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FROM FAILURE TO SUCCESS: CHANGING THE EXPERIENCE OF ADULT LEARNERS OF MATHEMATICS

ABSTRACT. For the last few years, the author has been part of a team developing a mathematics course for students most of whom are women, many of whom are black and all of whom are attempting to gain entry to a teacher-training course by successfully completing a one year re-entry course. It is a requirement that teacher-training students should have attained a suitable standard in mathematics. Further Education colleges where re-entry courses are sited have a sad history of student failure in mathematics. The theoretical environment in which the development of this course took place is described in order to place the course in context. In particular, attention is drawn to the re-definition of mathematics which encourages student enquiry and experimentation in order to establish a basis for understanding the subject, and to the teaching/learning model which creates an environment of respect and confidence. The roles of students and staff in a learning environment of this kind are discussed. Particular attention is paid to the attitudes and feelings of the students and the effects on their expectations.

1. BACKGROUND

The project on which this paper reports was devised to support one year return-to-study courses for adults, mostly women many from minority groups. Such courses are known as 'Access' courses because they lead directly to particular Higher Education establishments offering specific professional training such as teaching. To gain admission to a Bachelor of Education degree course leading to a qualification to teach, students must have reached a required standard in English and Mathematics. Normally, this is an Ordinary level pass in the General Certificate of Education.

There is evidence that members of the Afro-Caribbean community underachieve in the English educational system and substantial evidence as to the under achievement of women (The Cockcroft Committee, 1982; The Swann Committee, 1983). When performance in Mathematics is assessed, poor achievement and poor motivation appear to be widespread. Thus, the adults presenting themselves as Access students have an educational history of failure in relation to the learning of mathematics but are highly motivated to achieve entry onto the course of their choice. For many past Access students, the mathematics has proved their downfall, confirming previous failure. In January, 1983, the author was asked to collaborate in the planning of a new Access course for entry onto the B.Ed. (primary) and B.Ed. (secondary

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Youth and Community Studies) courses at Thames Polytechnic. The associated college was Hackney College of Further Education.[1]

2. THEORETICAL CONTEXT

The history of previous failure at mathematics of the students for whom the course was planned, placed them firmly within the reference group of the mathematics anxiety literature. The research interests of the author were in mathematical problem-solving, and the mathematics anxiety literature supports the effects on anxiety reduction of using an investigational, enquiry-based style of teaching (Buerk, 1982; Buxton, 1981). It was conjectured, therefore, that a course which

capitalised on the adult experience of the students and their motivation,
offered learning experiences which build confidence and a positive self-image,
encouraged students to change their perspective on the learning and teaching of mathematics, and
presented mathematics as an active, enquiry-based subject,

would enable these students *to change their image of mathematics* and *of their own relationship to it*. In the process, success should replace failure. There is a symbiotic relationship between the teacher's image of the subject and the choice of teaching/learning style. Those who subscribe to a view of mathematics as a body of knowledge, algorithmically based and servicing other subjects, not surprisingly tend to choose a prescriptive teaching model in which the main force is on 'knowing' and 'doing'. Equally, a view of mathematics as a pattern-searching discipline, attempting to interpret and describe phenomena using a particular language (for example, of number, space, and especially generalisability) demands an open, questioning, supporting classroom. The distinction that follows between the image of mathematics and teaching/learning model should be seen as a device for clarity and was not reflected in the way in which the course was devised or implemented.

2.1. *The Image of Mathematics*

The "closed and correct" image which much teaching of mathematics mistakenly gives to learners, encourages a view which is in conflict with the way in which many other subjects are encountered. Where learners find that a personal, interpretative, relativistic approach to other subjects allows them freedom to explore in a manner meaningful to them, they are likely to reject, or find incomprehensible, mathematics presented as mechanistic, non-personal and absolutist (Perry, 1968). Mathematics, for the students who joined the Access course, not only had a mystique which included the expectation that it was ritualistic and arbitrary, but they also had considerable experience of their own inability to understand. To change this image, mathematics was to be encountered as an active, investigational discipline, built upon conjectures. Students were to be given opportunities to question and then to try to resolve their questions such that they themselves could find out why something worked or did not work and under what circumstances this occurred. The messy procedures of enquiry would, it was hoped, replace students' former experience of formalised, codified and lifeless mathematics and give them an opportunity to enjoy creating meaning:

> In practice, a mathematician's thought is never a formalised one . . . one accedes to absolute rigour only by eliminating meaning; absolute rigour is only possible in, and by, such destitution of meaning. But if one must choose between rigour and meaning, I shall unhesitatingly choose the latter. It is this choice one has always made in mathematics. (Thom, 1973, 202–3)

Students would, therefore, encounter mathematics in a manner more closely resembling mathematicians than learners in school.

