are prescribed. They are consistently given messages from

principals and inspectors alike that they are incompetent and need much help and direction when it comes to managing and teaching their classes. The lack of confidence in the teacher as a professional engaged in responsible interaction with the learners is further emphasised by the rigid system of control that exists over time-tabling, lesson planning and other records that teachers have to keep meticulously up to date. It is evident that the teachers are oppressed by the system and people who operate the system:

> One of the basic elements of the relationship between oppressor and oppressed is prescription. Every prescription represents the imposition of one man's choice upon another, transforming the consciousness of the man prescribed to into one that conforms to the prescriber's consciousness.[7]

Teachers are often coerced into attending workshops and courses. Courses and workshops are mostly designed by outside "experts" and/or the staff of "head-office". Teachers are rarely, if ever, consulted about the contents of the courses. Others decide what would be best for them and a workshop is then offered. It would appear that those who design and run the workshops continue the work of the training colleges and concentrate on trying to give teachers more exposure to methodology and content ideas. Teachers are seldom, if ever, granted the opportunity to start "... learning to raise questions about the principles underlying different classroom methods, research techniques and theories of education".[8]

The courses are often run during the school day/week. The teacher has to leave his/her class unattended or the class has to double up with another class in the school. No supply/substitute teachers are ever appointed to take care of the teaching for the time that the teacher is away. Some courses/workshops are run after school hours. The teacher is required then to fit this activity into an already busy day.

Many teachers in the primary schools in the Khayelitsha and Old Crossroads areas have decided that the only way for self-improvement is to register for a degree from a university. Many teachers commit themselves to part-time courses at the University of the Western Cape, or alternatively, the University of South Africa. These studies make additional demands on their time and resources.

Teachers have seldom been consulted about what they perceive to be important for their development. They have thus constructed a view of themselves as not having valuable or important knowledge to share with other members of their profession. This is not unique to DET schools within South Africa. McDonald notes: "Teachers are not used to thinking that they know something which some theorists, at least, would consider valuable".[9]

Their experience and practical knowledge of educational practice as it exists within their classroom and system is negated at most levels and is rarely recognised as expertise to be used to devise a sound education for the pupils. This, coupled with the training that teachers receive, could go a long way to explaining the poor results of learners. Desforges and Cockburn in their conjecture on poor achievement argue that: "... we suspect that the failure lies in the unwillingness of the mathematics education establishment to take **seriously** (author's emphaisis added) the complexities of the teachers' job".[10]

Teachers within the DET are aware of the need to improve the education of the learners in their care. Teachers commented as follows:

> Zama : Our education is in tatters ... what are we to do?
>
> Lindiwe : ... this education system is a disservice to us and the kids.
>
> Nosisi : ... Yes, ... being a teacher ... if I do not do research and go outside and broaden myself about methods about teaching aids, then I don't see myself progressing or becoming a qualified teacher.
>
> Ncedo : We must discard these traditional methods ... they have meant nothing to the children in our classes.[11]

The indication is that the teachers are willing to work very hard at doing what is best for the learners since they recognise how deficient the system has been.

Towards a more successful mathematics education

Because of the failure of many pupils to learn mathematics successfully, it is evident that change has to occur. Effective change has to start with the teachers because "to successfully implement changes in curriculum or in teaching practices, it is necessary to enable teachers to change their beliefs and attitudes".[12] Educators involved in in-service training and support for teachers will have to realise that teachers are not empty vessels waiting to be filled with the wisdom and wit of another expert. Their subjectivity will have to play an important role in the transformation of the teaching of mathematics in primary schools.[13] As Ahmed notes:

> Thus if improvements in the learning of mathematics are to be widespread, it is inevitable that sustained change must begin with the teachers themselves. Their beliefs about the nature of mathematics, how children learn and about their own role, are crucial factors in determining what actually happens in the classroom and therefore in determining the quality of children's mathematical development. Hence, any in-service provision that does not recognise these factors and merely "tells" the teachers what to do without enabling them to re-examine their beliefs based on their own experiences is unlikely to provide a platform for sustained teacher development.[14]

Giroux and McLaren emphasise that teachers "... need to become enmeshed in the "struggle" to create activities/exercises for their classes. Thus they are active agents of change and taking ownership of the syllabus - to interpret and emphasise what they want to".[15] If teachers do not have full ownership of the changes that must occur in their teaching of mathematics, attempts to improve the lot of the learners may be futile.

To be lasting and genuine, change has to start with the personal and professional growth of the teachers. They have to learn to experience themselves as confident decision makers concerning their practice as well as experts in their own classroom practice. For if "the teacher visualises himself as the servant of the system, to be told what to teach (and, preferably when), then he is unlikely to use successfully materials devised by the innovators who see the teachers as an autonomous producer/director of what happens in the classroom".[16]

If growth and change in teaching practice is to be lasting and meaningful it has to take place within a supportive environment over a substantial period of time. This change is essentially a long and difficult process that "is best accomplished by teacher educators working together with teachers to provide stimulating experiences

that are likely to give rise to reflection and the reconstruction of beliefs".[17] Koughton affirms that professional growth of teachers ocurs over a considerable period of time.[18] There is no instant solution to the problems that teachers face and there is no quick method to force teachers to change their long-standing beliefs and values.

However, it is not enough that outside agencies support and stimulate the teacher to change. It is essential that this process is supported by other colleagues engaged in the same process of exploring and starting to reflect on their practice. McDonald notes that: "... teachers need opportunities ... to talk to each other about the work they do. They need to teach each other (as, for example physicians do) their profession's technical variations and its subtle specialities".[19] It also needs to be supported in a broader sense by the principal of the school.[20]

One of the biggest problems experienced in MEP was the difficulty of engendering in the teachers the idea that they were their own greatest resource and that all the other prepackaged ideas and courses were of secondary importance.

It is very necessary that mathematics teachers start developing the sense that they can take charge of what takes place within their classroom although they may still operate within a rigid system. Teachers can take charge of transforming their practice in order for change to occur in their classes. For this transformation to begin, it is necessary that teachers start reflecting on their practice. It is by reflecting on their practice that teachers can start codifying (that is, representing actions that have taken place in symbols or some other form of imagery) their practice to make it more accessible for critical examination. Burton emphasises that if any real learning is to take place conscious reflection has to occur.[21]

This process of reflection does not happen spontaneously. It has to start taking place slowly, starting where the teacher feels most comfortable. The role of the outsider or facilitator is getting to know the teachers and then to start working with them, exploring their practice from the point at which they feel safest.

Within the MEP (primary) this process of encouraging teachers to start reflecting on practice has occured in three main ways:

a. consulting with teachers about teaching mathematics to primary learners;
b. running workshops with teachers which emphasise the various aspects of teaching mathematics, for example, lesson ideas, language and mathematics, causes for learner underachievement; and
c. working closely with teachers in their classrooms, and supporting them in the changes which they want to bring about here.

Conclusion

In the process of MEP work it has become increasingly obvious that there are serious problems in our primary classrooms. It is clear, too, that there will be no "quick fix" solutions to the varied and complex difficulties. Only a carefully designed, on-going programme of inservice-support which recognises the autonomy and expertise of teachers will provide space for teachers to start growing and developing professionally. Such a programme will have to take into account that if real changes are to occur, then many basic beliefs and assumptions concerning the role of the mathematics teacher, the powers of the learners and the nature of mathematics will have to undergo dramatic changes.

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