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ABSTRACT

This publication contains seven papers by the staff of the University of Exeter School of Education and by invited outside contributors. The focus is on issues that consider the social context of mathematics. The papers are: (1) "Images of Mathematics" (Leone Burton); (2) "Of Course You Could be an Engineer, Dear, but Wouldn't You Rather be a Nurse or Teacher or Secretary?" (Zelda Isaacson); (3) "Mathephobia" (Jenny Maxwell); (4) "The Politics of Numeracy" (Jeff Evans); (5) "What is Multicultural Mathematics?" (Marilyn Nickson); (6) "Multicultural and Anti-Racist Mathematics Teaching" (Derek Woodrow); (7) "Becoming a Mathematics Teacher--Grounds for Confidence?" (John Hayter). (MNS)

THE SOCIAL CONTEXT OF MATHEMATICS TEACHING

PERSPECTIVES 37

Series Editor
Peter Preece

Issue Editor
Paul Ernest

Perspectives is a series of occasional publications on current educational topics

Issues contain papers by the staff of the University of Exeter School of Education and by invited outside contributors

Forthcoming topics include:

Gender and Education
Open Learning
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PERSPECTIVES 37

THE SOCIAL CONTEXT OF MATHEMATICS TEACHING

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EDITOR'S INTRODUCTION

Mathematics teachers have long been aware of the importance society attaches to their subject. All school leavers are expected to be numerate, and an examination pass in mathematics is a required entry qualification in many areas of employment and for most courses of higher education. This importance has been reflected in a series of official reports on the teaching of mathematics from Board of Education (1909, 1912) to Cockcroft (1982). However, only in recent years has the relationship between society and mathematics been explored beyond the level of exhortations to improve.

Following Griffiths and Howson (1974), there have been an increasing number of researches into broader aspects of the social context of mathematics teaching. The Committee of Inquiry chaired by Sir Wilfred Cockcroft commissioned both a survey of curriculum development and research in the teaching of mathematics (Howson, 1983), and a survey of research on the social context of mathematics teaching (Bishop and Nickson, 1983). Leading British researchers in the field hold regular symposia on Research into Social Perspectives of Mathematics Education, convened by Steve Lerman and Marilyn Nickson. Increasing recognition, both British and international, has led the Sixth International Congress on Mathematical Education, (Budapest, July 1988), to devote a full day to 'Mathematics, Education and Society'.

With all this interest, the question arises: what issues do a consideration of the social context of mathematics teaching raise? Although there is no generally agreed answer to this, the following are a number of the key questions that arise:

What societal forces determine the mathematics curriculum?

What are the aims of teaching mathematics? What is the role of mathematics in general education?

What social and political values are implicit in the mathematics curriculum?

Is mathematics teaching meeting the needs of all its clientele, including the needs of the less academic and the lower social classes?

Mathematics and gender: are girls disadvantaged? If so, how can this be remedied?

Multicultural mathematics: how should mathematics education reflect our multicultural society?

The profession of teaching: what are the consequences of its structure?

What is the social status of mathematics and the mathematics teacher?

Teacher education: is it a qualitative or a quantitative problem?

As these questions show, a consideration of the social context of mathematics teaching raises some controversial issues. The traditional status of mathematics and mathematics teaching as value free and politically neutral can no longer be taken for granted. For example, the issue of whether mathematics in the classroom should foster cooperation or competition is now seen in some quarters as a political question.

Recent events have confirmed this: a consideration of some aspects of the social context of mathematics and its teaching have led to a great furore.

The June 1986 CSE mathematics examination (London Regional Examination Board) presented candidates with data on world military spending and then asked:

" 'The money required to provide adequate food, water, education, health and housing for everyone in the world has been estimated at 17 billion a year'

... New Internationalist 1980

How many weeks of NATO + Warsaw pact military spending would be enough to pay for this? (Show all your working)"

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In the days following the examination, newspapers carried headlines and sub-headlines including:

"Sinister" (Sun, 14 June),

"Row as maths CSE examines arms spending" (Guardian, 14 June),

"Examiners to vet maths papers for political bias" (Guardian, 14 June),

"Question: What has arms spending to do with a maths exam?" (Daily Mail, 14 June).

Another contentious area is the movement for anti-racist mathematics, founded by a number of mathematics teachers and educators concerned with issues of race and multi-culturalism. For example, the Campaign for Anti-Racist Mathematics was active at the Lambeth Teachers Centre, London, in 1986. This movement was attacked by the Prime Minister, Margaret Thatcher, who told her Party Conference in October 1987 that:

> "children who need to be able to count and multiply are learning anti-racist mathematics - whatever that means - and political slogans" (Guardian, 3 November 1987)

These examples suggest that mathematics and the teaching of mathematics have lost their innocence. It is increasingly difficult to argue that mathematics education is socially and politically neutral. An increasing number of publications, such as Maxwell (1985) and Ernest (1986), reveal some of the values implicit in the teaching of mathematics, to the gaze of all. Some will mourn this loss of innocence. Others, myself included, see this as a sign that mathematics education is coming of age. That it is beginning to take responsibility for the actions carried out in its name.

The papers in this issue of <u>Perspectives</u> do not try to avoid these questions. They treat a number of the key issues in the field. Some areas are more contentious than others, such as the politics of numeracy, and anti-racist mathematics. Some are less apparently controversial, but deal with issues of deep social and political consequence, such as gender and mathematics. They all treat matters of importance for the education community, and for society in general. Together the papers show that now, more than ever, for those with the courage to probe be ath the surface of things, mathematics teaching can be an exciting intellectual adventure.

Paul Ernest

REFERENCES

Bishop, A.J., & Nickson, M. (1983), A Review of Research in Mathematical Education Part B: Research on the Social Context of Mathematics Education, NFER-Nelson, Windsor.

Board of Education (1909), The Teaching of Geometry and Graphic Algebra (Circular 711), HMSO, London.

Board of Education (1912), Special Report on the Teaching of Mathematics in the United Kingdom (Volumes 1 & 2), HMSO, London.

Cockcroft, W.H. (1982), Mathematics Counts, HMSO, London.

Ernest, P. (1986), 'Social and Political Values', Mathematics Teaching, No.116, pp.16-18.

Griffiths, H.B., & Howson, A.G. (1974), Mathematics: Society and Curricula, Cambridge University Press, Cambridge.

Howson, A.G. (1983), A Review of Research in Mathematical Education Part C: Curriculum Development and Research, NFER-Nelson, Windsor.

Maxwell, J. (1985), 'Hidden Messages', Mathematics Teaching, No.111, pp.18-19.

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IMAGES OF MATHEMATICS

Recently I have been working with some top Junior pupils who were inventing their own mathematical games. The children had chosen with whom they wished to work and had devised their game, made it, created the packaging to house it and then tested it within their own class and with younger pupils in the school. Finally, the class decided upon a set of criteria which made a game 'good', and applied their criteria to their own games. As a result, six games were chosen as the best. Five of the six had been made by groups of girls. I discussed this with some girls in the class.

Leone: Why do you think five of the six chosen games were made by girls?

Pupils: Oh, that's obvious - the best people in the class at maths are girls.

Leone: So, you are all good at maths?

Pupils: Oh, no, not us! Louise is though, Louise is brilliant at maths.

Louise, who according to her teacher, is by far the most able child in the class, sat muttering deprecatingly about her own ability.

Leone: Well, are you all looking forward to the maths you will do at secondary school?

Pupils: No, definitely not.

Leone: Why not?

Pupils: Because it will be too hard.

Leone: Has it been hard this year?

Pupils: No.

Leone: When you were eight, did you expect it would be hard when you were eleven?

Pupils: Yes.

Leone: But you say it hasn't been hard this year.

Pupils: That's because as it got harder, we got older.

Leone: But, at secondary school you will be older than you are now.

Louise: But everyone knows that boys get cleverer at maths as they get older, so it will get harder for us and easier for them.

Many of the issues which are currently the focus of research interest are present in this short exchange. The statement as a whole reflects the recorded disparity in mathematical performance between girls and boys as conventionally measured by results at formal examinations. Thus, the Royal Society reported that, while 1984 entries and results for C.S.E. were fairly evenly distributed between girls and boys at each grade, the distribution at grade A of the 'O' Level examination was roughly 2:1 in favour of the boys, girls being 47.3% of the entry. The results at grade A of the 'A' Level examination were 3:1 in favour of the boys, girls being 30.3% of the total entry (Royal Society, 1986). While the performance of girls on tests taken in the primary years tends to be comparable with boys, and Louise herself could accept that it was reasonable that she should out-perform the boys at age 11, she has articulated a mis-perception built upon actual bias in mathematical involvement and performance. Everyone might not 'know' that boys get cleverer at maths as they get older, but there is certainly a tendency for many people to behave as if boys' styles of learning, their interests and the link between mathematics and their future careers constitute the norm. The imbalance is then seen as a problem which is located in girls. For example, Elizabeth Fennema and Penny Peterson (1985) have defined "autonomous learning behaviours" as necessary to "do high level cognitive tasks in mathematics. (They) include working independently on high-level tasks, persisting at such tasks, choosing to do and achieving success in such tasks". Fennema and Peterson assert that "females are more dependent than males" where dependency is defined as "seeking physical contact, seeking proximity and attention, seeking praise and approval, and resisting separation". But this value-laden definition of dependency is by no means necessarily the opposite of the independence being cited above. For example, Louise and her friends had certainly worked independently on the invention, construction and testing of their game, they had persisted, and they had achieved success. But they were also extremely articulate in the advice that they offered to some younger pupils who were about to begin a similar project. They said:

** make sure you choose to work with friends with whom you will be able to sort out difficulties so that you don't waste time quarrelling.

** make sure that you think ahead, and plan what you are going to do and why, before you get started, so that you don't lose time and get frustrated.

** make sure that you pool all your ideas so that you can choose the best.

** share out the jobs according to who wants and likes to do certain things. That way you will get the best possible game.

Here was a group of girls building upon their autonomous learning behaviours in a context of 'proximity' and 'approval' but where the autonomy was a function of group rather than individualised action. Further, the group was adamant that they had learnt together and through one another and that the experience had been a positive one for all. This group was not unique. The other groups of girls reported in the same terms.

I suppose that autonomous learning behaviours are as important to the learning of other disciplines as they are to mathematics and, certainly, girls' success in the non-technical, non-scientific areas indicate that they do not lack these behaviours where their acquisition and use is seen to be appropriate and consistent with their own and others' expectations. The percentage entry of girls for English at 'A' Level in 1984 was 70.7%, almost exactly the same as that of boys for Mathematics (68.7%) (Royal Society, 1986). In my view, there is a sufficient amount of bias experienced through patterns of socialisation over the period from birth to the end of formal education to explain divergence in subject preference and performance. And it is always salutary to remember that the total number of pupils succeeding at mathematics is too low to warrant any complacency about competency of any pupil, girl or boy, whether at the individual level or in terms of social needs. When we focus on the situation which is highlighted by the discrepancy in performance between girls and boys, we are raising questions about the learning experiences in mathematics which are offered to all our pupils.

What image of mathematics do the pupils have? Let the fourth year Juniors speak for themselves:

"I like maths but as you go along it becomes harder and takes more time ... I'm not looking forward to going to my new school and doing maths there." (girl)

"Some maths are easy and some maths hard, we find Add, takeaway and times quite easy ... we prefer doing math investigation because we find it easy than normal maths." (girls)

"Maths are sums like Division, Taking away and lots of other things as well ... when you come to do an assessment test there are always things we do not understand ... I am not looking forward to Maths in senior school." (girl)

"Maths is learning to add, subtract, divide and multiply ... Maths will help us in later life to get good jobs and to work well in our jobs. I don't really like maths, but it is necessary. I think Maths stands for Massive And Torturing Hard Sums." (boy)

"Maths is an educational subject which enables you to learn about adding, dividing, subtracting and timesing, etc." (boys)

"Maths is Addition, Subtraction, Division and Multiplication you need it when you go in sweet shops because if you buy a Mars bar you might not get the right amount of change back. You need it in cricket and football results. SMP involves maths as well." (boys) - textbook authors please note!

These children had been working at mathematical projects for the majority of their time during the term preceding their writing these comments. Many aspects of the remarks are worrying. The girls refer to their feelings about maths and particularly their concerns about changing schools. But the boys are just as convinced that, despite being necessary, mathematics is not very pleasant! And despite a great deal of effort, all of mathematics is still just the four rules.

The image of mathematics as being difficult arises, in my view, from the children's early contact with the subject. Far from developing a mathematical language to match and complement the demands that they are making upon it, children are introduced to a codified language and rules for usage which are distanced from their own concerns and largely irrelevant to them. As a long line of researchers and authors have pointed out, children "need to be capable not only of operating within the formal code, but also of making fluent translations between formal and concrete representations of the same problem" (Hughes, 1986). These kind of translations between formality of coding and the contextualisation of the concrete representations being recorded do not appear to present a barrier to girls when linking their language development with the skills of reading and writing. Nor do the girls appear to stumble over their 'dependency'. However, girls' facility with language is validated. They are not only expected to be successful with reading and writing, but their interest in stories, poetry, drama, singing, indeed anything connected with language, is seen as appropriate. At the same time, teachers perceive as 'natural' the exploratory, constructional, 'tinkering', often disruptive behaviour of the boys. Indeed, such patterns of behaviour are often inadvertently reinforced by teachers through their very attempts to 'deal' with the boys. The more attention the behaviour attracts, the more likely it is to be confirmed. So, one is left wondering how much the stereotypes of compliant, submissive, undemanding girls and boisterous, noisy, attention-seeking boys are themselves self-fulfilling prophecies resulting from parent and teacher behaviour. The result of such confirmation can be that, arguing circuitously, the very behaviour is then identified as necessary to success in learning mathematics and the negative descriptors are appended to the girls who are failing to learn in this style. So, boys' attention-seeking behaviour which is enthusiastic, eager and confident is defined positively despite being just as demanding and reward-dependent as the negatively defined girls' behaviour. The moral of this story is that it is extremely difficult to resist the effects of gender stereotyping even when framing researchable questions.

Louise's strong convictions about the mathematical potentialities of boys spring, therefore, from the social stereotyping of mathematics, science and technology as a male domain and the coincidence of power, both in the human and the technical sense, with maleness. So, the images in the media, in language, in advertising reinforce the roles and behaviour of active, powerful, controlling men and attentive, submissive and attractive women. As Gilah Leder (1986) pointed out, "The preoccupation with the negative rather than the positive aspects of success in articles depicting successful females is unfortunate, and may help to explain not only why certain goals have different values for males and females but also why fewer girls than boys concentrate on the still male perceived areas of mathematics and science". In a society where scientific superiority is an integral part of power and control, it is not surprising that the domain of mathematics, science and technology is attributed to men. A trivial, but pervasive, example was the recent advertising campaign by the Action Bank, which spelt out the name of the bank using human figures to represent each of the letters. All the figures, except two, were male. The two were a bespectacled secretary standing ready with her typewriter awaiting instructions, and a gardener entwined around a flowering tree! Jacobsen (1985) recently pointed to differences in child-rearing practices, peer group expectations, and social attitudes, all of which contribute to the image of mathematics as a male domain. He cited an incident at the XXV International Mathematical Olympiad in Prague in 1984 at which he was "firmly told by the team leaders of two countries that the percentage of women competitors can never exceed 8 per cent, as this is due to biological reasons which we simply cannot alter".

Child-centred education which has been so enthusiastically embraced especially by primary teachers can provide a framework within which the differential needs of certain categories of pupils are not considered. Many primary teachers say that they do not notice the sex of a pupil, they are too intent on the pupil as a person and yet numerous research studies have demonstrated that teachers do treat children differentially according to their sex. For example, in making comments on children's work, they tend to criticise boys for presentation, girls for the quality of the mathematics (Dweck, Davidson, Nelson & Enna, 1978). In class, they tend to interact with boys much more frequently than with girls and, indeed, girls have many more days when they do not interact with the teacher at all. High-confidence boys interact at higher cognitive levels more frequently than do high-confidence girls (Reyes & Fennema, 1982). Walden and Walkerdine (1986) have drawn attention to the phenomenon which they called rule following/challenging and how this relates to the procedural rules of mathematics and the behavioural rules of the classroom. "Challenging the internal rules of the mathematical discourse, relating particularly to the teacher's authority as guardian of those rules is important in producing what the teachers describe as 'real understanding'. Such challenging requires considerable confidence because it necessitates the recognition that rules are to be simultaneously followed and challenged. That many girls do not have such confidence, nor would dare to make a challenge offers a different explanation of girls' mathematical development than one which relies on the naturalistic or immutable."

