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MEANING AND MATHEMATICS EDUCATION

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Introduction

- Barnes' Transmission Model
- Research on 'understanding'
- Expanding the boundaries of the psychological research

'Meaning' in Mathematics Education

- Thom: "The central problem facing mathematics is the construction of meaning"
- Bishop: "The social construction of meaning, a significant new area of research for us in mathematics education"
- Pimm:
  - English meaning and mathematical meaning
  - Constructing mathematical meanings
  - Metaphors and the construction of meaning

'Meaning' in other disciplines

- Anthropology: (linking culture and mathematical meanings)
  - Goodenough: Culture is a cognitive system -a system of knowledge, beliefs and values- that exist in the minds of individual members of society. Individuals, however, do not share the same model of their culture; and, in his view, culture belongs to the same realm as language. These two are, in fact, largely interchangeable; since the study of both entails inferring ideational codes that lie behind the realm of obsevable events.
  - Geertz: Culture is a symbolic meaning system; where symbols function to communicate meaning from one to another. Cultural symbols, like linguistic and mathematical symbols, encode a connection between a signifying form and a signaled meaning. Culture is public, because meaning is, and so are symbols. These are perceivable objects, actions or events, that signal meanings between the minds of individual members of a society.
- Philosophy: (the nature of mathematical meaning)
  - Wittgenstein: It is impossible to identify meaning with an entity; whether these entities are images or mental acts or any other entity, many things would be true of them, that it makes no sense to attribute to meaning. "Meaning of a word is its use in the language" i.e. the special circumstances, the surroundings, in which it is spoken or written. The use of an expression is the language-game in which it plays its part.
- Linguistics: (the construction of meaning in maths education research)
  - Sassure: 'langue' (language), the rules of the game as in chess.
    'parole' (speech), the actual games of chess played by people in the real world.
  - Structuralists: it is possible to re-construct reality in its totality from an instance of it, e.g. the reality of the maths classroom from transcripts.

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QUESTIONS

- Are the diferences in conceptualising 'meaning', presented here, similar or analogous, to the different conceptions of 'meaning' that figure in the literature of mathematics education?
- Are they all significant for mathematics education?
- Are some more significant than others? In which ways?

VERY NICE DEAR - INVESTIGATIONS

I am currently running the Mathematics Assessment Project (MAP) at Cambridge Institute of Education. As part of this work, groups of teachers join me in trying to determine some ways in which to assess practical mathematics and investigations. Although progress is inevitably slow, I have begun to define the questions a little more clearly. Answers will take a little longer!

At the conference I wanted to try out with interested 'guinea-pigs' how it feels to be a pupil being set an investigation. At the same time, a parallel group looked at a video and some pieces of associated work to see if they could decide on how this kind of work should be judged.

As the complete group was not large, those attempting the investigation were about six. In the time allowed, it was impossible to complete the task allocated, partly because it was extremely open-ended, and the group expressed feelings of intense frustration. Their criteria for success included their sense of involvement as well as their ability to cope in some way with the problem. They reported feelings of panic and they only got to grips with the problem once they had redefined it in their own terms. They did not like such an open-ended problem where there were so many choices and no right or wrong answers. However, having overcome that feeling they became most attached to the exercise and did not want to give it up before they felt it was completed.

The group looking at the video and examples of work felt that they had to know a great deal more about the children and their background before judging the work. They became concerned with questions of presentation and were attempting to judge processes from written evidence and some video experience. Although trying very hard, this group did not feel able to judge the work presented without talking to the pupils concerned and it was clear that any work presented to an external examinr would have to be set out very carefully indeed.

It is difficult to know at present how far we must go along the road of formalising investigative work in order to make it acceptable to examining groups. One thing is clear: it is not possible, or even fair, to judge pupils' efforts from the kind of work they currently hand in and we must spend some time aligning what the pupil gains from investigative work with the recorded demonstration of some kind of ability. The next meeting of BSRLM may well see the next stage emerging. On the other hand....

Diana Downing

MATHEMATICAL DISCUSSION: AN AID TO UNDERSTANDING?

The Leverhulm Trust has awarded us a research grant for 3 years to explore the value of discussion in the classroom as an aid to understanding mathematics. Although the project does not officially commence till September 1986 we are devoting time this year to three preliminary tasks: firstly the identification of teachers with whom we wish to work; secondly the clarification, at least in our own minds, of the kinds of discussion to be studied; thirdly the selection or creation of schemes and systems for dealing with the data we hope to collect. Our purpose at the BSRLM meeting was to seek help with the second and third of these tasks.

Discussion can be broadly grouped under four headings:

teacher ⟷ whole class
teacher ⟷ small group
teacher ⟷ individual
pupil ⟷ pupil

We hope to encounter and study all of these; the proposed methods are outlined below.

Five schools have been selected in each of which we have already identified a teacher who genuinely uses discussion as part of his teaching style. The aim is for these teachers to take a first-year class from September 1986, for us to identify a group of pupils within that class and to follow their progress over three years. We shall visit each class for every lesson in a block of 3 or 4 weeks, twice a year. These visits will be balanced by our also following a parallel class taken by a different teacher. In the second year we hope to pick up some further classes to follow through for 2 years.

Some of the research questions which we shall address are:

Which types of discussion are of value mathematically? for learning? for understanding?

In which areas of mathematics is discussion appropriate or valuable?

What effect can teacher intervention have in pupil discussion? Does it focus or inhibit individual thinking?

What are the effects of leaving children with their misconceptions until they can resolve them themselves?

What are the special benefits to be derived from pupils engaging in discussion with their peers?

How long and deeply must pupils be immersed in this style of working before any benefits become evident?

Does making the aims of the discussion explicit to pupils enhance their learning?

Do pupils of different ability benefit to a greater or lesser extent?

Is gender related to the effectiveness of discussion as a path to understanding?

Are some mathematical topics more suited to this type of treatment than others?

Our current working definition of discussion - which, it must be stressed, we do not intend to give to the teachers we are observing lest they be influenced by it - is that

IT IS PURPOSEFUL TALK

There are well defined goals, although not all the participants may be aware of them since they may have been created by the group or the teacher. They are, however, implicitly or explicitly accepted by the group as a whole.

ON A MATHEMATICAL SUBJECT

Either the goals themselves, or subsidiary goals which emerge during the course of the talking, are expressed in terms of mathematical content or process.

