An 11–14 Mixed Ability Project in Science.

The Report on
A Local Curriculum Development

Location. Swindon Curriculum Development Centre

Funding. The School Council

Director. Jack Whitehead Bath University
School of Education

REPORT ON

THE MIXED ABILITY PROJECT IN SCIENCE 11 - 14

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The Mixed Ability Project in Science 11 - 14

Introduction

The mixed ability project in science emerged from the concern of teachers to improve the resources and organisation of classroom learning for their 11-14 year old pupils. The question which lies at the base of this project is:

> "How can teachers be helped to improve the quality of their pupils relations activities and products in mixed ability groups."

In an attempt to explore some of the issues involved in this question the following account describes and interprets the formation, operation funding and evaluation of a working group of teachers who design, produce, organise and evaluate inquiry learning situations in science for 11-14 year old pupils in mixed ability groups.

A complex array of questions, rather than a coherent theory confronts those teachers and researchers who are interested in curriculum innovation and evaluation. It is hoped that this study will prove informative and useful to those teachers and academics who are interested in learning in mixed ability groups, inquiry learning, independent learning, local curriculum developments, illuminative evaluation and the politics of improving educational practice.

Part I consists of a description of the formation operation, funding and evaluation of the workshop group. In Part II the project is interpreted from three different perspectives:-

Firstly, as an attempt to synthesise four different models of curriculum innovation the Social Interaction/Diffusion, Research Development Dissemination, Problem Solving, and Creativity models.

Secondly, as a process of change in the teaching/learning situation, moving from formal and informal instruction and discovery methods in Phase I of the project towards inquiry learning in Phase II.

Thirdly as an attempt to develop an alternative model of evaluation. The process of evaluation will be interpreted:-

1. As an example of an emerging model of democratic evaluation, Macdonald (76)[1] in relation to:

2. A general research strategy

3. As an attempt to balance a present day emphasis on Norm and criterion referenced assessments with illuminative evaluation procedures. Parlett & Hamilton (76).[2]

4. As an initiative to develop a new view of the curriculum.

PART I

The Workshop Group

1. The Formation of the Group

The Workshop group formed as a result of an agreement between a lecturer from the University of Bath School of Education and the Warden of Swindon Curriculum Development Centre to offer teachers in the Swindon area a particular form of inservice support.[3] This form of support, which is described in Part II, rests upon teachers meeting to discuss apparently common problems and to isolate areas of common concern. The teachers are encouraged to commit themselves to work together on a common problem. Material resources and an evaluation service are provided to help produce learning resources and/to sustain any curriculum innovation which emerges.

The Warden of the Centre circularised the Swindon secondary schools, giving notice of three meetings to discuss the problems teachers experience in organising their third year science courses.

In January and February 1974, the meetings were held at the Curriculum Centre and attended by between 15-24 science teachers from eight comprehensive schools. At the first meeting the teachers discussed their problems and it became evident that all the teachers had some aspect of the curriculum they wanted to improve. In the second meeting six teachers from three comprehensive schools agreed that they all had the problem of improving their resources and the organisation of learning for pupils from 11-14 especially in mixed ability groups.

In the third meeting the teachers and lecturer committed themselves to

work together to design, produce, organise and evaluate individualised and small group learning situations for their 11-14 year olds, the majority of whom were organised into mixed ability groups. The lecturer was asked to help co-ordinate the groups activities and provide assistance with evaluation. He explained that he could collect information about classroom practice using interviews and video tapes with teachers and learners, as well as giving some help initially with the production of resources.

II The Operation of the Group

At the first meeting of the Workshop Group in March 1974, the most urgent problem was agreed to be the design and production of workbooks which would allow the pupils to work at different rates. An accepted assumption, to be questioned later, was that the structure of knowledge in the workbooks should follow the pattern in the Nuffield Combined Science Course[4] for the first two years and the Schools Council Integrated Science Course[5] for the third year.

Each teacher agreed to design and produce a workbook on a particular topic. The first drafts were criticised, modified, typed out on Gestetner skins at Bath University Science Centre and class sets reproduced in each school.

The lecturer would visit a school once a fortnight, to observe classroom practice, video tape and interview pupils and teachers. Transcripts of the tapes concerning the teachers' intentions and learners' interpretations would be given back to the teachers once a fortnight. The video tapes would be viewed either immediately after the lesson or at a full meeting of the workshop in the participating schools.

By the end of April 1974 it was obvious to the group that the increasing need

for paper, duplicating equipment, secretarial, teacher and lecturers time could not be met within the informal procedures in use. The lecturer pointed out that the Schools Council had recently become committed to supporting local development projects[6] and could be approached for financial support.

III The Funding of the Group

The following Round I proposal was formulated in April 1974, and accepted in principle by the Council in June 1974. The Round II proposal was submitted in December 1974 and accepted in January 1975.[7] The two phases in which the project was conceived are given on p 13.

a) ROUND I PROPOSAL

June 1974

RESEARCH AND DEVELOPMENT PROGRAMME

1	Description of the purposes of the project This is an attempt at local level to respond to the needs of teachers faced with the problems of teaching science to 11-14 year olds of wide ability ranges, individually and in small groups. Teachers from five schools are attempting to solve their problems by forming workshop groups to reorganise existing resources from the Nuffield and Schools Council Projects and creating additional resources to meet specific needs. The outcome of this general attempt to look at what the children and teachers are doing in science will be a co-ordinator's report, which will describe and evaluate the curriculum developments.
2	Originated by Teachers working as a group at Swindon Curriculum Study Centre, Swindon
3	To be conducted by A Group of Teachers co-ordinated by Mr Jack Whitehead, Bath University School of Education.
4	Approximate duration and desirable starting date 2 years - September 1974. (Changed in January 1975 to 1 year, and to finish in August 1976.)
5	Approximate Total Cost £7,000 (Changed in January 1975 to £6,000)
6	Discussed/Approved by the following Committees
7	Numbers of any relevant papers
8	Existing relevant Council Projects

b) ROUND II PROPOSAL

December 1974

MIXED ABILITY PROJECT

1 Origin

The proposal originated from a group of science teachers who formed a workshop group to solve their problems of organising a learning situation for 11-14 year olds, in mixed ability groups, to engage in scientific activity.

Background

In November 1973 a request was made by Jack Whitehead of the University of Bath for £1,000 to support teachers who were producing independent learning schemes for children of all ages and abilities. The Science Adviser to the Council, Dr Burdett, replied that the procedural lines for local development proposals would be clarified in the new year.

Early in January 1974 a course was organised at the Swindon Curriculum Development Centre for teachers who had problems with their third year science teaching. The course dealt with the teachers' intentions, forms of assessment and the range of science resources available, for teachers and 11-16 year olds, from the Nuffield Foundation and Schools Council Projects. Following this course teachers in five comprehensive schools decided to form a workshop group to design, produce, organise and evaluate an individualised learning situation for 11-14 year olds in mixed ability groups. In the light of Schools Council's concern with local curriculum developments, the teachers decided in April 1974 to request financial aid from the Council. The Round I proposal was submitted with the approval and

support of the Chief Education Officer and in June the proposal was placed in the B category.

The L E A has recognised that the work of the project is well under way and are anxious to ensure that it is not hindered during any waiting period which may occur. Limited funds have been made available for the project and these funds are administered by the Curriculum Development Centre.

The Present Situation

The teachers concerned in the project possess a wealth of experience in the use of modern source materials in science, developed for the 11-14 age range. They and many of their colleagues in the locality are involved in the teaching of mixed ability groups in science. They have progressed through a number of stages, beginning with the implementation of the modern schemes as they stand, proceeding to adaptations of these schemes for the mixed ability situation and have now reached the significant stage of writing material of their own, using the feedback of the experience of earlier stages.

The project has reached the point when normal school resources cannot meet the heavy demands of a development programme of this kind; when support from a Centre of Higher Education must be on a regular and systematic basis; when reprographic facilities must be enhanced and when skilled evaluation methods are needed.

The initiation of the project by this local group coincides happily with the wishes of the L E A and Schools Council to provide support for school generated curriculum development.

II The Aims of the Project fall under two headings:-

Strategic Aims

1 To establish a network of mutual support between teachers, lecturers, advisers, scientists and industrialists.

This aim has been achieved in fact, in Wiltshire, where a contract is already in being between Wiltshire L E A and the University of Bath, to enable lecturers to promote individualised learning in Wiltshire schools. In the project locality, there are extensive connections between schools and local industry and the locality has very strong associations with technological education. There is already very effective co-ordination from the Curriculum Development Centre which has considerable administrative potential.

This particular project is seen as a specimen development, based in schools, but embodying the kind of relationships envisaged in the concept of a Professional Centre.

2 To establish a resources retrieval system

The concept of group development implies growth and proliferation. The resources produced are a tangible means of demonstrating the value of group development in both the processes and the end product.

Educational Aims

The main concern of the teachers is to provide for their pupils meaningful and enjoyable scientific situations which are relevant in the best educational sense. They feel that the best learning situations occur

when pupils are encouraged to devise solutions to their own questions.

The educational aims of the project correspond precisely with those of individualised learning in general, namely

1 to place the pupil in an active learning situation;

2 to allow the pupil to operate in an atmosphere of success and reward, derived from his own operations;

3 to enrich the natural development processes of children;

4 to promote a situation of pleasing and motivating interpersonal relationships involving pupils and teachers;

and, in addition

5 to use the particular qualities of science, its empiricism, its discipline and its imaginative thinking to complete the whole education of children.

The mixed ability situation is often seen as one which creates insoluble problems and yet is a situation which draws attention to learning methods which might well have been used in any class grouping and which have not only been neglected in traditional teaching to a great extent but are also highly efficient and productive.

The Motivation of the Groups

The range of teachers from whom this proposal emanated are convinced of the value of the source material in modern science teaching schemes. At the same time they recognise that these schemes, with one exception, are science centred in structural and organisational terms. They wish to relate the science to the child, to teach individuals and to enrich their experience, whilst maintaining the integrity of the discipline of science. They realise that group development is necessary as well as

desirable. They are aware of shortcomings in expertise and in resources and have thus sought professional and financial support.

Objectives in terms of proposed outcomes

1 The design, production, organisation and evaluation of resources in the learning situation, which are responsive to individuals' enquiries in mixed ability groups

2 The formulation, expression and criticism of learners' questions about physical phenomena

The importance of this outcome rests upon the view that the generative act of scientific reasoning is the asking of a question, the creation of an idea or the formulation of an hypothesis.[8] It is assumed that this process is outside logic but that once an opinion is formed and expressed it can be exposed to criticism. This criticism involves the empirical testing of the logical consequences of the beliefs usually through experiemntation.

