CONTENTS

Secondary Partnership in Practice

Alan Bloomfield, Clare McKay, Denise Strutt

Gloucestershire Initial Teacher Education Partnership

Graham Newson, Richard Woodcock

University of York

Dave Miller

University of Keele

At the 1993 *Annual Conference of the Association of Mathematics Education Teachers in Sheffield a day was given over to a discussion of initial teacher education ([TE) partnership in practice. In the sessions focussing on secondary ITE, members of the Gloucestershire Partnership and the York Partnership described their courses and gave a brief idea of what it was like to be involved in partnership from the point of view of higher educat~on institutions (HEIs), schools and the intending teachers themselves. In this article the two partnerships are described and a summary of the ideas emerging from the subsequent discussion groups is presented.*

Gloucestershire Initial Teacher Education Partnership The partnership is the result of discussions between Cheltenham & Gloucester College of Higher Education <CGCHE) and the Gloucestershire Association of Secondary Headteachers (GASH) with the involvement of personnel from the Gloucestershire local education authority (GlosLEA). On September 20th 1993 an initial intake of 88 Postgraduate teachers began a PGCE Secondary Course, involving seven subject pathways: English, Geography, Mathematics, Modern Languages, Physical Education, Religious Education and Science. It would be inappropriate after some six weeks to give a critical analysis of the partnership and the course. The following is a brief outline of the Gloucestershire initiative.

The Planning Phase

The representatives of GASH and CGCHE came together with an open agenda to plan for ITE in Gloucestershire. It soon became clear that there was a strong commitment to teacher education within Gloucestershire. This commitment has survived the planning stage and the early stages of implementation. It was agreed to proceed with planning a PGCE route for consideration by both GASH and the College Management. A small planning team produced an outline structure and started to plan individual modules. The planning team consisted of three HEI tutors and one Deputy Headteacher from a Gloucestershire 11-18 Comprehensive School. Consultation with the two main representatives from GASH and with college Senior Management occurred throughout.

The planning took place within the context of three key criteria from circular 9/92:

- Students must spend 24 weeks in schools
- Schools and teacher training institutions are to be full partners in the planning organisation and delivery of the course
- The course will focus on the development of the competences of teaching.

The course was validated by the College procedures, including external peer assessment. The validation panel visited a local school and spoke to potential training managers and other teachers involved with the project, as part of the validation process.

Gloucestershire schools involved 1993-94

In 1993-94 there are 25 schools and colleges which are members of the Partnership: 19 as parent schools and 6 just as twinned schools with a single placement in the Spring Term. They reflect the wide variety of institutions in Gloucestershire.

Key personnel

There are four main groups of people involved with the programme:

Training managers, Subject Mentors, Subject Co-ordinators, and the PGCE teachers themselves. Given the variety of labels used in school-based partnership these need explanation.

Training Manager (TM)

A senior member of the teaching staff of the school: in most cases the TM is a Deputy Headteacher. The TM has to have 'clout' in order to manage the PGCE teacher's programme within school. A considerable proportion of both teaching and assessment of the PGCE teachers is the responsibility of the TM, who also has the responsibility for writing interim and final references. As part of the process of applying for full membership of the partnership all schools nominated a TM who was then interviewed by a panel of three from GASH, CGCHE and GlosLEA. The successful school TMs then received training prior to the commencement of the Course.

Subject Mentor (SM)

For each PGCE teacher a member of the relevant subject department within school is appointed to act as a mentor supporting the PGCE teacher's classroom teaching. The SM is able to act as a critical friend, with final decisions on assessment being the responsibility of the TM.

Subject Co-ordinator (SC)

For each main subject pathway a Subject Co-ordinator was appointed. This person has the responsibility of planning, implementing and evaluating the subject pathway modules. In many ways the SC undertakes the traditional role of the Subject Education Teacher within the HE!. In the main, supervision of teaching practice is now the responsibility of the school. Of the first seven SCs, four are based within the college and three are in Gloucestershire schools.

PGCE teachers

By virtue of the school's commitment to the course and the length of time now spent in school by the PGCE teacher, the nature of the relationship of trainee to school has been strengthened. Schools are treating the trainee as a member of staff rather than a 'visitor' from the college.

Course structure

The course consists of twelve modules and lasts 36 weeks. There are three main strands to the course: Professional Preparation; Subject Pathways; School Placement.

PROFESSIONAL PREPARATION

Review of the Learning Process

Management of the Learning

Environment Consideration of the Learning School

MAIN SUBJECT PATHWAY Introduction to Teaching the Subject

Development of Teaching the Subject

Extending Teaching the Subject

SECOND TEACHING STRENGTH

One of the following:

A Second Subject

Provision for 16-19 year olds

Special Educational Needs

Professional Preparation modules are the joint responsibility of the college and school. There are sessions in College with HEI teachers and sessions in school with the TMs. Assessment is by the TM with moderation within clusters of schools and support from the college.

School placement modules are assessed with the support of evidence from a profile of competences. The profile was developed in partnership between schools, the college and the LEA. The time spent in school occurs in three main blocks.

TERM 1: 10 WEEKS IN PARENT SCHOOL 30-50% teaching

TERM 2: 7 WEEKS IN TWIN SCHOOL 50-60% teaching

TERM 3: 8 WEEKS IN PARENT SCHOOL 60-80% teaching

Interviewing and Funding

Interviewing is the shared responsibility of TMs and SCs. In the interviewing period prior to the start of the first cohort in September 1993, some interviews were held in school and some in college. With such a significant element of responsibility devolved to schools, it was essential that an appropriate element of funding was transferred to schools to support teachers in their new role. Funding is used to release teachers from teaching and provide resources. An element of the devolved funding provides for monitoring of the programme by a GlosLEA Inspector who visits all schools involved with the programme, including Grant Maintained and Independent schools. The college has released a senior member of the Department of Professional Education for an equivalent amount of time to work in partnership with the Inspector in this monitoring role.

Issues raised by the Gloucestershire Partnership

- Placements: do PGCE teachers live near and belong to the school or near the college?
- Communication: between school & college and within school
- Funding: between school & college and within school
- Empowerment of Training managers: flexibility versus prescription (i.e. the balance between support for TMs and allowing for flexibility.)

The York Partnership Scheme

Graham Newson, the Curriculum Area Tutor at York University, and Richard Woodcock, School Curriculum Area Tutor for Mathematics at Huntington School in York, outline the York Partnership Scheme, now in its second year.

The basic model is for students to spend two days a week in partnership schools in the Autumn and Summer Terms; one day in cross curricular groups looking at whole school issues developed at the University earlier in the week; and one day in subject departments building up experience from observation to some teaching by Christmas.

All students spend the whole of the Spring Term in a different school on full Teaching Placement - using partnership schools and many others. In the Summer students return to their first school and the aim is for them to be a more positive resource for the school.

As the money given to schools has increased this year, more responsibility has been devolved to teachers in partnership schools. The University tutors do not visit the schools in the Autumn, the schools write a progress report on the Autumn students and in the Spring Term the usual pattern of a minimum of three TP visits by University tutors is kept for non-partnership schools but only one visit will be made to students in partnership schools, the school staff doing the other observations and reports.

The written assessment tasks have also been rationalised and refocus sed to be even more based on school activities.

Issues perceived by the University

From the limited experience so far the issues which seem to be emerging for the future from the University are:

- The irony that as more money goes to schools and more pressure is applied at the University for research and/or income generation there will be less genuine partnership.
- Related to this, the fact that many students will only be seen once in a classroom by their University tutor raises issues about references.
- The resources issue, especially Information Technology (IT).

How realistic is it to try to develop or maintain an up-to-date representative range of equipment, books and IT, as students move more into schools where often facilities are better than at the HE institution.

- Quality control of the students' experience.
- Elements of the PGCE course and, in some cases, subject areas and part time staff from schools having to go.

The Teacher's Perspective.

What are the gains, losses and issues from the perspective of a teacher (the mathematics tutor) in a partnership school?

Huntington School receive three or four students in terms 1 and 3 and two students in term 2. The purpose of the Thursday visits is for the PGCE students to gain classroom experience, mainly through observation and assisting but also by doing some teaching. As Huntington School has adopted a five, one-hour lesson day this year, and with the University indicating that the PGCE students should be in lessons for about 75% of the day, a timetable was constructed as follows:

Lesson 1 Year 7 (in pairs, where possible)

Lesson 2 Free to prepare, complete lesson observation booklet etc

Lesson 3 Year 8 (individually)

Lesson 4 The students to discuss their experiences with the school mathematics tutor

Lesson 5 Year 9 (individually)

With hindsight, it was felt that the students should have participated in four lessons, rather than three, as lesson 2 tended to be under-utilised, especially early in the term.

The school mathematics tutor teaches one hour less per week (which costs the school about £800) than he would normally do, which gives him some time to fulfil his new role. In practice, he finds that he spends far longer carrying out the tasks related to the 'post'. His new duties include:

- attending about three meetings per year at the University
- attending about 6 meetings per year with my professional tutor (in addition to numerous 'corridor conversations')
- preparing Autumn, Spring, Summer timetables for the students
- meeting each PGCE student weekly
- writing lesson observation reports and progress reviews

Throughout the year, the PGCE student should reflect on their developing skills as a teacher by completing a 'PGCE Student Profile'. This document is in three parts: (i) a competence diary; (ii) a competence discussion record; (iii) assessment task feedback forms/progress reviews. Parts 2 and 3 require some input from the curriculum area tutor.

The Mathematics Department is concerned that it has not received any finance to cover extra reprographics, text books and so on, even though they are four terms into partnership. There is also some disruption regarding schemes of work to accommodate the students. Careful timetabling is also necessary to ensure that individual pupils are not taught by too many students.

However, they recognise that there are some benefits from being in a partnership school. In the summer term especially, the PGCE students can be very resourceful. Last year two students wrote a report on primary/secondary liaison whilst another conducted a survey into why pupils choose to study certain A-level subjects with particular reference to Mathematics. In addition, there is the hope that the school may find innovative staff to appoint to the mathematics department from amongst their partnership students.