IN WHICH THERE ARE GENUINE PUPIL CONTRIBUTIONS

A contribution is defined as some input which assists the talk or thinking to move onwards. We are attempting here to distinguish between the introduction of new elements to the discussion and mere passive response such as factual answers to teachers questions. Not every pupil is expected to make such contributions, but we do not include in our definitions verbal exchanges in which the majority of thoughtful input is by the teacher.

AND INTERACTION.

Interaction here is taken to mean indication that the movement within the talk has been picked up by other participants. This may be evidenced by changes of attitude within the group, by linguistic clues of mental acknowledgement or by physical reactions showing that critical listening has taken place. We hope to distinguish between such genuine influence and mere instrumental reaction to being told what to do by the teacher or indeed another pupil.

To explore this definition at the BSRLM meeting we divided (by our arrangement of the furniture!) those participating in our session into six groups of four or five people. We would like to apologise to those whom we turned away, but we felt group size to be an important part of the activity. Each group was given a tape recorder and a different mathematical activity or problem on which to work about 20 minutes. The problems were deliberately devised to provoke different types of discussion between the groups and subsequent analysis of the tapes has certainly shown this aim to have been fulfilled. The recordings have definitely strengthened and enlarged our

understanding and analysis of the features and episodes occuring within mathematical discussion.

The final part of the session was devoted to the reporting back by each group on the type of discussion and its value as seen by the group itself. We would wish to involve the pupils we observe in such an activity from time to time, since we consider their perceptions of the value of a particular lesson to be an important factor in any learning which may take place.

We are both very grateful to all who took part and we hope to continue working intermittently as a group at BSRLM with anyone who is interested in the role of discussions in the mathematics classroom.

Susan Pirie
Rolph Schwarzenberger

HELPING STUDENTS ON TEACHING PRACTICE

This discussion group began with the presentation of a paper on 'Intervention in Student Teacher's Lessons'. The argument put forward was that it is by intervening in student's lessons that we can really help students both improve their teaching and reflect on the theoretical aspects of teaching. We all learn by reflecting on worthwhile experiences. The role of the class teacher and supervisor is to help create worthwhile experiences for students and to be involved in those experiences so that they can help students reflect. In addition, working in this way provides learning experiences for supervisors and class teachers as well as students. This makes teaching practice a useful form of inservice as well as initial training.

There then followed a wide ranging discussion on various models of teaching practice and teaching practice supervision. Few conclusions were reached but it was agreed that further thought needs to be given to what sort of experiences we give to student teachers in classrooms and how we structure those experiences.

The group felt that these were useful and necessary discussions and it would be worthwhile continuing at the next PME Conference Day in Exeter.

Owen Tregaskis

Differentiation and Ability Stereotyping

The discussion paper displayed in advance of this session argued:

that ability is a key concept informing organisational and pedagogical practices in mathematics teaching; ability grouping is unusually prevalent in mathematics teaching at both primary and secondary levels;a construct of stable, general ability is salient in the characterisation of individual pupils, and of groups of pupils, and informs much interaction between teachers and pupils in the classroom;

that the widespread view of mathematics learning as an ordered progression through a hierarchy of knowledge and skill, mediated by the stable cognitive capability of the individual pupil, can be sustained only as a gross global model; in particular, it is of limited value in describing and understanding the particular cognitive capabilities of individual pupils in order to plan, promote and evaluate their learning;

that individual pupils, and groups of pupils, are subject to ability stereotyping; they tend to be characterised in terms of a summary global judgement of cognitive capability, associated with overgeneralised and stereotyped expectations of their mathematical behaviour, and stereotyped perceptions of the kind of mathematics curriculum appropriate to them.

The discussion focused on a number of issues;

the likelihood that a more stratified system of curriculum and examinations at 16+, itself built on ability stereotypes, will reinforce stereotyped perception and treatment of pupils; in particular, such a system is likely to produce a further shift away from explicit, formal, summative assessment of pupils through examinations at 16, towards the implicit, informal, formative assessment which takes place when pupils are grouped by intended examination target at a much earlier stage in their secondary careers;

the impoverished conceptualisation of understanding within mathematics education; to understand a piece of mathematics is not to acquire a single, simple characteristic; is there too great an emphasis in mathematics teaching on 'progression'?

a comparison of current practice in mathematics teaching with that in the language arts; it is certainly possible to find language arts curricula with a narrow focus on a limited range of specific objectives; but there is a much wider and more influential range of alternative models.

Kenneth Ruthven

FUNCTION AND VARIABLE IN LOGO

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Rosamund Sutherland.

As part of the Logo Maths Project (Hoyles, Sutherland and Evans, 1985) I am carrying out research into pupils' understanding of variable in a Logo context. The case study pupils on the project have experienced:

- Variable as input to a procedure
- Variable which is operated on within a procedure
- Variable passed from a superprocedure to a subprocedure.

One aim of the research is to relate the pupils' understanding of variable in Logo to their understanding of variable in traditional paper and pencil algebra and to develop materials which aid transfer between the two. This working group discussed the pilot transfer materials. These materials are based on the fact that Logo is a functional language. The need for variable to define Logo functions is very similar to the need for variable to define functions in 'traditional' algebra.

For example the procedure definition

```
FUNC :X
OUTPUT :X + 4
END
```

is equivalent to FUNC(X) = X + 4

There are many important similarities between these two representations. One of which is that the name of the variable (in this case X) and the name of the function (in this case FUNC) is not important. In my work so far pupils have been introduced to the idea of function in Logo in the form of a game which involves one pupil defining a function and another pupil guessing the function by trying out a range of inputs. They are encouraged to draw a mapping diagram as a tool to help them guess the function. One way pupils seem to make these functions their own is in the naming of the variables. The following are some examples:

UGLY :NIC OUTPUT :NIC/3 END	equivalent to	$f(x) = x/3$
SLOAN :RANGER OUTPUT :RANGER + 0.5 END	equivalent to	$g(y) = y + 0.5$
JOB :J OUTPUT 13 * :J END	equivalent to	$h(z) = 13z$

Pupils seem to choose a range of variable names including single letters. The material can be extended to include the ideas of inverse and composite function. (fig) In the Logo context pupils are first of all using a function in a very concrete way i.e. to generate specific values, then through the 'guessing game' they are defining Logo functions from mapping diagrams. Preliminary testing of the material seems to indicate that if pupils can guess the function they have no difficulty in representing it by a Logo procedure. It is hoped that helping pupils to make the link between using variable in Logo functions and 'traditional' algebra functions will provide the basis for the transfer of variable from Logo to algebra.