Autonomy of learning is, indeed, the objective set by most teachers for the pupils in their charge. However, a classroom full of autonomous learners can be an extremely challenging and vulnerable place for a teacher to be Organisational devices such as textbooks which control the curriculum and leave the teacher free to adminster are introduced in part to reduce that vulnerability. Behavioural rules which require girls and boys to line up separately, to be listed separately on the register, to dress distinctively, even to hang up their coats in different places, are all mechanisms which are used in schools to reduce the pressure of numbers and the potentiality for loss of control. There is increasing evidence that when the staff of a school focus on equal opportunities, looking at such overt mechanisms, as well as considering teacher and pupil behaviour in the classroom, the impact of sexism in the curriculum, the use of sex-biased examples in texts, materials and examinations, the sex of the role models within the school, and so on, that the impact is measureable in the response of the pupils. As Stuart Smith (1986) reported: "In recent years, there has been a remarkable improvement in the number of girls from the school who have been successful in the 'O' Level Maths examination. This improvement ... appears to be closely related to a number of steps which have been taken to end the masculine image of Maths in school." Equally, Hazel Taylor (1986) asks: "how effective isolated strategies can be without the support of a general commitment to equal opportunities throughout the school?"

It is unreasonable to expect that teacher input or school environment can effect radical changes on the image of women and of mathematics in society. At the same time, it is unreasonable to deny that, as a social institution, the school has considerable influence on the attitudes and behaviours of those within it. It seems to me that it is important to remember:

* such changes do not happen quickly but are cumulative and therefore respond to structural adjustments of the kind mentioned above.

* changes in attitude demanded of pupils must be seen to be consistent with the attitudes of teachers.

* stereotyping incidents should be discussed openly within the class and the time given to such discussion be seen as important.

* criticism of materials or books does not imply throwing them away. Heightening sensitivity to sex stereotyping is effectively done through critical discussion of the materials or books and by raising the question of what would have been

more acceptable. In holding such discussions, many primary teachers are horrified to discover the firmly held sex-stereotyped views of some of their pupils.

In conclusion, it might be worth reflecting on what you, the reader, would say to Louise and in what ways you would ensure that what you said was reflected in the experiences that you provided for her in your classroom. Remember that next September Louise will enter her secondary school. Recall the anecdote of another girl who started secondary school in 1984:

"It was the start of the new school year in a secondary school. The boys and girls were lined up outside their first mathematics class. As the teacher supervised them filing in he said: 'Girls, sit at the back because mathematics is not such an important subject for you as it is for the boys." (Open University, 1986)

Leone Burton

NOTE

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REFERENCES

Dweck, C.S., Davidson, W., Nelson, S., & Enna, B. (1978), 'Sex differences in learned helplessness, II The contingencies of evaluative feedback in the classroom and III An experimental analysis', Developmental Psychology, Vol.14, pp.268-276.

Fennema, E., & Peterson, P. (1985),'Autonomous Learning Behaviour: A Possible Explanation of Gender-Related Differences in Mathematics', in L.C. Wilkinson & C.B. Marrett (eds.), Gender Influences in Classroom Interaction, Academic Press, Orlando.

Hughes, M. (1986), Children and Number, Basil Blackwell, Oxford.

Jacobsen, E. (1985), 'Reducing differences in mathematicsl expectations between boys and girls', Studies in Mathematics Education, Vol.4.

Leder, G. (1986), 'Mathematics Learning and Socialisation Processes', in L. Burton (ed.), Girls Into Maths Can Go, Holt, Rinehard & Winston, London.

Open University (1986), Girls Into Mathematics, Cambridge University Press, Cambridge.

Reyes, L., & Fennema, E. (1982), 'Sex and confidence level differences in participation in mathematics classroom processes', paper presented at the annual meeting of the American Educational Research Association, New York.

Royal Society (1986), Girls and Mathematics, Report by the joint Mathematical Educational Committee of The Royal Society and The Institute of Mathematics and its Applications.

Smith, S. (1986), Separate Tables? An Investigation into single-sex setting in mathematics, HMSO, London.

Taylor, H. (1986), 'Experience with a Primary School Implementing an Equal Opportunity Enquiry', in L. Burton (ed.), Girls into Maths Can Go, Holt, Rinehart & Winston, London.

Walden, R., & Walkerdine, V. (1986), 'Characteristics, Views and Relationships in the Classroom', in L. Burton (ed.), Girls Into Maths Can Go, Holt, Rinehart & Winston, London.

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OF COURSE YOU COULD BE AN ENGINEER, DEAR, BUT WOULDN'T YOU RATHER BE A NURSE OR TEACHER OR SECRETARY?

That fewer girls than boys engage in mathematics at school and beyond, and that girls on average perform less well than boys, especially at the higher levels of achievement, is well documented (e.g. Burton (1986), Isaacson (1982), The Royal Society (1986)). These facts are, increasingly, a cause of concern in the U.K. and indeed internationally (Note 1). In recent years the flow of literature on the 'gender and mathematics' issue has substantially increased, and much of this writing has been concerned with possible explanations of the phenomenon of female underachievement.

In this paper I wish to put before readers two theoretical constructs, namely, coercive inducements and double conformity, which individually, and even more together, offer powerful explanations and far-reaching insights and are therefore potentially of immense value to researchers in this field.

The notion of a coercive inducement is one which Helen Freeman and I developed some years ago. It seemed to us that to suggest that girls were prevented from taking up non-traditional roles in society - or 'not allowed' to engage in 'boys' subjects at school and higher education levels - was far from the felt experiences of most girls and women. Experientially, most girls do not see themselves as forced into submissive roles, or coerced into taking up low status and often subservient jobs - or into studying Child Development rather than Physics at age 14+. Rather, these female or feminine roles, jobs, school subjects, etc. are chosen by them, but they are 'chosen' because of a system of rewards and approvals which act as inducements and which are so powerful that they come to be a kind of coercion.

Observing young girls at play and at work in infant school classrooms (Note 2), these patterns are clear. Girls regularly choose to play in the Wendy House (it may officially be called the 'domestic play area', but children and teachers alike slip into the familiar name!); they do not often choose to play with Lego or other constructional toys; they choose pretty clothes, 'Care Bears' or 'My Little Pony' for their birthday presents. Six and seven-year-old girls often see their adult lives in terms of getting married and having children. If asked whether they will have a job when they grow up, even academically able girls name such things as, of course, nursing or teaching - or being a secretary or working in a sweet shop. It is crucially important, however, to acknowledge that the choices girls make day by day and hour by hour are, on the face of it, very attractive ones, and that the intrinsic and extrinsic rewards (e.g. personal satisfaction, the approval of significant others) accruing to girls for appropriately feminine behaviour (caring for others, helping others, building up relationships with others) are a further reinforcement of these patterns.

As Helen Freeman and I wrote in a draft paper when we were developing the notion of a coercive inducement a few years ago:

> It has been suggested that a submissive role is forced upon girls through punishment of non-conformist behaviour. It seems to us, however, that it would be closer to the truth to suggest that, rather than being coerced into 'feminine' behaviour, girls are induced by a system of rewards and approval to accept a more passive role.

And in a recent paper (Isaacson, 1986) I expressed the idea in this way:

> There is a sense, I believe, in which many girls are persuaded to adopt typically female modes of behaviour and to choose stereotypically feminine occupations and life styles because the rewards for 'feminine' behaviour are too great to be refused, rather than because they are prevented from choosing others...

Earlier this year (1987), in a 'That's Life' programme on television, viewers were shown a small girl taking part, with an adult male partner, in a ballroom dancing display. The rewards she obtained for this were enormous - applause, lots of attention, being treated as 'grown-up' and being dressed up in a miniature version of the bespangled costumes of the adult women dancers. Very few children would be able to resist such delights. Certainly, this little girl revelled in her role. The inducement to play the feminine role was so great that it, in a very real sense, could not be refused by that child and so was a form of coercion - an offer which could not be refused. All the little girls who watched that programme, too, were being exposed to this coercion. The message came through loud and clear: 'be a real woman, wear pretty, spangled clothes and dance on a strong man's arm, and you too will be applauded and feted'.

What has any of this to do with mathematics learning? Very simply, it is that the learning of mathematics cannot be divorced from the social context in which that learning takes place. Mathematics (and science and technology) carry strong 'male' images, partly because they are seen as 'hard' - not necessarily intellectually difficult, but hard as opposed to soft (or feminine, yielding etc.). The male image of these subjects has a long history. This image is further reinforced both by the fact that they have traditionally been dominated by men, and that their public concerns are typically masculine concerns, such as warfare, machinery and work aimed at subduing or controlling nature. (See, for example, Easlea 1981, 1983.) Girls and women often come to believe, therefore, that these 'masculine' subjects, and the jobs they lead to, are not for them. Worse, they often believe (at a subliminal level even if this is not made explicit) that if they engage in these activities they will put their valuable femininity (valuable because of the rewards it brings) at risk.

The effect on mathematics learning is cumulative. At option choice time, girls are often reluctant to continue with study of the physical sciences and technical subjects; because of the male image they carry; because of a relative lack of experience in these subjects which goes back to infant school days; and because they are making positive choices for 'feminine' subjects (human biology, needlecraft, art). At this stage of education we see mathematics becoming increasingly unpopular amongst girls. This is in part because in itself it carries an offputting male image, reinforced by boys in mixed sex classrooms who claim the subject as their own. It is also because one of the most compelling reasons, currently, for pupils to learn mathematics - i.e. that it will be useful for other subjects studied and for future careers - is also absent for the girl who has already opted out of science and/or technology and has decided that that sort of job is not for her. There is research which suggests that pupils who study physics or technical subjects alongside O level mathematics do better at mathematics than those who do not (Sharma & Meighan, 1980). This reinforces the hypothesis that pupils who study these subjects (i) practise their mathematical skills in another context, and (ii) have strong motivation to learn mathematics. So, although mathematics is a compulsory subject for the vast majority of pupils to age 16 in the U.K., adolescent girls often disengage themselves from the activities of the mathematics classroom. Although they are generally not permitted to drop out of mathematics altogether, they can and do 'vote with their feet' and gradually drop down - from near the top of a class to nearer the bottom or from a high set into a lower one. The observable outcome is that many girls do not achieve as much as might have been predicted for them at an earlier stage of their schooling.

I grant that the system of rewards and approval for feminine behaviour which I said act as 'coercive inducements' would not normally be called coercion. The coerced person is usually understood to be doing what they are unwilling to do, because of fear of unpleasant consequences ('your money or your life'). The coerced person is thus normally understood to be unfree, whereas acting in response to an inducement is usually regarded as acting freely. I wish to argue, however, that this juxtaposition of the two concepts offers a way into understanding the mechanisms of female underachievement. Girls and women who 'choose' the path of conventional femininity are in one sense acting freely - they could have chosen otherwise - but in another sense are unfree. When the rewards for being a 'proper woman' are huge, while by not conforming one risks the loss of these rewards, then one's freedom is no more real than the freedom of a person living below the poverty line to take an expensive holiday abroad.

The notion of a coercive inducement on its own, I suggest, goes a long way to explaining why females are underrepresented in 'male' subjects and occupations. However, when combined with the second construct under consideration in this paper, that is, double conformity, its explanatory force is greatly increased.

I am indebted to Sara Delamont for this latter idea. In an essay entitled 'The Contradictions in Ladies' Education' (1978) she claimed that:

> The central theme which can be traced through the establishment of education for middle and upper class girls and women

> from the 1840s to the present day is double conformity. This double conformity - a double bind or catch 22 - concerns strict adherence on the part of both educators and educated to two sets of rigid standards: those of ladylike behaviour at all times and those of the dominant male cultural and educational system. (p.140)

Double conformity expresses the dilemma of any person who is in a situation where they have to conform, at the same time, to two sets of standards or expectations, where these two sets are mutually inconsistent. This was the case for the pioneers of women's education in the nineteenth century. It is also the case, I wish to argue, for many women today who reject stereotypical career choices but then find themselves competing with men in a world where the rules have been made by men to fit in with the ways in which men are expected to behave.

A piece of research carried out some years ago, into people's views of what are the characteristics of a mentally healthy, mature, socially competent (i) adult, (ii) man and (iii) woman, is very revealing (Broverman et al., 1970). The characteristics of a normal adult and a normal man match very closely, while those of a normal woman are quite different. It is not possible (according to these profiles, reflecting views held by both men and women) to be, at the same time, a normal woman and a normal adult! This

> ...places women in the conflictual position of having to decide whether to exhibit those positive characteristics considered desirable for men and adults, and thus have their 'femininity' questioned, that is, be deviant in terms of being a woman; or to behave in the prescribed feminine manner, accept second-class adult status, and possibly live a lie to boot. (p.6)

So, a woman working in a male dominated and male defined sphere, finds herself continually faced with having to choose between acting in ways which are appropriate to her as a woman, and appropriate to ... as, say, an engineer. For men in these jobs there is no such conflict, whereas for women, the conflict is an inevitable part of the job and, indeed, of being a mature and responsible adult in a sex-stereotyped world.

The combined effect of coercive inducements and double conformity is to increase enormously the obstacles which women have to overcome when they try to make their way in male dominated and defined areas of study and work. Competence and confidence in mathematics play a part in many of these, and girls who opt out of mathematics, science and technology at school, because they do not wish to enter these fields, are responding to very strong influences. They can hardly be said to be making choices based only on talent, interest or inclination. Although not usually expressed in this way, many girls see the choice as between living their lives under the stress of double conformity, and being continually in a 'conflictual position' or, alternatively, gaining the rewards for conventionally feminine choices and behaviour. These rewards may well be short term and short lived, but life beyond age 25 is not salient in the eyes of most girls.

When I consider the gender and mathematics issue with the aid of these explanatory constructs, I find myself ceasing to be puzzled by girls' underachievement in mathematics, but rather astonished that girls and women achieve as much as they do!

If changes are to be brought about, the loss of female mathematical talent abated, and greater equality of opportunity and genuine freedom of choice opened up, then we have to look both at and beyond school practice in ways which take account of these deep-rooted forces. We have to work simultaneously on a number of fronts. One of these is to change the climate within mathematics classrooms so that ways of working which girls find comfortable are welcomed. An example of this would be to develop classroom practices and types of classroom organisation which discourage competitive behaviour, (where the search for the right answer is dominant), and instead encourage cooperative, collaborative and exploratory behaviour where each person's contribution - as an individual or as a member of a group - is valued. I find hopeful in this respect the directions in which GCSE mathematics, properly applied in the classroom, could take us. Another is to look carefully at the content of the mathematics curriculum, and ensure that this reflects a broad range of human concerns, rather than being narrowly focussed on traditionally male concerns only. These sorts of changes serve to reduce the level of conflict for girls. We have rightly, and at long last, gone beyond the days when it was believed that improving girls' participation in mathematics required that girls were to be changed!

In Holland, when an alternative mathematics curriculum was introduced (Math A), with a higher 'social' content and broader based applications which are more obviously and immediately relevant to pupils, the proportion of girls studying mathematics to age 18 greatly increased (Isaacson et al., 1986). The Dutch experience suggests that changing the content of the curriculum alone can make a significant difference - how much improvement might we see if a number of the important variables were changed at once! The 'bubble' diagram (Figure 1) offers a schematic view of the complex of interrelating variables which are key influences on mathematics learning.