Issues for Partnership in Practice

It is recognised that there is now a considerable diversity of approaches to the challenge of school-based initial teacher education and that such diversity implies a number of different strategies will be employed. The following is a summary of issues raised in discussions at the AMET 1993 conference relating to ITE partnership in practice.

Quality Control within the Partnership

Does this become a joint responsibility? What authority and say do HE staff have over schools and/or departments used in partnerships? A range of practice seems to exist between the luxury of being able to select with discrimination and the constraint of having to accept placements because of other factors than those preferred. Do we select schools or departments within schools? What about the diversity of experiences which students get in schools? There are advantages as well as disadvantages to such diversity.

Assessment of Students in Schools

With enough debate amongst ourselves how can we come to a common agreement with teachers about understandings of satisfying competences? Where should we be aiming on the continuum between the holistic pass/fail judgement at one extreme and the checklist for each individual competence broken down into grades at the other? How can teachers in schools build confidence in assessing school-related work? Where is the mechanism for moderation and are the HEIs simply there to be troubleshooters? As the teachers take more control over assessment, the tension between their roles as advisers and assessors will be increased. If tutors in HEIs feel they manage it sensitively (or not), to what extent will teachers be as good as or worse than us in this regard?

The shortage of (suitable) placements

In general it is difficult to find placements for intending teachers, particularly in areas where HEI "catchment areas" overlap.

The assessment of competences

There are many frameworks of competence and many unresolved issues. For example, should competence assessment allow for development and use a graduated response by students, teachers and HEI teachers?

Paired placements

Is is important to aim for two PGCE students to be placed together in a department?

Method Tutor's Roles

Some partnerships seem to be resulting in a lessening of contact between method tutors and schools - in some institutions the core education tutors are the link personnel leaving method tutors adrift.

Professional Development of Partnership Teachers

What training should mentors receive? Too many teachers, through no fault of their own may still have a narrow perspective in the area of ITE, teaching styles etc. How can staff development be effective here? In an ideal world all mentors could do an MA at the HEI which specifically involves looking at different schools, but we do not live in an ideal world.

The Non-Standard Student

Increasingly, PGCEs take 'non standard' students onto their courses (overseas, mature etc) - is there an issue here about training mentors to supervise these students?

Is Mathematics Different?

Is Mathematics more of a problem than other subject areas in the light of lack of consensus on teaching methods and people's lack of confidence with Mathematics? If so, does this imply more money and time for Mathematics PGCE?

Time to Reflect on PGCE courses

Many courses under partnership seem to be getting more contact time as a result. Are courses becoming too tightly timetabled with too little time for reflection and private study?

Integration within the School

There can be a PGCE subculture within the school staffroom. Should we discourage this and how might we do so?

Subject v Generic Tutors

A major implication of partnership schemes may well be that their structuring means a non-Maths tutor from **HE!** relating to a Maths tutor/mentor in school. Could this break down subject divisions so that (good/varied) practice transfers?

A Model for Learning How to Teach

The following model for a three-stage approach to learning to teach with a goal of becoming a teacher capable of , reflection- in-action' is proposed:

1. Being offered a closed model for teaching: the *here is one I did earlier* tactic. The trainee teacher is asked to try an approach to a lesson plan and evaluate it. An example of this is parallel teaching, where the teacher takes a lesson with one group and the student tries the same lesson with a parallel group.

2. Selection from a range of approaches: Student selects from a number of predetermined possibilities and then evaluates the outcome.

3. Reflection-in-action: evaluation during the process of teaching ... teaching decisions are made in real-time by evaluating the reactions of pupils.

The impression of mathematics educators may be that all PGCE students are asking is: "Tell me how to teach"." However, it may be more accurate to regard this as an initial reaction of the PGCE teachers, the majority of whom then move to a later stage in the above structure.

Original pagination of this article – pp1-9

Learning to Become a Mathematics Teacher

Kiril Bankov

University of Sofia, Bulgaria

(based at University of Southampton, School of Education in 1993)

This paper deals with the training of secondary mathematics teachers in the University of Sofia, Bulgaria, where the author works permanently. The problem of the division of responsibility for teacher training between universities and schools is discussed briefly. It is argued that the prior responsibility should rest with the universities.

Introduction

Who should be responsible for the preparation of future mathematics teachers? This question concerns every mathematics educator. The general answer is: the responsibility must be taken by the organization which is the most competent to do this job. It may be a department at a university, or at a research centre, or some schools, etc.

I have seen that this question is now on the table for lots of mathematics educators in England, who are concerned about the recent trend towards the transfer of duties for teacher training from the universities to the schools. I am not going to judge whether it is good or bad for this country. I am describing the organization ofthe teacher training for mathematics in Bulgaria, hoping that this will be interesting and helpful to the reader.

The Organization of Teacher Training in Mathematics at the University of Sofia

The teacher training in mathematics in Bulgaria is carried out by four universities. As the organization at all of them is quite similar, I am taking as a case study the University of Sofia. Moreover it is the biggest and most popular place for studying the subject in the country.

The Department for Education in Mathematics and Informatics (EMI) is one of the departments of the Faculty of Mathematics in the University of Sofia. It takes the responsibility for the preparation of mathematics teachers.

The university students at the Faculty of Mathematics take general and basic courses in mathematics during the first three years. After finishing the third year at the University they must choose how to continue their academic education. The following choices are available: (1) To graduate after one more year at the Faculty of Mathematics; (2) To get the degree of Master of Science of Mathematics after two years specialization in pure mathematics or informatics (computer science); (3) To become a Teacher of Mathematics and Informatics by taking both mathematics and pedagogical courses for two years at the Department of EM!. The number of students entering the Department of EMI varies. For example four years ago about 50 students chose this Department. Since then their number has been rising and last year there were about 150.

Notice that there is a structural difference between Schools of Education at the universities in England and the Department of EMI at the University of Sofia. Schools of education provide teacher training in all basic school subjects while the Department of EMI (being a department of the Faculty of Mathematics) trains teachers of mathematics and informatics only. For example teachers of Bulgarian language are trained in the Department of Bulgarian Philology.

Main Courses Offered by the Department of EMI There are two pedagogical courses: "Pedagogy" and "Psychology", which are offered during the first year at the Department.

The course "Didactics of Mathematics" gives basic knowledge on mathematical instruction in the secondary school (for 10 to 18 year-old students). This is a large course which includes a lot of mathematical examples as well as theoretical principles and practical skills on teaching and learning school mathematics.

A similar (but shorter) course on "Didactics of Informatics" is offered, which deals with the problems of using computers in school.

So that students become more familiar with secondary school mathematics two courses are offered: "School Geometry" and “Algebra and Number Theory”. They are devioted to topics and mathematical problems from the national mathematics syllabus for the secondary school.

Mathematics educators at the Department of EMI believe that any teacher of mathematics must have a good background on school mathematics. That is why a course on "Practice on Problem Solving" is offered. Students practise problem solving by dealing with problems on a slightly higher level than the exercises and problems in the school textbooks.

There are some non-obligatory mathematical courses devoted to school mathematics (extracurricular work, evaluation, statistical methods in educational practice, etc.), which vary depending on the pressure of work of the lecturers.

For those who want to become more familiar with the potential application of computers in school some optional courses are offered: "Programming" (contains general principles of programming using PASCAL and BASIC) and "Problem-oriented Languages" (provides brief characteristics of the different programming languages, used for educational purposes, e.g. LOGO and LOGObased educational environments.)

School practice

During the second year at the Department of EMI, students spend most of their time at schools. The school practice consists of two stages which take place during the first and the second terms of the school year, respectively. (The University/school year in Bulgaria has two terms each of 15 week duration.)

The assessment of the school practice is based on the teacher's opinion as well as the impression obtained by the member of the staff during the two terms.

First term

Students are separated into groups of 10. Each group spends two periods of 45 minutes per week in a class together with a tutor who is a member of the department's academic staff. Students observe lessons and discuss each of them together with the tutor and the teacher. By the end of the term each of the university students gives one lesson to the school pupils in order to experience the atmosphere from the teacher's point of view.

Second term

Students are separated into groups of two or three. Each group is attached to a particular teacher, who supervises their work at school. During the term students take more and more lessons and by the end of the term each of them has about 75-80% of a teacher's load. A member of the department's academic staff visits each of the groups twice.

Some Comments on the Partnership

In order to be able to ensure school practice for about 150 students the Department of EMI needs to get into partnership with approximately 20 schools. This is not easy even in a town like Sofia in which there are hundreds of schools. Obviously taking university students causes lots of additional work especially for the supervising mathematics teachers. They are given small additional payments, which do not reflect the responsibility taken. One possible benefit is that though being in touch with the Department of EMI a teacher has the opportunity to become familiar with innovations in school mathematics instruction, i.e. to see how the land lies. Unfortunately fewer and fewer teachers volunteer to obtain this benefit.

On the other hand in order to ensure competent supervision the Department of EMI states some conditions under which a teacher may become a student's supervisor. That is why the problem of finding supervisors is becoming harder and harder: meeting the conditions, and the decrease in the numbers of volunteers.

Responsibility for the Training of Mathematics Teachers Let us turn our attention to the question raised at the beginning. Obviously the Department of EMI is responsible for the future teacher of mathematics in Bulgaria. There is no doubt that it comprises the most competent specialists in this field. What about the schools? It seems that the above statement excites apprehension on the participation of schools in this process. As a matter of fact, schools which agree to take university students for practice are very close to the teacher training. Not only because the mathematics teachers are very important in supervising the students' practice but also because a great deal of its depends on the teachers.assessment

Is it possible then to transfer the responsibility for teacher training to schools? Definitely not, bearing in mind Bulgarian reality. First of all schools have lots of work to do, which is so important and specific that no other organization could help. Although there are very good mathematics teachers who are acquainted with teacher training, they have neither the time nor energy to take on this additional job.

Teacher training is as important and as highly competent a matter as any other university discipline. There is no point in transferring it to non-academic organizations and in achieving the consequent devaluation of the training. The range and diversity of the courses offered at the University of Sofia is possibly the most convincing evidence that the responsibility for teacher training is rightly placed there and not in the schools.