3 A network of relationships between teachers, lecturers, advisors, scientists and industrialists which are responsive to solving the teachers' problems in the provision of dialogue and material resources

This outcome has partly been achieved between teachers, lecturers and advisors in Wiltshire and is manifested in the contract negotiated between the Wiltshire Authority and the University of Bath to enable lecturers to promote individualised learning in several Wiltshire schools. Scientists and industrialists are also being requested to comment on the content and relevance of the materials and will halp to evaluate the teachers' intentions and learners' scientific activities.

These outcomes are being achieved in two phases. In phase I the teachers facing mixed ability groups have changed their classroom organisation for individual and small group teaching. This has included the production of a variety of worksheets with most of the problems "given" to the pupils.

The outcome of phase II will be the learning situation described in 1, 2 and 3 above and will include a resource retrieval system which, with the teacher, will be responsive to the learners' enquiries.

III The Proposed Pattern of Organisation and Operation

The pattern of organisation is centred on the activity of teachers in the workshop group, designing, producing, organising and evaluating the individualised learning schemes for their pupils. These activities are being co-ordinated by a lecturer from the University of Bath. This co-ordination involves the development of closer relationships between advisers, lecturers, scientists and industrialists for the criticism and evaluation of pupils' scientific activity. Meetings are being held at fortnightly intervals in the schools for an on-going dialogue on fundamental goals and criticism of resource materials. The latter are modified and reproduced at the schools or local teachers centres.

IV Evaluation[9]

This will be a co-operative activity between learners, teachers, lecturers, scientists and industrialists. The teachers will express their intentions verbally, in writing and with practical examples. The learners will be interviewed and video-taped whilst working to detect the state of their scientific activity. The view will be taken that language is inadequate to express a person engaged in scientific activity, it is the kind of phenomena which can only be shown. The evaluation sessions will be dialogues

between the above people as they attempt to make available to each other their interpretations of the teachers' intentions and the learners' activities, and the assumptions on which they are based. Records will include written statements, transcripts of interviews and evaluation sessions and video tapes of the learners' activities.

IV The Near Collapse of the Group

During this period of negotiation the group nearly collapsed for three reasons:

1. A local authority adviser and the Warden of the Centre became involved with the group when the submission was being formulated and submitted to the council in order to obtain 'official' L E A support for the project. The teachers felt threatened and anxious because they were being watched by non-participants in the groups workshop activities. The lecturer experienced anxiety because he perceived an expression of the power of non-participants within the group as disturbing the climate of trust. Whilst these threats perceptions and anxiety were not accepted as justified by the non-participants they were experienced as real by the members of the group. The efforts outside the group by the advisor and warden in gaining the support of the Schools Council and local authority, and in ensuring the supply of resources to the group when Schools Council support was taking months to formalise were, however, substantial and effective.

The problems arose when trusting relations, established between members of the group were disturbed on seeking support from Bath University; Wiltshire L E A and the Schools Council. They emerged when previously informal personal committments had to become formalised into three sets of institutional procudures.

2. The two teachers in the group who had agreed to be seconded for one day a week, gained promotion, which in one case meant leaving the area whilst the other moved into a post as Head of Lower School.

3. Schools Council support was taking so long to formalise that only the efforts of the Warden and Adviser in supplying necessary paper resources allowed the group to function. The co-ordinator had to continue his full-time teaching, research and administrative duties for the University which often appeared to conflict with the needs of the teachers. For example, the form of in-service support, and attempt to develop an alternative model of curriculum development, variously titled, Action Research[10] and Evaluation as Illumination[11] appeared to conflict with the dominant form of in-service and research activities within the University.

The crucial time for the group was between September and December 1975. The resources produced in the previous term were tried out with many more classes and the results in the classroom in terms of pupils' behaviour, organisation of resources, and learners' products convinced several more teachers in the three schools to participate in the production and criticism of the resources.

In January 1975 the Schools Council formalised its support and other teachers in different schools began to attend meetings of the reformed group and share their resources. A second Group formed in Salisbury in April 1975[12] in the same way as the Swindon Group had formed in January 1974. The influence of this form of innovation is spreading into Avon with collaboration between the Swindon and Salisbury Groups and the Avon Resources for learning Cooperative.

As one of the important aims of the mixed ability project is to establish a network of mutual support, it may be helpful at this point to describe the relationship between two local development projects, Independent learning in Science (ILIS)[13] and the Mixed Ability Project.

V The Relationship between I L I S and the Mixed Ability Project

Eric Green, the coordinator of I L I S has made explicit the relationship between I L I S and the formation of Workshop Groups in the following document.

At Easter 1973,a course/conference was held at Countesthorpe College,Leicester, entitled,Individual and small group methods in the teaching of science.' Teachers in schools and universities,lecturers in schools and colleges of education,representatives from industry and the inspectorate,publishers and salesmen from commercial interests took part,and in their role as conferees,set up the national organisation 'Independent Learning in Science'.

What are the members of ILIS striving for ? What have they been working at so far? Where do they think they are going ?

"For our part as science teachers,we must learn to provide learning opportunities differentiated according to the needs of our students,and the students for their part will provide a considerable spectrum of response depending on their age, ability and aptitude."

"Most teachers would admit that an ideal teaching situation is one which permits each child to be treated as an individual in which he is able to progress at his own pace,and in which his mistakes and misconceptions are recognised and clarified immediately,before the next stage in the learning process is embarked upon."

"Most educationalists would probably agree that it is desirable to put much of the control of the learning situation into the hands of the learner himself and to encourage interaction between small groups of learners."

"The independent study programme is based on a belief and a hope : the belief that existing school organizational structures and teaching patterns inhibit the full exercise of students' potential for learning,and the hope that a modification can be devised that makes students' experience in learning how to learn whatever they need to learn,the activity of prime importance."

"We seek a new beginning to enable the individual to experience a little of the spirit of the scientists of the past,to feel the joy of discovery and understanding and to develop a deeper awareness of the role of science in his society of today and tomorrow."

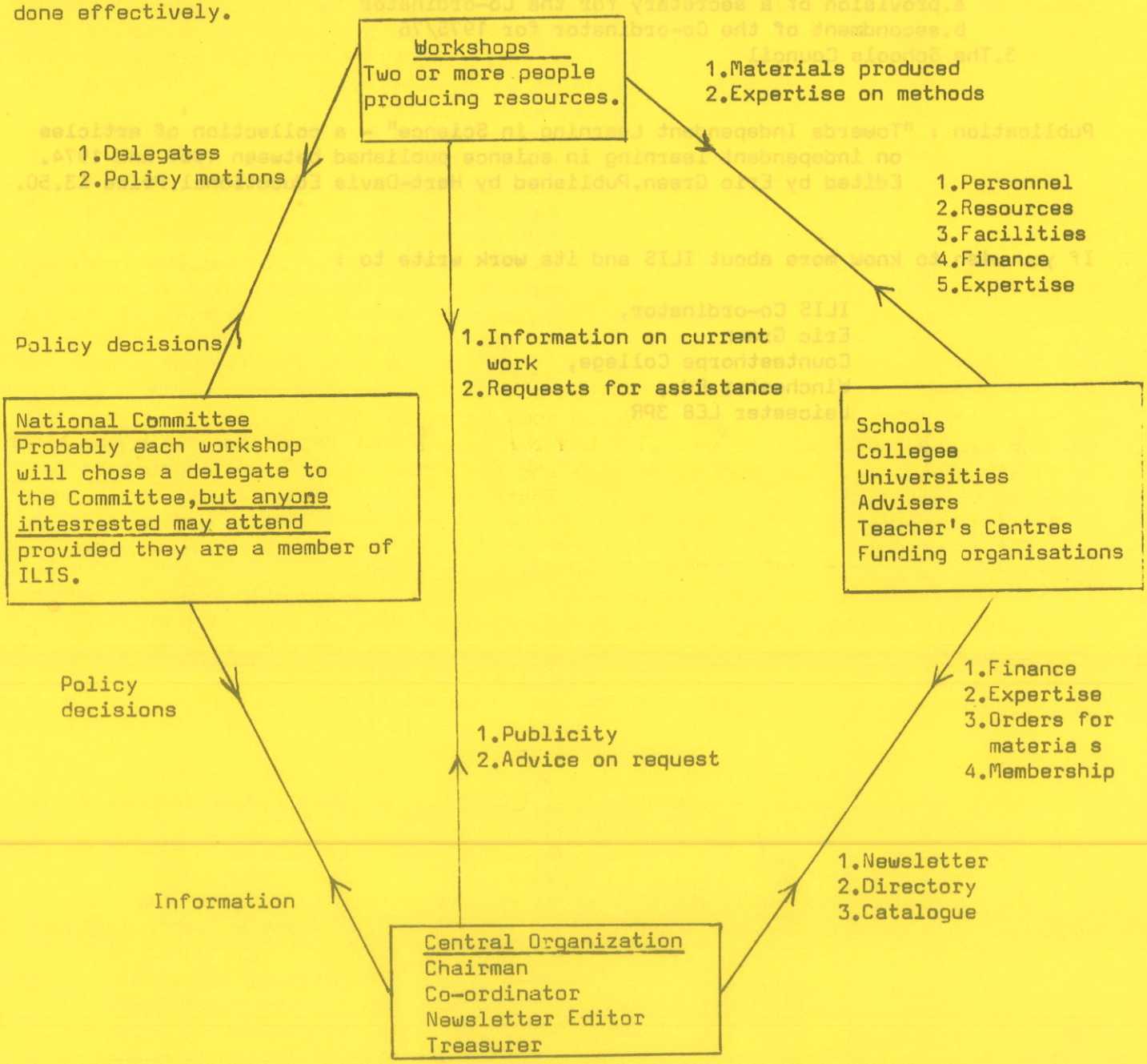
"It is my hope that the lives of ILIS members who are professionally bound to the task of realising humanity will help to transform the forces of decay and destruction into situations where the creative spirit of persons in our society will be elicited and fortified."