At the next B.S.R.L.M. meeting I will discuss in more detail the pupils' use of these materials and their evaluation.

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FUN WITH FUNCTIONS

Build two function machines:

e.g.

```
ADDFOUR :X
>OP :X+4
>END
```

```
MULTEN :Y
>OP :Y * 10
>END
```

What happens when you type:

PRINT ADDFOUR MULTEN 5 ?

Try with some other numbers.

UNDOING A FUNCTION.

Build a function e.g.

```
ADDFOUR :Z
>OP :Z + 4
>END
```

Complete the table.

ADDFOUR FUNCTION

IN	OUT
1	
6	
5	
-4	

You can now build a function to undo the ADDFOUR function

```
UNDOADDFOUR :Y
>OP :Y - 4
>END
```

Try:

PRINT UNDOADDFOUR ADDFOUR 5
PRINT UNDOADDFOUR ADDFOUR 9

What function will undo the UNDOADDFOUR function ?

Curriculum development and teacher training - are our methods effective? How should we judge?

Alan Bell

At present many of us are engaged in various activities aimed at improving the quality of mathematical education in schools. In some cases, such as the graduated assessment projects and the new primary project, very substantial resources are involved. The question was meant to open up consideration of the means by which we might judge the effectiveness of these various activities. I had particularly in mind the way in which the JMB Shell module Problems with Patterns and Numbers has been developed through a number of substantial revisions using data collected by observation of the use of the trial material in classrooms with randomly selected schools and teachers, the observations being made by the development team themselves and not relying simply on questionnaires. In this case there was the linkage with the examination, the development of interesting initial material, and a high quality form of presentation. Even so we do not know which of these features has contributed to the substantial take-up of this material. Further, we know from the observed trials that on the whole the material was used in the way in which it was intended, but we do not yet know how successful were the pupils who have used the material in the attainment of its aims. Information on this question will become available when the examination is taken and marked this summer.

With regard to innovations like the introduction of graduated assessment, it might be thought desirable to conduct some kind of HMI survey of a sample of schools before and after the introduction of these schemes.

In the event, the relative merits of different forms of evaluation were not much discussed by the group. Rather people contributed their own beliefs arising from their own experiences of curriculum and teacher development. The general feeling was that a necessary condition for successful development was the involvement of teachers in development work and that local scale developments could thus be valuable. The distinction needed to be drawn between the development of specific materials which were fed into the system from the outside and the development of individual teachers' own ideas, skills and style. The latter was unpredictable and might happen in response to almost any kind of turbulence; and it depended on the teacher being able to create a space for personal development within the demands of the task.

WORKING GROUP: LOGO MICROWORLDS IN SECONDARY SCHOOL MATHEMATICS

After a brief introduction describing the research projects at the Institute of Education University of London, the group divided into four sub-sets, each exploring a different microworld.

These were:

- An investigation where the starting point was the construction of a chess board
- 3D Turtle Geometry
- Functions in Logo
- Exploring the relationship between the intrinsic and extrinsic ways to draw a circle in Logo

At the end of the workshop the group came together to discuss the mathematics they felt they had used during their activity - the strategies and generalizations, the mathematical knowledge they had needed and the obstacles that they had come up against.

Celia Hoyles, Chronis Kynigos, Richard Noss, Ros Sutherland.
University of London Institute of Education

The Role of Practical Work in Secondary Mathematics

Barbara Jaworski and David Pimm

The first session involved a discussion of issues concerned with the role of practical work. We looked at some recordings on videotape of excerpts from lessons where pupils were working practically, to act as a focus for discussion. The videotapes used were PM644 Secondary Mathematics: Classroom Practice, available from the Open University; and Working Mathematically with Low Attainers, available from the Mathematical Association.

In the second session we provided practical activities, on which to work in groups, as a means of investigating some of the thoughts and ideas raised in the earlier discussion.

We offered a few thoughts on the subject for people to think about in advance:

Practical work provides:

1. A means of illustrating something mathematical?
2. A concrete representation of an abstract concept?
3. A tangible means of exploring mathematical ideas?
4. Physical activity which can generate mathematics?
5. A means of using mathematics in everyday situations?
6. Involvement which is central to motivation?

Practical work centrally involves interaction with the material world, whereas mathematics is essentially a mental activity which may have application to the physical/material world, but is no part of it.

"The concrete is the abstract made familiar by time."

Some dangers of practical work:

1. It emphasises the particular at the expense of the general.
2. It provides a means of erroneous justification - making the results fit the theory - or aiding false implications due to physical imperfection/ inaccuracy in the apparatus.
3. It is always a danger that pupils will get sucked into the technical difficulties of using the apparatus at the expense of the mathematics involved.

4. There is a danger when using practical work or activity to illustrate a mathematical concept, that the illustration itself absorbs attention in its own right at the expense of the mathematics.
5. The physical manipulation of apparatus may never, on its own, establish the concept for which it is intended.

Some Teacher's Comments

1. "It takes 10 minutes to give out at the beginning, 10 minutes for me to explain how to use it, and 10 minutes to collect it in at the end. The pupils then have 10 minutes to use it!"

   (Quote from a teacher: "It" = the apparatus.)

2. "It's untidy and time consuming. I could explain things more efficiently. It takes more time to plan than I have available. I don't like doing it myself. I get frustrated just standing around and watching. I want to get in there and show them how to do it the "right way".

During the first session the discussion revolved around the video excerpts:

what did we actually see?

what contribution was the apparatus making to the pupils' learning?

what conclusions (if any) can we draw about the role of practical work more generally?

In the final discussion at the end of the practical session, some of the "dangers" of practical work were considered alongside the more obvious advantages.

Developing Mathematical Processes in the Primary School

PrIME Project Team

The SCDC Primary Mathematics Project, PrIME (Primary Initiatives in Mathematics Education) is undertaking development of the whole primary mathematics curriculum. The work is being undertaken by local teacher groups spread throughout England and Wales with support from advisory services and institutions of higher education.

One of the areas for consideration is mathematical processes. There have been few groups willing to undertake work in this area, which is understandable considering the complexity of the topic, and the working group was invited to consider ways of helping the Project move forward.