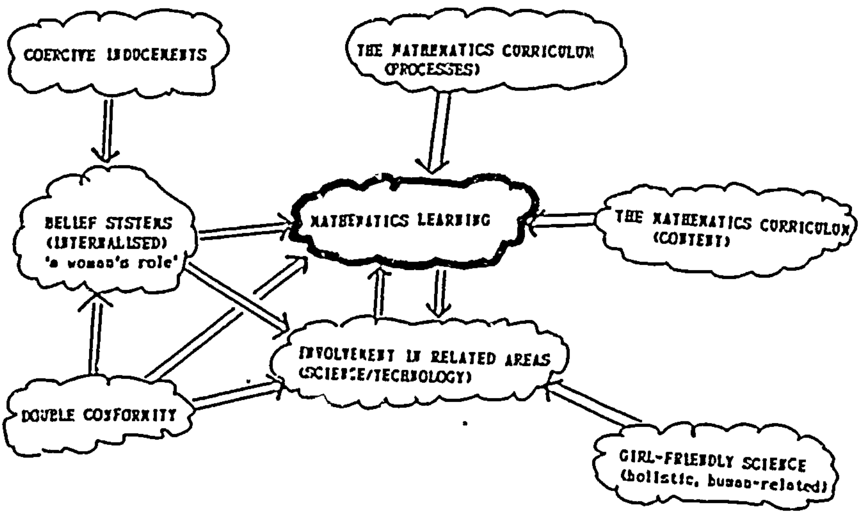

Figure 1. Influences on the Learning of Mathematics

A final comment and a final claim - I believe that work on gender and mathematics must go on, not only because of arguments derived from justice (women should not be discriminated against) or because of arguments derived from need (we cannot afford to neglect so much potential talent), important though both these are. A further and most compelling reason is that through work on this issue we begin to learn much which is of broad significance for the pedagogy of mathematics. Research and discussion on gender and mathematics are leading to a deeper understanding of the factors which influence mathematics learning in general, not just in females. This has been an unexpected bonus, and may in time prove to have been as valuable an outcome of the work as those originally intended - perhaps even the most valuable in the long term.

Zelda Isaacson

NOTES

1. IOWME (International Organisation of Woman and Mathematics Education) holds regular international meetings and publishes a biannual newsletter. In 1986 in London, a number of 'state-of-the-art' reports from around the world were presented, as well as information gleaned from the SIMS (Second International Mathematics Survey) data, all pointing to a continuing imbalance between female and male achievement in mathematics. In March 1987, the Dutch government funded a conference organised by Vrouwen & Wiskunde (Woman and Mathematics) on the theme 'Images of Mathematics'. In the U.K., the publication by the Royal Society of a report on 'Girls and Mathematics' (1986) is a measure of the public recognition now given to this issue.

2. The author spent a term in an Infants School in 1986, observing gender differences in children's play, style of dress, choice of companions and activities. She also explored with 6 and 7-year-old children their views on a number of questions through in-depth individual interviews.

REFERENCES

Broverman, I., Broverman, D., Clarkson, F., Rosenkrantz, P. & Vogel, S. (1970), 'Sex-role stereotypes and clinical judgments of mental health', Journal of Consulting and Clinical Psychology, Vol.34, No.1, pp.1-7.

Burton, L. (ed.) (1986), Girls Into Maths Can Go, Holt, London.

Delamont, S. (1978), 'The Contradictions in Ladies' Education', in S. Delamont & L. Duffin (eds.), The Nineteenth Century Woman: Her Cultural and Physical World, Croom Helm, Beckenham.

Easlea, B. (1981), Science and Sexual Oppression, Weidenfeld and Nicholson, London.

Easlea, B. (1983), Fathering the Unthinkable, Pluto Press, London.

Isaacson, Z. (1982), 'Gender and Mathematics in England and Wales: A Review', An International Review of Gender and Mathematics, ERIC.

Isaacson, Z. (1986), 'Freedom and girls' education: a philosophical discussion with particular reference to mathematics', in L. Burton (ed.), Girls Into Maths Can Go, Holt, London.

Isaacson, Z., Rogers, P. & Dekker, T. (1986), 'Report on IOWME discussion group at PME 10', IOWME Newsletter, Vol.2, No.2, pp.3-6.

The Royal Society (1986), Girls and Mathematics, A report by the Joint Mathematical Education Committee of the Royal Society and the Institute of Mathematics and its Applications, The Royal Society, London.

Sharma, S. & Meighan, R. (1980), 'Schooling and sex roles: the case of GCE 'O' level mathematics', British Journal of Sociology of Education, Vol.1, No.2, pp.193-205.

MATHEPHOBIA

"Mathephobia is irrational and impeditive dread of mathematics" (Lazarus in Resek and Rupley, 1980). It was through Myrtle that I first recognized and became interested in the condition. I knew that many people disliked mathematics or found it difficult but until I met Myrtle I was unaware of the terror and panic it can arouse. Myrtle was a student for five years in the adult class which I taught. She was an articulate lady whose achievement in other subjects was clearly much greater than in mathematics. This discrepancy was obvious to her and for a year or more the overwhelming necessity of hiding her difficulties from the rest of the class impeded any learning. With adults it is relatively easy to build a relaxed and communicative atmosphere and we all helped Myrtle by sharing tales of beatings for not knowing tables and of unfulfilled parental expectations. After five years she was still apologetic for her mistakes but she did recognize that they are common and can be fruitful. Above all she enjoyed mathematics.

It is possible to be a competent mathematician who dislikes the subject. The mathephobic's stomach churning fear and panic produces total inability to do mathematics. Inability is relative to expectations so that for many in the lower ability ranges the incomprehensible fog of mathematics merely confirms, and is confirmed by, their other experiences. It does not produce mathephobia. Laurie Buxton (1981) chose his research sample to be people who "panic(ked) about maths" in spite of, or perhaps because of, achieving success in other fields. His most vivid example is of a headmistress who likened the panic when her husband was late home from a business trip to Israel to that experienced as a child when she was unable to remember 7 x 7. Women arts graduates are particularly prone to mathephobia though both Laurie Buxton (1981) and Bridgid Sewell (1981) found that men were more reluctant to admit their fears so there are probably more male mathephobics than would appear from their statistics.

A certain amount of anxiety is necessary for the educational task of learning mathematics. What is needed is previous success combined with just enough anxiety and pride to drive towards activities which are thought to be within reach. Aiken (1970) gave students a questionnaire asking them to write true or false by each of three statements:

"I am often nervous when I have to do arithmetic"

"Many times when I see a maths problem I just freeze up"

"I was never as good in maths as in other subjects".

His results accord with those of Janet Morris (1981) who speaks of students displaying "panic, tension, helplessness, fear, distress, shame, sweating palms, clenched fist, queasy stomach, dry mouth, cold sweat". Resek and Rupely (1980) speak of "knots in the stomach and throbbing in the head at the mention of fractions or variables".

About half of Brigid Sewell's (1981) intended sample refused to be interviewed. She attributed this to "the painful associations which they feared (she) might uncover". Of those who did agree to be interviewed the "perception that mathematics is daunting pervaded a gread deal of the sample selections". During the interviews people chain-smoked and there was much nervous laughter.

One of Laurie Buxton's (1981) subjects distinguishes between the emotional and physical reactions to mathematics. "Panic in the mind and emotional feeling in the stomach are distinct. The mind itself is thrown into a confusion and cannot make the necessary connections...Perhaps...I haven't asked for the right (message). I haven't made the right demand of my brain and the brain knows it and...rebels". To solve a problem the brain makes a plan and follows it through. The process can go wrong at each of its three stages. The expectation of failure can be so great that the brain cannot even begin to plan, it can try to plan but fail or it can make a plan which it cannot execute. The second and third of these cause frustration. To the first, which causes panic, mathematical problems arc particularly susceptible. An English undergraduate is unlikely to interpret the problem on a University mathematics paper. The mathematics undergraduate would have a better chance of making sense of an English question and, given library facilities would have at least a rough idea of how to approach its solution. This peculiar characteristic of mathematics is recognized universally. Teachers whom I interviewed (Maxwell, 1984) agreed almost unanimously that "In the maths department (they had) a little extra aura as far as the other staff (were) concerned". While most thought such reverence misplaced and undeserved they nevertheless thought it was a view generally held by the public.

Mathematics lends itself particularly to an authoritarian teaching approach which fosters this mystique, creating fear and panic. Many children are encouraged to accept the teacher's word without question even when she appears to be behaving oddly. A language graduate told Bridgid Sewell (1981) that on starting algebra (for many children the end of meaningful mathematics) he failed to understand why a mathematics teacher should be writing letters. He was so accustomed to mathematics being incomprehensible and to the teacher's infallibility that he attributed all blame to himself, a view likely to be endorsed by the teacher.

It is hard for a teacher to empathize with a learner, but important, for a small piece of mathematical misunderstanding can support an edifice of nonsense. "Take the number 10. We are so used to it that we cannot imagine (being) told that when you put (1 and 0) together, it stands for something much bigger than either of them. We should acknowledge the...nuttiness of this...so (the children) will not feel on the outside of a baffling mystery. Otherwise their first encounter with 10 may give children a shock from which they never fully recover and which freezes up their minds every time they think about it" (Holt, 1969).

Students are helped by teachers who can admit their own mistakes. A teacher was asking 4th year juniors to make given amounts of money using a minimum number of coins. As an example she gave 30p = 3 x 10p. The most disruptive child remembered what the teacher had forgotten - the new 20p piece. Her praise and the admission of her mistake had many positive consequences. The class relaxed, the boy was pleased, they were reminded that mathematical success is attainable by ordinary people, that mistakes are not fatal but inevitable and that this teacher welcomed questions and discussion.

Mathematics is seen by some as an infallible truth with absolute standards of right and wrong, words conveying moral values which extend beyond the classroom. It is more likely than any other subject to be taught in a way which "hardly permit(s) a doubt or a suggestion from (a) student" (Joffe, 1981). It is over a hundred years since Isaac Todhunter wrote "If (a schoolboy) does not believe the statements of his tutor...his suspicion is irrational and manifests a want of the power of appreciating evidence, a want fatal to his success in (mathematics)" (Griffiths and Howson, 1974, p.296).

A century later W.H. Auden (1973) recalls being taught:

"Minus times minus equals plus
The reason for this we need not discuss".

This equation, he says, was "traditionally imparted by the rule of authority". It should be possible for students to question and discuss such knowledge until it seems reasonable. One of Laurie Buxton's (1981) subjects says, "You are forced to accept something when you don't want to, the whole of you revolts against it".

Written constructive comments intead of a tick or a cross could remove the judgemental element from mathematics. So could the recognition that a variety of methods and even answers is possible. The answer to the problem "how could we best get to Birmingham City Centre to go shopping from the University two and a half miles away?" could include consideration of speeds, parking facilities, costs of bicycle, car, bus, train or walking, producing many different possibilities. Discussion between tutor and students, including peer tutoring, is the basis of the "Math Without Fear" project in San Fransisco (Resek and Rupley, 1980).

John Holt (1969) believes that society conditions teachers into deliberately frightening children. Of an otherwise intelligent boy who is unable to learn simple number bonds he says:

"His memory does not hold what he learns, above all else because he won't trust it...How can you trust any of your own thoughts when so many of them have proved to be wrong? ...We have made him afraid, consciously, deliberately, so that we might more easily control his behaviour and get him to do whatever we wanted him to do".

Whether or not you agree with Holt, it is certainly true that 'society' produces examination systems. These not only dominate curricula but introduce time constraints. Many people trace their unhappy memories of mathematics to their early years when they were required to give rapid mental answers. A friend remembers, like Myrtle, the fear and anticipation of physical pain causing total paralysis of her brain. After twenty five years she has not recovered from her terror of mathematics. Some years ago at a day conference for adult numeracy tutors we were given a test of thirty mechanical questions including fractions, decimals and percentages, to be answered in ten minutes. It was of a type given to people to enrol on job training schemes. It needed little imagination to see how such a test could induce paralysing panic. My own anxiety was that I should not fulfil the expectations that I and others in the room had of me. The relief at avoiding the "anti-goal" (Buxton, 1981) of failure was heightened by the knowledge that most other people had thirty right answers too.

For many children mathematics is a series of such anti-goals to be avoided. Emphasis on speed and accuracy creates the view of mathematics as an "answer centred rather than problem centred subject" (Holt, 1969). Instead of learning mathematics children develop devices such as copying for producing right answers and "defense mechanisms to protect themselves from defeat" (Holt, 1969). Two junior children in a special unit honestly thought that all that was required was a line of right answers and were surprised to be told that copying (as opposed to genuine helping, a most valuable way of learning for both helper and helped) was an inappropriate way to produce them.

Part of the teaching skill in avoiding fear is finding the right level of question. One of Laurie Buxton's (1981) group was succeeding until she was presented with the Wassan problem. Her increasing confidence was badly shaken by her failure to solve it. An adult student once came to my class wanting to multiply two digit numbers. He had no concept of tens and units but when I tried to take him back to this he was deeply offended, his confidence shattered and he never came back.

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Mathephobics attach much blame to those teachers whom they have found to be impatient and unsympathetic, who shout or rely on fear or physical punishment to motivate their students. Children will accept that punishment is just for idleness or naughtiness but not for misunderstanding. It is more comfortable for a teacher to attribute a student's failure to inattentiveness than to an inadequate explanation.

Many teachers, often ill trained and teaching mathematics unwillingly see it as cold, impersonal and sub-human. It is a barrier to, rather than a means of, communication, which is not only about methods, hypotheses and answers but about feelings. Communication takes time - to play, relax, discuss, absorb, assimilate and understand. Lynn Joffe (1981) working with dyslexic children spends the first ten minutes of every session on a relaxation programme. Examination syllabuses, backed by parents and teachers who demand speed, conspire to frustrate proper learning. Some of my own most rewarding teaching was with two very slow junior children in a special unit. For two separate hours every week for a term, I had a completely free hand. The results were remarkable but increasing cuts and lack of resources in schools mean that such ideal conditions are becoming ever more rare.

Not all mathephobia is avoidable. Laurie Buxton believes that recall of a piece of learning which took place at the time of a traumatic unconnected event in a person's life can bring to the surface emotional responses to the event. These can be so distressing as to subconsciously convert unwillingness to recall the mathematics into inability to do so. A person whose parent died while they were learning division might be for ever incapable of dividing.

Avoidance is the most common way for children to cope with mathephobia. They prefer to sit in silence rather than ask questions and risk ridicule. Others play the clown or affect a lack of concern and pride at their inability to do mathematics. Does "I can't do mathematics" really mean "I think I might not be able to do it so I sha'n't risk trying"?

There is another mathematical fear which is utterly different from mathephobia. This is fear of success, occurring mostly in high ability girls (Leder, 1982). They fear social rejection and loss of self esteem from doing well in a traditionally male-dominated subject.

Struggle is not always to be avoided, and confidence is increased by overcoming obstacles not by removing them. However it should be "disconcerting for mathematicians to realize the extent of the antipathy to the subject among the population" (Sewell, 1981). The irregularities of our spelling and pronunciation, incomparably more illogical than mathematics, make learning to read in English an abominable task. Yet most people manage it. I find it very sad that something which gives me so much pleasure should be so distressing to others, and know I have been lucky to teach in conditions incomparably easier than a classroom, where it is easier to avoid and overcome mathephobia. The present political climate favours a return to Victorian educational values, the beliefs of Isaac Todhunter and an atmosphere which nourishes mathephobia. I am grateful to Myrtle who gave me the opportunity to "teach some mathematics to an ardent hater of the subject" (Buxton, 1981). I hope I am wrong but I fear there may be many more such opportunities in the future.

Jenny Maxwell

REFERENCES

Aiken, R. (1970), 'Attitudes Towards Mathematics', Review of Educational Research, Vol.40.

Auden, W.H. (1973), Observer, 20th May.

Buxton, L. (1981), Do You Panic About Maths?, Heinemann Educational Books, London.

Griffiths, H.B., & Howson, A.G. (1974), Mathematics: Society and Curriculum, C.U.P., Cambridge.

Heritage, R. (1977), Mathematical Education for Teaching, Vol.3, No.1. pp.9-12.

Holt, J. (1969), How Children Fail, Penguin, Harmondsworth.

Joffe, L.S. (1981), Dyslexia and Attainment in School Mathematics, unpublished Ph.D. Thesis, Applied Psychology, University of Aston.

Leder, G. (1982), 'Mathematics Achievement and Fear of Success', Journal for Research in Mathematics Education, Vol.13, No.2, pp.110-123.

Maxwell, J. (1984), Is Mathematics Education Politically Neutral?, unpublished M.Ed. dissertation, Faculty of Education, University of Birmingham.

Morris, J. (1981), 'Math anxiety, teaching to avoid it', Mathematics Teacher, Vol.74, No.6, pp.413-417.

Resek, D., & Rupley, W. (1980), 'Combatting Mathephobia', Educational Studies in Mathematics, Vol.11, No.4, pp.423-441.