In no way is this document an attempt to give a comprehensive statement of all that is intended in science education by members of the ILIS organisation.The quotations given above are a but a very small sample...a taste if you like...of the thoughts that are being expressed,the hopes that are being realised,the endeavours undertaken by teachers presently involved in schemes of independent learning in science.A new kind of interaction of students and teachers is emerging in the science departments of our educational institutions which allows for fuller self-expression for each in the development of mutual understanding,as well as for better learning of the science which is the raison d'etre for their coming together.Such interaction requires an important shift from the kind of organisation of syllabus,apparatus,books,and laboratories which met the needs and convenience of teachers to a kind of organisation that makes these factors flexible to the many and various needs,interests,ideas and enterprises of our students.The viability of such changes,at every level,from infant to university,is now beyond dispute.The handful of schools initially involved with ILIS at the secondary level alone,has now increased to several hundreds and continues to grow apace.But what of the future ? How do we put teeth into this development ? How can we make it come alive for every science teacher and his students ? In part the solution lies with the science teacher and in part with those who have the funding resources to enable the science teacher to make that development effective.

What then has ILIS done for itself ? The primary aim of the organisation is to support and stimulate the development of independent learning in science education in

in their pressure on all interested parties in achieving the conditions they believe are necessary for the workshop to function effectively.H.M.I's and advisers have been and can be very effective allies in achieving these ends.

The function of the Central Organisation is effectively described in the functions of its officers.The Co-ordinator is there to maintain a healthy and effective life in the whole organisation by ensuring good communications and support,wherever needed,at the same time seeking new opportunities and ideas and stimulating further developments,so widening the base of the work of the ILIS organisation.This clearly involves time spent in visiting those already involved,observing the work that is being done,advising where it is appropriate to do so and of course speaking to groups of interested science teachers who feel that independent learning might be important and appropriate to their situation.Inevitably the Co-ordinator must be seconded part-time if this work is to be done effectively.



The Newsletter Editor clearly has a particular interest in the communications aspect of the organisation and has the responsibility of telling a very wide audience about the kind of work we are doing,the ways in which others can become involved,also keeping us informed of other developments,articles and books relevant to this work.Since ILIS began its work the Newsletter has rapidly established itself as an important journal of independent learning in science.The central organisation publishes,as well as the Directory and Newsletter,a Catalogue of materials which are available from ILIS members, either freely,by barter or to be purchased.

Members of I L I S formed the nucleus of both the Swindon and Salisbury groups. One teacher in the Salisbury group received material resources from the mixed ability project in the form of workbooks, paper and plastic wallets, whilst being seconded for one day a week with money from the I L I S project.

The purpose of both groups is to produce independent learning resources where necessary and to evaluate the changes in the learning situations.

VI Resources Produced

By July 1975 a number of workbooks[14] and worksheets had been designed, reproduced and used in mixed ability groups on the following topics.

First and Second Year	Third Year
Classifying things	Electronics and Ions
Separating Mixtures	Communities and Populations
Forces	Motion
Heating Substances	Optics
Electricity	Classifying Building Blocks
Examination of Hens' Eggs	Atoms, Molecules
Flower Structure	Osmosis
Earthworms	
Mammals	

The workbook on Forces is reproduced below to show the form of the resources being produced up to September 1975.
The resources are characterised by written statements aided by diagrams which require the pupil to do various activities, answer questions and do experiments with procedures laid down in the worksheets. Of 19 activities and experiments, 17 have answers prespecified by the teacher. Of 50 questions, 41 are closed in the sense that the answer is prespecified by the question. No experiments are encouraged to emerge from questions posed by pupils.

In the description of the process of evaluation which follows the workbook on Forces the teachers show their awareness of the problem of stifling the creativity of their pupils through the structures in the resources and their commitment to move into phase II of the project i.e. into inquiry learning.

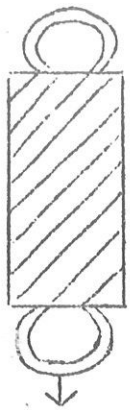
FORCES

F1 We are going to start our work on forces by looking at "elastic" things.

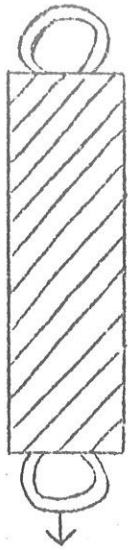
In all your experiments, be careful not to break the apparatus by pushing or pulling too hard.

Pull a small spring as shown, to stretch it.

unstretched spring



spring pulled out
to double its length



spring pulled out to
three times its length

In which case do you have to pull hardest? .....

Now try the same thing with a rubber band. What result do you get? ....

.....

Try squashing a big spring. Squash it flat, now squash it half way. Which required the greatest push? .....

Did the springs and rubber bands go back into shape when you let go? ...

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Try squashing, twisting and gently pulling the sponge rubber. Describe what happens and what you feel. .....

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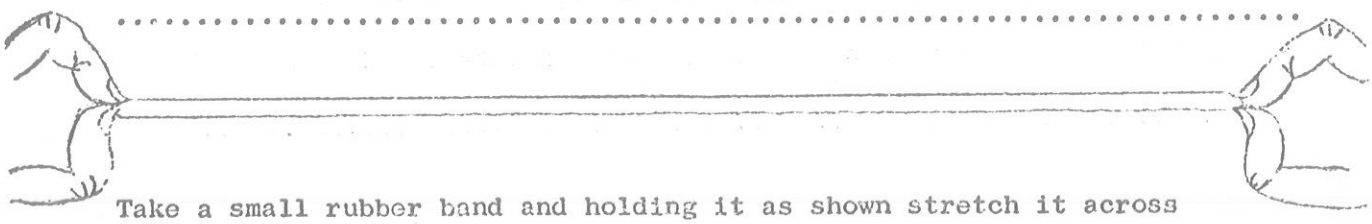

Take a small rubber band and holding it as shown stretch it across the page.

Now hold two bands in the same way and stretch them to the same length.

Then repeat the experiment with three rubber bands.

FI cont.

Stretch the thin rubber (valve) tubing. Describe what happens to it and what you see and feel. .....

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Twist the thick red rubber tubing, what happens to the square marked on it? .....

.....

Now bend it, what happens? .....

.....

Try the same experiments with an eraser (rubber), or the foam rubber. What happens? .....

.....

.....

Make your own spring with copper wire. Explain why you think it is a good spring or a poor spring. .....

.....

.....

All the materials we have used so far are called elastic, can you say why?

.....

.....

Can you think of ways in which any of these experiments could be used to measure or store forces? .....

.....

.....

In what ways do you think any of the experiments could be made better?

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.....

Cut some pictures from old magazines showing forces. Group pictures showing the same kind of force together, then stick them on to the paper provided to make a chart showing different forces at work.

List below some of the different kinds of forces you found.

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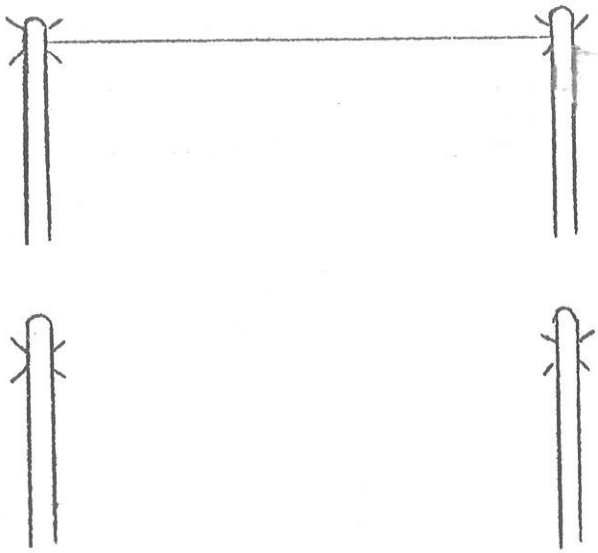
Look at the following pictures:

a) Here is a washing line on a still day.



Mark on this picture what happens to the line when some washing is hung on the line.

After the next three pictures say how many forces you think are working in the picture, and say what they are.

b) A stretched spring.

.....

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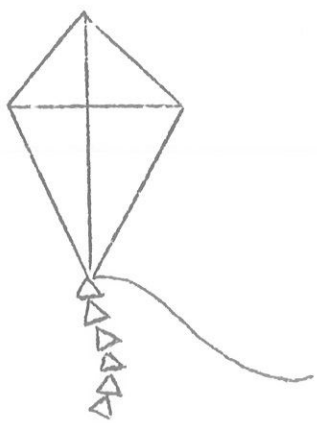
c) A kite flying.



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d) Someone unscrewing a jam jar lid.

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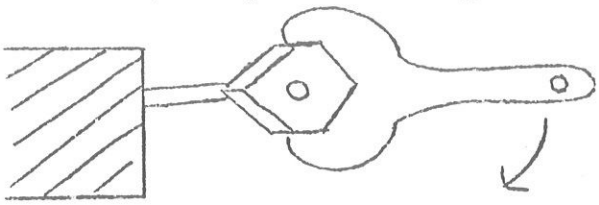
e) A spanner turning a nut.



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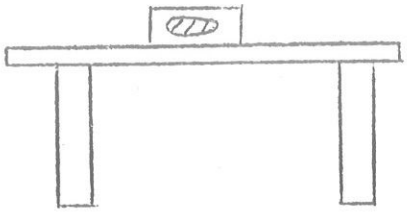
Now draw a picture of your own and mark in the forces.

F1.3a

Here is a brick standing on a table.



What would happen to the brick if the table top were made of very thin wood or paper? .....

.....

Why must the table top be made of thick wood? .....

.....

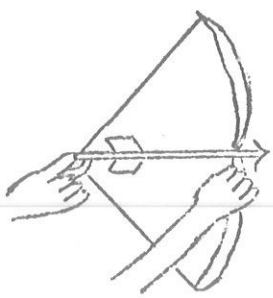
With a normal table, what force does the brick have on the table? .....

.....

What force does the table have on the brick? .....

.....

Draw a picture of anything that makes use of the force in the wind.



Here is a bow and arrow with the bowstring pulled back. What will happen if the bowstring is released? .....

.....

Where did the force in the bowstring come from? ..

.....

If you happened to be in the way of the arrow would it hurt?

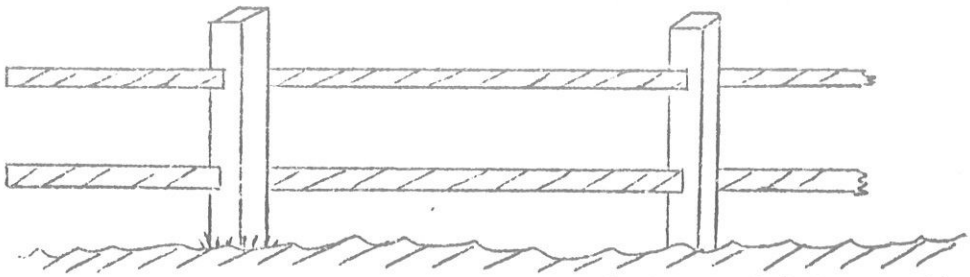
.....