Original pagination of this article – pp10-14

Unpacking Your Bags

Mary Briggs

School of Education, Open University

At the end of 1992 *I had just started a lecturing job at the Open University which included responsibility for the course EM236 Teaching and Learning Mathematics, and its associated examination. This was my first experience of examination marking for a distance-taught course in mathematics education. I was struck by the responses to one of the questions on a three-question, three-hour paper (Briggs,* 1993). *This question required students to work on a mathematical task and then analyse their work using course frameworks. In this question no specific invitation was made for students to express their feelings as they carried out the task, even though the 'affective domain' was discussed in course materials. A high proportion of the students did comment on their emotional responses. During this year I have compiled a new examination paper and in particular tried to take account of comments in the affective domain. The question selected and the responses drawn from ninety papers are discussed below. The responses fall broadly into three categories, those about the structuring and organisation of the question, those about the links between the question and previous experiences and finally those who linked their experiences in empathising with others. All the responses explored in detail their experiences of learning and to a lesser extent teaching mathematics. Whilst relating some of these directly to the examination question, they were unpacking their experience more generally.*

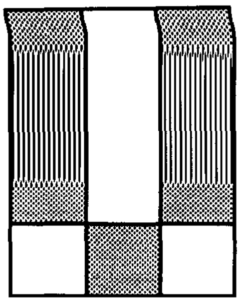
The Question

In this question you are asked to describe and analyse your work on a counting / algebraic task. Squared paper is provided. (Spend AT MOST 20 MINUTES on the task).

Coloured squares

3 of the 6 *squares in the diagram have been shaded. In what other* <u>*different*</u> *ways can this be done?*

Diagrams are acceptable though not required.



If you have already worked on tasks like this you may need, <u>*in order to answer the rest of the Question.*</u> *to extend the problem by varying the number of colours used, number of squares shaded, size of the grid ..... ?*

a) Give a brief account of your work on the task. We are more interested in your awareness of how you approached the problem than in a pre-determined solution in this part of the question. You should therefore indicate clearly the main steps which you went through when working on the problem; this may include decisions made and / or feelings at particular stages.

b) Analyse what you have done in terms of:

* *stressing and ignoring;*

* *systematically identifying different cases;*

* *the following aspects of mathematical knowledge: imagery, symbols and experience.*

The Structuring and Organisation of the Question

Before looking more closely at the specific responses to this question there are some general points that can be made. Firstly the question must be accessible to all the students, who for this course mayor may not have a mathematical background and could teach or have access to learners from five year olds to adults. The range of potential questions for such a purpose therefore is limited by those factors and also by the main themes of the course.

Unfortunately the reproduction of the question on the examination paper caused problems for a number of students as the small squares in the diagram were printed as (oblong) rectangles on the examination paper. This created negative feelings about the task right from the start, as one student articulates below:

''Also I feel 'picky' because the 'squares' in the diagram are 'rectangles'. Feeling totally negative therefore, I found 3 different shapes ... "

Making graph paper available for students answering this question I had also felt would help but there were other views .....

"My initial feeling when reading that graph paper was provided for question 3 *was total panic because I haven't used proper graph paper in years."*

At this point I was beginning to feel that far from easing the students' passage through this question I had inadvertently made things more ambiguous and produced more unnecessary anxiety!

Many of the comments in the affective domain were at the beginning of the accounts of the students' work on the problem. For one student it was the very words used that started the increase in the level of anxiety, showing clearly the effects of baggage from past experiences.

"The words 'Algebraic task '. All I could do was think that an algebraic equation was needed. I could not find one, the thought became horrifying to me so I decided to forget about algebra."

For others it was the type of task required and the match or mismatch with their expectations of this kind of task in an examination. The extracts below are clear examples of students unpacking their bags in the examination. They display their baggage regarding what they consider mathematics to be all about. This is highlighted by the use of the word 'proper' by one student.

"The first decision I made was to leave it till last. I'm glad I did because I have found it very difficult to come to terms with what the question is about- I cannot visualize what we're expected to do or *make sense of the question. I feel annoyed and frustrated because the question is either blindingly obvious (it can't be just that .. .)* or *too complicated. I want to get some sort of solution but won't*

be able to because I feel its' not a 'proper' question .... "

"My first thought was this task seems stupid, how on earth am I going to be able to work on it for 20 mins.",

“I found it frustrating to begin with to have no clear focus for possible work, but challenging to have the opportunity to develop something from it. "

"Initial feeling- PANIC- oh my God - what does it mean? Feeling - I don't feel as if I am thinking mathematically about this. I am not sure what is wanted. "

"My initial feeling when confronted with a task like this is a little flutter of panic! Is this an IQ test? What is the question?"

"I wanted my experience of maths to be more use in this question- I tried to think of different 'settings' to make sense of the problem, but it didn't work. I would have liked to know more about how the pattern was generated, how one could predict what came next, and what formulae could be used to describe the rest of it. It just reminded me of BATs. Typical of exam past experience: 'catch you out',"

It is impossible to ignore the additional anxiety of completing this type of task under examination conditions, especially for the mathematically anxious. The choice of question was designed to be a task that was achievable within the time allowed. It was not chosen to test the students' mathematical knowledge but an opportunity for them to show how they could use the process skills that had been explored in the course. At the same time they were asked to reflect upon their work on the given problem including their feelings- comments in the affective domain.

It is worth commenting that as part of the continuous assessment for this course students had been asked to carry out work on similar problems. In addition after the first year's reactions to the examination question tutors were also briefed about students concerns in this area,

Links Between the Question and Previous Experiences Vague memories

Some students had half-remembered facts that they thought would be useful but weren't able to recall the connections,

"Initially I was annoyed because I know somehow this is related to '3 *from* 6' *on Pascal's triangle or that formula with n,* c, *v and factorials everywhere but I couldn't remember exactly. "*

"There were feelings of panic as I didn't seem to be able to find very many patterns and I was sure there were more."

Half-remembered facts can often impede work on a task, blocking the possibility of returning to first principles. I have clear recollections of this occurring for me when asked to work on a number pattern sequence and the only thing that I had a clear image of was half a formula. This image was so strong that it became impossible to blot it out and work from information I could gain from looking at the task afresh. At the same time these extracts highlight a feeling that with mathematics you must be able to continue to work on a task right to the end and that not being able to implies failure.

Memories from teaching

This issue of memory occurred again in some of the initial comments focusing on recalling the problem in another setting. In the case of the examples here the previous setting was in their teaching of mathematics apparently based on tasks already undertaken with learners.

"Looking at the given diagram I remembered doing something similar with a Year 9 *last year and recalling one of them saying that you needed to do it methodically or you get into a muddle."*

"My first impressions on seeing the task were - good, I remember working on an activity like this with children. They had to place eggs in a carton and record the different combinations available for 1 *to* 6 *eggs. "*

"My heart sank when I saw the problem. I have just been working on this with a Year 11, *low-attaining pupil, as part of her coursework. The sinking feeling was due to the painstaking colouring on her part and frustrated attempts on my part to explain that the shading is incidental - to try to see some connections and generalisations. "*

Anotber two examples focussed on images from commercially published textbooks. What is difficult to gauge from these examples is how those reporting the examples and/or the learners might have been introduced to this type of task. The mere fact that someone may have more experience of working on similar tasks may not always be of positive value. This may mean someone has more potentially unpleasant memories to draw upon.

"My first reaction was to think 'oh' shading a half. .... For most of it 1 *was feeling a bit frustrated because it is such a standard textbook question although the words 'how many other ways can you shade a half, wasn't put."*

" ... my immediate concern was to do with what this question is actually about, as it reminds me of children's' texts, e.g. Fletcher's Mathematics for Schools, in which children may be asked to draw diagrams showing different ways of illustrating a half, or as in this case, 3 out of 6. "

Images from memory

Several of the students actually tried to put this problem into another context before they felt they could begin work on the task or at least would have preferred the question worded in a more familiar context. These examples show students choosing wellknown pictures to aid their imagery as a strategy that provided them with support and potentially more confidence in tackling the task.

"1 put the task into a real life situation. I visualize the problem as being one of six tiles over a sink in the kitchen. My task was to find out how many different arrangements I could come up with using three coloured and three non coloured tiles. "

" .... 1 decided to ignore my negative feelings and thought the squares were probably squares of chocolate perhaps finding ways to show half a block. "

" .... 1 am now thinking about a draughts board. I have seen squares like this before, oh yes and a car racing flag'the chequered flag'. "

One student clearly articulated the reasoning behind this approach to tackling the task.

"*I found it impossible to work without an image of what [was doing - which makes clear the importance of context and relevance in the teaching situation. [wanted to be able to use some automated skill or technique to tackle the problem but without an image of what was required couldn't really do this with any confidence. "*

Few memories

Perhaps the greatest difference in the comments on this year's paper from those of last was in the area of the students' own previous experiences of teaching and learning mathematics. This was a substantial source of comments in the affective domain. For some of the students contemplating teaching as a profession this was a major issue affecting their attitudes to mathematics.

" *I approached this problem with feelings of trepidation, the only time I have done any mathematics of this kind has been in the work for this course. Mathematics was taught by rote and example when I was at school, consequently I do not have great confidence in my ability in this area .... "*

"Not being a trained mathematics teacher this task is a new one to me. [n fact my first response was what on earth shall I do! Shall I pack up and go home. As you know I haven't. My mind transferred to school and I thought of pupils who no doubt feel, probably too often as I have done. I then Panicked looking at the clock! I must do something. I felt dreadful. I could not visualize a counting as algebra situation, however I stopped and collected my thoughts. "

"My mathematical knowledge and experience is not vast and to some extent this task has taken me by surprise. I found that imagery was predominantly fixed on a grid with moving shapes."