Sewell, B. (1981), The Mathematical Needs of Adults in Daily Life, A.C.A.C.E., London.

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THE POLITICS OF NUMERACY

1. Introduction: What is Numeracy, and Why is it Important?

'Numeracy' is a term which has taken its place, if not in the public consciousness, then at least in the language of circles where education is discussed, in the 1980's in Britain - following the publication of the Cockcroft Report 'Mathematics Counts' (1982). What meaning does this term have?

The term 'numeracy' was coined "to represent the mirror image of literacy", by the Crowther Committee (1959, pp.269-70). The Cockcroft Report discusses a range of definitions: from Crowther's broad conception - including familiarity with the scientific method, thinking quantitatively, avoiding statistical fallicies - to narrower ones, e.g. the ability "to perform basic arithmetic operations" ('Collins Concise Dictionary' - and for many in the public at large?)

Taking an intermediate position, Cockcroft uses the word 'numerate' to mean the possession of two attributes:

(i) "an 'at-homeness' with numbers, and an ability to make use of mathematical skills which enables an individual to cope with the practical mathematical demands of his everyday life";

(ii) "an appreciation and understanding of information which is presented in mathematical terms, for instance in graphs, charts or tables or by reference to percentage increase or decrease".

That is, they are concerned with the wider aspects of numeracy, and "not...merely...the skills of computation" (Cockcroft, para 39, p.11).

There are several noteworthy aspects of this definition. First, both attitudes - an 'at-homeness' - and skills are considered important: <u>confidence</u> counts, as well as competence. Second, the touchstone for which skills are important is <u>practical</u>, and the relevant context is provided by the demands of the person's everyday life. And, third, attention is directed to the appreciation of numerical information as well as the use of techniques, and this appreciation is implicitly <u>critical</u> or sceptical.

Several examples may illustrate the noteworthy features of this definition of numeracy: confidence, practicality, and its critical potential.

First, a quote from a series of reflections on schooldays by Margaret Drabble, a well-known British writer:

> I dropped mathematics at 12, through some freak in the syllabus...I cannot deny that I dropped maths with a sigh of relief, for I had always loathed it, always felt uncomprehending even while getting tolerable marks, didn't like subjects I wasn't good at, and had no notion of this subject's appeal or significance.
>
> The reason, I imagine, was that, like most girls I had been badly taught from the beginning: I am not really as innumerate as I pretend, and suspect there is little wrong with the basic equipment but I shall never know.
>
> ...And that effectively, though I did not appreciate it at the time, closed most careers and half of culture to me forever. ('The Guardian', 5 Aug. 1975, p.16).

Second an example where an apparent lack of numeracy had substantial practical consequences. On Saturday 23 July 1983,

> A simple metric mixup...nearly cost the lives of 61 passengers and eight crew members aboard an Air Canada Boeing 767...The airline admitted that the fuel for Flight 143 from Montreal to Edmonton was calculated in pounds instead of kilograms (resulting in less than half the fuel necessary for the trip)...The incident may re-kindle opposition to metrication.
> ('Toronto Star', 30 July 1983, pp.1 & 4).

Finally an example concerning the critical appreciation of information. In both the 1983 and 1987 British elections, one of the issues has been the reductions in public expenditure - whether there really have been 'cuts' in particular areas, and, if so, whether there have been reductions in actual services - rather than just the 'elimination of bureaucratic waste' (as the supporters of the cuts often put it).

In Britain, people are particularly concerned that the National Health Service should be preserved. In the run-up to the 1983 election, the Secretary of State for Health claimed that the N.H.S. would have grown between 1979 and 1984 by 7.5%. As a leading newspaper commented, "The Government claims that it has increased spending on the National Health Service. Everyone else seems to believe otherwise" ('The Guardian', 14 Mar. 1983). In 1987, a major issue has been whether or not the government has maintained the level of funding for state education.

In both cases, critical analysis would require the confidence to seek out the relevant information, and to challenge government assumptions on issues like the following:

(i) what level of inflation is appropriate to use for changing costs of health or education over time;
(ii) what are the best indicators of relevant provisions, e.g. spending per student, pupil-teacher ratio, the 'capitation allowance', etc.;
(iii) how 'needs' are changing, e.g. because of falling rolls, or the ageing population; and
(iv) which disaggregations are relevant, e.g. current vs. capital spending, secondary vs. primary vs. nursery levels? (Note 1)

The mention of assumptions about the rate of inflation is significant. The government's claims to have reduced the rate of inflation, discussion of what the levels of unemployment actually are, and debates on the need for Britain to have nuclear weapons, in the context of the actual balances of forces in Europe, have been major political issues for some time - and all are based, to some extent at least, on numerical information which must be interpreted critically.

The Politics of Numeracy

A number of people have written about the 'politics' of numeracy. Sometimes the concern is with the impact of the social and political values implicit in the traditional curricula and pedagogy (e.g. Ernest, 1986). Sometimes the focus is on inequalities in the distribution of numeracy, or the lack of it, 'non-numeracy' - and the effects of these inequalities.

In line with this second focus, this article discusses questions such as:

- Which social classes, gender groups, races etc. benefit in terms of 'getting more than their share' of numeracy, and which lose, in terms of being 'deprived' of numeracy?

- What advantages flow from being numerate, and what disadvantages from lacking numeracy? and

- What are the ideological, as well as material, consequences of whatever inequalities there may be in the distribution of numeracy?

2. Non-Numeracy among Adults

There is a great deal of information available on the measured skills of school children of various ages, but relatively little on adults' levels of skills, with the exception of two surveys to be discussed in more detail below.

A. The Survey of Adults for Cockcroft

The Gallup survey which formed part of the evidence submitted by the Advisory Council for Adult and Continuing Education (A.C.A.C.E.) recruited a sample of almost 2900 adults in February 1981 (Note 2).

All eleven of the questions were meant to test everyday or 'practical' maths; Questions 4 to 7 are given as illustration in Fig.1. Overall, six of the questions had to do with shopping or eating out, e.g. Qu.5. Perhaps three of the questions were rather more 'formal': Qu.4, and Qus.9a and 9b which required the reading of a graph about temperature changes. On the other hand, Qus.6 and 7 were about reading a railway timetable and understanding 'inflation', respectively.

4. Which is bigger, three hundred thousand or a quarter of a million? (Read out and show CARD 4)

ANSWER (write in): ....

Method: 1 Oral
2 With writing
3 Calculator used

Response: 4 Confident
5 Unconfident
6 Immediate
7 'Pause for thought'

BREAK

5. If you buy five Xmas cards for 65p, how much is each card costing you? (Read out and show CARD 5)

ANSWER (write in): ....

Method: 1 Oral
2 With writing
3 Calculator used

Response: 4 Confident
5 Unconfident
6 Immediate
7 'Pause for thought'

7. Suppose that the rate of inflation had dropped from 20% to 15%, which one of these results would you have expected:

(a) Prices would have gone down, or

(b) Prices would have stayed the same, or

(c) Prices would still be rising but not as fast as before, or

(d) Prices ought to have gone down but didn't

6. Here is a railway timetable. I live in Leicester and have arranged to meet a friend at the station in London at 4 o'clock in the afternoon. Assuming the trains run on time which is the *latest* train I can get from Leicester to arrive in time for the meeting?

Mondays to Fridays

Leicester dep.	*London* arr.
01.36	03 52
02 20	05 22
05 00	07 34
06.17	08.18
06 52	08 47
07.17	09 02
07.33	09.12
08 07	09 45
09.23	09 50
08 34	10.11
08 55	10 36
09.11	10 45
09 33	11 36
10 22	12.06
10 40	12.50
11.27	13 08
11.42	13 40
12.27	14 08
12.48	14 59
13 25	15 02
13.44	15.42
14 27	16.10
14 42	16.52
15 31	17.13
15 44	17.42
16 27	18 08
17.13	18 51
17 28	19.10
17.53	19 55
18 27	20 05
19 30	21.03
19 41	21.42
20.30	22 04
21.24	23 31

Figure 1. Questions 4-7 in the National Gallup Survey of Adults

The results analysed by sex age and social class are given in Table 1.

CORRECT ANSWERS (PERCENTAGES) ANALYSED BY SEX. AGE AND SOCIAL CLASS

		SEX		AGE					CLASS			
	Total	Men	Women	16-24	25-34	35-44	45-64	65+	AB	C1	C2	DE
Base	2,890	1,385	1,505	529	581	493	812	476	463	636	943	848
Question 4	77	87	67	73	83	79	78	70	89	82	78	65
Question 5	68	72	65	66	75	70	67	54	84	77	65	58
Question 6	55	61	50	59	68	63	52	34	79	67	57	37
Question 7	40	45	36	48	51	44	34	28	63	49	38	29

CORRECT ANSWERS (PERCENTAGES) ANALYSED BY TERMINAL EDUCATION AGE

		TERMINAL EDUCATION AGE				
	Total	14 or under	15	16-18	19-20	21 or over
Base	2 890	813	750	1,058	73	199
Question 4	77	70	74	79	88	93
Question 5	68	60	65	72	92	93
Question 6	55	37	53	64	82	85
Question 7	40	27	35	47	69	72

Table 1. Results of Gallup National Survey on Numeracy Skills

We can summarise the results as follows:

- the questions on simple operations, percentages were answered correctly between 64% and 88% of the time, but Qus.6 and 7 were answered correctly less than 60% of the time;

- men did (2-20%) better than women, and the difference is largest on Qus.4, 6, and 3 (to do with calculating a 10% tip on a restaurant bill) (Note 3);

- the young, especially the 25-34 age group, generally do better, and the over 65s least well - though the difference is less on 'shopping' questions like Qu.5;

- social classes AB (professional and intermediate occupations) do best and classes DE (semi-skilled and unskilled) do least well -- and the higher the terminal education age (another indicator for social class), the better the level of performance.

This survey provides further information on the three aspects of numeracy discussed above. Thus, in addition to the responses themselves, interviewers recorded whether each response was made in a 'confident' or 'unconfident' way, and whether 'immediately' or after a pause for thought. In general, the higher the proportion of correct answers in a group, the more confidently and immediately the answer was given.

Though posed in a formal interview situation, all of these questions involved reasoning which might be required in an everyday situation rather than merely performing a purely abstract sum (Note 4).

None of the questions required skill in critically assessing numerical information before doing calculations with it. However, Qu.7 addresses an issue of considerable political and public policy importance - that of the meaning of the notion of 'inflation'.

It was by far the least well answered question. Any of the wrong answers on this question indicate that the respondent will be substantially confused over an issue which has been widely discussed over the last 20 years, and which the government has specified as a top priority. Of the 54% of people answering this question incorrectly, about one third (or 17% of the whole sample) gave response (d): "Prices ought to have gone down, but didn't." This particular incorrect answer is clearly based not only on a confusion between the level of prices and the rate of price rises (as in response (a)), but also on despair that their expectations are not satisfied. This might lead the respondent to be cynical about statistics and politicians and perhaps the media in a way that is, in this particular case, apparently not deserved.

B. The Survey of 23-year-olds

Another study used data from the 4th 'follow-up' of the National Child Development Study, which interviewed some 12,500 British 23-year-olds (ALBSU, 1983). It found that 5% reported problems with numeracy ('number work' or 'basic maths'), as compared with 10% for literacy (reading, writing and spelling), and 2% for both. Of the 5% reporting problems with numeracy, over a quarter reported difficulties in everyday life arising from these problems.

In seeking to reconcile the results from the two surveys, we note the following. The ACACE's results are based on answers to 11 questions given by an interviewer, whereas the ALBSU/NCDS study is based on the individual's own assessment of his or her skills. The 95% reporting no problems in the latter should be compared with a 73% average of correct answers for the 16-24 age group, on the former: the 5th percentile for this age group is only 3 questions correct. It therefore appears that ALBSU's respondents' self-ratings of their numerical skills may have been over-optimistic. Willis (1983) echoes this skepticism: "Can this really be true? Only 1 in 20?".

Some further evidence is available. The ALBSU was quoted during National Numeracy Week in 1983 (TES, 9 Sept.) as believing that 1 in 4 adults are not able to calculate change from £5 for 1 item. M[illegible] recently, 1 in 4 of a Lancaster University sample of 500 teenagers and 500 adults were reported as unable to work out that 13 £5 notes made up £65; and the Manpower Services Commission estimates that 20% of the long-term unemployed have some kind of literacy and numeracy problems (The Guardian, 14 May 1987).

These two surveys are the only large-scale ones (so far known to me) which allow us to assess adults' skills in numeracy in the U.K.; further, they allow us to estimate inequalities in this area related to social class and gender.

C. Interviews with Adults

Brigid Sewell was commissioned by ACACE and the Cockcroft Committee "to provide evidence and information on the mathematical needs of adults in daily life" (1981, p.1).

Sewell decided to interview members of her sample twice: the first time to "ease tension", to discuss selected situations in which maths might be used (numerical "needs"), and the respondent's attitude to mathematics; and the second time to discuss in detail strategies for solving problems chosen for their common relevance, and the solutions.

Besides indicating how wide-spread were various needs for numeracy, the first interview produced some indicators of attitudes in two senses. First, the refusal rate for that interview was about 50% (p.11), and Sewell attributed this to people's perceptions of maths as a "daunting subject" (p.11). Second, in answer to Qu.22: "Do you enjoy working with numbers?", half the sample said 'yes' and the other said 'no' "with varying degrees of antipathy"; in answer to Qu.23: "How well would you say you can manage in everyday situations when numbers are involved?" 76% answered "very well" or "all right", 18% "mostly" and 5% "with difficulty". The unsolicited remarks about the experience of maths were much more negative (p.16).

For the second interview, a number of respondents, considered to have interesting patterns of experiences with, and perceptions of, maths, were selected from 3 bands of competency - depending on their facility with percentages at the first interview. The level of correct responses was, if anything, lower than on the Gallup survey (ACACE, 1982, p.42). For example, the answers to the question on inflation, similar to Qu.7 on the Gallup Survey, were: 32% correct; 44% wrong (e.g. falling inflation means prices should fall, but they don't: "it's all a big con trick!"); 14% don't know,; 10% ambiguous or incomprehensible.

Any apparent differences would need to be interpreted in the light of differences in the way the data were produced, such as:

(i) the interview questions were more 'practical', using for example wage slips, maps and electricity bills;

(ii) sampling methods (Notes 2 and 5), non-response rates, and further selection for the second interview (ACACE, 1982, p.40); and

(iii) differences in the survey and interview situations.

3. What are the Consequences of Low Levels of Numeracy among Adults?

My purposes here are to sketch the sorts of consequences which flow from lacking numeracy. Here, I shall organise my discussion on the basis of distinguishing individual and societal levels, and also 'material' and the ideological spheres.

A. Consequences at the Material Level for an Individual

These have to do with restrictions on one's freedom of access to further education and training, restriction on access to jobs (and the related rewards of income, companionship, sociability, satisfaction, etc.), and also self restriction in the form of subject choice (and job choice). It also has to do with the ability to perform in - and to enjoy - one's job and everyday life. Thus non-numerate adults will tend to avoid training or courses which seem to them to involve maths, even if they are not already barred by their lack of qualifications, or performance on a TOPS test, and they may tend to skip over graphs in a newspaper, or tables of figures in a budget.

In considering access to education and training, we first need to consider the formal measures which are used by institutions to offer or refuse such access. The pre-eminent qualifications which are used (validly or otherwise) as indication for numeracy in Britain are GCE Exam Results - 'O' levels, and in some cases 'A' levels.

Concerning access to higher education, I considered social science degree courses in universities and polytechnics, and the B.Ed.. 'Which University?' shows that the overwhelming number of social science degree courses require 'O' level maths for entry. For B.Ed. degrees, the DES has ruled that, from the 1981 intake, all students shall have 'O' level maths, except for mature students who sit a special entry test at the time of selection.

In the case of access to jobs for school leavers, the 'Careers Advisers' Handbook 1982-83' indicated over 200 jobs; of the 65 or so jobs mentioned as having a GCE qualification, 54 of these include Maths qualifications, compared with 40 including English.