Where does the force in the arrow come from? .....

.....

Why must the archer (bowman) hold the bow firmly whilst pulling back the bowstring? .....

What forces are there in this fence?



A car travelling at 50 m.p.h. goes off the road into a wall. What happens to the car? .....

.....

What happens to the wall? .....

.....

.....

The next day a large lorry runs into the same wall. Which of the two, the car or the lorry makes the largest hole in the wall? .....

.....

Can you give a reason for your answer? .....

.....

.....

1. Long ago a party of soldiers attacked a castle gate with a battering ram. They carried a huge log of wood under their arms and ran with it up to the gate so that the log crashed against the gate and broke it. Just before the log hit the gate the men stopped clutching the log and left it loose to slide in their grasp. Why? .....

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What would happen to a man who held on to it? .....

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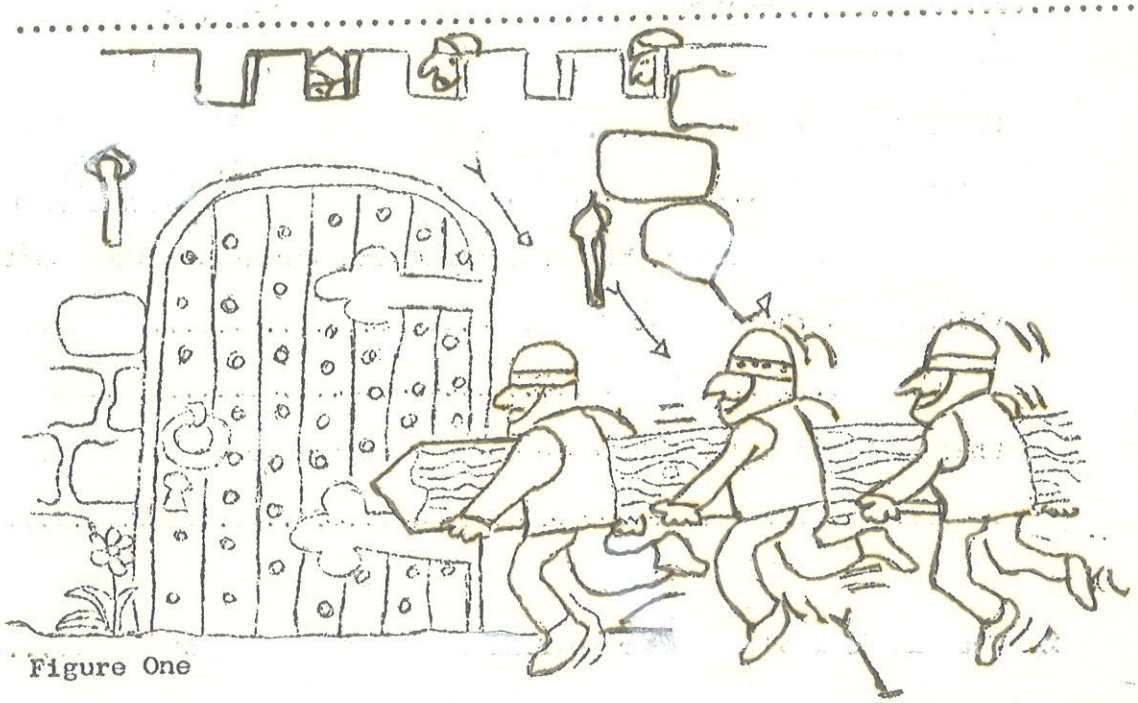


Figure One

2.

Figure Two

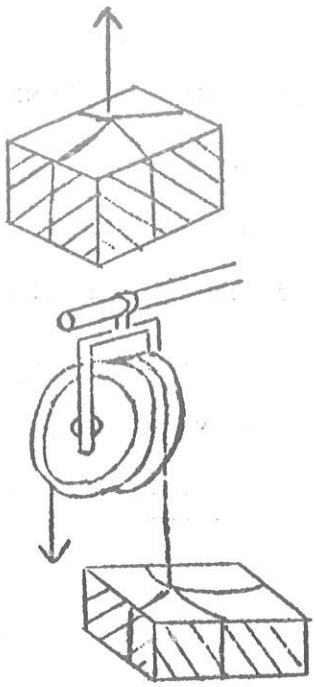
What happens here if you are not careful? .....

.....

What forces are at work in this drawing? .....

.....

3. Which of these needs the most force?



Lifting a load straight up.

Or lifting a load with a pulley.

Set up the apparatus and see for yourself.

Which is easier? .....

Why? .....

Now that you have done the experiment can you answer the question as to which needs the biggest force? .....

.....

What problems did you have in finding an answer? .....

.....

4. What do we need in order to find the size of forces? .....

.....

Can you think of any forces you might want to measure or any places where it would be necessary to measure forces? .....

.....

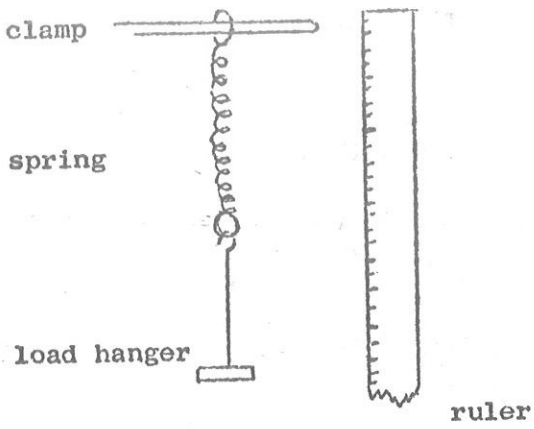
.....

Design your own force measuring machine. Draw a diagram of it below.

Ask your teacher if you can make it and try it out.

F1.4 Loading a Spring

Set up the apparatus as shown in the diagram.



Measure the length of the spring with no load on.

Add the load discs one at a time and measure the new length each time.

Record your results in the table below.

Load	length of spring in cms.
0	cms.
1	
2	

Ask your teacher for some graph paper and plot a graph of load against spring length. Your teacher will help you if you have any difficulties.

Put your graph in your file facing this page.

What shape is the graph? .....

What happens to the length of the spring as more loads are added?

.....

What explanation can you think of for what happened? .....

.....

One day Isaac Newton was sat under an apple tree, in his orchard. Suddenly an apple hit him on the head. "A bit of luck that, I was feeling hungry",

he thought, munching away. It would have been even better if it had landed on the grass or at least fallen gently. I wonder why things fall so hard, come to think of it, why do they always fall down to earth anyway?"

Isaac Newton was already a famous scientist and this chance accident made him realise that the earth pulled everything towards it and he called this force "gravity".

It was this force of gravity pulling on your loads which made your spring stretch.

Would the apple have fallen as hard, if Isaac Newton had been living on the moon? .....

Can you name any places where there is no "gravity" at all? .....

.....

If such a place exists, what would happen if you let go of your cup of tea? .....

Hard questions. Can you think of any places where the pull of gravity is more than on Earth, if so name them. .....

.....

What would happen if you fell over in such a place? .....

.....

F1.5 Measuring Forces

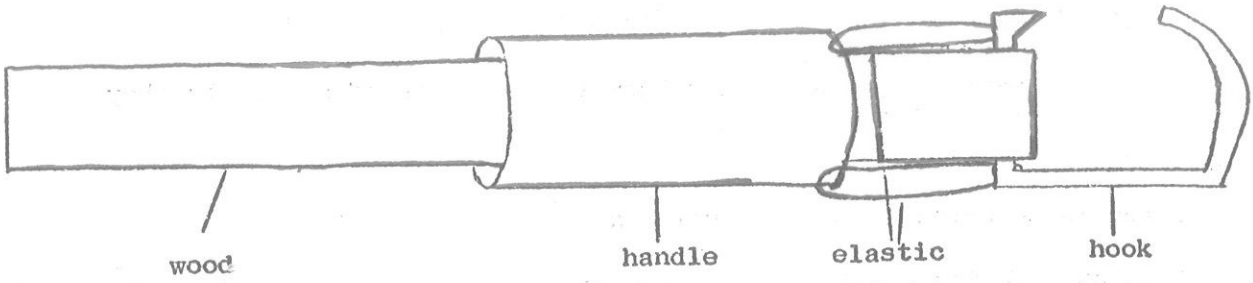
In the last experiment we used a ruler and a spring to measure the pull of the Earth on pieces of metal (loads). Scientists and Engineers often need to measure forces, so they know the strength of materials they need to use

Force is measured in Newtons using a Newtonmeter.

Look at a Newtonmeter. They have a spring inside them, some are stronger than others, so they can measure different sized forces. Be careful how you use the Newtonmeter. If you want to measure a force bigger than can be shown on your Newtonmeter, get another one, which will measure larger forces or you will break the spring by pulling too far.

Use Newtonmeters to measure the forces you need to do simple tests around the laboratory. Record your results in the chart below.

Test carried out	Force (in Newtons)
Force to stretch a spring	9N



This is a home made push pull meter. Can you make one, like this, or one of your own design? If you make your own draw a diagram of it.

You could not use this push pull meter to measure a force.

Why not? .....

What is missing? .....

Can you find a way, with the help of a Newtonmeter, to help you use this push pull meter to measure forces.

Describe what you did, and say what forces you measured, and how big they were on the lines below.

.....

.....

.....

.....

.....

.....

.....

.....

.....

In the Process of Evaluation described below, examples are given of the teachers' evaluation of their own activities and products. The teachers could see that their resources and organisation were within phase I of the project i.e. within the structure described later of Formal Instruction - Informal Instruction - Discovery.

From September to December 1975 six teachers in four schools discussed the problems of moving from phase I of the project into phase II, that is into inquiry learning. Two teachers felt that they would stay in phase I, whilst the following four teachers in three schools agreed to try to move into phase II in January 1976.

Vivien Bellamy at Dunworth School Tisbury produced ten folders of material, two on each of five topics from the Combined Science Course on:-

Forces and Movement

Patterns of Growth

Heating Things

Air

Electricity

The plastic folders opened into six sections with instruction cards, question cards, information sheets and experimental cards in different sections. Video tapes made between January - April 1976 show pupils entering the classroom and organising their own work from the teachers selection and arrangement in the folders. Vivien states that there has been a noticeable improvement in behaviour and the quantity and quality of work produced.