" *I have not worked on a task like this before so tried to spot patterns, systems and knowledge that I may have had previous experience of through a different context. This was in my head. My feelings were of slight dismay – time is running out quickly and I need to spot a starting point (quick!)"*

" *I find problems like this very difficult to approach in* a *pressurized situation. I like time to mull them over and decide how I'm going to tackle them. This indicates my experience. I have met mathematical problems of this nature before, they are a part of my experience but not* a *regular feature, therefore as far as experience in terms of mathematical knowledge is concerned in this case it does not provide me with an immediate approach."*

" *I wanted my maths teacher to be behind me giving me guidance or reassurance that all was well, or to help me to find other possibilities perhaps not telling me the answer but by guiding me through questioning. "*

Empathising with other learners' experiences

A large number of the students on this course this year were not practising teachers but were in the process of completing their degrees prior to applying to study a PGCE course either through the Open University or other institutions. This might explain the reflection on their own learning of mathematics in the previous set of examples. It may also explain the next set of comments focusing on the parallels with pupils' feelings.

" *I can now sympathise* a *lot with pupils. "*

"This may parallel a *pupil's reaction when the teacher says we are going to 'do __ ' today. "*

"When I had completed the 15 *different rectangles I stopped and tried to think of* a *formula that] could use to explain what] had done, but all that kept coming into my mind was x=? I decided that his did not matter, as] may not have an algebraic solution, but] was able to give an answer whether it be right or wrong. I suddenly felt, like I used to at school when algebra was my fear. The task gave me no purpose, what use was this going to be for anyone?]t made me realise what rejection children may feel if they can not answer* a *question in the way they think the teacher wants or, in my case, the exam marker, wants to see. "*

"My feelings are how to get pupils to work on this in an algebraic symmetrical way. "

Not all the comments in the affective domain were negative. In fact, some were very positive, at different points through the task.

"The first feeling was one of relief that the task was straightforward and something that I could do. I have met this before and therefore thought it might be too simple. Should I attempt one of the more difficult suggestions, was my next thought. Knowing that there are many solutions I decided to start with

this and progress to one of the more difficult ones after about 10 mins. Once I started I was engrossed. I really enjoy a problem. ".

" .... *The ease with which I did the first bit encouraged me but I could not at first decide what the point of the exercise was.* ".

' ..... All of a sudden I began to SJ£.the possibilities'.

"My own upbringing in maths was one where there was always a 'right' answer so I find this kind of task difficult and occasionally threatening. However as I do more of them. I'm becoming more at ease with this approach. "

By altering the wording of the question to highlight acceptance of the students' feelings in written form, through the process of working on this problem, there has been a definite increase in the number of comments in the affective domain. This has produced substantial changes in the qualitative aspects of the comments. These have been more wide ranging and both positive and negative. They have not always focused specifically on the task in hand but have related to experiences of teaching and learning mathematics in general. One reason for this may be the changing population of the course even though it is only in its second year. There has been an increase in the number of students who are not trained teachers but hope to become teachers in the future.

The results of altering the question have been to encourage the students to reflect upon their experiences not only whilst engaged with the task but also on the wider issues in teaching and learning mathematics. Since a large proportion of these students are prospective teacher training students, this course and the experience of the examination may well have given them a head start in the process of becoming refletive practitioners.

References

Briggs M. & Crook J. (1991) Bags and baggage, in Love E. and Pimm D, (eds) *Teaching and Learning Mathematics,* Hodder and Stoughton

Briggs M. (1993) Bags and baggage revisited (or another suitcase on the rack) *Mathematics Education Review, no 2*

Original pagination of this article – pp15-24

An Attempt to Make Mathematics Accessible to Physically Disabled Pupils Through Information Technology

Veronica Pilkington and Pinder Singh University of North London

This report discusses a school project undertaken by the final year students as part of their college-based course; it looks at special needs of physically disabled pupils in a mathematics classroom. The project was an attempt to observe the needs of a particular group of children and to try to improve their access to the curriculum via the vehicle of specific software. The reader must be made aware that throughout the project, for all concerned, this was a learning experience where more questions were raised than were answered.

Introduction

Beginning-teachers on a two-year BEd course in secondary mathematics spent eleven weeks of the final year studying a theme related to special needs in the mathematics classroom. Each beginning-teacher managed to visit pupils with special needs in two different types of schools- a special school and an integrated mainstream school. The initial two visits occurred twice a week and the third visit consisted off our days where the trainee teachers had an opportunity to tryout some specially prepared curriculum materials with chosen pupils.

Presently, Northumberland Park Community School (NPCS) has a unit for physically disabled pupils attached to it. These pupils come from a special school nearby and the intention is to integrate as many of the physically disabled pupils as possible over the next few years. The support staff in the special unit in NPCS expressed a desire to offer appropriate support to those pupils during mathematics classes. In the unit there are fifteen physically disabled pupils.

Background to the Project

The project originated from the identified needs of NPCS. These were to improve the access of the disabled pupils to the mathematics curriculum through the use of appropriate software.

This concept took on a whole school perspective in that the chosen packages were to be of value to able-bodied pupils. And in turn, as the intended software becomes widely used, disabled pupils should become empowered as maths IT experts.

On a voluntary basis, seven of the ten beginning-teachers undertook the task of identifying the special needs of six physically disabled pupils. Disabilities ranged from cerebral palsy, scoliosis, spina bifid a and hydro caephalus. The pupils all had general mobility and most had poor motor control. The general problems were with motor responses, particularly those involving co-ordination of both sides of the body. All the pupils concerned had difficulty with writing, drawing, and using mathematical Instruments.

The beginning-teachers' objective was to overview software in order to access the curriculum for classroom use with the chosen pupils.

Method

At first the emphasis was for the beginning-teachers to set up meetings and to allocate tasks within the group. Each member of the group was allotted a software package to evaluate. Findings were brought back to the group for further analysis in order to sift and retain or discard as appropriate to the needs of the pupils concerned.

The first stage of trialling was set up on an informal basis where the pupils could play and become familiar with the software. This had been decided by the group as an observation period for them to reflect upon and use in their curriculum material planning. The retained software was related to parts of SMILE and with respect to the National Curriculum. Cards were adapted for use pertaining to the software or alternatives were found.

The second stage of trialling was to tryout the revised curriculum materials, and the final outcome was to develop a collection of materials to produce for the use of the pupils at NPCS. It was also the intention of the group to present their findings and to introduce the recommended software to the support staff of the unit.

The Results

A few of the software packages were discarded following group discussions. *Derive* and *LOGO-Mac* were dropped at the onset as not meeting the needs of the pupils in this particular case. *Supergraph* and *LOGO 2000* offered the same area of the curriculum and it was decided to use *Supergraph* for graphical representation as it was more apt for the needs of the selected pupils. *LOGO 2000* was used as a data base package. Hence the group became more discriminatory as overlaps in the use of different software were identified. It was finally decided to use *Cabri Geometre* , *Access Maths, Supergraph, Excel* and *LOGO 2000.*

Different mathematical topics were chosen and related to SMILE or directly to the National Curriculum. It was found in theory, but not in practice, that most of the National Curriculum targets and levels could be met using a combination of the software used.

As a result of the beginning-teachers' findings it was decided to give feedback in the form of INSET to NPCS. It was a period of change-over to the school. The school was happy to take on board and explore further the findings of beginning-teachers in the coming academic year. The school went on to acquire a particular software appropriate to their needs given the recommendations of the group.

Discussion

The school felt that not all the software that they had originally intended to acquire was now appropriate for their requirements. They felt that the beginning-teachers' evaluation of the software had helped them to identify how it could be put to use in the classroom. The results of the project had aided future planning for the implementation and the use of the chosen software in the classroom. The findings had helped in the preparation for bids for funding the purchase of the chosen equipment and software. Following an introduction to the software during the project and INSET, support staff went on to relevant courses.

The project was a two-way process. All of the beginningteachers felt that the experience of working in a team in a real-life situation set in school was invaluable for future practice as a newly qualified teacher. Previous assumptions that support teaching staff were totally versed in the running of a particular scheme and that mainstream teachers were familiar with all of the pupils' needs were dispersed as a result of this partnership. These wrongful assumptions were replaced by a real partnership consisting of mutual co-operation and respect .

By working with the support staff, the group realised how extensive the gaps in the curriculum actually were for a pupil with physical disability working independently. They also began to realise the huge potential for actually openming up a scheme of work giving access to special needs pupils through the use of software. It was found theoretically possible to cover a wide range of the curriculum using all of the above software but in practice this proved to be impossible due to the limitations of this project.

The pupils were generally highly motivated and gained satisfaction from being in a position of empowerment. Once they became enabled, confidence grew as a result. The more empowered the pupil, the more intrinsic the motivation. The benefits here were two-fold. On the one hand the pupils would gain access to the curriculum, and the other benefit held latent potential for improving future classroom practice. If this learning technique was adopted and the pupil was so empowered, less teacher intervention would be required as the pupil became increasingly independent.

In retrospect, for the beginning-teachers, watching a pupil express delight in being able to do geometric drawings independently, such as a circle or a straight line, created an awareness and a sensitivity to the learning and emotional experiences the pupils face. The beginning-teachers reflected on the need to develop an awareness of these dynamics and know when to withdraw and resist too much teacher intervention. This awareness could only be gleaned by hands on experience and not learnt on an entirely theoretical basis.

Within the time scale of this project extensive evaluation was not completed on any particular software. Any rigourous evaluation could only be done over a much longer period.

Conclusion

To keep a perspective on this, only a minute insight was gained here. The project unfolded as a direct result of the current move of integration into mainstream. The magnitude of the problems met could not be answered within the confines and limitations of this project. But the resulting outcome was considered to be a step in the right direction.

A stream of questions that arose remained unanswered. Issues were raised, such as, how best was the software utilised to meet the needs of pupils in mainstream classroom practice? Would the teacher have the time to do this, or the desire, in a busy timetable? Would it add more pressure to the teachers' existing load, or could teachers be convinced as the beginning-teachers had been of the long term benefits for all concerned? Could this use of IT be built into the scheme of work of a department, or would it meet a resistance? An opinion was considered by the team that access to the curriculum by this method could only be improved if mainstream teachers adopted this approach in their classrooms. A further extensive study would have to be done before any hypothesis could be made.