This message is emphasised by Lucy Sells (1978), in her 1972 survey of educational and vocational opportunities for American women. "Without four years of high school maths, students at Berkeley were ineligible for the calculus sequence, unlikely to attempt chemistry or physics, and inadequately prepared for intermediate statistics and economics. Since they could not take the entry level courses in these fields, 92% of the females would be excluded from ten out of twelve colleges at Berkeley and twenty-two out of forty-four majors" (Tobias, 1978, p.13). And Sells is cited as arguing that "knowledge of algebra and geometry divides the unskilled and clerical jobs from the better-paying, upwardly mobile positions available to high school graduates. She estimates that mastery of high school algebra alone will enable a high school graduate to do so much better on a civil service or industrial exam...Just one more year of high school maths could make the difference between a starting salary of $8000 and one of $11,000" (reported in Tobias, 1978, p.26).

The generally-accepted finding is that income depends on the <u>number of years</u> of schooling. What is being suggested here deepens this to say that <u>what</u> is studied - in particular, how much maths - matters too.

Sells' message is confirmed in the U.K. First let us consider male/female differences in subject choice. In examination entries in ILEA in 1976, for example, Maths was third in number of 'O' level entries overall, behind English Language and English Literature, but among the major subjects, Maths had the fifth lowest percentage of female entrants. This, of course, may be both a consequence of developing gaps in numeracy between boys and girls, and a contributory influence on differing levels of numeracy between adult men and women.

Next we consider ethnic differences in the percentage gaining Maths 'O' level among West Indians (5%), Asians (20%), and others (23%); the corresponding figures for English were 9%, 21%, and 34%, respectively (Rampton Committee, 1981, p.63).

So far, a lack of numeracy has been captured almost entirely by a lack of school maths qualifications. The consequences of lack of numeracy for performance in jobs and in everyday life can also be documented graphically in other ways.

For example, in the profiles of interviewees presented in Sewell (1981), Ian, a modern languages graduate in his twenties, was one of the intending O.U. students interviewed. He admitted avoiding numbers as much as possible: "Numbers are anathema to me". His reaction to the inflation question was that he hated it, did not know what inflation meant, did not know how it affected him; altogether he felt "terribly out of it". Sewell concluded: "his lack of mathematical confidence...has heavily influenced his choice of career and everything he does" (Sewell, pp.48-49).

This of course echoes Margaret Drabble's feelings about being excluded from one of the 'two cultures' (quoted earlier).

B. Material Consequences on the Societal Level

These include loss of production, in quantity or quality, waste of resources, production of inaccurate or useless information, and threats to life and limb, as in the ai line mix-up described above.

Examples can be found, in the public policy-making area, by the way clerical errors, once incorporated into the numbers, are allowed to pass without being detected. The following examples are cited in a discussion of the production of official statistics: an accidental omission of a zero by an Olivetti employee reporting the firm's exports generated a phoney balance of payments crisis; a clerk's copying two lines of figures onto a coding sheet in the wrong order caused the trade figures to go haywire over a period of many months; the accidental counting of the same set of movement twice led to a major error in Home Office migration figures. The authors conclude: "Serious errors would certainly occur less often if staff had the ability to recognise figures as implausible and the initiative then to get them sorted out" (Government Statisticians' Collective, 1979, p.144). Doubtless readers can recall their own stories of this type.

Nor are these societal consequences likely to be confined to the public sector: low numeracy may well be one aspect of the problem of the alleged shortcomings of British management. It is argued by Lynn Osen, a mathematician, that business today needs people "who can understand a simple formula, read a graph and interpret a statement about probability" (Osen, 1971; quoted in Tobias, 1978, p.27). An illustration is given by Chris, in his thirties, who is managing director of his own building firm; he manages at work by "bluff(ing) my way", and at home through his wife dealing with the domestic bills. At the time of his interview, he was attending adult literacy and arithmetic classes as he wanted to be able to understand building plans and quantity surveyor's estimates (Sewell, 1981, p.42).

C. Ideological Consequences at the Individual Level

These consequences of a low level of numeracy include not only a lack of competence among adults, but a low level of confidence in their constructive skills and critical insights. This leads them to be dependent on the views of the 'expert' or 'professional' for their opinions and susceptible to the mystique of mathematics. This mystique derives no doubt from the conciseness of mathematics, its apparent precision, its obvious abstraction and strangeness (e.g. the use of many Greek symbols) and its association with modern science; and it tends to lead to the following ideas:

(i) arguments involving numbers are (or tend to be) more 'rigorous' than those without;

(ii) this rigour means that in such arguments there is less room or debate (after all, there was only one right answer in maths at school - and usually only one way apparent to get it);

(iii) people who use numbers are (or tend to be) more rigorous, and hence trustworthy, than others;

(iv) such people have a 'mathematical mind'; if you don't there is no hope for you with numbers;

(v) because maths is cumulative, if you fall behind, you'll never get a second chance to learn it. (Note 6)

At the individual level, the result of this diffidence and dependency is often that people lurch between two traps: uncritical acceptance of claims made, and an equally uncritical rejection, based not on a consideration of the evidence, but on prejudice or the unexamined authority of 'experts'. Sometimes the failure to consider the evidence comes from <u>reluctance to seek it</u>, sometimes from mistakenly <u>mistrusting</u> evidence which is available, sometimes from <u>misinterpreting it</u>.

An example where <u>evidence was mistrusted</u> by an individual comes from a prime-time television discussion about access to higher education, 'Inquiry: The Race for a Place' (BBC 2, Friday 4 November, 1983, 7.30 - 9 pm). In response to presenter Ludovic Kennedy's claim that the U.K. was well behind its European partners in providing access to H.E., Sir Keith Joseph, the Secretary of State for Education, argued that, because of our shorter-length degree courses, differences in definition of courses etc.. we were not behind other European countries (though we were behind the U.S.). The response of Ludovic Kennedy - not generally known as an unthoughtful or uncritical person - was to fall towards the second trap specified at the beginning of the previous paragraph (uncritical rejection): "Well, Sir Keith, we all know you can prove anything with statistics...".

D. Ideological Consequences at the Societal Level

When evidence is not sought, or when it is mistakenly mistrusted, or misinterpreted, <u>at the societal level</u>, we may sometimes speak of <u>myths</u>: ideas which are partially, or largely, false but which influence the beliefs, and the actions, of large segments of society, and affect the practices of society's institutions.

Some myths seem to have grown up fairly 'naturally', for example, myths around the role of women in areas such as employment, such as the following:

(i) 'A woman's marital status is a crucial determinant of whether or not she works';

(ii) 'Most married women don't need to work';

(iii) 'Women leave work to have babies and don't come back';

(iv) 'In times of high unemployment, women who work are taking jobs away from men'; and

(v) 'In the current crisis, women are becoming unemployed at a greater rate than men'.

Ways of critically addressing these myths using evidence from official statistics such as the 'General Household Survey' are discussed in Lievesley et al. (1983). Despite the fact that the statistics on which these critical scrutinies are based are available in many local authority or college libraries, and are published by at least some national newspapers, the level of discussion of them in the media is rather low, and most members of the public are probably not aware of their existence, let alone of their content. Thus, there is great reluctance to seek evidence relevant to myths as important as (i) to (v) above.

Other myths seem to have to be fostered rather more actively. When people are convinced, through the use of 'scientific' or 'mathematical' arguments, to accept myths that it is against their interests to believe, we may speak of 'mystification' (see Irvine, Miles and Evans, 1979, Introd.).

An example of mystification, showing misinterpretation of evidence, comes from the relationship between class size and pupil attainment. In a number of educational studies done over the last twenty years or so, there appears to be a 'positive correlation' between the two, i.e. as class size increases (across different classrooms), the average level of attainment also tends to increase; or else there is found no relationship at all, i.e. as class size increases, attainment appears to remain relatively unchanged. Thus, the statistics seem to challenge what teachers know by 'common sense'.

Some people have tended to interpret the 'findings' as saying that we could pack at least a few more children into a particular classroom without any appreciable negative effects. Teachers are equally clear that increasing class sizes will interfere with many important processes in the classroom. Yet they may not be confident enough to challenge the interpretation of the statistics which ignores that 'correlation is not causation' and which fails to investigate alternative explanations for the correlation observed (Note 7).

4. Why do Adults Have these Problems with Numeracy?

When we come to explain these sorts of problems with numeracy, we find that much of the research in mathematics education understandably focusses on:

(i) school factors, including teachers, which affect performance in school maths (e.g. Bell, Costello, and Kuchemann, 1983), with less attention to extra-school factors and processes. The latter are clearly important in forming adults' numeracy, and include:

(ii) home, parents, and siblings;

(iii) out-of-school activities and peers;

(iv) post-school education;

(v) work and work-training schemes; and

(vi) everyday life and adult subcultures.

We also find, as with other problems in the social sciences and education, that we are faced with what appear to be two different kinds of explanation. We might explain how and why people act as they do by reference to 'socialisation pressures' which have moulded them in certain ways; or we might see them as acting in accordance with their 'perceptions and purposes' (Note 8).

I do not believe the distinction between these two approaches is as neat as is sometimes maintained. We might say that socialisation pressures are what make children what they are, and that a person attains adulthood to the extent that they are able to transcent such pressures, and decide to act on the basis of their perceptions and purposes. But this would be too simple: it would ignore the already developing autonomy of children, and it would forget that adults too are constrained by social forces: "Men make their own history - but they do not make it in conditions of their own choosing": thus Marx tried to reconcile determination and freedom in his explanations of social action.

The conceptual map I have developed therefore includes both socialisation pressures, and perceptions and purposes; a sketch is given in Fig. 2.

Thus family and school provide socialisation pressures, and 'personal characteristics' may act as a distillation of these pressures in the life history of the individual; 'motivation', 'interest' and 'attitudes' are involved as perceptions and purposes (though attitudes are also sometimes considered as personal characteristics). Work and post-school education could be seen as resources which may be used by the emerging adult working towards desired outcomes. We may also need to consider as societal constraints, factors such as the following: the professional interests of mathematicians, political interests of e.g. public servants, and the mystique of mathematics (discussed above). All of these features may help to explain the progress of adults towards outcomes such as:

- competence and skill in using numbers practically and critically/skeptically;

- confidence with numbers rather than anxiety;

- perseverance with using numbers - especially with enrolling for maths courses - rather than avoidance;

- enhanced choice of courses of study and occupations; and, ultimately,

- richer personal development and experiences. (Note 9)

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SOCIALISATION PRESSURES	"PERSONAL CHARACTERISTICS"	
HOME	ATTITUDES	OUTCOMES
-PARENTS	*anxiety	
*own ability		QUALIFICATION
*expectations	MOTIVATION	CONFIDENCE
-SIBLINGS	*interests	PARTICIPATION
*competition		COMPETENCE
*comparisons	POSITIONS	ACCESS - F/HE
	*gender	ACCESS - JOBS
SCHOOL	*soc.class	
-TEACHERS	*ethnic	
*methods		
*own anxiety	PEER SUB-	
-ATMOSPHERE	CULTURE	
*ability gps.	*labelling	
*questioning	e.g."swot"	
ACCIDENTS OF BIOGRAPHY		
*chg. of schl. *illness		
EVERYDAY LIFE	POST-SCHL.	RESOURCES/
*activities	EDUCATION	
e.g.budgeting	*"second	CONSTRAINTS
games	chances"	
ADULT	WORK	
SUBCULTURE	*skill need	POL.INTEREST
*discussion	*encouraged	PROFESSIONAL
	by workmates	INTERESTS
		*mystique

Figure 2. Why Problems with Numeracy?

5. Conclusion: What is to be Done?

Our discussion of 'numeracy' and of its consequences above shows that a lack of numeracy is a disadvantage for most adults; it can further be considered a facet of the oppression of women, the working class, and ethnic groups. This suggests a number of changes that could be made in the ways that maths is taught and numbers are used in order to help improve adults' numeracy.

1. 'Second chance' courses for adults seeking to develop their numeracy need to take account of the oppressive features of early maths experience - starting with their setting and their style: thus, the importance of the informality and accessibility of centres or programmes aiming to attract working class participation, e.g. the walk-in numeracy centres in Hammersmith or Edinburgh (Jordinson, 1987), or the ITV Programmes such as 'Counting On' (Sept. - Nov. 1983). Similar conditions need to be specified for courses aiming to attract (mainly) women (see Tobias, 1978).

2. The process might start with a diagnostic interview in which a 'counsellor' asks about past experiences with numbers, aiming to build a mathematics autobiography (Tobias, 1978, pp.250 ff.) or consciousness-raising (see Frankenstein, 1983, for a relevant discussion of Paulo Freire's ideas on pedagogy). The aim would be to help the participant to understand better his or her experiences, to find out what the learner <u>does</u> know rather than what (s)he does not, and to formulate goals for the future.

3. Curriculum development should be linked with a discussion of the practical needs of adults, and of the maths actually used by adults in everyday life (Sewell, 1981) and at work (Cockcroft, 1982, Ch.3) (Note 10). As may be inferred from the discussion here, I consider statistics to be a promising context in which to involve many adults in numeracy. (See also Evans, 1986).

4. In our pedagogy, we can challenge the following assumptions and practices that have made maths formidably off-putting:

(i) it is cumulative and strictly ordered: there are <u>many</u> interesting places to start (see Tobias, Chs. 6 and 7);

(ii) there is always one correct route to one correct answer and no room for discussion: we can teach with seminars where numerical issues are debated, (see e.g. Frankenstein, 1983), and give assignments that are really essays reporting the sometimes tortuous path of an 'investigation';

(iii) maths involves struggling alone, often under the eye of the teacher: we can use group work (Frankenstein, 1983), and also an element of self-pacing exercises (using microcomputer resources);

(iv) maths teachers are often oppressive as human beings: we can see confidence-building as one of our major aims - both to contribute to personal development of our students, and to help them sharpen their critical potential.

5. In assessment, we can challenge the impression that maths involves doing timed tests made up of abstract sums. Besides emphasising practicality, we can use project assessment and investigations.

6. We can try to insist on - and contribute to - clarity of presentation of numerical material in the media. The experiences of the Open University broadcasts (e.g. those for 'MDST 242: Statistics in Society') - plus those in popular broadcasting, e.g. Prof. Bob MacKenzie's 'swingometer' to dramatise the effects of changes in percentage of the electoral vote - show that where ingenuity is applied, clarification of people's ideas may well result.

7. We can help adult students, and our fellow citizens, to avoid both 'Scylla', uncritical acceptance of numerical arguments, and 'Charybdis', uncritical rejection, in several ways:

- by using our skills as maths educators to show that the arguments are not <u>inaccessibly</u> technical;

- by reassuring them that the arguments are not <u>wholly</u> technical (as, for example, when 'needs' are part of the argument, as in myth (ii) about working women above); and

- by fostering people's confidence to make critical assessments.

Thus, for example, "analyses of government spending can be carried out by anyone with access to an appropriate library; expert knowledge is not needed" (Radical Statistics Education Group, 1987).

Jeff Evans

NOTES

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1. For further discussion of how to critically scrutinise government spending in education and in health, see Radical Statistics Education Group (1987) and Radical Statistics Health Group (1987), respectively.

2. Sampling took place at 200 sampling points in 10 regions in England, Wales and Scotland. The interviewers were given quotas for sex by age, social class and employment of respondents.

3. These results are subject to sampling variation (see ACACE, 1982, p.9); thus, any difference between the male and female subgroups of 4% or less would not be impressive (since it could be expected to occur, due only to chance, 19 times out of 20).

4. This distinction between formal and everyday contexts is parallel to that made between 'folk maths' and 'school maths' in Maier (1980), which gives approximation as an example of a skill used much more in everyday contexts than in formal ones.

5. The sampling method for the first interview might be called 'multiple snowball recruitment' with the snowballs starting from the enquiry officer's friends, colleagues, adult numeracy classes, WEA class, and an Open University introductory course (for the Arts Foundation Course).

6. These arguments are discussed in Tobias (1978, passim).

7. For further discussion of these issues, see Simpson (1980) and Radical Statistics Education Group (1982).

8. See Pring (1980) for a discussion of these issues in relation to the Rutter research.

9. For further development of this conceptual map, and its use in a study of 'maths anxiety' among adult students, see Evans (forthcoming).

10. See Riley (1983) for cautions against uncritical adoption of the goal of 'functional numeracy'; see also Harris (1982) for scepticism that employers are clearly aware of the needs of the jobs in their establishments.

REFERENCES

Adult Literacy and Basic Skills Unit (ALBSU) (1983), Literacy and Numeracy: Evidence from the National Child Development Study, ALBSU, London.