Paul Hunt at Dorcan School, Swindon, has allowed small groups of 3 or 4 pupils to explore their own ideas whilst the main body of the class were doing prescribed work. Paul has taped, transcribed and commented on one group of 4 girls who were exploring their own ideas. Part of this transcript[15] on p 60-62 shows enquiry learning in action in the classroom.

Maggie Hannam and Tony Cole at Wootton Bassett have organised a class of 24 pupils for enquiry learning. They have stated in March 1976 that there is an improvement in the relationships activities and products of the learners. Their main problem is to construct a profile to show the quantity and quality of the work done.

The teachers in the project are continuously evaluating the activities relations and products described above in relation to their intentions. Examples of their evaluation will now be given from the evaluation report given to the teachers in September 1975.[16]

VII The Process of Evaluation

"This will be a co-operative activity between learners, teachers, lecturers, scientists and industrialists. The teachers will express their intentions verbally, in writing and with practical examples. The learners will be interviewed and video-taped whilst working to detect the state of their scientific activity. The view will be taken that language is inadequate to express a person engaged in scientific activity, it is the kind of phenomena which can only be shown. The evaluation sessions will be dialogues between the above people as they attempt to make available to each other their interpretations of the teachers' intentions and the learners' activities, and the assumptions on which they are based. Records will include written statements, transcripts of interviews and evaluation sessions and video tapes of the learners' activities."

from the Round II proposal p 13.

The lecturer interviewed the teachers to detect their intentions and fundamental goals as educators as well as their interpretations of classroom practice and reactions to the project. Learners were interviewed and video-taped to detect the state of their scientific activity and responses to the learning situation. Samples of the learning Resources and learners Products were collected and included in the evaluation report presented to the teachers in September 1975. The form of the report will be given in outline and examples included to show the critical questioning and collaboration between a group of teachers as they see themselves as participating in the process of evaluation and development as something central to and not separate from their everyday classroom practice.

OUTLINE OF THE EVALUATION REPORT

1. Initial Exploration of Teachers' Intentions

"I try to base my relationship with my pupils on mutual trust and respect. From this I try to provide the opportunity to explore their own ideas."

P Swanston Dorcan School

"The first step in creating the learning situation I believe in is to move to a more individual approach because then you **can** respond to the kids' questions, you can say, 'go on and try it'."

R Barrow Wootton Bassett School

2. Statement of Teachers' Problems

"My problem is to make sure children are interested and informed enough to pick and cope with Science options in the Senior High (14-18) or to arrange with the Senior High a coordinated three-year course (11-14) with selection as late as possible."

T Cole Walcot School

3. Imagined Project to improve learning situations

see Rounds I & II proposals

p 7-15

4. Examples of Resources

see Forces Booklet

p 23-34

5. The Learners Responses

DENISE and LINDA - 12 years old

Jack: You said that you liked working in the groups, and not when you were taught in the classes. Why was that?

Denise: Well, we just get bored sitting there, and it's more difficult to understand.

Jack: Is it? Why's it easier to understand in groups?

Denise: Don't really know.

Jack: And what about what you learn, is that different?

Denise: I think so, yes.

Jack: Could you give me an example, or not?

Denise: I don't really know.

Jack: Where did you get your ideas?

Denise: Well, Mr Sheard wrote them out from this book.

Jack: Did he?

Denise: Yes.

Jack: And what did you do?

Denise: We just copied his instructions.

Jack: And as you copy those instructions, is that what you think doing science is?

Denise: No, not really.

Jack: What do you think doing science is?

Denise: Well, more doing it on your own really.

Linda: Finding things out.

Jack: Finding things out?

Denise: Yes.

Jack: But, what have you found out?

Denise: Don't really know.

Linda: We just do the experiments.

PHILLIPPA 12 years old

Jack: Where do the ideas come from? That you follow up in your science lessons.

Phillippa: Well the teachers think of a course we have to follow and we have to follow it up. Well, we're given a topic to learn, we're doing water at the moment, and then we have to investigate it, set up experiments.

Jack: So the teachers have the ideas?

Phillippa: Yes.

Jack: Do you think that's what scientists do?

Phillippa: No, I think they have their own ideas.

Jack: Do you? Why don't you have your ideas?

Phillippa: I wouldn't know where to begin.

Jack: Have you no ideas about anything?

Phillippa: Yes!

Jack: Have you? Well, why don't you follow those ideas up in your science lessons?

Phillippa: I don't know - I wouldn't know what experiments to do. Well, sometimes we do individual work, but I don't know.

Jack: What's that individual work?

Phillippa: Well, we're told to try to find something, find out something about say, well last week we had to dissolve powder, milk powder, and we had to find out how much water you had to put into the milk to make it into proper milk. And we had to do a series of experiments to find out that.

Jack: Who gave you that idea?

Phillippa: Mr Barrow.

The children sometimes show a remarkable ability to not only judge their own performance but evaluate the value of a particular lesson or subject.

TOMMY

Tommy is 12 years old.

Paul H What sort of things do you think about when you leave the lesson, about what you've done?

Tommy Was it worth it?

Paul H Was it worth it. What do you mean?

Tommy Well sometimes the experiments that you do, you know, we'll say, like, can't really explain it. You might do an experiment and it might just be worthless, just a waste of time, or do one that might be worth the time.

He then, on prompting, gives an example of both worthwhile and unworthwhile experiments. We continue.

Paul H When do you learn most, then?

Tommy When the teacher tells you, talks to you, and tells you something interesting, when you're interested, it helps you. And say the teacher says, explains how to do something and instead of, you know, every time you get stuck, you say, Sir will you do this for me, you know, it's just, Sir, will you just, you know, help me, not do the whole thing for you just give you a bit of a hand.

We talked about experiments that he liked, things he got excited about, things he thought worthwhile.

Paul H Can you think of reasons why you liked doing those particular experiments?

Tommy More interesting and things ..... you're independent when you go out it's not the teacher helping as well - it's more that you can do by yourself than with the teacher as well and all the other people.

I believe that these children deserve and need listening to.

Paul H. - Paul Hunt of Dorcan School.

6. The Teachers' Evaluation of Changes in the learning situation.

ROGER BARROW

Jack: How far do you think that the basic ideas that we are working with are unfeasible?

Roger: Well, I think the questions pupils ask fall into three categories, there are those who are asking a shallow, trivial question for the sake of asking a question, or because sir said they were to think about some questions on the topic; there are those who ask a question quite seriously but are totally lacking in the ability to follow through their question with any sort of mature thought about it because the questions they've asked require some kind of thought and therefore they need guidance. This is where they need a resource, something you can put into their hand, at least to start them. This is the biggest problem with any project, getting them going. Once you've started the lesson off, or particularly the project overall off, then one can spend time in individual groups, one can then help them. Now the third group asks serious questions and are capable of following them through, like Ian and Gary with that plastic stuff. They asked questions, they attempted to find the answers. They were capable of a very mature level of thinking and the way they faced up to the problems they met on route was exceedingly encouraging.

MAGGIE HANNAM

Jack: We have tried out several ideas during the past year, some have succeeded some haven't. What is your impression of the project?

Maggie: We are still saying that there is a logical sequence to the work and that we know what this sequence is ..... We might be kidding ourselves that we are getting away from presenting the kids with set formula. We might simply be doing what was done to us only a different way round.

BRYAN ENTWHISTLE

Jack: I'd like to examine the three ideas of creativity, scientific method and finding the answer to a problem. Yesterday I saw the apparatus all set up, the question was on what causes rusting and I could see the way in which the Combined Science Course or yourselves had set up the problem, but I couldn't see at all that the pupils were in any way engaged in the process of formulating a problem or setting up an experiment in a scientific way.

Bryan: Yes, I think you are right, but I still think that we need our framework of scientific thought in order to be able to give them a method by which they can solve problems at a later date. We are stifling the creative instinct that these kids may well have. We are imposing our so-called scientific method into them.

In retrospect and through the criticisms of others, the lecturer acknowledges that the interim evaluation report would have benefited from a more detailed discussion on how it was compiled.

The influence of the groups activities continues to spread through their invitations to discuss their work at local teachers' centres, at conferences, through their articles in the I L I S newsletter[17] and through the support given by the Warden of Swindon Curriculum Development Centre and the Principal Adviser for the Local Authority. The implications of this process of Innovation and Evaluation will now be interpreted from three related perspectives involved in models of the process of innovation, teaching/learning, and evaluation.

Jack: So you're saying on the one hand they need it, and on the other hand we seem to stifle their creative acts.

Bryan: Yes.

Part II INTERPRETATION OF THE INNOVATION AND PROCESS OF EVALUATION

The Mixed Ability Project can be viewed from three frameworks

I. AS AN ATTEMPT TO DEVELOP A MODEL OF INNOVATION which syntheses the Diffusion (d), Research Development and Dissemination (RDD) and Problem Solving (PS) models isolated by Havelock[18] with the strategy of innovation proposed by U N E S C O in which the 'creativity' of the school is emphasised.

II. AS A CHANGE IN THE TEACHING LEARNING PROCESS in the direction.

Formal instruction —>Informal Instruction —> Discovery →Enquiry

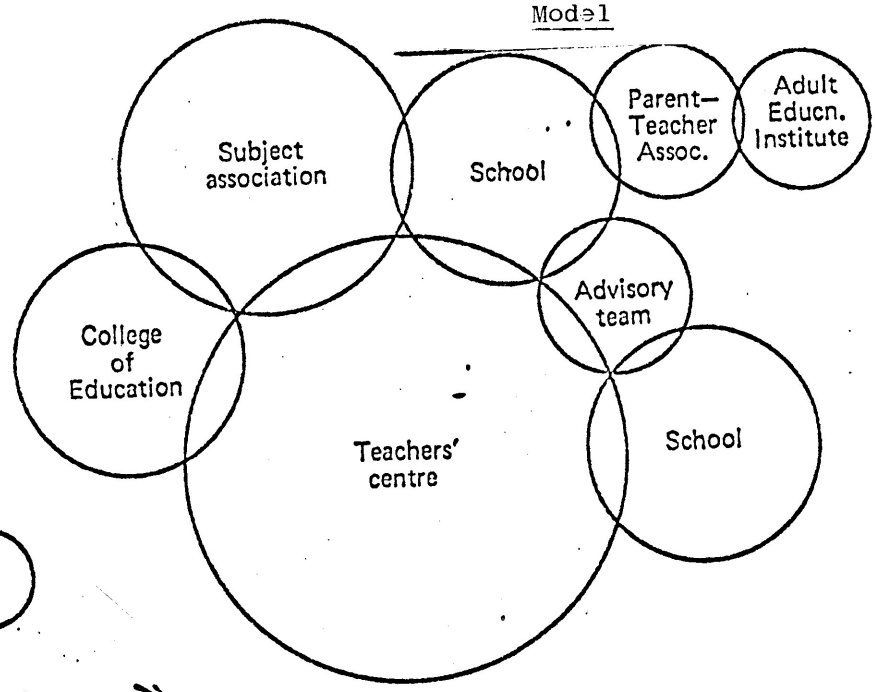
this analytic framework has been developed by The Ford Teaching Project,[19] and will be described in detail below.