The possibility was discussed of moving into other areas of special needs such as hearing impairment and severe learning difficulties. But again the scale of the project would not allow for any exploratory investigations and now it can only remain for others to take up the invitation to pick up where we left off.

Finally, with less and less flexibility possible in Initial Teacher Training courses, we are left wondering what opportunities will exist in the future to be able to respond in the kind of way described in this report to the needs of a school, beginning-teachers and pupils?

This article is converted from the print version published by the Association of Mathematics Education Teachers (AMET)

Articles available online at www.amet.ac.uk

Original pagination of this article – pp25-29

Calculators in the Primary School . since the Introduction of the National Curriculum

V. Warren and J.G. Ling

University of Hertfordshire

This article provides a summary of research carried out in Hertfordshire into the use of calculators in primary classrooms since the introduction of the National Curriculum. Factors determining classroom practice are identified together with teachers' attitudes towards calculator use. The implications for INSET provision and Initial Teacher Training are considered.

Introduction

Although the use of calculators in the primary school has been advocated by mathematics educators, HMI and DES for the past fifteen years, it has been controversial because it challenges the traditional content of the mathematics curriculum particularly regarding methods of calculation. Hilary Shuard (1986) noted that, "the new technology of calculation provides the biggest challenge to the content of school mathematics throughout the whole history of compulsory schooling in this country." Consequently, the adoption of the use of calculators has not been as widespread as might have been expected. In 1989, HMI reported that calculators were rarely found in infant classes and were used in only two fifths of upper junior classes. However, the debate about calculators and methods of calculation has detracted from the potential of the calculator as a tool to enhance understanding of number for skills acquisition, concept formation and reinforcement and for number investigations. "The calculator is a pocket laboratory for exploring how numbers work." (Parr 1990) These uses were given further support by Ofsted (1993:21) which recommended that teachers should "make greater and more effective use of calculators ... to assist children's understanding of number."

A significant development in the debate about calculators and methods of calculation occurred with the introduction of the National Curriculum in 1989. The use of calculators in the primary school ceased to be optional because specific references to calculators in the Attainment Targets made their use a statutory requirement and the Non-Statutory Guidance recommended that they should be used at all four Key Stages. The requirement to use calculators was further reinforced by their inclusion in the Key Stage 1 Standard Assessment Tasks.

The Survey

As part of the continuing debate about the use of calculators in the primary school,' this research aims to assess the impact of calculators on primary mathematics by examining actual practice in Hertfordshire three years after the introduction of the National Curriculum. A questionnaire survey, which included an attitude scale, was the main method of data collection and this was preceded and followed up by interviews. The sample population, which consisted of 199 teachers from 25 schools in one education division, was considered to be representative of the County in terms of socio-economic background, location (urban/rural) and school size. The schools were randomly selected maintaining the overall ratio of infant, junior and JMI schools in the division.

The initial, exploratory interviews were used to identify those issues which were of importance to teachers. On the basis of this information, variables to be included in the questionnaire were identified and the research hypotheses were formulated to test the significance of the relationship between variables. These variables included age group taught; the number of calculators available; frequency of use; course attendance, and teacher attitude towards calculator use in the classroom. The latter was measured using an attitude scale consisting of ten statements about calculators to which respondents were asked to give their opinion. Each response was scored from -2 to +2 and aggregated to give an 'attitude score'. The questionnaire was also used to find out how calculators were being used in the classroom and the reasons given by teachers for use and non-use of calculators. The follow up interviews were used to probe questionnaire responses in greater depth.

Results

The results are considered in two sections:

a) Actual classroom practice indicated by frequency of use, calculator availability and type of use which are considered against official recommendations.

b) Factors determining this practice indicated by teacher attitude

and reasons given by teachers (or use and non-use of calculators. **Actual Classroom Practice**

i) Frequency of use

Table I Frequency of Use in the Classrooms of all Respondents

Frequency	Number of Respondents	(N=155)
Not at all	12	(8%)
Occasionally (once/twice a term)	70	(45%)
Moderately (weekly)	60	(39%)
Frequently (most days)	13	(8%)

Recommendations do not specify how frequently calculators should be used, but the Non-Statutory Guidance of the National Curriculum states that, "Calculators ... should be available for pupils to use at all four key stages." (DES 1989, Section E: para. 4.1) 92% of the sample were following this advice. They were being used weekly or more often in nearly half the classrooms; in the remaining classrooms they were being used once or twice per term or not at all. They were used more frequently in junior classrooms, and the majority of those who did not use them at all were Reception teachers.

ii) Calculator Availability

Table II Number of Calculators Based in the Classroom

Number of Calculators	Number of Classrooms	(N=156)
5 or less	73	(47%)
6 - 10	56	(36%)
11 - 15	16	(10%)
16 - 20	5	(3%)
21 +	6	(4%)

These results can be considered with reference to the recommendation from the Hertfordshire County Mathematics Adviser that every classroom should have a minimum of six calculators. This advice has been implemented by just over half of the sample. Junior classrooms had a greater number of calculators with over a quarter having eleven or more.

ii) Type of Use

Table III Calculator Uses in Order of Popularity

Uses	Order of Popularity: Grand Total of Ranked Scores	Number of Times Selected
Investigations	555	99
Reinforcement	471	90
Checking	430	83
Difficult calcs.	421	81
Free Play	349	69
Mental Skills	211	48
Basic Concepts	182	43
Other	57	15

(154 Respondents. More than one choice possible)

The main types of calculator use i.e. investigations, reinforcement and difficult calculations, were in accordance with official recommendations. Checking calculations was also a common use although it is not usually recommended, on the grounds that if a calculator is used to check an answer acquired by another method, it would be more appropriate to use the calculator in the first place. The popularity of this use of calculators may be due to the fact that it has the added advantage of aiding familiarity which was the most common reason given for the use of calculators. The possibility must also be considered that it enables teachers to continue to use more traditional methods while providing a 'nominal' opportunity to use calculators. The recommended uses of calculators to enhance mental facility and to teach basic concepts were less common.

Factors Determining Classroom Practice

In the initial interviews three factors were identified which might influence classroom practice. These were teacher attitude, the age group of the children being taught and course attendance. Frequency of use was taken to be the measure of classroom practice and research hypotheses were posed to test the significance of the relationships.

i) Teachers' Attitudes Towards the Use of Calculators

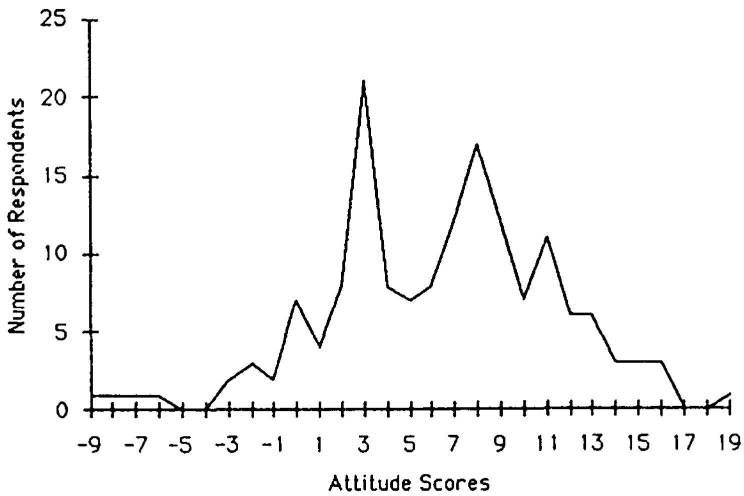


Figure 1 Frequency Distribution of Attitude Scores Towards the Use of Calculators

The mean of the attitude scores for the sample was 6, the standard deviation was 4.85 and the range was from -9 to +19. (The possible range of scores is from -20 to +20.) This suggests a tendency towards a positive attitude, which may be due to the fact that as calculators are supposed to be used in primary schools, teachers may feel obliged to view their use favourably. Teachers with positive attitudes towards the use of calculators did use them more frequently in their classrooms, but as the determinants of both attitude and behaviour are extremely complex, it must be emphasised that there may have been other extraneous factors involved.

ii) Age group of children in class

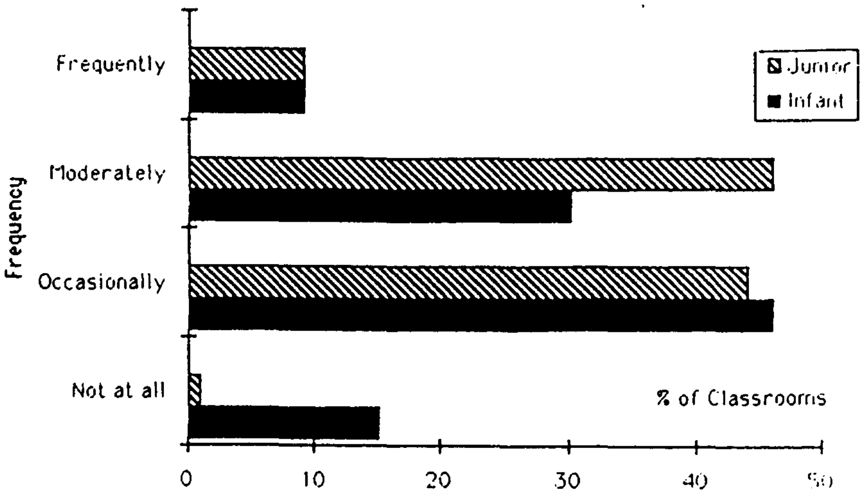


Figure 2 Frequency of Use in Infant and Junior Classrooms

The main difference between infant and junior classrooms was in those where calculators were not used at all. This was the case in 15% of infant classrooms (mainly Reception classes) but only 1% of junior classrooms. Although the overall picture indicates that calculators are being used more frequently in junior classes, the difference is not statistically significant.

iii) Course attendance.

Just under a quarter of all respondents had attended a course and two-thirds expressed a wish to do so.