Advisory Council for Adult and Continuing Education (1982), Adults' Mathematical Ability and Performance, ACACE, Leicester.

Bell, A.W., Costello, J., & Kuchemann, D. (1983), A Review of Research in Mathematical Education, Part A: Research on Teaching and Learning, NFER-Nelson, Windsor.

Buxton, Laurie. (1981), Do you Panic About Maths? Coping with Maths Anxiety, Heinemann, London.

Careers Advisers' Handbook (1983), New Opportunity Press, London.

Cockcroft Committee (1982), Mathematics Counts, HMSO, London.

Crowther Committee (1959), 15 to 18, HMSO, London.

Ernest, P. (1986), 'Social and Political Values', Mathematics Teaching, No.116, September.

Evans, J. (1986), 'Statistics and Numeracy for Adults: the case for the barefoot statistician', contributed paper for the International Conference on Teaching Statistics, Victoria, Canada, August.

Evans, J. (forthcoming), 'Only Girls are Anxious: femininity, masculinity, and maths anxiety', in V. Walkerdine (ed.), Girls and Mathematics: New Thoughts on an Old Question, Methuen, London.

Frankenstein, M. (1983), 'Critical mathematics education: an application of Paulo Freire's epistemology', Journal of Education, Vol.165, No.4, pp.315-339.

Government Statisticians Collective (1979), 'How Official Statistics are Produced: views from the inside', in Irvine, Miles & Evans (eds.) - see below.

Harris, M. (1982), 'Turn Upsidedown and multiply', Struggle: Mathematics for Low Attainers, No.9, ILEA.

Irvine, J., Miles, I., & Evans, J. (eds.) (1979), Demystifying Social Statistics, Pluto Press, London.

Jordinson, R. (1987), 'The Edinburgh Walk-in Numeracy Centre (EWINC)', Discussion Paper 16, Association for Recurrent Education, Nottingham.

Lievesley, D., Waine, B. et al. (1983), 'Myths about Women: how statistics can help', Radical Statistics Newsletter, No.27, May, pp.5-7.

Maier, E. (1980), 'Folk Mathematics', Mathematics Teaching, No.93, December.

Osen, L. (1971), 'The Feminine Math-tique', K.N.O.W., Pittsburgh.

Pring, R. (1980), 'Cause and Effect', in The Rutter Research, Perspectives 1, School of Education, Unversity of Exeter.

Radical Statistics Education Group (1982), Reading between the Numbers: a critical guide to educational research, BSSRS (25 Horsell Rd. London N.5).

Radical Statistics Education Group (1987), Figuring out Education Spending: trends 1978-85 and their meaning, BSSRS.

Radical Statistics Health Group (1987), Facing the Figures: what is really happening to the National Health Service, BSSRS.

Rampton Committee (Committee of Enquiry into the Education of Children from Ethnic Minority Groups) (1981), West Indian Children in our Schools: the Interim Report, HMSO, London.

Riley, T. (1983), 'Functional Numeracy', Numeracy, Viewpoints 1, pp.2-4, ALBSU, London.

Sells, L. W. (1978), 'Mathematics - a critical filter', The Science Teacher, February, pp.28-29.

Sewell, B. (1981), Use of Mathematics by Adults in Everyday Life, ACACE, Leicester.

Simpson, S. (1980), 'Wrong questions, wrong tools', TES, 18 April, p.13.

Tobias, S. (1978), Overcoming Maths Anxiety, Houghton Mifflin, Boston.

Which University? 1976, Haymarket Press, London.

Willis, J. (1983), 'Who are these people with Numeracy Problems?', Numeracy, Viewpoints 1, pp.19-21, ALBSU, London.

WHAT IS MULTICULTURAL MATHEMATICS?

Classroom mathematics has undergone many changes throughout recent decades each of which has been brought about by a variety of agencies and has exerted a new kind of demand on the curriculum. In recent years, the Cockcroft Report (DES, 1982) has called into question what was seen as a 'back to basics' movement at primary level, and at secondary level has made recommendations which have influenced the formulation of a mathematics curriculum leading towards the new GCSE examination. These changes have been brought about to a great extent in response to society's perceptions of what is seen as failure on the part of schools to teach mathematics successfully enough to meet the demands of a highly technological society. In recent years, a new concern has surfaced which adds a further perspective to the problems which influence the effective teaching and learning of the subject. This concern arises from the extent to which society has increased in cultural diversity and the way in which resultant cultural differences have come to manifest themselves more strongly in schools. A key problem now being faced is how to accommodate these differences within the curriculum so that the learning of mathematics can be enhanced for all.

There are essentially two points of view which provide the ends of a spectrum of approaches along which such accommodation might be achieved. A brief exploration of each of these helps to clarify the different interpretations of multicultural mathematics and to shed some light upon how they can affect classroom practice.

Mathematics as 'Culture-Free' Content

Any consideration of how to accommodate cultural diversity within the mathematics curriculum presupposes that this is a feasible undertaking in the first place. However, the nature of mathematics as it is perceived by many suggests that it is 'culture-free' and need not (indeed, cannot, in the view of some) be 'adapted' to the idiosyncrasies which may be determined by the culture of an individual or individuals. This view of the nature of mathematics is one which has long been held and probably still is dominant in the minds of many teachers and teacher educators and tends to be reflected in the pedagogies that they adopt. Studies and surveys of mathematics education in recent decades at primary and secondary level have tended to reflect a curriculum in both content and style of teaching that is dominated by this kind of perspective (e.g. DES, 1978; DES, 1979; DES, 1982; Hilsum and Strong, 1978; Ward, 1979). In spite of the efforts of some, (including professional bodies such as the Association of Teachers of Mathematics and the Mathematical Association) to bring about change through the adoption of different methodologies and approaches to content, the influence of this kind of belief about the nature of mathematics is still strong. While it is clear that new demands such as those being imposed by the GCSE involving a more open-ended approach with investigational, practical and oral work could, with time, gradually lead to the questioning of long-held beliefs about mathematics, such moves are already being seen to have a somewhat superficial influence. For example, there are signs that investigational work is becoming rigidified rather than providing an opportunity for a more exploratory approach to mathematical ideas as was intended (Lerman, 1987). Taken altogether, attempts to free teachers from this rigid perspective have not met with a great deal of success so far.

The epistemological foundations that have led to mathematics being accepted as unchallengeable received knowledge lie in what Lakatos (1976) calls a 'formalist' view of the subject firmly grounded in logical positivism. Many in mathematics education have been transfixed by this formalist perspective of the subject which, as Lakatos (1976) suggests, allows a view of mathematics in terms of formal systems to dominate at the expense of a more open and exploratory interpretation. He describes those that hold such a view as 'dogmatists' who see mathematical ideas as having been "purged of all the impurities of earthly uncertainty" (Lakatos, 1976, p.2).

Clearly, it could be particularly difficult for anyone under the influence of such a view of the subject to allow that uncertainties may arise as a result of the differing cultural backgrounds of individuals engaged in mathematical activity. If mathematical knowledge is by definition pure and unadulterated, then the task is to see that it is received as such and that it should not be tampered with. This in turn suggests that any intervention in the mathematics curriculum to accommodate cultural differences of learners (if it takes place) is unlikely to be of a very fundamental nature; on the contrary, it will necessarily be of a superficial kind.

This approach can be seen in attempts to adopt a multicultural approach to the curriculum which in essence set out to provide different cultural contexts for traditional types of mathematical problem. The words change but methodology and content remain the same. Another approach is to introduce more of the history of mathematics and thus to show its multicultural nature by identifying the important roles played by the Chinese, Indians and Mayans for example, and not to leap in time from the Greeks to western culture in the development of mathematics as we know it now. (See, for example, Hudson, 1967). In a sense, such approaches are accommodating the existence of other cultures by referring to different cultural artefacts but not by considering the possible cultural differences that exist in ways of thinking or construing that have brought such artefacts about. This leads us to consider the other end of the spectrum of approaches to multicultural mathematics referred to earlier.

Mathematics as a 'Culture-Bound' Way of Thinking

The extreme opposite to the notion of culture-free mathematics would be that of mathematics as culture-bound. This immediately suggests a number of 'different' bodies of mathematical knowledge that could be mutually exclusive and contradictory. The idea of the total objectivity of mathematical thought would seem to disappear together with the notion of absolute truth linked with it. How can such a viewpoint be accommodated and, in particular, how can contradictory ideas exist side by side?

The answers to such questions lie, in the first place, in adopting a different view of the nature of mathematical knowledge and how it comes into being. The essential difference to that of the formalist perspective lies in accepting the fact that mathematics is founded in social activity and human intercourse as is any other kind of knowledge.

It is no longer accepted as infallible knowledge generated in some erudite vacuum which as Lakatos (1976) suggests "denies the status of mathematics to most of what has been commonly understood as mathematics" (p.2). Contradictory ideas become competing theories as mathematical knowledge develops. Objectivity is arrived at, as Toulmin (1972) says, by taking into account the accumulation of experiences "in all cultures and historical periods" thereby reaching an objective point of view "in the sense of being neutral" (Toulmin 1972 p.50). The adoption of such a fallibilist approach to the nature of mathematics permits us to approach mathematial knowledge and to interpret it in terms of its growth and the context in which it grows and has grown.

Clearly the adoption of a perspective of mathematics seen in these terms can have a profound effect on how the subject is approached in the classroom and several mathematics educators have explored the potential outcomes and benefits of such an approach (e.g. Confrey, 1980; Nickson, 1981; Wolfson, 1981; Pimm, 1982; Lerman, 1986). More particularly, however, this theoretical perspective provides a fresh viewpoint from which to approach the whole question of a multicultural mathematics curriculum.

Inherent in the acceptance of the notion of socially constructed mathematical knowledge, there is the freedom to recognise cultural influences both at the broad societal level and at the level of the individual. Rather than simply looking for aspects of different cultures to exemplify mathematical ideas (thus supposedly providing familiar social contexts for learners), what we should be looking for is how their cultural perspective may affect their mathematical mode of thought. This is being done at a national level, for example, in Mozambique where the mathematics imbedded in local cultural activities (such as basket-weaving) is used as the foundation for curricular mathematics (Gerdes, 1986). However, catering for cultural perspectives in a situation where there may be an assumed cultural and ethnic homogeneity is a different matter to catering for it in a society where this does not exist. It is a tall enough order in the first situation but it becomes an even taller order if we consider culture as, for example, D'Ambrosio (1986) does when he writes:

> "We have built a concept of society out of cultural attitudes and cultural diversity, that is, different groups of individuals behave in a similar way, because of their modes of thought, jargon, codes, interests, motivation, myths."
> (D'Ambrosio, 1986, p.5)

To view culture defined according to such a variety of criteria appears to make a complex problem seem even more complex, but is this, on closer examination, really the case? Defining culture in terms of 'groups of individuals' bound together by factors other than ethnic origin redirects our attention to the individuals in their social context and emphasises the problem of catering for cultural individuality in a shared setting. Where mathematics in particular is concerned, Bloor's (1976) identification of what he calls "social causes of mathematical thought" provides some indication of the kinds of factors that could be taken into account when trying to accommodate such cultural individuality within the construction of a mathematics curriculum.

Conclusion

It is clear from this discussion that the notion of multi-cultural mathematics is a very demanding one when it comes to catering for it within school curricula. On the one hand, there is the temptation to opt for a somewhat simplistic solution to the problem by including references to cultural phenomena related to different ethnic groups in teaching and learning materials. This is, as we have seen, often the outcome of a particular set of beliefs about the nature of mathematics which exerts powerful constraints upon how mathematics is done in the classroom. On the other hand, a more complex but more meaningful solution could lie in re-examining those beliefs and in considering mathematical knowledge more in terms of its social nature and foundations. This would help to open the subject up so that the cultural identity of the learner could potentially be more readily accommodated. The freedom to see mathematical knowledge in more problematic terms brings with it a flexibility that can have profound effects upon the way it is approached in the classroom.

It was stated at the outset that these points of view present the extreme ends of a spectrum. Clearly, a solution to the problems posed in devising a multicultural mathematics curriculum must lie somewhere between the two and involve a combination of elements of both. It must be said, however, there has in the past been an imbalance in favour of the first of these extremes. Until more thought is given to the social nature of mathematical knowledge and its implications for the curriculum we are unlikely to succeed in devising a mathematics curriculum that meets the demands of the multicultural society in which we live.

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REFERENCES

Bloor, D. (1976), Knowledge and Social Imagery, Routledge and Kegan Paul, London.

Confrey, J. (1980), 'Conceptual Change Analysis: Implications for Mathematics and Curriculum Inquiry', paper presented at the AERA National Meeting, Boston, February.

D'Ambrosio, U. (1986), 'Socio-Cultural Bases for Mathematical Education', in M. Carss (ed.), Proceedings of the Fifth International Congress on Mathematical Education, Birkhauser, Boston.

DES (1978), Primary Education in England: A survey by HMI Inspectorate, HMSO, London.

DES (1979), Aspects of Secondary Education, HMSO, London.

DES (1982), Mathematics Counts, (W.H. Cockcroft, ed.), HMSO, London.

Gerdes, P. (1986), 'On Culture: Mathematics and Curriculum Development in Mozambique', in H.M. Johnsen and S. Mellin-Olsen (eds.), Mathematics and Culture, Caspar Forlag, Bergen Laererhogskole, Bergen.

Hilsum, S., & Strong, C. (1978), The Secondary Teacher's Day, NFER, Slough.

Hudson, B. (1987), 'Multicultural Mathematics', Mathematics in School, Vol.16, No.4, pp.34-38.

Lakatos, I. (1976), Proofs and Refutations, Cambridge University Press, Cambridge.

Lerman, S. (1986), Alternative Views of the Nature of Mathematics and their Possible Influence on the Teaching of Mathematics, unpublished doctoral dissertation, King's College, University of London.

Lerman, S. (1987), 'Investigations: Where to now? (Problem Posing and the Nature of Mathematics)' in P. Ernest (ed.), Perspectives 33: Teaching and Learning Mathematics Part 1, School of Education, University of Exeter.

Nickson, M. (1981), Social Foundations of the Mathematics Curriculum: A rationale for change, unpublished doctoral dissertation, University of London Institute of Education.

Pimm, D. (1982), 'Why the History and Philosophy of Mathematics Should Not be Rated 'X'', For the Learning of Mathematics, Vol.3, No.1, pp.12-15.

Toulmin, S. (1972), Human Understanding, Princeton University Press, Princeton.

Ward, M. (1979), Mathematics and the Ten-Year Old, (Schools Council Working Paper 61), Evans/Methuen Educational, London.

Wolfson, P. (1981), 'Philosophy Enters the Mathematics Classroom', For the Learning of Mathematics, Vol.2, pp .2-26.

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MULTICULTURAL AND ANTI-RACIST MATHEMATICS TEACHING

It is a commonly held belief that mathematics is an essentially acultural subject. It is arguable whether this is in fact a valid statement - the nature of argument and the language of implication are both culturally determined - but it is certainly not true that the teaching of mathematics can be acultural. The attempt to convey the ideas and concepts to the learner must take place using the metaphors and imagery available to the learner and these are clearly the consequence of the society and culture within which the learner lives. Bishop (1985, 1986) has raised the issue of the social construction of meaning in mathematics and reports that even simple actions such as counting on the fingers appear to have regional variations and points to many further examples of cultural influences in significant mathematical conceptual structures (see also Lea, 1987). D'Ambrosio (1985) argues that the very learning of mathematics creates a conflict with the 'natural' or 'folk' processes which the learner might utilise which he calls ethnomathematics. The learning of a formalised response to a situation prevents the application of the more free-wheeling methods. Thus a partially learned (or inadequately understood) procedure invoked by learning mathematics may well be less effective in practice than an informal intuitive (even if less powerful) method. It is not uncommon for pupils to produce intuitive accurate responses to calculations but be quite unable to apply the usual algorithms.