Changing the personal mathematical experience of these students was seen as a pre-requisite for prospective teachers since many efforts to affect the behaviour of mathematics teachers have foundered on the discontinuity between the model being proposed to the teacher in training and the model experienced by that teacher as a learner. That is, trainee teachers appear to require more than the experience of a different model of learning in their course to substantiate a shift from the model of classroom behaviour familiar to them from school. It was conjectured that a student who had achieved the required standard of mathematics for *entry* onto a course of teacher training, by experiencing a different model of learning, and for whom that model was reinforced during their course and in their practice teaching, would be more likely to adopt it than a student for whom the new model was met for the first time *on* the B.Ed.

2.2. *The Teaching/Learning Model*

The following constructs were used:

- (i) learner autonomy
- (ii) personal knowledge
- (iii) enquiry-based learning
- (iv) collaborative organisation

(i) An autonomous learner was contrasted with a dependent learner, for whom actions from the trivial to the complex are subject to validation by the teacher. The end product of dependency is that the learning itself 'belongs' to the teacher, rather than the learner. Constructing learner autonomy thus necessitates a teacher re-negotiating discipline and control. Discipline is the collection of rules by which the classroom community operates to everyone's satisfaction, and control of the learning is vested in the learner rather than the teacher. The implications include the negotiation of the curriculum. The teacher, of necessity, comes to the classroom with expectations and activities. The learner has the power to choose to linger on, or accelerate through a particular task, or initiate a related piece of learning. Negotiating is central to autonomy of learning. It demands greater respect for the learner than for the subject matter since

> mathematics (is) a creation of the human mind, with no existence other than in the minds of people and characterised by some typical human mental activities. (Plunkett, 1981, 46)

Since this course was devised for adults it was felt that an appeal to their independence and autonomy would establish a more productive classroom climate and build upon strengths that they already recognised.

(ii) Many have commented on the apparent ease with which a learner acquires knowledge defined as personally useful compared with the difficulties associated with learning mathematics in school. The starting point for such personal knowledge (Polyani, 1974; Kelly, 1970) are the learner's questions which define the area within which enquiry takes place.

> Often our formal education suppresses the relationship between the asking of questions and coming up with answers . . . Indeed we need to find out why some questions may not have good answers . . . (or that) the difficulty in answering the question lay in the assumptions behind the question itself. (Brown and Walter, 1983, 2–4)

Enquiries involve the learner in many different states –

> the approaches that didn't work, the approaches we thought worked but didn't, the inquiries we raised and pursued, the emotions and reflections we experienced in the process of coming to know. (Gordon, 1978, 265)

Sustaining such enquiries and constructing personal knowledge consequently requires that the individual has a willingness to be involved, has confidence, ascribes value to the activity, and finds consistency between what is being learnt and their personal belief system. In addition to recognizing the impact of values, attitudes, beliefs and expectations on personal knowledge, the mathematical thinking processes must be validated by the classroom climate (Mason *et al.*, 1982; Burton, 1984). Learning to recognise possibilities and to make reasonable choices between them, exploring through pattern-searching, testing pattern recognition to validate or falsify conjecture, these, and many other processes, provide the means to move through an enquiry towards understanding. Again, it was conjectured that adult learners would be ready and willing to adopt this approach.