Table IV Frequency of Use by Course Attendance

Frequency of Use	Course Attendance Yes	No
Not at all	2 (6%)	11 (9%)
Occasionally	12 (35%)	57 (48%)
Moderately	15 (44%)	45 (38%)
Frequently	5 (15%)	7 (5%)
Total	34 (100%)	120 (100%)

The difference in frequency of use between those who had attaended a course and those who had not is not significant. The fact that only 22% had attended a course may be a contributory factor.

iv) Teachers' Reasons for Use and Non-use of Calculators

Teachers were asked to provide two reasons in favour of the use of calculators and two reasons against. These are categorised as follows:

Table V Frequency of Categories of Reasons for Use of Calculators

Categories For Use of Calculators	Item Frequency	Category Total
DEVELOPING NUMBER FACILITY		95
Large numbers, difficult calculations	33	
Save time, quick answers, accuracy	23	
Checking answers	27	
Mental maths	6	
Encourages estimation	6	
UNDERSTANDING OF NUMBER		85
No. patterns, invests. experiments with nos.	29	
Reinforce number work (including place value)	20	
Enrich no. work, no. awareness, breadth,	17	
Focus on problem, problem solving	11	
Aids understanding	8	
Diagnostic	3	
NEW TECHNOLOGY		62
Familiarity, competence, a skill	37	
Preparation for adult life, useful tool	19	
Introduction to I.T, part of I.T.	6	
ATTITUDE		36
Enjoyment, fun, confidence, success	36	
STATUTORY		6
National Curriculum requirement	6	
MISCELLANEOUS		4
Fine motor skills	2	
Concentration	1	
Children can work at own level	1	

Table VI Frequency of Categories of Reasons for Non-use of Calculators

Categories for Non-use of Calculators	Item Frequency	Category Total
REDUCING NUMBER FACILITY		150
Mis-use (cheating, unnecessary use, laziness, dependence)	86	
Reduces mental agility	23	
Basics first	29	
Discourages learning of tables	9	
Must be able to estimate first	3	
DISCOURAGING UNDERSTANDING		32
Get answers without understanding	30	
Discourages learning, causes confusion	2	
AVAILABILITY & TECHNICAL CONSIDERATIONS		30
Not enough available	7	
Easily broken, lost, unreliable	14	
Wrong button, frustration, buttons too small, display too complex, digital nos., interpretation	9	
CLASSROOM MANAGEMENT		11
Too teacher intensive, cannot check correct use	7	
Time	4	
MISCELLANEOUS		4
"Fiddling", time-wasting, children too young	3	
Parental opposition	1	

Additional factors influencing classroom practice which arose in the follow-up interviews included: availability and durability; demands of implementing the whole of the National

Curriculum; lack of knowledge; and lack of compatibility between traditional mathematics teaching and the use of calculators.

Conclusions

The evidence of this study suggests that changes have taken place since the introduction of the National Curriculum and that greater use is now being made of calculators in the primary classroom. Although the study does not provide conclusive evidence, it is likely that this incrtease is due to the National Curricuulm requirements. In the Hertfordshire Mathematics Advisory Service, the majority of requests from primary schools during the year following the introduction of the National Curriculum related to the use of calculators. In a review of mathematics since 1989, Margaret Brown (1991) has suggested that the increase in calculator use is due to the National Curriculum. A closely related issue is the content of the SATs (Standard Assessment Tasks), These were referred to by very few teachers in the survey; nevertheless, in 1993 the Key Stage 1 tests included more calculator items than in the previous year, and the extent to which they are included in the Key Stage 2 tests in 1994 is likely to be significant in influencing classroom practice.

Although the evidence in this study suggests that calculators are being used more frequently since the introduction of the National Curriculum, this needs to increase further if, "calculators . . . are to offer an opportunity to increase standards of attainment." (DES 1989: Non-Statutory Guidance, Section E, para 4.2) In order to achieve this, the number of calculators available still needs to be increased; this is supported by the findings of Ofsted (1993:18) that "electronic calculators were usually insufficient in quantity."

Three main issues have arisen from this study which have implications for further research and for mathematics educators. Firstly, there was a clear lack of agreement about the consequences of using calculators which was shown in the reasons which teachers gave for use and non-use of calculators. Secondly, there was considerable lack of consensus among teachers about the role of calculators as an aid to understanding. This was evident in the reasons given for use and non-use of calculators and in the responses to the attitude statements in which a third of the respondents recorded 'uncertain' for 'Calculators increase understanding'. Thirdly, a lack of knowledge about ways of using calculators was identified by several respondents in the follow-up interviews, and two thirds of the survey sample expressed the desire to attend a course.

The lack of agreement about the consequences of calculator use in the primary classroom needs to be addressed by further empirical research into whether children make more progress using calculators than they do without them. Although there have been experimental studies carried out in the United States, Rowland (1992) points out that most research in this country has been in the form of curriculum development projects such as CAN (Calculator Aware Number). Although such projects have indicated the benefits of calculator use there has been no comparative dimension by which relative progress of children can be judged.

What are the implications for Initial Teacher Education and INSET provision? In ITE the foundations of good practice in mathematics teaching must continue to be laid during the core curriculum course. This should be facilitated by the new criteria of 150 hours 'directed time' for mathematics stipulated in Circular *14/93: The Initial Training of Primary School Teachers: New Criteria for Courses.* The course should include ways of using calculators to enhance learning and understanding; the rationale for their use; a familiarity with the Attainment Targets of the Mathematics National Curriculum, which specifically refer to calculators, and an awareness of the advice given in the Non-Statutory Guidance.

Teachers in the survey expressed a need for and a willingness to attend INSET courses. The reasons they gave for the non-use of calculators suggested that the view that the use of calculators reduced number facility, enabling children to 'cheat at sums' was common. Therefore there needs to be input on INSET courses on ways of using calculators as a tool to enhance the understanding of number. For INSET courses to be effective, they must not on Iy improve knowledge and enable teachers to reflect upon their practice, but also the knowledge gained must be disseminated to other teachers within the school. A particularly successful form of INSET which has met these criteria has been provided by the designated 20 Day Courses. The NFER review 'Mathematics and Science Courses for Teachers' (Harland & Kinder 1992) has shown that the effectiveness of this model has been widely recognised by schools, LEA's, H.E. institutions and the Department of Education. These courses need to continue if more teachers are to have the opportunity to attend them or to benefit from feedback from colleagues who have been able to do so.

The challenge for mathematics education is to build upon the changes which have already taken place in classroom practice in order to enhance children's understanding of number by realising the full potential of calculators as a teaching aid. The evidence of this study regarding teacher's attitudes towards the use of calculators and their perceived need for further INSET, are positive indicators for the achievement of this goal.

References

Brown, M. (1991) The National Curriculum: a Progress Report *Mathematics Teaching* No 134, pp.34-37

DES (1989) *Mathematics in the National Curriculum* (London, HMSO)

DES (1989) *Aspects of Primary Education: The Teaching and Learning of Mathematics* {London, HMSO)

Harland, J. & Kinder, K (1992) *Mathematics & Science Courses for Primary Teachers: lessons for the future* (NFER)

Ofsted (1993) *The Teaching and Learning of Number in Primary Schools* (London, HMSO)

Parr, A. (1990) *The Calculator Collection* (Hertfordshire County Council)

Rowland, T. (1992) Inadmissible Evidence? in *Micromath* Vol. 8 No 1

Shuard H. (1986) *Primary Mathematics Today and Tomorrow* (SCDC Publications)

Original pagination of this article – pp30-40

Introducing Primary PGCE Students to their Mathematics Course

Rod Bramald

University of Newcastle upon Tyne

Alison Wood

Homerton College, Cambridge

Introducing primary PGCE students to their brief but important course in mathematics education is not easy. Below we have set out in some detail how two particular institutions introduce their courses. Each is trying to do a similar task and each does it in a different way. The experiences are offered in the hope of stimulating perhaps other contributions and certainly constructive comment upon how these might be improved upon. Neither writer claims their work to be unique nor to be totally original but they are offered in a spirit of professional sharing.

The Homerton Experience

We believe that the first 15 minutes of a PGCE mathematics methods course for Primary teachers is crucial. Our students arrive with varying attitudes towards mathematics. All of them have G.C.S.E grade 1-3 or equivalent. The majority have done no formal mathematics for several years and, for many of them, their recollection of mathematics is of a set of algorithms, often taught in an uninteresting way which had to be remembered and regurgitated at the appropriate time. Students who have had this experience at school fall into two categories. Firstly those who could remember the algorithms - they often claim to have enjoyed mathematics because they could do it. Secondly those who could not remember the algorithms - inevitably they did not enjoy it.

Few people enjoy spending an hour each day on something in which they achieve, by their own standards, little success, especially if they are high fliers in other academic areas. Fortunately there is always a small group of students on the course who failed to gain an O-Level in mathematics at school and have recently returned to study the subject and take G.C.S.E in order to enrol on the PGCE course. This minority are usually very positive about the experience and speak enthusiastically about their interest and success and the way their teachers helped them to understand what they were doing. Most students are somewhat nervous about entering the mathematical arena again and are frightened of showing their ignorance to their new colleagues in what they see as a black or white subject. They expect the mathematics course to supply them with a "kit" which will enable them to teach standard algorithms for the four rules to their pupils. Whilst, of course, wishing to develop in our students the skills which will equip them to teach A.T.2, it is essential that we challenge them to reflect upon their own experiences of learning mathematics and decide whether they would have gained more from their ten years of attending mathematics classes at school if they had understood why the rules work.

Our experience of many groups of PGCE students has taught us that we have to convince them of four things very early in the course :

- that children should know that the relationship between themselves and the teacher is independent of their ability to understand mathematical ideas;

- that many adults use non-standard methods for basic four rule calculations and that children may have idiosyncratic though effective and quick methods for finding answers. These methods must be respected and good reasons given for requiring such a child to apply a standard algorithm rather than use his or her private method;
- that there are several styles of teaching which are appropriate for mathematics sessions and that discussion (in pairs, groups or a class) should playa major part;
- that variety is essential to maintain a child's (or PGCE

student's) interest.

Below, I describe the all important first session that we have successfully used to start the course.