The outcome will be a pack or book designed to help teachers move away from a content dominated view of the curriculum. The working group spent a long time considering the issues and concluded that teachers needed help in identifying what was meant by "process" and that one way of doing this would be by giving examples of good practice.

Since the session a working group has been established in the North-West to consider this further.

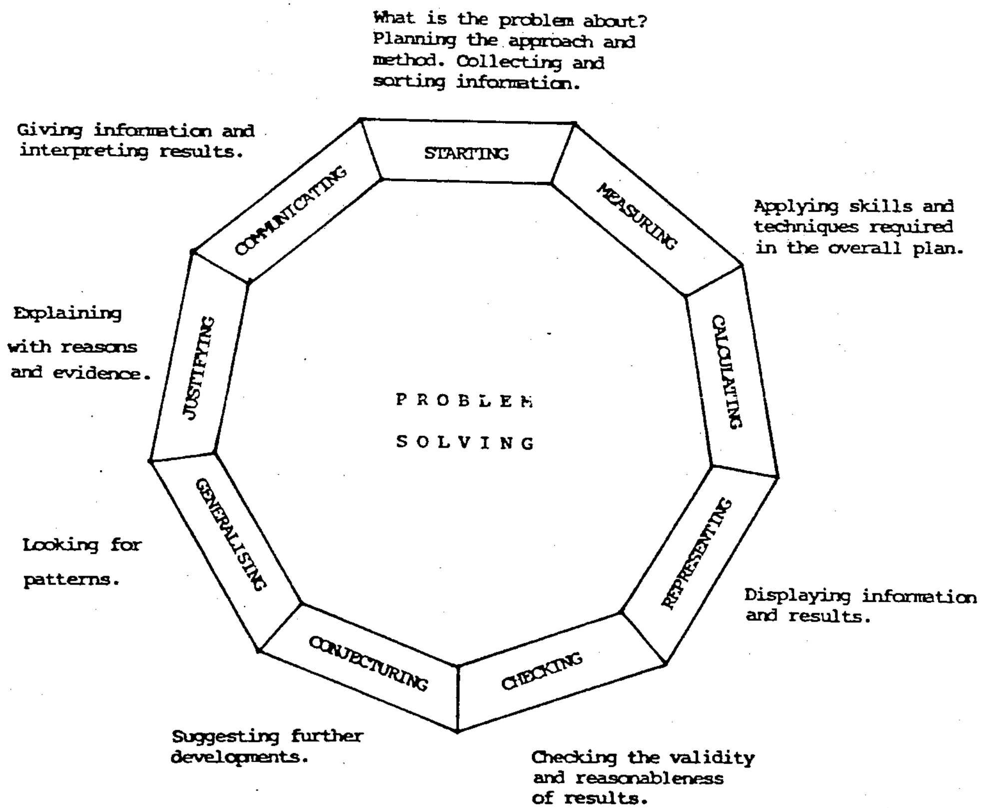
Assessing Achievement in Mathematical Processes

Gill Baden

The emphasis of the Mathematics component of the Oxford Certificate of Educational Achievement is on raising the status of processes in assessment. This implies a change of focus in the classroom, towards the application of strategies, skills and reasoning. Our aim is to devise an assessment framework which is process-based and does not prescribe content, so that it can be applied to a school's own syllabus. Features central to the assessment model are:

- criterion referencing
- multi-assessment methods
- bottom-up development
- integral importance of student involvement.

Our initial approach has been from the idea that problem-solving is the essential use of Mathematics. The illustration below indicates how the choice of 'processes' applies to a problem solving model.



Under each process heading we have identified a set of criteria which specify what it is thought appropriate to assess. The criteria are designed to encompass the positive achievements of students of all abilities. We regard grading as inappropriate because it involves ranking and discrimination. We intend that reporting shall be in a way that credits students with different achievements positively, celebrating success.

Three aspects of OCEA Mathematics warrant particular comment:

1) Students are required to experience a wide range of types of work in achieving the criteria. These include quick response questions, short problems, practical problems, longer projects and investigations.

2) Students' achievements can be communicated in various ways: in written or diagrammatic form; orally; during interaction with the teacher or by teacher observation. (Piloting has shown that dialogue between the teacher and student is essential in some cases to ascertain whether a criterion has been satisfied.)

3) 'Achievement' of a criterion is based on an accumulation of situations where the criterion has been satisfied in a particular context. The teacher's professional judgement is of major importance in deciding when a criterion has been generally achieved rather than satisfied on one occasion.

Last year a set of Foundation Criteria was devised to define the lower limits of the OCEA Mathematics assessment framework. A pilot pack was produced with a Teacher Guide and sample assessment materials; these have been tried out in schools this year. Feedback has helped in the development of the complete framework. Currently we are in the process of trialling materials for a second pilot pack, to test the complete model.

Four LEA s are involved in this project as well as the University of Oxford Delegacy of Local Examinations and the University of Oxford Department of Educational Studies. Seconded teachers from Coventry, Leicestershire, Oxfordshire and Somerset are carrying out the research and development work. Trialling and piloting are going on in those four authorities and also in schools elsewhere which are interested in the OCEA approach to assessment.

Information about the Oxford Certificate of Educational Achievement can be obtained from the OCEA Administrator at Oxford.

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Mathematics and the Deaf Child

Jeffrey Barham

The "Maths for the Deaf Child" Project was begun in 1985 at the University of Cambridge Department of Education under the directorship of Dr. A. J. Bishop. It received funding for a two year period from the Sir Halley Stewart and Leverhulme Trusts.

Its aims are -

1) To investigate the problems young deaf children experience in learning early Mathematical concepts.

2) To initiate, test and publish teaching material appropriate to those problems.

3) To evaluate the use of microcomputers as an aid to investigating and handling those problems.

4) To make available to teachers items of software for use in the classroom situation.

It is becoming more important for teachers in ordinary schools to be aware of the problems of the hearing impaired child, for, although it might be expected that better health care and counselling might reduce the incidence of deafness, a higher proportion of handicapped children are being integrated into the normal school situation.

Although a teacher in an ordinary class may be encouraged to adjust his teaching technique to accommodate the deaf child, there is a danger that he might feel that this will solve the child's problems. Yet it is a truism in Deaf Education that being unable to hear is by no means the biggest problem a deaf child has! The teacher needs to recognise that he will also encounter emotional problems, impulsive behaviour, anxious inhibition, preoccupation with the unnecessary, even aggression and isolation.