III. AS AN ATTEMPT TO DEVELOP AN ALTERNATIVE MODEL OF EVALUATION from that derived from experimental psychology to one which owes more to social anthropology. This alternative model has been variously titled Collaborative Research;[20] Action Research;[19] and Evaluation as Illumination.[2] The approach is not entirely new and the SSRC and the Ford Foundation have sponsored research based on similar models at the Institute of Education of London University[21] and the Centre for Applied Research in Education at the University of East Anglia.[22] A Schools Council Research Professor[23] has stressed the importance of such models and the evaluation approach of this project is in the Spirit of Schools Council Pamphlet 14 on Dissemination which called for greater involvement of teachers in the creative side of project development.

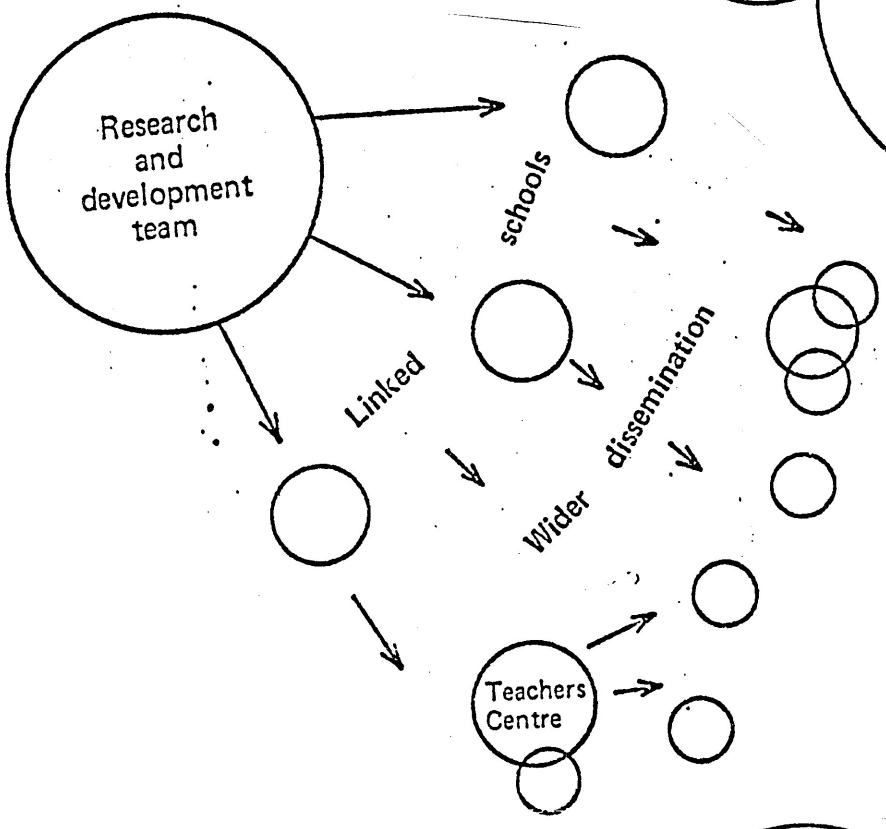
1. AS AN ATTEMPT TO DEVELOP A MODEL OF INNOVATION

Three models of curriculum innovation, the Social Interaction or Diffusion, the Research Development and Dissemination and Problem Solving model have been characterised diagramatically[24] as follows.

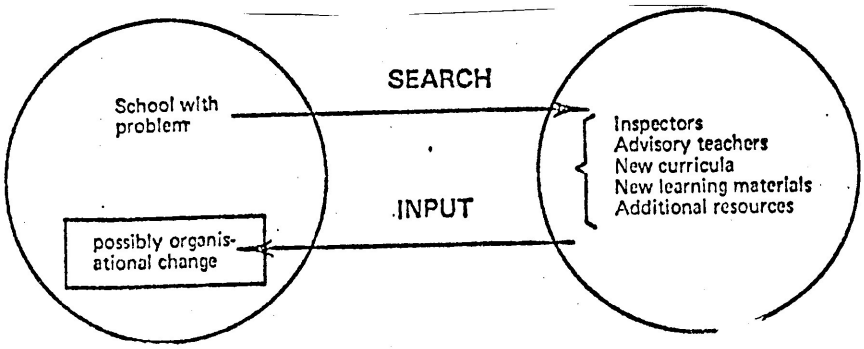
Social Interaction/Diffusion Model



Research Development Dissemination Model



Problem solving model



a. DIFFUSION

The diffusion model rests on the assumption that improved curricula will be seen as self evident by teachers and their advisers and will perculate through the system with little intention on the part of advisers, teachers or Schools Council to disseminate the curriculum developments.

b. RESEARCH DEVELOPMENT AND DISSEMINATION

The Research Development and Dissemination model assumes that one must gather together a small number of people who are actively improving their curriculum. They must be given funds and time to be able to develop this curriculum and then actively engage in the dissemination process.

c. PROBLEM SOLVING

The problem solving model emphasises the need to change teachers' attitudes. The primary problem is seen not so much in terms of producing material resources but as changing teachers to begin to see why the curricula is being improved. It is believed that if teachers see that the changes are relevant and important to their situation then they will attempt to improve the curricula.

d. CREATIVITY

The model suggested by U N E S C O is characterised in terms of the "Creativity of the School". By this is meant the power of a school to evaluate, accept or reject and institutionalize innovation. The task is to create the circumstances and provide the support which will enable effective innovation to be generated, sustained, and carried forward in the institution by the people directly concerned with the problem.

e) THE MIXED ABILITY MODEL

The characteristic of the mixed ability model is that it incorporates the essential features of the four models above.

In the process of innovation some information on resources and organisation have perculated (the diffusion model) through to the teachers. For example the information provided in The National Press, The Schools Council, Dialogue and Educational Supplier's newsletters and catalogues. The information made the teachers aware that others were experiencing similar problems.

From a concern to solve their problems a small group of teachers had gathered themselves together, supported by individuals in the local teachers centre, advisory service and University School of Education, and negotiated funds and time to develop their curriculum (the RDD model).

In the formation and operation of the Workshop Group a central theme for analysis and continuous questioning was why the curricula was in need of improvement. Through seeing the changes were relevant and important to their situation the teachers attempted to improve the curricula (problem solving).

The formation and funding of the workshop group, described in part I is an example of an attempt by teachers, lecturers and advisors to create the circumstances and provide the support which will enable effective innovation to be generated, sustained and carried forward in the schools by the teachers directly concerned with the problems. (The creativity model).

The model of innovation which can characterise this dynamic process is given below in terms of four values and five activities.

The Four Values

a) Concern with improving learning situations for pupils

b) Committment to work with others in a climate of trust and critical dialogues

c) Faith in each others capacities to evaluate their own activities relations and products

d) Determination to provide information on the areas of concern from local, regional and National institutions.

From an acceptance of these values, individuals in the various institutions engage in the following five activities:

a) organise meetings for teachers with similar problems.

b) listen carefully and encourage teachers to formulate their problems.

c) work with the teachers in designing, producing, organising and evaluating the changing learning situations.

d) obtain information from the National institutions on the teachers areas of concern.

e) disseminate information to other interested individuals.

by substituting learner for teacher above similarities will be seen between this model of innovation and the form of teaching/learning process described as inquiry learning below.

II AS A CHANGE IN THE FORM OF TEACHING-LEARNING PROCESS

An analytic framework to interpret changes in the teaching/learning process has been developed by The Ford Teaching Project.[25] A detailed description of this framework will be found in The Language and Logic of Informal Teaching. The four basic forms which characterise the teaching/learning process are:-

FORMAL INSTRUCTION	Formal - structured - directed
INFORMAL INSTRUCTION	Informal - structured - explicitly guided (person-ends)
DISCOVERY	Informal - structured - implicitly guided (person-ends)
	Informal - structured - open ended
INQUIRY	Informal - unstructured - guided (person-means)
	Informal - unstructured - open ended

Person ends and Person means refer to two types of responsive guidance. Both indicate a concern to protect and foster the pupils' own powers of self-direction. Person ends indicates a primary concern with the ends of learning by indicating the direction in which the conclusions desired can be discovered. Person means indicates a primary concern with the process of learning, with means rather than ends.

The Directors of the Ford Teaching Project believe that the framework above, clarified by the values and principles in their analysis can function as a basis for generating a theory of teaching which is significant for innovation. They believe that the teachers' attempts to implement particular patterns of teaching/learning indicate the theories of innovation implicit in their practice.

The Mixed ability project in science can certainly be interpreted as a process of change, moving from Formal and Informal instruction & Discovery

in phase I to Inquiry learning in phase II. The above framework rests however on a particular evaluative point of view about the Nature of educational processes. Namely that they should protect and foster the rational authority of the individual pupil. The Ford Teaching Project team analysed the aim of the teachers into the following four values, which specify the freedoms pupils ought to exercise in the learning situation, and nine principles of procedure which specify role responsibilities for promoting and maintaining conditions which are necessary for realising the four values.

4 VALUES

a) to identify and initiate their own problems for inquiry

b) to express their own ideas and develop them into hypothetical solutions to problems

c) to test their ideas and hypotheses against relevant evidence

d) to rationally defend their own ideas and conclusions, and to submit the ideas of others to reasoned criticism (freedom of discussion).

9 PRINCIPLES

Negative principles

1) Refrain from preventing pupils from identifying and initiating their own problems.

2) Refrain from preventing pupils from expressing their own ideas and developing their own hypotheses.

3) Refrain from restricting pupils' access to relevant evidence and drawing their own conclusions from it.

4) Refrain from restricting pupils' access to discussion.

5) Protect pupils from other external constraints on the exercise of independent reasoning, e.g. peer group and institutional constraints.

Positive Principles

6) Help pupils to develop the power to identify and initiate problems.

7) Help pupils to develop their own ideas into testable hypotheses.

8) Help pupils to evaluate evidence in the light of its relevance, truth, and sufficiency.