Within a mass education system it is perhaps arguable that it is not even appropriate for any subject to attempt to avoid cultural implications. In such a system any element within the curriculum must be principally directed towards the aims and objectives of education, which are concerned with the development of effective and participatory citizens committed to the support and development of their society (see Ernest, 1986). Mathematics exists within the compulsory curriculum because it is effective in educating pupils; the creation of mathematicians, whilst important, is very much a secondary consideration. In this context the comment reported in the Cockcroft Report (Mathematics Counts, 1982) that "many lessons in secondary schools are very often not about anything" becomes a significant and important concern. To quote from Cuff (1985), "Mathematics Counts - but not for all" is only really acceptable in a selective and option situation and not in a mathematics-for-all curriculum. In a compulsory curriculum it is not acceptable to dismiss pupils as 'not able to do mathematics' without thereby identifying a special educational need for which particular provision must be made! This need for mathematics education to relate to people and society was anticipated, some years ago, by David Wheeler in a lecture to the Association of Teachers of Mathematics when he challenged the annual conference that for ten years the final lecture should be concerned with 'humanising' mathematics education. Society has raised the issue of racism and the development of a genuinely pluralist society as a major and significant concern. Education has consequently been charged with working towards this as a priority concern, and mathematics teachers have begun to ask how they can respond.

In responding to these changing priorities within society and education it is important to notice that the issues which arise are very often already significant concerns of mathematics education. The response to the multicultural society in effect resonates with those developments and concerns already identified - pupil centred learning styles, the need to develop ideas from those which pupils already hold, active rather than passive learning, problem centred objectives, group work and methods of using the power of discussion. In looking, therefore, at the issues which consideration of multicultural/antiracist concerns have raised we are in effect reviewing the significant current concerns of mathematics teaching in general.

Reflecting Other Cultures

It is symptomatic of the philosophical position held by mathematics teachers that when the issue of multiculturalism first arose the initial search was for mathematical content items. Hemmings (1980a, 1980b and 1984) offered an excellent collection of such items including in particular the very rich field of Islamic art patterns (see also Tahta, 1987). The impact of this work in creating effective internal imagery can also be seen influencing the work of the Leapfrogs Group (published by Tarquin Products) and in the very evocative collages frequently found in recent issues of 'Mathematics Teaching' edited by Hemmings and

Tahta. Zaslavski (1975, 1979) introduces similar activities from an African context, and it is interesting to see almost the same activity appearing as a Rangoli pattern in Hemmings, a unicursal curve in Zaslavski and in a micro-computer activity and investigation called 'snook' (all three involve an (n x m) lattice). Joseph (1984) also suggests some fascinating methods of calculating using a system called Vedic arithmetic which offers a quite different approach to algorithms. Another useful activity is the investigation of different calendar patterns, our own sun dominated Roman system compared with the Islamic moon-focussed year (when will Ramadan fall near the shortest day in our year - why should that be important?) and the contrasting methodology of our leap year with the Jewish extra month.

All these topics provide excellent opportunities for mathematical activity and belong in the mathematics curriculum without requiring the justification of multicultural concerns. Which multicultural education objectives, however, are attained by such insertions? It is clearly important not to import content merely in order to satisfy external requests and pressures. Tokenistic responses never meet such needs and usually result in increasingly heightened concern. Care must also be taken not to introduce such topics as marginal or trivial activities since this can clearly imply a dismissive view of other societies and values. This same problem relates to the inclusion of historical information in an attempt to counter the eurocentric view commonly held of the development of mathematics. Most English people tend to think that mathematics really started with the Greeks and gradually worked its way north! Whilst they might acknowledge the very early contribution of the Chinese and Indian mathematicians, the abiding thought is that that was a very long time ago, with perhaps an implicit unspoken question as to what they have done since then. Such chauvinistic attitudes are of course at the very centre of the whole issue of multicultural and antiracist mathematics and concern the views and attitudes of teachers rather than pupils. It is the transmission and continuity of such intuitive responses through the classroom which makes the issue so vital.

The significance of including such elements in the curriculum is also affected by the structure of the community within which the education is taking place. In a culturally mixed classroom it is important that pupils feal abla to bring thair own cultures into the classroom and that that culture is acknowledged and respected. This echoes tha growing commitment of mathematics teaching to a more pupil centred action curriculum and towards a constructivist view of learning. This is particularly important with younger children who are less likaly to impose thair own images on those presented. In presenting pictures, images and illustrative references it is important that teachers should not present only those which come from their own experience. Whera a classroom is mono-cultural tha significance of presenting alternative images takes on a quite different, though no less important, aspect. It is particularly in such classrooms that open and accepting attitudes to alternativa ideas and customs need to be fostered and encouraged. It may indeed happen that such situations give risa to racist and discriminatory comments and attitudes. It is important that schools have policies for meeting such eventualities, since without such professional support teachers may seek to supress rathar than to expose views which unlass made public ara difficult to change.

Educating for a Multicultural Society

It is an implicit assumption of education that one of tha most significant ways of affecting attitudes and beliefs is through tha acquisition of knowledge. It is for this reason that tha often quoted comment that "mathematics lassons are not about anything" is so important. Gerdes (1981), in describing mathematics education in Mozambique, indicates the ways in which lass politically inhibited societies attempt to influenca their futura citizens, and in the analysis implies that all mathematics curricula carry such elements whether explicit and deliberata or implicit and involuntary. The distinction between 'folk' mathemagics (sic) and colonial mathematics as compared to 'democratic' mathematics bears resemblance, of course, to changes in English school mathematics from what we might tarm tha 'clarical' mathematics in Victorian schooling to 'industrial' mathematics in the first part of this Century to the mathematics of understanding and processes which dominates current discussions. Remnants of pravious ages always remain, of course, and mathemagics (rules without reason) hava certainly not disappeared from most syllabuses! Less acceptable in tha English context, however, is the intrusion of explicitly value laden extra-mathematical concepts, such as Gerdes' 'guerrilla fighters', which will be seen as bordering upon 'indoctrination', although the promotion of literacy and health care by such means is probably less objectionable. There is growing evidence of the ways in which similar but far less obvious indoctrination takes place within English texts, (see for example I.L.E.A., 1986, and Northam, 1982). Other examples of implicit value judgements are given by Maxwell (1985) who also intimates that since such implications are unavoidable they are best planned and intended. This is particularly significant for mathematics which is assumed to be free of value judgments and social commentary and the indoctrination is therefore in some senses subliminal and less susceptible to rejection. Clearly the uncommented incorporation of discussion of stocks and shares in mathematics texts assumes that such activities are legitimate, which they are, of course, in a free western economy. The implied assumption that women should earn less than men, common in many questions about wages, is not supportable in the same way, and some Examination Boards now take care to 'balance' such questions so as to avoid reinforcing any latent assumptions. The humourist Stephen Leacock long ago pointed up the assumptions about the virtues of hard work contained in the stories of A, B, and C digging ditches which often provided the meaning of 'problems' in the texts of the 1940s and 50s. Values and judgments with which a society is in total agreement are often invisible to readers from that society who assume that such inclusions merely represent the natural order of things. Where groups within the society do not concur, however, then the inclusion of debatable issues often causes controversy, and ultimately, censorship. The inclusion in a G.C.E. mathematics examination of a question relating the cost of feeding the world to the cost of nuclear weaponry resulted in the imposition of a vetting committee for future papers, with an assumption that either such content had arisen by accident or that views of one group of examiners should outweigh the views of another group.

Less controversially the mathematics curriculum could make a positive contribution to the provision of information about our society in all its facets including those relevant to its multicultural nature. Grugnetti (1979) in a fascinatingly titled article 'School Mathematics makes Sardinians Healthier' provides an example of the deliberate insertion of information valuable to pupils, in this case a statistical investigation of hereditary diseases likely to afflict the pupils. The increasing use of problem solving within the mathematics curriculum will support such a developing programme of conveying useful general information. It should also lead to a clearer sense of relevance for pupils of the mathematics they are studying. But it may well depend upon the ability (willingness?) of teachers to abandon prescribed plans on occasion in order to follow up topical events (the question of what constitutes an uneconomic pit is a very mathematical concern but would obviously have needed a very sensitive, and probably whole school, approach). Health issues are clearly ones of interest for insertion into the curriculum for social rather than mathematical reasons, but it is also possible to provide situations in which different eating patterns are made evident and in which comparative costs in different contexts can be investigated; an interesting analysis has been made of comparative costs of items in 1935 and 1985, using the cost of a Mars bar as the unit of value. The reason why some societies don't drink coffee or eat cornflakes can soon be made obvious by reference to their comparative costs. For many pupils the enormous variety of vegetables and foods provides a much wider experience than was available in past times, and enables many issues to be raised such as their costs, including the transport and handling charges needed to provide the rapid delivery some need. For some pupils there may be a need to deliberately widen their awareness of the way in which the international market operates. There are a number of sources of useful information, in particular the Development Education Centres and some examples of material in use will be found in an article by Hudson (1987) who has also produced a database of information. As indicated above with the question about uneconomic pits there are many pitfalls for the unpractised mathematics teacher who may be unwittingly drawn into issues of opinion and belief, and the experience of colleagues in other disciplines more used to facing this dilemma may need to be utilised. On many social issues the teacher's own beliefs may need to be subsidiary to those of the society he/she is called upon to represent.

Learning by Individuals

At all levels of education there exists a conflict between learning as a social activity and the individual level at which it occurs. Whilst the problem may be the same, however, the symptoms and solutions may be very different. In the early years the issue of how and when to use the mother tongue is a concern and appropriate materials may be difficult to come by unless the support of the home and the involvement of parents is sought. There is then the problem of the second hand transmission of what may be subtle ideas (see e.g. Dawe, 1983, and Jones, 1982), nevertheless the creation of strong home/school identity is likely to be indispensible for maintaining a harmonious society. Emblem (1986) presents a valuable picture of issues in teaching young children, unusually well informed by a visit to the Indian subcontinent. Some learned skills such as visual discrimination seem to be very dependent on the ambient culture (see Mitchelmore, 1980) and although these are likely to be less noticeable in a single dominant environment it is clearly an area in which pupils might be expected to show wide variations as a result of varying experiences. There is also the issue of styles of learning, which whilst affected by many ingredients, is also related to home culture and such issues as the nature of authority and adult-child relationships (see e.g. Head, 1981). Whilst these issues do not directly affect the mathematics which is taught they are major elements in the decisions about how it is taught and the content and the teaching approach have a symbiotic relationship. Thus rule-bound algorithmic skills quire an essentially authoritarian environment, whilst real problem solving may well require an act of deliberate withdrawal of authority by the teacher. Pupils inevitably respond differently to these situations, just as some are reticent and others forthcoming, some are born to be leaders whilst others have leadership thrust upon them. Clearly these differences exist across and within all cultures and all races but the ways of responding and dealing with these differences are often cultural traits.

It was stated earlier that most of the issues raised by the multicultural debate in mathematics teaching were already concerns of such professionals. The provision of a more accepting, acceptable and enjoyable mathematical environment for all pupils would clearly help towards the achievement of a more accepting, acceptable and enjoyable society.

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REFERENCES

Bishop, A.J. (1985), 'The Social Construction of Meaning - a Significant Development for Mathematics Education?' For the Learning of Mathematics, Vol.5, No.1, pp.24-28.

Bishop, A.J. (1986), 'Mathematics Education as Cultural Induction', Nieuwe Wiskrant, October, pp.27-32.

Cockcroft, W.H. (1982), Mathematics Counts, HMSO, London.

Cuff, E.C., & Payne, G. (1984), Crisis in the Curriculum, Croom Helm, London.

D'Ambrosio, U. (1985a), 'Ethnomathematics and its Place in the History and Pedagogy of Mathematics', For the Learning of Mathematics, Vol.5, No.1, pp.44-48.

D'Ambrosio, U. (1985b), 'Mathematical education in a cultural setting', International Journal of Mathematics Education in Science and Technology, Vol.16, No.4, pp.469-477.

Dawe, L.C.S. (1983), 'Bilingualism and Mathematical Reasoning in English as a Second Language', Educational Studies in Mathematics, Vol.14, pp.325-352.

Emblem, V. (1986), 'Asian Children in Schools', Mathematics in School, Vol.15, No.5, pp.26-29; Vol.16, No.1, pp.7-9.

Ernest, P. (1986), 'Social and Political Values in Mathematics', Mathematics Teaching, No.116, pp.16-18.

Gerdes, P. (1981), 'Changing Mathematics Education in Mozambique', Educational Studies in Mathematics, Vol.12, pp.455-477.

Grugnetti, L. (1979), 'School Mathematics makes Sardinians Healthier', Mathematics in School, Vol.8, No.5, pp.22-23.

Head, J. (1981), 'Personality and the learning of mathematics', Educational Studies in Mathematics, Vol.12, pp.339-350.

Hemmings, R. (1980a), 'Multi-Ethnic Mathematics: Part I: Primary' New Approaches to Multicultural Education, Vol.8, No.3, pp.29-38.

Hemmings, R. (1980b), 'Multi-Ethnic Mathematics: Part II: Secondary', New Approaches to Multicultural Education, Vol.8, No.4, pp.1-4.

Hemmings, R. (1984), 'Mathematics', in A. Craft and G. Bardell (eds.), Curriculum Opportunities in a Multicultural Society, Harper-Row, London.

Hudson, B. (1987), 'Global and Multicultural Issues', Mathematics Teaching, No. 119, pp.52-55.

I.L.E.A. (1986), Everybody Counts, I.L.E.A., London.

Jones, P.L. (1982), 'Learning Mathematics in a Second Language: A Problem with More and Less', Educational Studies in Mathematics, Vol.13, pp.269-287.

Joseph, G. (1984), 'The Multicultural Dimension', Times Educational Supplement, 5th October.

Lea, H. (1987), 'Traditional Mathematics in Botswana', Mathematics Teaching, No.119, pp.38-41.

Maxwell, J. (1985), 'Hidden Messages', Mathematics Teaching, No.111, pp.18-19.

Mitchelmore, M.C. (1980), 'Three-dimensional Geometric Drawing in Three Cultures', Educational Studies in Mathematics, Vol.11, pp.205-216.

Northam, J. (1982), 'Girls and Boys in primary mathematics books', Education, Vol.10, No.1, pp.3-13.

Tahta, D. (1987), 'Islamic Patterns', Mathematics Teaching, No.119, pp.48-51.

Zaslavski, C. (1975), 'African Network Patterns', Mathematics Teaching, No.73, pp.12-13.

Zaslavski, C. (1979), Africa Counts, Lawrence Hill & Co., London.

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BECOMING A MATHEMATICS TEACHER - GROUNDS FOR CONFIDENCE?

In a note in Marion Bird's book 'Generating Mathematical Activity in the classroom', Afzal Ahmed suggests that the Cockcroft report was about confidence: "Children's confidence, teachers' confidence and public confidence in mathematics teaching in schools" (Bird, 1983) To what extent are we entitled to be confident about the state of the mathematics teaching profession?

At a time of low teacher morale, recently renovated initial teacher education courses and continuing problems with recruitment to mathematics teaching, the theme of confidence seemed an appropriate one to use for considering entry, training and professional future for new mathematics teachers.

Such a review is not being conducted without an awareness of my personal decision 25 years ago to enter teaching or of my experiences in teacher education over about half that time. Since the latter period has been almost exclusively concerned with postgraduate students, this may determine or at least colour some of the views expressed.

Assuming that many readers are mathematics educators at some point within the system, it is worth asking the question, 'Would you, given your career choice again in 1987, choose to enter mathematics teaching?' Would our answers be affected chiefly by the experience of being a teacher, by the perceived nature and state of mathematics teaching today or by the current wider range of opportunities which are available to mathematics graduates? In practice, it is probably impossible to give any kind of reliable answer but the evidence a falling proportion of mathematics graduates entering teaching suggests that out of 4 of us deciding to teach in the early sixties, only one would do so now. Does it matter? I would suggest that it is not irrelevant if one accepts that the nature of new entrants must be one determinant of the teaching profession. The training they are given and the receiving state of the profession must be the other major factors.

One further piece of self examination before considering some aspects of confidence; as mathematics educators in initial training, are we essentially recruiting officers for the system - a system with a high success rate (as judged by the proportion of students on courses who obtain a professional qualification) and a high placement rate (proportion of certificated persons who obtain a teaching post)? Or are we honest brokers playing a significant part between an education system needing teachers and young people making a career choice? Or more distantly perhaps, are we through AUMET, NATFHE and SCAMES (Note 1), members of pressure groups for raising levels of awareness and provoking action on quality and quantity? Or are we in practice, operating at the baser level of perpetuating our own kind or even protecting our own future employment by ensuring that there are sufficient customers? Again such issues seem worth consideration at a time when there is encouragement of various kinds to increase the flow of new teachers into mathematics teaching and when teacher educators are significant in designing the schemes, attracting the customers and carrying out the training.