(iii) Enquiry-based learning is dependent upon activities which engage and challenge the learner to frame questions. In attempting to find answers to these questions, knowledge is constructed or re-constructed. Achieving a construction which is satisfying is pleasureable, so a learning pattern of this kind meets with learner approval. But the process is not without struggle. A classroom which aims at contentment is likely to result in boredom. A classroom in which there is a struggle for meaning contains intensity, frustration and satisfaction but because the struggle is a personal one, it is available to each learner at an appropriate level. The environment then becomes one in which each person can monitor some progress. From the teacher's perspective, there is a responsibility to provide challenging activities which might be games, puzzles, practical problems from the environment, or questions arising from the learners (see for example, Papert 1980; and Rowland, 1984).

(iv) Collaborative organisation promotes sharing and discussion. Through sharing what is known and understood with others, misunderstandings and mis-conceptions are revealed. This process, referred to in the literature as the negotiation of meaning, requires task-focused discussion, tolerance, listening skills, exchange skills and skills of representation. The classroom is organised to facilitate and to expect small group discussion. The information that different people understand different things by a mathematical statement frequently comes as a major shock to learners. The subsequent learners' discussion provides information to the teacher enabling insight into, and informed diagnosis of, learning difficulties.

3. COURSE DESCRIPTION

The course has two components, independent study packs and group problem solving. The set of fourteen independent study packs consists of six on number, entitled Numbers in Use, Numbers in Place, Whole Number Patterns, Bits and Pieces, Percentages, Ratio and Proportion; three on geometry; two on the use of graphs and statistics; and three on algebra. The packs have been created out of carefully selected existing curricula resources boosted by specially written materials. The choice of what to include reflects the aims and objectives of the course and suitability for adult learners. The format of each pack is the same.

- The first sheet consists of a flowchart which guides the student in the use of the pack.
- The second sheet is a set of objectives for the pack. In the Numbers in Use pack, for example, this sheet states:

  This pack will help you to:
  1. State the value of a digit in a decimal number.
  2. Use place value to multiply and divide by powers of 10.
  3. 'Round off' quantities to a reasonable degree of accuracy.
  4. Approximate using the four operations (addition, subtraction, multiplication, division).
  5. Calculate accurately using the four operations.

  If a student is unable to cope with any of the objectives, she is advised to work through the complete pack.
- The third sheet is a list of materials which are the resources associated with each objective. These include computer programs, video and audio tapes, manipulable materials and activity sheets.
- The fourth sheet is a self-evaluation sheet designed to assist a student who does not feel the need to study all the materials in the pack as some of the objectives deal with familiar ideas/methods. The sheet has a set of questions corresponding to each of the pack objectives together with a final question requiring the student to demonstrate understanding by reacting to a frequent pupil response and interpreting it. This context is appropriate to aspiring teachers. A student chooses to enter the pack at the section which corresponds to the objective which presented difficulties. For example, lack of success with question 2 on the self-evaluation indicates the use of section 2 of the pack. The pack materials are sequential so entry at section 2 infers completion of all remaining sections.
- The pack materials follow.

If a student does not feel the need to work a pack, or on completion of it, she is tested. The test consists of a set of questions most of which have been taken from former General Certificate of Education 'O' level mathematics papers, thus ensuring that the appropriate standard is demonstrated. A minimum of 65% must be achieved to pass a test. There isno choice of questions on the tests. It is permitted to resit a test although it was hoped that students would not choose to take the test before they were ready. As the G.C.E. 'O' level paper does not necessarily contain questions on every part of that syllabus, and a pass can be obtained with approximately 40% of the marks from a choice of questions, it was felt that any student gaining at least 65% of the marks on each test of fourteen packs would have amply demonstrated understanding and facility to 'O' level standard.

The second component of the course consists of group problem solving sessions initiated by the tutor. These offer opportunities to use games, puzzles, and investigations, and to reflect upon the processes that are employed. A positive atmosphere encourages students to recognise and consciously to utilise their problem solving processes. This conscious reflection is directed at building confidence in two ways:

by encouraging recognition of their mathematical thinking skills within their current repertoire of behaviour, and then

by promoting the use of these skills to encourage a problem solving style of learning when using the packs.

4. EVALUATION

In the first two years that this pilot course was offered, twenty-six students began and twenty-two completed. Three students were counselled out of the Access course as a whole and one withdrew from the mathematics course because she already had 'O' level. Twenty of the twenty-two succeeded on the course, nine in the first year (1983/4) and eleven in the second (1984/5), a success rate of 91%. The students were mixed in terms of age and ethnic origin. Very few were men. The first nine completed their initial year of tertiary education in June, 1985 and the second eleven started in September, 1985.