Introduction

(A very brief outline of my aims for the course)

- To increase your confidence and pleasure in doing maths.
- To discuss methods of teaching maths in particular to children at Key Stage 2 and point out some of the problems children experience.
- To familiarise you with the N. C.
- To familiarise you with the resources available in schools and their use
- To equip you to cope on school visits and for your first two years as teachers.

(This comes as no surprise to the students, this is what they expected and are hoping for!)

Plan for the session:

Because you will soon discover that the overwhelming problem is not going to be the CONTENT of the N.C. but the ORGANISATION and, in the new scene in schools, ASSESSMENT, the rest of this session is to be spent in showing you a possible way of splitting up a 2-hour period to provide variety both of activities and styles of teaching.

Development of session:

The actual content of this 'lecture' is not important so DON'T WORRY if you can't do all the maths, it is the ~ of activity of both you, the consumers, and me, the teacher, which matters.

ACTIVITY 1 (10+ mins)

A didactic "mini-lesson".

In this activity I stand by the chalkboard teaching a new mathematical idea which (so far) no student has heard of before. After each dollop of information students do a few examples to check they can use the rules they have learnt. At no stage is any application of the idea put forward, nevertheless, all students can, and do, learn the the necessary algorithms. This experience of "learning" mathematics is usually familiar to the students. This is a dead easy lesson for me.

The example is that of a field isomorphic to the field of rationals where aIb is written as aNb. The numbers are described thus:

Noitcarf numbers.

A Noitcarf number consists of two whole numbers separated by the capital letter N, e.g. 5N2

Question (i) Give two more Noitcarf numbers

We can learn to multiply, add, subtract:

To multiply: 5N2 x 3N7 = 15N14

Question (ii) How did I do it? so: 2N1 x 6N5 = ? (12N5)
Question (iii) Find 4N3 x 2N8, 0N(-1) x 4N6

To add is harder: 5N2 +3N7 = {(5 x 7) + (2 x 3)}N2 x 7 = 41N14
2Nl + 6N5 =? (16N5)
Question (iv) Find 4N3 +2N8, ON(-I) + 4N6

Have you learnt anything? What? Eventually someone usually realises that the title, NOITCARF NUMBERS, is significant.

ACTIVITY 2 (5+ mins)

Open ended activity on number sorting, working in pairs with very little teacher input.

The usual notation employed in a Carroll diagram is explained at the end of the activity.

Each student writes down five numbers (nearly always all of them are positive and whole numbers!)

They are invited to sort the ten numbers the pair has produced into 4 sets, according to some sensible, stated rule, by putting each number somewhere into a 2x2 (Carroll) square.

They are then asked to label the rows and columns.

Discuss results.

Lewis Carroll was interested in logic and he devised the "Carroll Diagram". Show even, not even, +ve, not +ve labelling.

Now draw another Carroll Diagram and sort according to *three* properties using their original ten numbers and also 1.5, -8, 1000, .075, 0.

ACTIVITY 3 (15 mins) *Watching a Video*

I chose a video which demonstrates the gap between being able to solve a problem and being able (or not) to use an algorithm. I usually stop it several times during the run and ask students what they would do, what the child is thinking, etc. We have a very short discussion at the end.

"The Grandfather Clock" (From an old Open University video)

This will show you better than I can tell you some of the problems children experience in applying maths.

The excerpt shows a discussion between a ten-year old and a teacher in which the child is asked to calculate the age of a clock.

The information given is:

- the clock was made in the year granny was born

- granny died in 1962 at the age of 76

(The child finds great difficulty in tackling the question and has the usual glazed look of someone who does not understand how to start a maths problem. He cannot verbalise what he is trying to do. He is eventually handed a calculator and immediately enters 196276 With considerable prodding he says "the clock is 1886" and the teacher helps him to give the answer to the actual question asked.)

ACTMTY 4 (10 mins)

A practical activity needing careful classroom management. This activity involves students physically "crossing a river" by using stepping stones. One student moves across the river and has to perform a calculation on each stone. They quickly realise that they can help one another to do the sums.

I record the results on the board and we look at the pattern which emerges. We then look at what would happen if we went backwards over the river, or rearranged the order of stones.

Stepping Stones

The "stones" are A4 laminated paper in bright colours labelled: x5, +4, x2, -6. Initially they are laid across the river in this order.

Each student who crosses the river calls out a number before leaving one shore and performs the operation on each stone when s1he gets to it.

The table of results is recorded as follows-

IN	**2**	**6**	**9**
OUT	**22**	**62**	**92**

The pattern is predicted and other examples tried.

- What went in if 42, ... 312 came out?
- Could 43 come out? What sort of number went in?
- What if we rearrange the order of the stones?

• How could you adapt this idea for Key Stage 1 children?

ACTIVITY 5 (3 mins)

Open ended question with lots of possible answers. Individuals offer suggestions to:

"The answer is 36, what was the question?" (No further explanation is needed.)

ACTIVITY 6 (15 mins)

A whole class card game.

This can be played in a way - which some students find threatening – in which each individual is responsible for the questions and answers on one or two cards, or it can be played by putting a set of several cards on each table and allowing anyone on the table to answer.

The game is the familiar one in which the answer to one question is written on one side of the card and the next question written on the reverse. My set consists of 24 cards. The aim is to give the answers in the correct order and to get through the whole set of cards as quickly as possible .. One card has "Start" written with the question on one side of it and "Finish" written with the answer to the 24th question on the reverse. This card is given to a student with the question uppermost, all the remaining cards are given so that only an answer is visible. The lecturer needs a copy of the answers in order, especially if the questions are such that students are likely to be wrong. My set has one question "Which is bigger 0.3 or 2/7?" In the set I have included a question whose answer is 2/7 in addition to providing the correct 0.3 for this question. I have also included three questions whose answers are respectively, 1000, 10,000 and 100,000. These can be guarantied to cause difficulties!

ACTIVITY 7 (2 mins)

A song. (If you want the music please write to Alison!)

I start singing and the students join in. In each verse a simple addition or subtraction question has to be answered before the verse can be completed.

"Three wood pigeons Three wood pigeons

Three wood pigeons sat upon a wall.

One flew away (aaah)

One flew away (aaah)

Two wood pigeons sat upon a wall.

Four flew back (hooray)

Four flew back (hooray)

Six wood pigeons sat upon a wall

etc”

We sometimes have negative or fractional numbers of pigeons.

I am always somewhat self-conscious in this activity but find that students often use it in school.

ACTIVITY 8 (10 mins.)

An imaginative exercise. Students work in groups of four or Jive on the same task.

The task is to find mathematical questions to ask about some pictures. Each group records their ideas and we share suggestions at the end of the activity.

Each group has part of a sheet of wrapping paper, laminated.

The picture is of three rows and three columns of male torsos each dressed differently. Students come up with ideas like:

- 3x3=?
- How many wearing red?
- How many buttons?
- What fraction have a jacket?
- Intersection! union of sets
- Label rows, columns with the numbers 1,2,3. Describe (2,3)
- Ties cost £2.50, shirts cost £12.25 etc. find cost of each outfit
- Draw three more torsos, and clothe them so that half of the

men have something red

We then usually discuss ways in which they could use the cards for drama, language, art. : .

ACTIVITY 9 (10 mins.)

A problem involving use of multiplication.

Each student is given a slip of paper with the problem on it. They are told that they can confer with one another if they want to. Initially they work independently but, very quickly they MOSTLY want to pool ideas. We discuss possible solutions (usually several are suggested!) and the different preferred methods of working of the students. The "Aha" feeling is also mentioned.

The example I use is of a multiple-choice letter in which the sender can choose one word from each of four columns offive words. The problem is to find the total number of letters which could be written.

e.g. ***Thank you for sending the***	***I thought it was very:***
letter	***amusing***
postcard	***sad***
drawing	***interesting***
present	***surprising***
cassette	***attractive*** *etc.*

Conclusions:

Did I achieve variety of types of activity and teaching styles? Which activity did you enjoy most? A chart is drawn up on the board. We analyse both the role of the student and the role of the teacher in the most popular choices and the least popular choices.

Throughout the rest of the course I find the students frequently refer back to this session and say things like "It is a stepping stones type of activity" (ACTIVITY 4) or "I'm doing a

NOITCARF" (ACTIVITY 1).

The Newcastle experience

We also see the first session as crucial to setting the right tone and message for what is to follow in the rest of the course and why. The students arrive with a whole baggage of preconceptions based upon their personal and occasionally their own children's experiences and certainly upon the stereotypical images of primary teaching and classrooms projected by the media. Our first session therefore is very much one where we are trying to burst a few old bubbles whilst at the same time, trying to inflate a few new ones which perhaps have not been seen by the students.

The purpose of the session is to get the students questioning their assumptions. In order to achieve this, we try to involve them immediately in a hands-on, investigative and questioning approach in a workshop which will, hopefully, both answer some of their unasked questions and raise other, unthought of questions. There is common thread to the activities but this is not made explicit to them. In fact, it is one of the final points of the session to invite them to try to identify the thread which connects all the activities.

ACTIVITY 1: 5's and 3's (20 mins)

An introduction to practical apparatus.

A large pile of multilink cubes is tipped onto their table. They are invited/instructed to build towers of three or five cubes. Each tower is to be of a single colour but different towers may be of different colours. They are shown that towers can be joined so that a '3' and a '5' make a new '8' or two '3's make a new '6' and so on. They are then challenged to build complete a staircase of the early numbers from 1 up to around 18 or 20 using pre-drawn outlines on paper. As they get near to completing this task, many will simply stop because they see the task as finished. At this point we are able to prompt them with a whole battery of questions:

- Why have you stopped? Does reaching the top of the paper mean you have to stop? What happens if you DO go on?
- Which numbers can't be made? Are you sure? Can you convince me/someone else that this is true?
- What is the biggest number you can't make?
- How can you be sure you can make all the 20's? What about the 30's? etc.
- How would you make 27?
- What about 33?
- “Oh look! 15 can be made with EITHER three 5's OR with five 3's. What's the next number you can make in more than one way?” Etc
- What happens if the basic towers are changed to 4's and 7's?

In summary of this activity, we point out that they have been involved in lots of addition work, a good deal of mental work and that, once the cubes are put away, there will be no written evidence of their efforts.