Confidence in the Recruits to Courses

Meeting aspirants to teaching at interview is a time consuming but not uninteresting part of my work - particularly if for a significant proportion of the interviewees the meeting is a first tutorial. Interviewing with an experienced teacher is a luxury which I have welcomed in these days of cutbacks. The reaction of many such teachers is one of surprise at most applicants' lack of awareness of educational issues and a disappointment that so few are able to enthuse about their mathematical studies at University. Their application forms express enthusiasm and interest in mathematics but discussion usually reveals this to be linked to their success and their experience of mathematics at school level.

For 'mature' applicants the present aliveness of their mathematics can be a greater problem. A handful of Open University graduates have been notable exceptions. However for many, their statement that mathematics was their favourite subject at school twenty years ago projects an image of mathematics as a repository of knowledge rather than a current interest. Tentative inquiries about recent involvement with mathematics usually leads to variously dressed apologies for not doing any further (meaning even higher) mathematics. Yet I cannot believe that interviews relating to an aspiring english teacher's current interest/

activities in their field would produce such an arid outcome. Interest in literature, the theatre, writing, could be expected to be current rather than just successfully encountered while at school; further one might expect current interests to be readily communicable.

In recent years, it has been illuminating to require the mathematics students in my PGCE group to teach us something unrelated to mathematics. The ease of communication and particularly their enthusiasm contrasts with much that is to be seen in later months in maths classrooms. Sharing knowledge and pleasure at making pastry, playing an instrument, climbing a rock face or communicating in a foreign language, reveal characteristics which the teaching of mathematics all too easily seems to smother.

But why do people choose mathematics teaching as a career? Or perhaps more appropriately, why do people choose to enter a course in training to become a maths teacher? Straker (1984) inquired into the attitudes of final year mathematics undergraduates in six Universities towards mathematics teaching. Of the 17% of respondents who put teaching as first choice (likely to be an overestimate in relation to the whole graduate output from these universities) there were noticeable differences between women and men. The views of the female students suggested a higher level of commitment and caring than their male counterparts whose responses reflected a greater concern about material issues.

In my experience, it is often difficult to disentangle students' motivations. Some students who describe a long-term commitment to becoming a teacher can face as many surprises/crises as those who have decided negatively to go into teaching, against going into 'computing, accountancy and other 'office' jobs'. A wish to do something useful in society (often seen as an application of their Christian faith) features prominently, together with a wish to recapture an enjoyed experience while a school pupil and not infrequently to imitate a respected teacher. Few appear to believe that educationalists can change the world and regrettably many have little experience in working with children. Individual tuition of a brother or a friend may be their only experience of teaching but it has had a positive influence. Without Sunday School and Church Youth group experience the pool of experience of working with young people would be drastically reduced.

What does seem likely is that in deciding to train as a secondary mathematics teacher, a graduate may experience the response from press and general public that might be expected by someone joining a minority religious sect: surprise, lack of comprehension, and a concern for future well being.

Concerns about the shortage of mathematics teachers have reached new heights in the late eighties. Special funding for innovative courses and bursaries for those undertaking PGCE courses reflect a growing awareness of a chronic problem in mathematics and several other subjects.

What Kind of Shortage?

In 1963, a subcommittee of The Mathematical Association reported on the supply and training of mathematics teachers. The introduction (Mathematicsl Association, 1963) states

> "The shortage of mathematics teachers is now generally recognised: the danger is that it may be accepted. Available statistics, however incomplete and however cosily interpreted, reveal serious shortages, some now chronic, all now seriously impairing quality" (p.1)

Although over 40% of honours graduates in 'mathematics' were entering teaching at that time (300 out of some 700 in 1961), half of these were entering without a professional training. In grammar schools alone, it was estimated that the deficiency in honours graduates could absorb two years total output of mathematics specialists. But at the same time expandi training colleges were said to be in need of about 250 mathematics graduate lecturers in the following few years and the supply of potential university teachers was said to be only half that required to maintain University staffs. Even for the relatively small number of mathematics posts in University Departments of Education, there was a shortage of adequately qualified applicants.

To read this catalogue of shortages is to realise that shortage situations do change! During the present decade unusually able young mathematics graduates have had very little opportunity to gain lecturing posts in University mathematics departments. A state of affairs which led Jones (1981) to suggest compulsory retirement of the members of the 35-45 'bulge' group to be found in University departments, as the most effective solution.

The same paper reports an output of some 3000 mathematics graduates per annum from Universities in the late seventies. In addition, there were several hundred from Polytechnics. At that time about 12% of mathematics graduates were going into teaching. The prospect of declining school populations offered hope for a significant improvement in the supply of mathematics teachers in the mid to late 80s, before the expected decline in the number of entrants to Universities in the early nineties has its effect on output at just the time of an increasing secondary population. This future, as opposed to present problem, is illustrated in the DES's consultative document 'Action on Teacher Supply in Mathematics, Physics and Technology' (DES, 1986) (See Table 1).

	Secondary School population (thousands)	Population aged 20-24 (thousands)
1980	4110	3630
1985	3750	4140
1990 (Projected)	3020	3950
1995 (Projected)	3130	3370

Table 1

As the consultative document points out, it is useful in discussing the shortage of mathematics teachers to distinguish between overt shortages (unfilled vacancies), hidden shortage (tuition given by inadequately qualified teachers), and suppressed shortage (subject under represented on timetable because of a lack of suitable teachers). The first is easiest to identify while the last is perhaps of less significance in mathematics than it is in Physics and CDT. However the teaching of mathematics by those with minimal qualification is a particular problem in a subject which all teachers have studied in secondary school and many have carried as a potentially useful subsidiary subject.

The statistics for shortage are notoriously difficult to collect, but the figures given in DES (1986) are likely to be as reliable and up-to-date a guide as any we could expect. What is not easily apparent is the progress of particular cohorts of applicants from the number applying to the number becoming established members of the profession. The use of statistics from DES (1986), GTTR and UCET (Note 2) enables some picture of the process to emerge, though at times the degree of correspondence between data from these sources is difficult to establish.

From Applicant to Qualified Teacher Status

Various routes towards becoming a qualified teacher in secondary mathematics are possible. The routes and size of enrolment for courses starting in 1985 are indicated below:

Postgraduate Certificate:	through GTTR	666	(Universities 529 Polytechnics and Colleges of HE 137)
	non GTTR	30	
Concurrent B.Sc. or Honours B.Ed.		160	

Statistics prepared by the GTTR make it relatively easy to monitor the entry to postgraduate courses, while this source and data collected by UCET make it possible to follow the intake to University departments through to their eventual post-course employment.

Using the 1985 entry data again we have:

Total number of applications for PGCE mathematics places	1182
Number of these who enrolled for the course in October 1985	666
Number withdrawing from the GTTR system at some stage	458
Number who remain in the GTTR system but were not placed	58

Those withdrawing fall into three categories

* those who had received an offer of a place (estimated to be about 30% of withdrawals)

* those who withdrew before receiving an offer

* those applicants assumed to have withdrawn after failing to respond to GTTR offers to try further institutions

Of the 529 on University courses

477 were successful in obtaining a PGCE qualification

390 obtained teaching posts in the UK

15 were still seeking teaching jobs in October 1986.

These figures are somewhat smaller than those for the previous year, but proportionally similar. They show approximately 10% of entrants not successfully completing the course, rather less than 20% not entering teaching on successful completion and the remaining 70% of the entry obtaining a teaching post.

Observing current patterns is not to give them the status of having any particular long term significance. It is possible that we might accept or re´ ,c a higher proportion of applicants or fail a higher proportion of students following a course. Nevertheless when numbers of applicants and numbers of entrants are often quoted independently, it is worthy of note that the total applications for PGCE places of about 1200 became an entry of about 500 teachers (1985-6 figures for all PGCE courses) in a system with a target of rather more than 900 training places.

A Local Problem?

At the Fifth International Congress on Mathematical Education held in Adelaide in 1984, one working group considered the problem of shortage of mathematics teachers. Australia, America and France were amongst those reporting shortages. Many of the reasons were familiar - poor status and unattractive conditions of teaching, more lucrative posts in commerce and industry particularly in relation to computers. In Australia, postings to bush schools in the early years of teaching were unattractive. In France where the problem is more recent and regional it was suggested that the dogmatic teaching style which has been prevalent in French schools tended to turn students against mathematics (Carse, 1986, p.93).

Yet the problem is not universal. In Malaysia, excess mathematics teachers are currently being retrained for teaching English as a second language. Closer to home, it was reported in late 1986 that the Secretary of State for Education was considering the possibility of importing some of the surplus German mathematics teachers to ease our problems. The roots of such a surplus are presumably embedded in a whole social structure of attitudes, expectations, opportunities and rewards both in the world of commerce and of education. No simple technique seems likely to produce a radical change in the situation.

Confidence in Quality of Entry

People outside the teacher education field sometimes ask me about the quality of entry in these times of shortage. At meetings of teacher educators I sometimes hear claims that an institution is maintaining its standards of entry in spite of a dearth of applicants. 'Am I?', I wonder. Judgements about teaching potential on the basis of an application form, references and an interview always seem unreliable, even if a practising teacher is involved. One is always taking risks in selection and at times of shortage more risks are likely to be taken than in times of plenty. Mathematics students do fail PGCE courses - perhaps more than do students in other subjects. Bishop and Nickson (1983, p.41) suggest that there is evidence that more mathematics teachers than teachers of other subjects have their probationary year extended.

But absolute quality is difficult to assess. The list of desirable qualities for a teacher suggested in various DES and HMI publications often seems somewhat unrealistic in the light of the total population of applicants being considered. Energy, resilience and marked communication skills, while undoubtedly welcome, do not always appear in abundance at interview, yet some certainly demonstrate this range of qualities as the year progresses. One measure of academic quality which is available is that of class of degree. While it is probably certain that the correlation between class of degree and teaching quality is modest, it is noticeable that in University departments of education, the quality of entry by degree class is markedly different for the mathematics entrants than for the entry population as a whole. It is even more marked if we compare mathematicians and historians. Data for the 1986 entry to University departments of education, collated by UCET, for the percentages of group intake under degree class is shown in Table 2.

	Higher degree	1st	2i	2ii	2un-divided	3	Pass/ General	Other
Overall	3.3	2.9	33.2	39.2	2.5	9.4	7.3	2.5
History	3.3	3.3	47.2	40.7	3.9	0.7	1.0	-
Maths	2.8	4.3	19.3	27.9	5.2	19.7	17.8	3.0

Table 2

So while less than 2% of history entrants have lower than a second class degree, about 40% of mathematics students have this background of achievement in their first degree. We might find ourselves agreeing with the teacher who commented that if there are a limited number of mathematics graduates around, she would rather that it was the able ones designing the planes and guided missiles. My concerns are twofold. First, what sort of an educational/mathematical experience was it in getting a third class or pass degree? By definition, it seems to suggest very modest success when it is borne in mind that very few students fail their degree altogether. Second, what are the longer term implications for the profession in decision making about the curriculum, in 'A' level teaching etc? Will it be possible, in any sense, to expect a different quality in History and Mathematics education in schools because of this difference in academic quality of entry? Do we consciously or unconsciously modify what we do as teacher trainers in the light of this difference? _If_ it is irrelevant, should we be campaigning amongst our colleagues for historians with third class and pass degrees to be given a chance as teachers?

Dore's book 'The Diploma Disease' (Dore, 1976) made evident on a world scale the nonsense and the dangers of chasing inappropriate qualifications. A Ph.D. is not necessary to drive a taxi, but it might help in some countries if it puts you ahead of the rest of the field in formal qualifications. As a disappointed applicant for a taxi driving post, one might have to revise one's academic aspirations if a Ph.D. becomes necessary in the scramble for jobs. This educational inflation is usually evident where jobs are in short supply but there are many jobs in which people feel overtrained for what the job actually requires them to do. Some have even suggested this about the relatively prestigious job of General Practitioner for which the training is some eight years post 'A' level. Is it also true for the mathematics teacher?

The most recent messages from HMIs and the DES are unclear. On the one hand training institutions are being encouraged to accept only those with a strong academic background in mathematics, while on the other, innovative methods are being sought to bring in, through retraining or longer PGCE courses, students whose background in mathematics is considerably weaker.

While many of us might argue that a mathematics course focussed on the needs of the intending teacher may be more valuable than much of what is experienced and 'failed' by many a mathematics graduate who enters a PGCE course, it does raise questions about the knowledge needed to be a mathematics teacher and the relative importance of other qualities which are not subject specific.

Beyond Initial Training

Longitudinal studies of teachers of mathematics seem to be in short supply. Yet concerns over input and output are short sighted unless viewed against longer term contributions to teaching. Professional life expectancy is of significance both to course designers and tutors and to those financing such training programmes. A one year programme, even of 36 weeks, may be all too short for preparing someone for the demands of full time teaching, but it is an expensive investment if the teacher only contributes for two or three years in the classroom.

A pilot study of teacher movement carried out by Cornelius (1981) in 69 secondary schools in the North East of England recorded 127 changes of mathematics staff in a two year period (1978-80). While 47 involved a change of school and 12 were through retirement or death, some 34 represented true wastage by virtue of a move into another job, failure or illness/personal reasons. The future of the remaining 34 who moved for reasons of pregnancy, family, movement of spouse was uncertain with respect to possible re-entry to mathematics teaching.

More recent data in DES (1986) suggests wastage figures of 8-10% per annum. It seems likely (and Cornelius' pilot study figures give support) that wastage rates are likely to be higher in the early years of teaching as people decide whether teaching is an appropriate career for them. Adding to this the other hazards (pregnancy, spouse movement without necessarily another teaching job being found), the loss in the early years could well be 15% per annum. Using this model the number of our original 500 entrants surviving to years 2-5 would be 425, 360, 305, 260. Such statistics, even if only crude projections, raise major questions about counteracting wastage, the timing of training investment and the ability, achievement and characteristics profile of those who survive.

Data and analysis of inadequacies can present a rather depressing view of what is, as opposed to what might have been. Yet the experience of working with those in training is probably as rewarding as it ever was. The talents, skills and initiative of some is a frequent palliative to other indicators of quality. Developments in PGCE courses give cause for optimism about the linking of theory and practice and the relationship between teachers and teacher educators. Only the complexity of the teacher's work in the late 80s makes one query whether we are moving fast enough to make the preparation adequate.

Finally, what confidence is there in the receiving profession as new entrants join? There can have been few more difficult times to join the teaching profession than in the last year or two, with the low state of morale. And yet the support systems for new teachers are probably better than ever before: schools with only limited numbers of probationers and consequently more scope to look after them; heads of department with clearer ideas on their role in looking after a new probationer; advisory teachers largely freed from administrative chores to be able to work alongside new teachers in schools; two professional associations more active than ever in providing materials and in organising meetings and conferences. Amongst the prevalent gloom there are signs to encourage.

John Hayter

NOTES

1. AUMET - Association of University Mathematics Education Teachers

   NATFHE - National Association of Teachers in Further and Higher Education

   SCAMES - Standing Committee of Associations concerned with Mathematics Education in Schools

2. GTTR - Graduate Teacher Training Registry

UCET - University Council for the Education of Teachers

REFERENCES

Bird, M. (1983), Generating Mathematical Activity in the Classroom, West Sussex Institute of Higher Education, Bognor Regis.

Bishop, A., & Nickson, M. (1983), Research on the Social Context of Mathematics Education, NFER-Nelson, Windsor.

Carss, M. (ed.) (1986), Proceedings of the Fifth International Congress on Mathematical Education, Birkhauser, Boston.

Cornelius, M. (1981), 'The Wastage and Movement of Secondary Mathematics Teachers', The Bulletin of the Institute of Mathematics and its Applications, July, Vol.17.

Dore, R. (1976), The Diploma Disease, Unwin, London.

Department of Education and Science (1986), Action on Teacher Supply in Mathematics, Physics and Technology, D.E.S., London.

Jones, D.S. (1981), Whither Mathematics, paper prepared for and made available by University Grants Committee.

Mathematical Association (1963), The Supply and Training of Teachers of Mathematics, The Mathematical Association, Leicester.

Straker, N. (1984), 'An unattractive option?', Times Educational Supplement, 11 May.

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