9) Help pupils to learn how to discuss.

The team believe that past attempts to produce a general theory of teaching have been fruitless in practice because researchers have refused to involve teachers in the development of a conceptual framework for understanding the teaching situation.

In the mixed ability project the teachers agreed that they should 'enable independent reasoning' on the part of their pupils. Their primary value, however, was establishing a particular relation in which the pupils experienced trust. This particular experience loses most of its meaning when expressed in conceptual form. I would suggest that the values and principles of the Ford Teaching Project may be ignoring the primary values of teachers and that their categories ought to be tested further by observations and interview in the classroom before they function as a basis for generating a theory of teaching which is significant for innovation. The mixed ability project has emphasised the importance of creating a climate of trust and of expressing faith in each others capacity to evaluate their own relations activities and products. Whilst the four values of the Ford Teaching Project are made explicit in the Mixed Ability Round II proposal to the Council it is suggested that two further values should be added. These are given as numbers 1 and 6 below.

1) To establish a climate of trust.

2) To identify and initiate their own problems for inquiry.

3) To express their own ideas and develop them into hypothetical solutions to problems

4) To test their ideas and hypotheses against relevant evidence

5) To rationally defend their own ideas and conclusions, and to submit the ideas of others to reasoned criticism (freedom of discussion).

6) To express faith in each others capacity to evaluate their own relations activities and products.

Values 1 and 6 are also central to the model of evaluation which is described below.

III A MODEL OF EVALUATION

The process of evaluation can be interpreted from several different perspectives. Examples will be given to show that it is

1) within an emerging model of democratic evaluation. It will be suggested that this form of evaluation can be viewed.

2) as a general research strategy

3) as an aid for improving learning

4) as containing a new view of the curriculum

a) An emerging model of democratic evaluation.

The process of evaluation from the round II proposals and its realisation in practice have been described in part 1. p37-43. The key issues for the evaluator were the creation of a climate of trust in which the teachers and learners felt free to express their fundamental goals and interpretations.

The basic value of the evaluator was to gather information about the intentions, activities and interpretations of learners, teachers, lecturers and advisers and to make this information freely available between the different groups who wanted knowledge of each other. The techniques of data gathering and presentation included video taping and open unstructured interviews. The data was easily accessible to non-specialist audiences.

The teachers had control over the use of the information they provide.

The democratic evaluation study is an emerging model[26] not yet substantially realised but one which embodies some recent theoretical and practical trends. The criteria used to distinguish this form of evaluation from other forms (see Appendix 1) are.

a) The evaluator acts as broker in exchanges of information between groups who want knowledge of each other. (see the form of the evaluation report p38)

b) The evaluators main task is the collection of definitions of and reactions to the programme. (See p39 & 42. No. 6 & 7).

c) Key concepts are confidentiality, negotiation, accessibility and the right to know.

The process of evaluation described on p 37-43 fulfils criteria 1 and 2 above as well as the key justificatory concept in 3 namely, the right to know. In fulfilling these criteria the process of evaluation can be seen to be within the emerging model of democratic evaluation. (Macdonald 76 Appendix 1).

b) As a general research strategy

Methodology in educational research is a complex and controversial area. This is often the case in new areas of exploration where value judgements are central to the processes being investigated and where objective accounts and theories are difficult to validate through controlled experimentation.

Research in education has been heavily criticised by both academics and teachers.[27] The criticism of academics is usually grounded on the facts that the experiments lack adequate empirical control over the variables and the psychological tests have dubious construct validity. Teachers criticise research on the grounds that the results are not helpful in indicating how to improve learning situations for their pupils.

This strategy has been variously termed action research (Adelman & Elliot 1974)[31] and Illuminative Evaluation (Hamilton & Parlett 1972)[32]

The shift from a model of evaluation derived from experimental psychology to one that owes more to social anthropology creates problems. This shift recognises the complexity of educational practice and makes the participation of teachers and learners central to the process of evaluation rather than treating them as producers of measurable outcomes.

The criteria appropriate for judging the research must be related to its stated aims. These relate to improving the critical questioning and collaboration among a group of teachers, improving the learning situations of their pupils, the collective production of resources, establishing a network of mutual support and a consideration of the implications of this kind of work for theories of curriculum development.

When compared to conventional research reports and other modes of evaluation, the interim evaluation report compiled for the teachers appears illogical fragmented and not always coherent. The transcripts of interviews with the teachers, however, show that this form of evaluation has opened up opportunities for the group of teachers to see themselves as participating in the process of evaluation and development as something central to and not separate from their everyday classroom practice.[33]

The transcripts of learners responses which are located in particular experimental tasks provide material specifically related to science teaching for the 11-14 age range. This form of material is of accepted value to teachers and students (Barnes).[34]

The improvements noted by the teachers include

1. less discipline problems
2. more care in the presentation of work
3. a greater quantity of work done
4. a greater degree of cooperative activity
5. more opportunities for pupils to try out their ideas and develop their own lines of inquiry.
6. more questioning from the pupils

The development of a network of mutual support can be seen in the closer cooperation between members of a University, an L E A Advisory Service and teachers. The form of support, initiated by this project is being extended to other areas of the curriculum in a local context.

In a Regional context it can be seen in the links between members of the Swindon and Salisbury workshop groups[35] and the Avon Resources for learning Project.[36]

At a National level the I L I S news letter, catalogue and directory contain contributions from the Swindon and Salisbury Groups[37]. The many requests for financial and other forms of support requested by teachers and advisers in Forming and Funding workshop Groups in London, Manchester, Newcastle and Cornwall, indicate the need for an extension of this process of innovation and evaluation.[38]

As a research strategy illuminative evaluation is not only valuable in curriculum innovation but as a procedure for improving the quality of learners relations and activities in classrooms.

c) As an aid for improving learning

The structure of evaluation in this country is based upon norm and criterion referenced assessments.[39] Norm referenced assessments are designed to differentiate between pupils. They are the dominant form of evaluation used by the GCE Boards and their major purpose is to select pupils for vocations and higher education.

Criteria referenced assessments are designed with behavioural objectives in mind. They detect whether or not a pupil has achieved mastery of a criterion behaviour in terms of knowledge and skills. These are the dominant forms of evaluation used by the CSE boards.

Illuminative evaluation is an attempt to help the pupil and teacher evaluate their own performance in order that they can see ways of improving their relations, activities and products.

It has already been suggested that teachers need different kinds of information from examining boards (Mathews and Leece 76)[40] Most of the feedback teachers have had from the examiners has been in the form of general examiners reports which have normally been applicable to general performance not the performance of candidates from individual schools. Recommendations have been made that feedback to individual schools should be an integral part of the continuous monitoring of some examinations on condition that teachers want this information. Mathews and Leece state that the information would allow the teacher to compare the performance of his group of students in all the various elements of the curriculum with that of the National Norm and modify his own curriculum if he thought it necessary.

Whilst the free flow of information may be welcomed by many teachers, the mixed ability project experienced problems when members of the group felt that they were being watched by non-participants.[41] The recommendation that the results of Norm referenced assessments should be fed back to the teachers could work against improving the curriculum unless a network of mutual support is developed between teachers, lecturers advisors and examiners whose binding force is the concern and committment to provide the information and resources which teachers require to encourage improvements to be made in the curriculum and process of evaluation.

The outcome of a process of schooling is too complex, too much a set of interrelated changes in the whole personality of the pupils to be given a full and balanced assessment in Norm and criterion referenced tests which focus on the pupils knowledge of facts and abilities. Examinations set and marked externally cannot evaluate the quality of the questions the learner has formulated or his attempts to answer them.[42] An example of illuminative evaluation as a teaching/learning strategy which takes account of these factors, is produced in the following reflections by a teacher on a transcript of an interview with four second form girls.[43] .

The information and interpretations offered to the pupils are intended to improve the learners scientific activity.

The four girls were measuring the acidity or alkalinity of lead monoxide by putting a liquid indicator into a mixture of powder and water. A simple operation and a 3 minute experiment. They got different answers and wanted to explore why.

Teacher: Denise, can you tell me about the experiment you are doing today?

Denise: Well, I get two test tubes, but I don't fill them up with the same amount of water and I measure up the same amount of lead monoxide, one spatula full and 7 drops of indicator.

Tracey uses dirty test tubes, Sandra uses exactly the same amount of water and indicator but different amounts of lead monoxide. Judith uses different amounts of indicator....

They say that the results were wrong the first week for one of four reasons:

1. They used different amounts of water
2. They used different amounts of lead oxide.

etc.

The experiments they devised used a sophisticated technique called 'a controlled experiment' where one variable is altered while all other factors are kept constant. This concept is notoriously difficult, for a major proportion of children at this age when taught in the more conventional ways. They obtained their results.

Teacher: Now you've said it's nothing to do with the amount of water, it's nothing to do with the amount of lead monoxide, or with dirty tubes, or the amount of indicator. In fact, it doesn't seem to be to do with anything that you have tested.

Sandra: No

Teacher: Now what do you think was different about the experiment that you did last week which makes it different to the experiment you did this week?

Tracey: Well I suppose what we could try, sir, is that we could have say, different amounts of water in the test tubes and different amounts of lead monoxide and dirty test tubes and see whether it was all four of them

They are saying "It wasn't one factor on its own that made the difference but it could have been caused by all these factors acting together.

Teacher: Yes, that is certainly true. It could have been. What about this idea. The lead monoxide should turn indicator a blue colour, but last week you had one tube that went red. Could it have been a dirty test tube which had had acid in it?

Tracey: Wouldn't it go neutral, because a certain amount of acid and a certain amount of alkali in there.. . shouldn't it turn neutral, but we didn't. We got a very strong acid and one got a very strong alkali.

Teacher: You think about that.

Sandra: I don't get what you mean.

Tracey: I thought about it before I asked you!

Teacher: Well, think about it again. Sandra, you don't understand what we are driving at, do you?

Sandra: No

Teacher: The mistake might have occured last week because you had a dirty test tube and it had acid in it already. Now what would happen if you did all this in a test tube which was dirty to begin with, with a bit of acid. What might happen?

Sandra: What... what, you mean if we did an ordinary experiment and it turned acid and then we tipped it out without washing it, do you mean?

Teacher: Mm

Judith: Well then it would turn acid wouldn't it.

Tracey: Well no, it wouldn't. If you have got lead monoxide and that's - well we found out it was a very strong alkali. A strong alkali and a strong acid is going to make neutral isn't it?

Teacher: Well, it depends

Sandra: You've got to have virtually the same haven't you.