If one asks a teacher of the deaf what is the biggest problem that the children encounter learning Mathematics, the answer will almost invariably be "LANGUAGE". Hearing children usually learn all the basic rules of grammar by the age of five, by which time they will probably have a vocabulary of 2-3000 words. The child born deaf, or who goes deaf pre-lingually has no language input and has to be taught slowly and patiently.

The lack of language produces many problems for the young deaf child learning mathematics.

1) Vocabulary. Not only do we use a specialised language for mathematics, but, more confusingly for a deaf child, many words we use in Maths have a different meaning in "ordinary life" e.g., "makes", "carry", etc..

2) Recognition of similarity and difference. Deaf children find the concept of "same" easier than "different", because a great deal more language based thinking is involved in recognising why things are different than merely acknowledging a similarity.

3) Sequencing. Most young children find cardinal numbers easier to handle than ordinal, but for deaf children putting things in order involves too high a degree of linguistic thinking. This problem continues throughout their schooling and even deaf children who may be high achievers academically find difficulty in such activities as writing up science experiments and remembering stages of development in living things.

4) Logical connectives. There are a host of words we use in daily speech - if, then, but, because, so, even, that hearing children learn to use spontaneously because they hear others using them. Deaf children do not, and often these words, and the ideas behind them, which of course lie at the heart of Mathematical thinking, cause them a great deal of difficulty.

Teaching methods, therefore, need to be developed which recognise that, although the deaf child may be able to integrate in an ordinary classroom situation, he is still a child with problems who needs special help. As with all languaged-impaired children, the most appropriate forms of communication must be explored and full use made of advances in such technology as microcomputers.

Even more than with normal children, the Mathematics curriculum of the deaf child must be relevant to his daily needs and experience, but not to the extent that no opportunity is given for aesthetic satisfaction and fulfilment. As Mathematics is ultimately about "thinking things through", it can be instrumental in developing a more complete personality, capable of intellectual enquiry and enrichment. That it should be taught well is vital for the education of deaf children.

Using the Computer in Teaching Graphs

N Blackett

The report given was a summary of research recently carried out in a Warwickshire secondary school on the effect of using a computer graphics program in the teaching, and learning, of the concepts involved in linear graphs and equations. An underlying assumption in setting up this research was that in many schools it would be unlikely that more than one computer would be available for use with any class, so that it would be impossible, even if it were desirable , to base a series of lessons around the use of the computer as a programmed learning package. An important factor in the research was therefore the preparation of a series of lessons which incorporated the graphs program into an overall strategy for teaching this topic.

The strategy involved the use of graph sketching and games activities which made use of the versatility and speed of response of the computer to check results and verify or refute hypotheses. It was essential therefore that the program used was truly interactive, rather than didactic, flexible and "user friendly". The "Supergraph" suite of programmes (D O Tall) was ideal for this purpose.

Three fourth year classes were used as an experimental group and three classes of similar ability used as a control group, with the results of a pre-test used to identify matched pairs. After the series of lessons were given, the control groups being taught by experienced teachers using text books and work sheets, a post-test was given and the results compared. The questions were compared individually to assess which concepts were more successfully taught by the different teaching methods, and an overall score used to compare the matched pairs. The results showed a significantly difference in the scores achieved by the pupils who had used the computer graphics approach.

The Development of Assignments for the Assessment Scheme of a Foundation Level Course

Eon Harper

Soon, all mathematics syllabuses will include 'extended pieces of work' or "Assignments" which pupils will complete as a part of their coursework. Although many teachers have had experience of both developing and assessing 'extended pieces of work' there are many more who have not. 'Mathematics from 5 to 16' talks about pupils' lack of experience in doing work of this kind - they are more used to dealing with short questions with a specific answer, which normally require a few minutes to complete. The same observation might also be made about many teachers' experiences. Their preoccupation in the past has been the development and assessment of 'short' questions. This research report outlined a study devised on behalf of the South Western Examinations Board, to assess the difficulties which might arise in developing and assessing 'extended pieces of work'. In particular, would it be possible for teachers to devise Assignments which fitted a particular curriculum requirement (i.e. to what extent could Assignments be considered to have content and construct validity?).

Thirteen Assignments were developed by teachers under the guidance of the S.W. Examinations Board, and a procedure was devised to assess the extent to which these provided comprehensive curriculum coverage, and the extent to which they were perceived by teachers to relate to a particular curriculum aspect. For example, what proportion of teachers perceived Assignment A to

represent 'investigation in the context of mathematics for everyday life'; what percentage perceived the same item to represent 'doing in the context of mathematics for everyday life' and so on.

For each Assignment there were 12 possible curriculum 'descriptions' of the type described in the preceding paragraph. These are represented by the 12 cells A - L in Fig. 1 below. (Thus A represents 'Planning in the context of Maths for Interest'.

Activity / Context	Planning	Doing	Investigating
Maths for Interest	A	B	C
Maths for other subjects	D	E	F
Maths for Everyday life	G	H	I
Maths for Vocation	J	K	L

Fig. 1. Curriculum Matrix for SWExB Foundation Course

The 'criterion for acceptability' of an Assignment is that 70% of teacher-users should agree upon its principal cell location (each teacher was asked to indicate all the cells to which s/he considered the Assignment had a relationship, and then to indicate the Principal cell of these.

Using this criterion only one Assignment was located with sufficient confidence (A 'planning in the context of Everyday Life' assignment).

The same procedure was used to decide how confidently Assignments could be assigned as 'Planning', 'Doing' or 'Investigation' items and, independently, how confidently they could be assigned as having a particular context (Interest, Other subjects, Everyday life, Vocation). Figure 2 shows the results:

	Activity dimension
	Assignment number
Planning	1, 3
Doing	5
Investigation	

	Context dimension
	Assignment number
Interest	4, 10
Other subjects	
Everyday life	1,6,7,8,12
Vocation	

Fig. 2. Acceptable Assignments in the 'Activity' and 'Context' dimensions

Results

A number of interesting results arise from the study which have implications for the development of 'extended pieces of work':

Firstly, the Assignments were produced either by individual teachers, or by groups of teachers working together. All the 'acceptable' Assignments were produced by groups. There appears therefore to be some curriculum benefit in the group production of Assignments. Certainly there is INSET benefit for departments and groups of schools in this activity.

Secondly, it is evident that when left to their own devices, the majority of teachers will produce Assignments in the context of 'maths for everyday life'. Positive discrimination will need to be employed here, if a suitable curriculum coverage is to be obtained.