In addition to those Access students, approximately forty students have followed a similar course at Thames Polytechnic, the major difference being that these students were not guaranteed entry if they succeeded. Nearly all of these are women and their ages range from early 20s to 83! The Hackney students spent approximately six hours per week either on the packs or in group problem solving. The Thames students could join one or two sessions of two hours per week, obtaining a maximum of four hours per week in class.

It is not the success rate of the course with the Access students which has been the most impressive result, although adequate performance in mathematics was crucial to these students meeting their goal of entry into higher education. Far more important has been the change in the students' perceptions of themselves and their ability to learn mathematics. One woman wrote:

> I failed the school mathematics system miserably – or did it fail me? I am no longer afraid of maths and I am sure this is due to the methods of this course.

Another reported that

there was so much I didn't know or else had forgotten. For example, I didn't know what a 'significant figure' was, or a 'flowchart'. I know now. 'Cumulative frequency curves', 'running total graphs', 'bar charts' and 'pie charts' meant absolutely nothing to me but I am pleased to say that I now understand what they are all about, and find myself reading statistical reports in the press that previously I would have ignored.

The intention of the course had been to build student autonomy and confidence through group learning and a changed teacher role, with the outcome of affecting student attitudes to mathematics and its learning.

(i) Student autonomy: The move to establish a classroom of autonomous students was accomplished but not without difficulties. Tutors initially were uncertain when to invervene or offer assistance and when to leave the students to develop their own thinking. They felt that part of their role was to help students to identify difficulties and recognise strategies for dealing with these. In this respect the problem solving sessions were invaluable. The students, too, commented on how much they had enjoyed these sessions.

I found the problem solving lessons, both singly and in groups, of particular interest, and often highly amusing.

To my surprise, I thoroughly enjoyed the projects and problem solving sessions.

Considerable time and interest was spent by some students on the problem solving component. One student wrote about two problems which she had turned into a family game:

Canoe and children across river is turned into a game with Fisher Price people. My six year old did it in three minutes. I had struggled for half an hour. Tea and cakes: dollies sitting around a table – three year old cutting out cakes, six year old counting money. Great fun!!

(ii) Student confidence: Confidence levels were too low initially to use the self-evaluation sheets as intended and students chose, instead, to work through the early packs from beginning to end. A few students opted to take the first test before they were ready and did not succeed in gaining 65% at this first sitting. This was unexpected. However, discussion with the students concerned indicated that the ability to judge readiness is, in part, a function of experience with learning. Consequently, with the early packs, the tutors adopted a responsibility to guide and suggest further work where appropriate. The students' ability to assess their own readiness and adopt responsibility rapidly developed. As a result, greater guidance was given to the second group of students in their use of the self-evaluation sheets.

Students commented freely on the lack of threat and on the confidence created by having short-term goals which are achievable. The environment was described by them in human and personal terms, contrasting sharply with their earlier 'academic' experience and contributing positively to their developing confidence.

Unlearning all that you were taught at school – must do own work, no talking, no copying, no asking somebody else for that is CHEATING!!!

It is only later in the course that one realises the value in being encouraged to seek answers and evaluate ourselves rather than being fed information as most of us were at school.

(iii) Group learning: Tutors were particularly supportive of positive group dynamics and persistently encouraged a collaborative working style to lessen anxiety and to build the confidence of students. It was not, therefore, by accident that a student had experiences which led to her writing:

Happiness is finding three other people as daft (silly) as you. Yippee – no longer struggling – helping each other out, asking questions of each other.

Another wrote:

As we all plunged into the packs and found our own levels, teaming up with those students at a similar stage, it became clear the not only was this the only way to deal with so many different backgrounds, but that we all had our triumphs and weaknesses and in helping each other, in turn we were increasing our own understanding.