ACTIVITY 2: Disappearing differences (20 mins) *An introduction to investigating: - 'What ifnot?"*

Four randomly chosen numbers are written on the OHP/Blackboard. The differences are calculated between 1st and 2nd, 2nd and 3rd, 3rd and 4th and 4th and 1st to create four 'new' numbers underneath. This is repeated untiL .... ? For example:

4		7		3		8			
	3		4		5		4		step 1
		1		1		1		1	step 2
			0		0		0	0	step 3 and stop!

They are invited to try some out for themselves. As before, we ask a whole range of questions:

- How many steps?
- Who can find four starting numbers which need more steps?
- What is the highest number of steps we can find?
- What happens if the starting numbers include fractions or decimals?
- What happens if you deliberately make a mistake in step 1?
- What happens if there are NOT 4 but 3 starting numbers?

As before, certain points are then made about this particular activity. Comparisons with traditional consolidation and practice 'sums' are made. The students are then challenged to count just how many subtractions 'sums' they have done - this is usually somewhere around 50! They areinvited to reflect upon what their reactions might have been had they been presented with 50 such 'sums' in a traditional format and told to complete them. This activity DOES produce written evidence but what is the teacher's role in marking it if, as they discover, it is self-correcting?

ACTRIVITY 3: A Lancashire* Number chain (15 mins)

An introduction to communal working and recording

(* *so called because it was first introduced to the writer by* a *colleague who was then an advisory teacher in Lancashire!)*

Working in at least twos and preferably threes, they are given 'rules' for generating new numbers from old ones. By following these rules, new numbers are created which generate number chains which form rings. Any number is to appear only once on the sheet no repeats are allowed.

"Take any number under 40, multiply the units digit by 4 and add the tens digit to create a new number. Repeat for all the numbers under 40." For example:

23 --> 14 --> 17 --> 29 --> 38 --> 35 --> 23

(This is NOT a task for children who are not secure in their place value concepts!)

The tasks involved are shared out - one student draws arrows, another writes numbers, the third does the arithmetic which they all check. In this way, different people contribute different things to the task but only a single record of the group's work is produced. Questions about wall display, ownership, continuous work, shared responsibilities, etc. are asked.

- What happens to numbers like 13 and 26?
- What happens if we start with numbers larger than 39?
- When is the task finished?

- Who gets to take the work home? Why?
- What is the teacher's role when two groups get apparently different chains?
- How can you arrange your working so that you can be sure of 'doing' all the numbers less than 40?

An important point drawn out of this exercise is the perennial one of children needing to learn and practise their times-tables. By the time they have completed this task with the numbers 1-39, they have 'done' an considerable amount of four-times table work!

ACTIVITY 4: Guzzinta game (10 mins)

Using games as part of teaching

Using a simple linear track board, various simple-division games are played using 0-9 and 1-6 dice and tiddlywinks. The deliberate use of the local colloquial term, "Guzzinta" (Remember, this is the far North East!) is an essential part of the atmosphere of the session.

Game 1 Roll the two dice. How many times does the smaller number 'guzzinta' the larger one? Move forward the remainder.

For example, if I get a 7 and a 3, 7+3 = 2R1 so move forward 1.

Game 2 Now get back to the start but this time move your tiddlywink the quotient. In other words, for 7+3=2R1, move forward 2

Game 3 Change the dice for two 1-6 ones, etc.

Points brought out from this activity are chiefly about the place that games can play in the teaching and learning of mathematics. Reference is also made to the need for social skills in a primary classroom.

ACTIVITY 5: Conclusions (15-?? mins) *Learning to reflect upon an experience*

The students are then involved in trying to share their experiences of the past hour-and-a-half. "What have you learned?" is used to generate blackboard/O.H.P. statements such as:

- Maths can be fun
- Not every lesson produces work in children's books
- Sometimes, we need to ask lots of questions
- Sometimes, the work is not all mine
- Teacher doesn't have to mark every last 'sum' in my book. • Garnes have a place in our teaching tool kit

Finally, the question of the thread running through the session is explored. It is not difficult and the students are usually sufficiently fired with enthusiasm by now to bring out, "Aha! Its the four rules

- *5s & 3s* is basically about ADDITION
- *Disappearing differences* is about SUBTRACTION
- *A Lancashire Number chain* is about MULTIPLICATION • *Guzzinta games* are about DIVISION

Summary

In these two examples, you will doubtless recognise things that you use with your own students, perhaps in a slightly different way or at different times in your course. Hopefully, you may even find a new activity or two to tryout yourself with your students. There are certainly similarities and common themes between and within the two models such as the variety of teaching and learning styles employed and the relatively brief time from the start of one activity to the beginning of the next. But our purpose in sharing these ideas with you was not just to offer possible models of good practice but to stimulate discussion and reaction. How do the models match or conflict with your first sessions? What do you do differently and why? How could we improve on our models? Colleagues working in primary initial teacher training are invited to respond.

Original pagination of this article – pp41-52

A Letter to China

Chris Onnell

University of East Anglia, Norwich

I HAVE BEEN IN CORRESPONDENCE with Dr Zeng, a Chinese philosopher, since he wrote to me early in 1993 *asking for a copy of the* 1992 *report which I edited* (New Thinking about the Nature of Mathematics MAG-EDU, University of East Anglia). *Recently he sent me a long thoughtful paper entitled 'From a Philosophical Point of View' in which he discusses the current movement in China aimed at 'Mathematics for all'. The following is a version of the letter I sent him in reply: I have edited it a little to make it suitable for general publication.*

Dear Dr Zeng,

Many thanks for your letter which arrived last month while I was in Canada. I enjoyed reading your paper 'From a philosophical point of view'. It raises a number of questions which mathematics educators are trying to come-to-grips-with all over the world, as well as questions relating to the Chinese mathematical tradition.

The great problem, as I see it, is that of balancing: (1) the general needs of the society (and of individuals) with (2) the need to be true to the deepest truths about the nature of the subject. Both these needs however are currently wreathed in cloud, and are very difficult accurately to read.

You will probably have realised from the report I sent you in the Summer, that we in the MAG are opening up new lines of thinking about the central essence of both these needs. (1) was treated in a new way in the Cockcroft Report (1982). This new, *practical* analysis has been enormously influential in Englishspeaking countries, but we in the MAG believe it still contains some mistakes. I am outlining my criticism of it in a series of three articles in the *Mathematical Gazette,* the first of which has just appeared. What happened in England in 1982, I believe, was that the Cockcroft Committee took *half* a step forward, but it was too timid to take the full step required. They had picked up, perhaps from hearing reports of our work in the MAG, that mathematics could be made much more vividly applicable in the classroom than it had ever previosuly been.

Unfortunately, however, the Committee listened too much to a group of professional, university applicable-mathematicians who claimed to be the *experts* on applicable maths. What these experts proposed was to revert to something like old-fashioned "applied maths", but extended into operational research type topics, cutdown to size, and energised by the use of computers. It was this half-loaf which was taken to be a great break-through in 1982. Since then doubts have begun to arise about whether it is really as *practical* - for the *average* child, that is - as it claims to be.

Views about (2) ("the deepest truths about the nature of mathematics") have been in a state of great confusion since foundationalism collapsed in the 1960s, but as I indicated in the 1992 report, the roots of the problem can be traced back to the fact that Russell's Paradox was never satisfactorily explained in i901. Really Russell tried to sweep the problem under the carpet, as we say in England. He was instrumental in creating foundationalism, which was an attempt to blind people with science, by adopting a set of *ad hoc* axioms for set theory. To an amazing extent he and his successors got away with it! It was only in the 1960s that it was first plainly revealed as a fudge.

In the 1992 report I offer a new *supple logic* explanation of Russell's paradox and the confusions which are associated with it. A fuller exposition of this approach is given in my monograph on the *superparadoxes,* and I am presently writing a second monograph, *Some Criteria for Sets in Mathematics* , showing how the new thinking applies to the way we operate in set theory. (This should be published by the MAG during 1993. Further developmeRt of these views can also be found in my series of six articles 'A Modern Cogito' in the journal *Cogito* beginning Winter 1992.) Of course these views are simply personal views about the way out of the morass, but they are not offered on a subjective basis, rather in the spirit of any putative solution to a difficult mathematical problem.

I would say that if "Mathematics for all" is to be a success it must get on the right wavelength for relevance in mathematics. We in the MAG have been working on this now for twenty-five years, and we are Quite sure that the answer lies in a Peirce an interpretation of the social reasons for doing mathematics: namely that mathematics throws a *forward* light onto practical things one is considering possibly doing (or someone else is) and, of course, historically in the Western tradition, a *forward* light onto the implications of a mathematical model one is trying to get to mimic a phenomenon in the physical world. The former everyone needs: the latter is the essence of the applicability of maths in science.

Everyone, I think, needs to recognise that the prime mathematical questions of ordinary life are these explorations of the (basically predictable aspects of) things one *might* do in the future. Of course only a few children will want to dedicate themselves to the study of the symbolic system itself: most individuals will be happy to let computer software or a calculator do the work for them (i.e. find the answers). Not only does this account make sense at every level, but it enables us to make mathematics education much more interesting for the average student. This is because one can introduce *might-bes* as topics which are intrinsically fascinating as practical ideas to think about. Some of this glamour then rubs-off onto the mathematics.

I agree with you that it is possible to interpret "mathematics" in many different ways. The philosophy of mathematics is currently a sort of Tower of Babel with scores of clever scholars around the world doing their own thing, from all kinds of idiosyncratic perspectives. But all this scholastic activity does not really help very much. Unless we are able to get the two main sides, i.e. (1) and (2) above, to be visibly consistent with each other, the result is going to be tears of one kind or another. We need a genuine variety of *mathematics for all* both in China and in Britain (and elsewhere), which really does educate children for the microchip based world we now inhabit. If we fail to conceptualise it properly, the world, I fear, will increasingly become a headless, and probably self-destructive, beast.

With best wishes,

Christopher Ormell 4 December 1993

Original pagination of this article – pp53-55