Thirdly, teachers who used the Assignments for trial purposes tended to use those which required few resources other than pencil and paper. Again action will need to be taken to ensure that pupils are given a 'balanced diet'.

Should readers like more details of the study please write to Eon Harper, School of Education, University of Bath.

COERCIVE INDUCEMENTS AND DOUBLE CONFORMITY

or

How to control women without legislation:

Explanatory constructs for research in gender and mathematics education

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A discussion paper for the BSRLM Conference, Homerton College, 21-23 March 1986

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The notion of a coercive inducement is one which the late Helen Freeman and I sketched out a few years ago. In a draft paper we wrote:

> *It has been suggested that a submissive role is forced upon girls through punishment of non-conformist behaviour. It seems to us, however, that it would be closer to the truth to suggest that, rather than being coerced into 'feminine' behaviour, girls are induced by a system of rewards and approval to accept a more passive role. This would not normally be called coercion, since coercion implies that a person is doing what s/he is unwilling to do because of the unpleasant consequences of not doing it. The coerced person is normally understood to be unfree. The person who acts as s/he does because of an inducement to do so is generally regarded as acting freely.*

The relationship of this notion of a coercive inducement to gender differences in mathematics achievement is one which I shall argue below. At this point, though, I hear some of my audience protesting 'But surely it's no longer true that girls achieve less well than boys in mathematics?' and so I shall first respond to this challenge.

Despite some improvement over time and despite girls' relatively good performance up to the end of primary schooling (and even this is controversial) it is still the case that girls as a group perform less well than boys in most public examinations at school level. At O-level, for example, of those pupils who were entered for this examination in 1984 (and more of these were boys than girls), 53.77% of girls as compared to 61.97% of boys passed, and 8.76% of girls as compared to 14.03% of boys achieved grade A. At A-level, the major difference was in the entry rate of girls to boys - approximately one girl entered for every two and a half boys. This is considerably better than the ratio in 1974 which was one to three and a half, but still very poor indeed.

Unlike O-level, the pass rate favoured girls in all mathematical subjects, but the percentages of candidates achieving grade A still favoured boys. (These figues are taken from the Department of Education and Science's Statististics of Education, 1984.) (DES, 1985) The composite effect of these statistics is of course that in absolute numbers far fewer young women than young men leave school with a good mathematical qualification - a lack which is of increasing importance as our society becomes ever more technological.

The Assessment of Performance Unit's research into mathematics achievement offers a similar picture (Joffe & Foxman, 1984). Although there are no gross gender differences overall, there are more boys at the top end of the attainment range in both age groups tested. Joffe and Foxman draw attention to the fact that

> *The differences in performance are minimal in most topic areas - except in the top attainment bands.*
>
> (p.26)

and go on to say

> *The proportion of boys to girls among 15 year old pupils obtaining the highest 10% of scores on APU concepts and skills tests is 61% to 39%. Among the highest scoring 10% of 11 year olds on the comparable APU tests, 58% are boys and 42% are girls.*
>
> (ibid)

To return to the notion of a coercive inducement and its possible effect on girls' (and boys') achievement in mathematics, I believe that part of the explanation for the statistics quoted above is that mathematics (and science and technology) still carry 'male' images and are believed to lead to 'masculine' jobs. Girls and women are induced by rewards and approval for 'feminine' behaviour to have conventionally female aspirations and to believe that these 'masculine' subject areas and jobs are not for them. To believe, in fact, that they would put their (valuable) femininity at risk if they engaged in such activities. In a recent paper (Isaacson, 1986) I wrote:

> *There is a sense, I believe, in which many girls are persuaded to adopt typically female modes of behaviour and to choose stereotypically feminine occupations and life styles because the rewards for 'feminine' behaviour are too great to be refused, rather than because they are prevented from choosing others... It is arguable whether the typical girl who chooses acceptably feminine school subjects and activities, whose chief aspiration is marriage, and who spends most of her time and energy thinking about boys and how she will appear in their eyes ... is making free choices. She would claim that she is, and that this is what she really wants, that a job is just a way of filling in time and earning some money (to buy more clothes and makeup) before marriage, and therefore not worth spending much energy on. The reality, I would argue, is however that many*

girls are being coerced by an inducement they can't refuse... girls are told loud and clear how wonderful it will be to be a bride, to be married and have babies - and what failures they will be if they don't achieve these things.

(pp 235/6)

Given that far fewer girls than boys 'choose' the physical sciences and technical subjects - for reasons such as those above among others - and that mathematical skills and knowledge are developed in many contexts and not just in mathematics classrooms, or in lessons labelled mathematics it is not surprising that at the top end of the attainment levels, girls are lagging behind. Curricular differences in science and especially in technical subjects are already marked in the primary school (DES, 1975, Grant, 1983) and could contribute the trend that the APU team draw attention to, that is, that:

The main differences in performance are already established by age 11.

If one adds to this already formidable package that mathematics is seen (rightly) by many pupils to be a service subject for the sciences and technical subjects and not just as a subject in its own right, it is hardly surprising if girls are often less willing to put in the effort which would perhaps gain them a higher grade pass at O-level or keep them in a higher mathematics set. When they are unable to drop out of mathematics, because it is still compulsory, girls often drop down instead and achieve less than they might have done. The massive drop out rate is, predictably, in the post compulsory stage.

I believe that the notion of a coercive inducement is a powerful explanatory construct. When women's and girls' behaviour and choices are examined in the light of this construct, some otherwise puzzling phenomena seem more understandable. Instead of girls' somewhat poorer performance than boys' being surprising or needing to be explained in terms of girls 'really' having less aptitude for mathematics than boys, what I now find surprising is that so many girls do as well as they do. And when the effect of coercive inducements is looked at in conjunction with the second construct I wish to discuss here, the notion of double conformity, its explanatory power is increased further.

In an essay entitled 'The Contradictions in Ladies' Education' Sara Delamont (Delamont, 1978) claims that:

The central theme which can be traced through the establishment of education for middle and upper class girls and women from the 1840's to the present day is double conformity. This double conformity - a double bind or catch 22 - concerns strict adherence on the part of both educators and educated to two sets of rigid standards: those of ladylike behaviour at all times and those of the dominant male cultural and educational system.