(iv) Tutor role: The role of facilitator adopted by tutors was seen by many students as a positive part of the course, although some took a little time to adjust to self-responsibility instead of their expectation of a 'this is how you do it' approach. While attempting the early packs, some students were reluctant to ask for guidance, and tutors commented on the difficulty of deciding when to support and when to intervene. The degree to which the tutors had to accept a stronger responsibility for the learning during the initial packs has already been described. However, student success at passing the end of pack tests supported the effectiveness with which tutors managed this. These tests were taken in the classroom on an occasion of the student's choosing and consequently were interpreted as self-assessment. The response of the students to this was very positive.

(v) Overall student attitudes: It was clear from interviews and written evaluations of students that they enjoyed the packs, the style of working, the problem solving sessions and the classroom atmosphere. They appreciated being able to work at their own pace with no feeling of competition although some felt that it took a little time to appreciate that the only person against whom one competed was oneself. They commented on their growth of understanding:

I now understand things I have been doing for years without knowing why.

Failure does not seem to have threatened these students during their course.

The activities were designed to build on strengths, the problem solving was in a supportive atmosphere, and tests were taken as an affirmation of understanding.

5. CONCLUSIONS

Further Education College teaching of mathematics has tended to adhere to a prescriptive teaching method which for many students has reinforced failure. This course has already demonstrated the validity of an alternative approach which is more dependent upon the sensitivity and intuition of the tutor than on didactic presentation skills. The enthusiasm of the students for the course –

> I loved it all. Could play with it all day. Would recommend the system to anybody whether they liked maths or not –

and their success with it is profoundly important to those whose former experience of formal education has been unfortunate. Positive changes in self-image and confidence led one student to write:

> I have adapted my new searching attitude to other areas of life and as a result I hope I am less 'gullible' than previously. I would encourage any female to think positively.

Courses which result in mathematical failures are both psychologically and economically expensive. Redemption of such failure has important individual and social consequences (Graham and Roberts, 1982). However, it also is very informative about the original conditions which helped to ensure the failure.

Emphasis on	competition	changed to	collaboration
	individual work		group work
	knowing		enquiring
Emphasis on	answers	changed to	questions
	formalisation		informality
	substantiation		conjecturing
	replication		creation

There were many other changes but these reinforce two patterns observable in the literature. One of these is the apparent preference and success of women in linguistically/humanistically based subjects. Use those means to teach mathematics, where they are just as pertinent, and women achieve. The other comes from the experiments in teaching mathematics to single sex groups. One persistent comment from the girls relates to how much more pleasant the teaching environment becomes (Burton and Townsend, 1985).

In this course it was successfully demonstrated that if learners work together, task-focussed, there is no opportunity nor any plausible reason for an individual, or a group, to dominate the class, nor to monopolise the teachers' attention, nor to indulge in any other of the tactics which have been described in the literature (see for example, French and French, 1984; or Spender, 1982). Under these conditions, it would appear that all learners benefit.

The course can be used by any group aiming at this level of mathematics learning. A small trial was conducted in a secondary school with pupils of 15–16 years but the degree to which the methods and the structure is transferable to schools has yet to be systematically investigated. Tutors must be capable of maintaining a relaxed atmosphere and a nonjudgmental, nonprescriptive style. This approach has recently been adovcated to schools by official publications such as "Mathematics from 5–16" (HMI, 1985) and future work will look at the feasibility of extending the approach into schools.

The hypothesis that trainee teachers who have experienced this learning/teaching mode prior to joining their B.Ed. course will find it easier to sustain in their own teaching will be investigated by monitoring the development of the Access students on the B.Ed. course and, it is hoped, once they become full-time teachers.

The course continues to run at Avery Hill College and its associated F.E. Colleges. Other interested institutions have visited and observed the course in action and this facility continues to be available. It is hoped that many more return-to-study adults in future might have the opportunity to generate positive feelings and substantive understanding of mathematics as a result of this development.

NOTE

[1] The Author wishes to acknowledge the other members of the team who undertook this course development: Geoff Coggins, Thames Polytechnic; Jean Condon, Hackney College of Further Education; Mike Hall, formerly Head of Mathematics, Crofton School, now Adviser, L.B. of Haringey; Geoff Sheath, Thames Polytechnic; Ruth Townsend, formerly Adviser L.B. of Croydon, now Thames Polytechnic; Angela Walsh, formerly Thames Polytechnic, now Deputy Director, PrIME Project.

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