(p.140)

She traces the effect of the pressures on parents of girls caused by the shortage of men in the nineteenth century (in this country due to Empire building and in the Eastern United States due to the development of the West). It was imperative that parents give their daughters the best possible chance to catch a husband as marriage would provide a girl with optimum life chances, but as so many women would be unable to marry, it was also advisable to provide her with the means of earning her own living decently if she failed.

The problem was that the type of education which they believed would catch a husband was useless for a spinster.

(p.143)

The pioneers in women's education had, at the very least, to reassure parents and other potential supporters that nothing they did in their schools would diminish their pupils' marriageability, or might be thought to be unladylike behaviour. Added to this was the determination of many of the pioneers that women *should do what men did, warts and all* (p.154)

The uncompromising group held that special women's courses would have no recognised standards or status, would allow employers to discriminate, and support the claim that women were mentally inferior to men.

(p.154)

Sara Delamont sums up her argument with this statement -

Thus, inbued with the desire to compete for equal educational goals on equal terms with men, yet unable to shake off the fear of being characterised as unladylike, or worse still unfeminine, the pioneers fell into an inevitable trap - the snare of double conformity.

(p.160)

Although Sara Delamont is mainly concerned with women's experience in the world of education in the nineteenth century, the notion of double conformity remains useful today and helps to explain the kind of double bind with which many women find it very difficult to deal. In the paper already referred to (Isaacson, 1986) I make the following claim:

Another kind of double bind is that created by the demands of double conformity, a phenomenon which all women who have stepped out of stereotypically female roles and occupations have experienced. I have discussed in some detail the way in which coercive inducements affect girls' and women's life 'choices'. A consequence of coercive inducements is that the majority of women make choices which result in behaviours which conform very closely to society's expectations of them. However, even women who reject these stereotypical choices are still expected to conform to the general behaviour patterns which society has deemed 'feminine'. In addition, these women have to conform in their studies and their work, to the 'correct' or

> *'appropriate' ways of doing these 'masculine' subjects or jobs. As these have been defined by men for men, conforming to these norms is often in conflict with 'feminine' behaviour or ways of thought. It is much harder for a woman to be successful in these subjects and careers than it would be for a man. She not only has to have the necessary intellectual and practical capacities, she also has to be secure enough in herself to make rational decisions about appropriate behaviour in various circumstances and withstand mockery and put-downs where her behaviour fails to conform in one way or another. This it inevitably will do, as consistent conformity is impossible.*
>
> (p. 238)

My argument is that the combined effect of coercive inducements and double conformity is to increase enormously the obstacles which women have to overcome when they try to make their way in 'masculine' areas of study and work. Many of these areas are mathematical or dependent upon confidence and skill in mathematics. It could be considered a very reasonable decision on the part of girls who do not wish to live their lives under the stress of double conformity that they drop out of 'masculine' subjects at school once this is allowed and refuse to entertain the possibility of working in male defined and male dominated jobs in their adult lives. We therefore have to look both at and beyond school practice in ways which take account of these effects if any changes are to be brought about.

Of potential interest to mathematics educators in this context is the work of Stephen Brown (Brown, 1984). Brown discusses in a very persuasive way the need to humanise mathematics, not just or even primarily for the sake of female students, but because he believes that mathematics and ourselves as students of the discipline would be enriched thereby. But because female ways of thinking are already more in tune with the purposeful, situation specific and people connectedness he advocates as concerns for the mathematics curriculum, it is very likely that girls and women would be less alienated than they are at present - and male students (and humanity) would also benefit. The effect of coercive inducements (from which girls in any case suffer) would then no longer be to make mathematics a forbidden domain. The mathematics classroom would instead become somewhat less male dominated in its concerns, attitudes and approaches. Similarly, the conflicts caused by the demands of double conformity would (I hope!) be lessened. In other words, instead of tackling girls' supposed deficiencies by trying to change *them* we accept female and feminine qualities as good in themselves and try to change the way mathematics is practiced.

A comparable theme with regard to science, and the need to redefine its content, context and methodology can be discerned in some recent writings. This arises from a recognition that the rigidity, lack of human relatedness and lack of concern for ethical questions in science and technology as they are typically practiced today are taking us in directions which many find fearful. Brian Easlea's work (Easlea, 1981, 1983) in this area is of especial interest. As with mathematics, a science and technology which incorporated typically

'female' concerns and insights would probably, for the sorts of reasons I have discussed in this paper, be more attractive to women. Such science and technology, equally importantly, would also be less likely to result in outcomes which could take the human race in ominous directions. And from the point of view of mathematics educators concerned about gender differences in mathematics achievement, if more girls opt into science and technology courses then our chances of maintaining these girls' involvement in mathematics is also increased.

I have made claims in this paper - claims which I believe to be true but which I have no hard research evidence to support. What kind of evidence would be appropriate here? What sorts of instruments do I need to develop to test for the existence and effects of the two constructs I have outlined here? What sort of methodology would be appropriate? How early can these constructs be detected - in the Junior school? the Infants school? or even earlier? These are the questions which I am exploring at the present. I hope to try out some tentative answers in a pilot study in an Infants school next term.

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Pask's Serialist/Holist Dichotomy: Implications for the Learning and Teaching of Mathematics

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The hypothesis put forward for discussion was founded on the belief that some pupils may be at a disadvantage in mathematics by the end of their primary schooling, because they are adhering to a particular set of strategies. The strategies have led to these pupils' early success in mathematics, but, when used exclusively, have negative implications for their later mathematical development.

Gordon Pask and his colleagues have established a strong case for the existence of two distinct learning strategies - serialist and holist: given a complex learning task, serialists will take a step-by-step approach, concentrating on immediate goals rather than speculating about relationships; holists, on the other hand, prefer to work primarily towards an understanding of the overall framework, exploring in order to discover links between initially disjoint areas before filling in the details. Pask maintains that there is a link between the adoption of one or other set of strategies and the level of uncertainty at which the learner is prepared to operate. Serialists proceed from certainty to certainty, learning, remembering and recapitulating a body of information in small, well-defined and sequentially ordered 'parcels'; they are cautious learners who are confident that the necessary knowledge will be gained steadily. Holists will in general remember and recall bodies of knowledge in terms of 'higher order relations' (Pask, 1976).

In order to ensure complete mastery of a complex topic area, teachers must intervene in ways that encourage the learner to adopt a flexible approach; experiments, in which students who were 'fixed' in one mode were provided with evidence illustrating the superiority of another mode, revealed varying degrees of cognitive fixity, and a great deal of 'persuasion' was required to make most students change mode. The degree of cognitive fixity demonstrated is an indication of the versatility of the learner, a versatile learner being one who may adopt either a holistic or a serialistic learning strategy if the subject matter to be learned is changed.

As far as the early content of the mathematics curriculum is concerned, there is no doubt that both serialistic and holistic strategies can be employed with success; in particular cases, however, one approach might prove to be easier or more efficient than the other. In later stages of a child's mathematical experience, when concept areas become more complex, a versatile approach becomes much more important.

The discovery methods which are encouraged in primary schools should allow all pupils the freedom to develop their ideas using their preferred learning strategies. However, there are still

many occasions where the teacher actively directs the learning process, and it is at these times that their own strategies become important.

Discussions with primary mathematics consultants, researchers and lecturers involved in training primary teachers have strengthened the writer's belief that it is still the case that the majority of primary teachers provide input in the classroom which is based on their own (rule-based) experience of school mathematics, and is reflective of a serialistic approach. This is perhaps a result of their own lack of confidence in relation to mathematics.

The effects of these teacher interventions will be different for holistic and serialistic learners; the serialists will become increasingly committed to the view that a step-by-step approach leads to success in mathematics; even those serialists with enough versatility to become more flexible in other curriculum areas, where they are actively encouraged to adopt other strategies, will fail to do the same in mathematics, because the value of alternative approaches will not have been demonstrated; the effect on the holists, on the other hand, will be mediatory; by showing the effectiveness of techniques associated with serialistic skills, the teacher provides the impetus for holists to supplement their self-developed strategies to produce the versatility of approach which underlies complete understanding of mathematical topic areas.

The hypothesis outlined above is discussed in greater detail, and with particular reference to the position of girls in mathematics classrooms, in "Girls and Mathematics: the Negative Implications of Success" (Scott-Hodgetts, 1986).

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300 ESGs in search of a role - Research Report.

Last September three hundred or so mathematics teachers took up newly created posts as advisory teachers following the allocation of an education support grant for this purpose. In my research I am asking how they perceived their new roles at the outset, how well they were prepared to fulfil them, and how their activities might be evaluated.

There seem to be three dimensions implicit in the definition and evaluation of the role of advisory teacher of mathematics within LEAs. These are

(i) the political dimension - are the ESGs providing "value for money" as improvers of the quality of mathematics teaching in schools?

(ii) the personal dimension - are the ESGs receiving appropriate feedback on their personal effectiveness in the situations in which the are working?

(iii) the professional dimension - are the experiences of the new post-holders being recorded/interpreted so as to define and develop the role of advisory teacher for now and for the future?

In the session I considered each of these dimensions in turn:

(i) Political :The government initiative which led to the provision of a specific education support grant to provide a team of mathematics advisory teachers in every LEA has discernible roots in the Cockcroft Report. In this the present and likely continuing need for in-service support for mathematics teachers in post is identified and the particular role ofthe advisory teacher is outlined. A natural question is how far these definitions have been fulfilled in practice, and if this can be demonstrated to be have the effects envisaged. In the session I reported the results of a small scale survey I have carried out of the composition of teams in various authorities, and the kind of preparation and direction they were offered when beginning these posts.

(ii) Personal :In order to provide personal feedback for members of a particular support team I am working with, I have visited schools in which individual members of the team have worked. In the session I circulated extracts from my reports of interviews with two of the teachers within such a school, and we examined these.

(iii) Professional: Although the interviews referred to above provided direct feedback to the participants which they were able to judge relative to the context of that school and their own expectations, questions arose both explicitly and implicitly which have a direct bearing on the professional role of the advisory teacher. These include:

- o what particular teacher concerns can be addressed by an advisory teacher and how can these concerns be most effectively communicated, by the teachers?
- o what kind of input do teachers expect from a support teacher?
- o to what extent are such expectations met, to what extent violated, and what are the effects of either of these outcomes?
- o in what ways can the support teacher's way of working with an individual teachers in their own classrooms be continued by those teachers?

The session concluded with a short discussion of these questions.

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BSLRM SEMINAR

INSERVICE WORK AS INFLUENCE

Initiated by Marion Stow and Jim Thorpe

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We presumed that inservice work lacks an accepted overview and that it would most properly reflect this state by taking several concepts as a basis upon which to share experience. These notes in consequence reflect the fragmentary character of existing theory of inservice work.

Views exist that inservice workers are 'agents of change', that they convey ideas to teachers based upon a view of what practice is desirable. Others lay stress upon the authority of the teacher and see the inservice worker as someone who cooperates with teachers.

We entertained opposing views:

inservice is about changing teachers
vs.
inservice is about helping teachers work as they wish.

Negotiation operates between these poles one may say. Others might see there being no set position.

We introduced the session by offering three notions central to the issues of inservice work.

INTENTIONS - ours, as inservice workers, for ourselves or towards others together with those of teachers involved with us.

RESPONSE - to needs of or to initiatives taken by teachers or inservice workers.

OPPORTUNITY- refers to matching provision to need. Opportunities for access of teachers and inservice workers to one another may be created by a recognised need and a knowledge of agencies set up to meet these needs, or less formally through personal contact.

An overview of inservice work will derive from a range of issues.

*There are morality issues about influence
-these may be submerged under the anxiety about making effective contact.

*Respecting authority of teachers
-wait to be asked?
-tell them what to do?
-what range of interventions exist?

*In what is the inservice worker an expert?

*What notions of enabling are relevant
-help?
-support?
-comradeship?
-instructor?
-negotiator?
-Manfriday?
-assistant?
-midwife?

*What modes of involvement with schools exist?
-Organiser of working group ex.guideline writing team
-Consultant on new kinds of activity, methods or content and their resourcing

*How do inservice workers become involved in the work of a school?
-Invited on the basis of known expertise or,
-On own initiative backed by advertising or,
-By right of institutional status.

This is a list of activities associated with the work of teachers; What part in these do inservice workers play?

1. Exchange of ideas between teachers
2. Practical classroom suggestions?
3. Teachers questioning their own practice: 'self-evaluation'?
4. Observing other teachers' classroom practice?
5. Theorising?
6. Developments in the curriculum?
7. Teaching method and management skills?
8. Knowledge of resources?
9. Booklists?
10. Working with colleagues?
11. Providing an example of practice; ex. specimen lessons?
12. Managing of a class to relax constraints on teacher?

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