Teacher: Yes it's a balance isn't it

Sandra: Tracey said "if you had a strong acid and a strong alkali - it would make neutral, but how is Tracey going to know how much acid is in there to add the same amount of alkali?

Teacher: Good point.

Judth: If we use a syringe, then we could put exactly the same in, so we know that it's balancing, or we know if it's stronger or weaker.

Sandra: But we don't know how much acid is in there.

A minute ago Sandra didn't understand the problem the other girls were raising. She has now grasped the idea of 'acids cancelling out alkalis' and of her own accord is appreciating the idea of balancing out different quantities of acids and alkalis whose 'strength' is unknown. A giant leap. This example answers some criticism that close attention to childrens' self-directed work does not produce the scientific progress that conventional methods do. On the contrary, I believe that work of this sort produces learning of higher quality and, in the long run, learning of greater quantity.

This idea goes some way towards the possibility that individualised learning in science can produce the examination results required - a stumbling block for children, teacher, parents and employers.

This study supports other findings (Ford T, Parlett & King 1971) that informality encourages the asking of questions and the provision of information and interpretation within the framework of trusting relations encourages the pupils to test their own hypotheses and be self critical of the outcome. This phenomena has been reported in the three classrooms moving towards inquiry learning between January and March 1976 where it did not appear between September to December 1975. The implications of this phenomena for a view of the curriculum will now be made explicit.

d) As a new view of the curriculum

A new view of the curriculum is implicit in the way the teacher selects and arranges the learning resources. The teacher selects topic areas and arranges resources which contain the conceptual frameworks of the scientific forms of knowledge as one set of possible interpretations amongst many others. The particular conceptual framework developed by each individual will emerge from the questions educator and pupil agree are in the pupils personal and social interest to pursue. The key notion is that the curriculum is to be defined in terms of the conceptual framework which emerges from the questions educator and pupil agree are likely to be in the pupils personal and social interest to pursue. This view of the curriculum is different to the dominant view which suggests that the curriculum of a school is a body of knowledge independent of the knower and there to be mastered.[44]

In conclusion it will be suggested that a shift of financial resources is needed from supporting the dominant views of the curriculum and examination towards encouraging the emergence of inquiry learning and illuminative evaluation. One way in which this movement could be encouraged has been outlined in this paper.

4. CONCLUSION

If the process of innovation and evaluation described in this report is to have a significant influence on the improvement of learning in secondary schools it must be an expanding field of exploration. To emphasise the continuing nature of this exploration the conclusion is in the form of two reports.

The first is a discussion document, for the Science Committee of the Schools Council, which requests financial support to establish a National Network of local workshops and regional resource centres.[45]

The second is a recommendation on assessment procedures which emerged from an ASE conference on mixed ability teaching at Southlands College in March 1976.[46] The recommendation in this report is that illuminative evaluation procedures should become increasingly important in the improvement of learning. The report is to be circulated to examining boards and efforts made to ensure that the recommendations are put into practice.

a) Proposal to the Schools Council to extend the process of innovation.

b) Recommendation to the Schools Council on the structure of evaluation.

A) Proposal to the Schools Council for support to develop local Workshops and Regional Resource Centres for I.L.I.S.

Origin

Recent projects from the Schools Council and other Funding Agencies have emphasised local curriculum developments projects, independent learning, learning in mixed ability groups, inquiry/discovery learning, resources for learning, action research and illuminative evaluation.[47] These projects have posed a complex array of questions rather than a coherent theory to those teachers who are interested in curriculum innovation and evaluation. One question appears to be at the centre of many of these projects.

"How can teachers be helped to improve the personal and social value of the pupils relations and products?"

This is the problem which will be considered in this paper. No one theory or model of innovations is central to this paper. An eclectic approach is adopted in an attempt to benefit from the strengths of different, models of innovation, research strategies and evaluation techniques.

The assumptions behind this document are:

1) The successful design and production of Teachers Guides and learning resources by central Project Teams needs to be matched by an effective local and regional organisation.[48]

2) To develop effective curriculum innovation and evaluation at local level the major task is to create the circumstances and provide the support which will enable effective innovation to be generated, sustained and carried forward in the institutions by the people directly concerened with the problem.[49]

3) The way to effective curriculum development may lie, not in more efficient projects, but in narrowing the distance between schools and the agencies in education that administer, advise and train or generate new ideas.[50]

Two development projects recently funded by the Schools Council were based on these assumptions. The Independent Learning in Science Project focused upon strengthening local and regional initiatives through visits by the coordinator to those centres which were attempting to form and fund workshop groups for the solution of particular problems. A news letter catalogue and directory keeps members informed of each others activities, views and resources which are available free of copyright.

The Mixed Ability Project based on Wiltshire has focused on the formation funding and evaluation of workshop groups to improve areas of concern in the 11-14 science groups. The distance has been narrowed between teachers, advisors, administrators and teacher trainers. This movement is now spreading throughout the secondary age range and into different subjects. Close links between three projects, I.L.I.S., the mixed ability and the Avon Resource for Learning Cooperative have proved beneficial to the teachers who are attempting to improve learning situations in science for the 11-14 age range in mixed ability and other forms of grouping.

The members of I.L.I.S. who are working with these three projects have seen the importance of the resources produced by National Projects being modified or copied through a system of local workshop groups and Regional Resource Centres for the reproduction and illustration of the modified materials.

They believe that there is now a need for a major effort to show teachers what is available in the form of resource materials and reprographic facilities and to encourage participation in the formation, funding and evaluation of workshop groups of teachers who come together to improve some aspect of their curriculum.

Throughout the country, in schools, institutions of higher education and Teacher Centres, individuals are coming together to design, modify and produce independent learning resources. There is a great deal of cross fertilization which could have occurred through an efficient newsletter service, for example between the members of working groups at the South London Science Centre,

Avon Resources for learning and the Swindon Curriculum Development Centre, who have been working independently on similar problems.

It is suggested that the members of I.L.I.S. who are taking initiatives at local and regional level to form workshop groups should have limited financial support which can be quickly used to fund the activities of the groups. As an integral part of the groups activities, a teacher, lecturer or adviser must be included who is familiar with Illuminative Evaluation. The evaluator will focus on the teachers intentions, resources and activities in classrooms, learners interpretations and the quality of the learners product.

The evaluators role must be clearly defined by the groups and detailed records kept of his activities.

It is envisaged that some part time secondment will be needed for the design, production, organisation and evaluation of the learning situations being improved.

In the five part time secondments arranged by the I.L.I.S. and the mixed ability project the seconded teacher has assumed a coordinator's role in calling meetings, producing resources, and informing other interested teachers of the groups activities.

If this form of in-service support for curriculum innovation and evaluation is to continue, support from the Schools Council is essential.

The members of I.L.I.S. would be grateful for the opportunity to discuss their views with and benefit from the experience of the members of Science Committee.

B. Recommendation on the structure of evaluation from the A.S.E. conference at Southlands College - March 1976

The structure of assessment is of fundamental importance to our system of education. The working group was conscious of the present context of the debate concerning 16+ examinations, with the Schools Council advocating a common examination at 16+[51] and the Committee of University Vice-Chancellors and Principals[52] pointing out the dangers of lowering the standards unless nationally agreed norms and criteria could be applied to whatever system of examining eventually emerged.

With these issues in mind, the working group attempted to answer the following questions:

1. What are the goals of evaluation
2. What forms of evaluation fulfil these goals
3. What structure of evaluation is most likely to benefit our educational and related social institutions.

1. The Goals of Evaluation

The goals of evaluation were defined as:

1a To improve the quality of the learners relations, activities and products

1b To provide information about the learners abilities intellectual skills and products.

1c To offer some guidance to agencies which select individuals for jobs and higher education.

2. What forms of evaluation fulfil these goals?

The most important aspect of evaluation was agreed to concern judgements of the quality of human relations. This creation of a cooperative spirit or climate of trust was viewed as a fundamental task of evaluation. This primary value could not be expressed in the form of linguistic of behaviour criteria yet it was affirmed as a central value of educators. In the description of the forms of evaluation below it should not be forgotten that they refer mainly to the activities and products of learners and not to the quality of human relations. The three goals above are ordered in terms of their educational value. In the structure of evaluation in this country at present, their value is reversed. This can be seen to be reflected in the dominant form of evaluation used by our examination boards.

a. The norm referenced assessments used by the GCE boards are primarily designed to provide information to the selective agencies which assign jobs and opportunities for higher education.

b. The criteria referenced assessments used by CSE boards are designed to detect mastery of a set of intellectual skills, abilities or knowledge. They are usually operationalised as a set of behavioural or cognitive objectives. Scales to detect the state of a persons attitude are also being used.

c. Illuminative evaluation procedures have rarely been used in our structure of evaluation. They are designed to help the learner improve the quality of his product by providing criteria and encouraging the creative and critical expression which allows the pupil to judge the value of his own work.

It is suggested that a reversal should take place in the order of importance of different forms of evaluation.

The chief function of examination boards should become to improve the quality of learners relations activities and products through an emphasis on illuminative evalution procedures.

3. The Suggested Structure of Evaluation

(a) Illuminative Evaluation Procedures

The illuminative evaluation procedures rest upon a climate of trust being established between a network of teachers, examiners and researchers. The primary purpose of establishing this network is to improve the quality of learners relations, activities and products. This is achieved through a series of evaluation reports written by teachers, examiners and researchers from their observations, enquiries and explanations of the learning situations in schools. An expression of faith in each others capacities to evaluate these reports in terms of improving ones own practice is essential to illuminative evaluation.

(b) Criteria Referenced Assessment

This form of assessment should be related to the intrinsic qualities of the subject. For science the following 4 categories are suggested which with a 5 point scale and a matrix of work done, will provide important feedback on progress to teachers and parents and future employers.

I	II Experimentation		
Creativity	Observation	Recording	Manipulation
e.g. Having ideas asking questions finding patterns forming hypothesis forming problems			

Evaluation III	IV Communication		
	Talking	Writing	Other media
Self criticism Response to criticism of others			

It is suggested that the 4 categories are equally weighted.

(c) Norm referenced assessments

The Universities are most anxious that some agreed and applied criteria are established for norm referenced assessments. This would be done efficiently and cheaply by isolating the key concepts within the forms of knowledge (agreed by the Universities as important) and applying the well tried techniques of developing standardised objective measures for examination.

It is suggested that the balance of financial resources should shift from emphasising norm and criteria referenced assessments to an emphasis on illuminative evaluation procedures which are designed to improve the quality of the learners products.

Appendix I

Bureaucratic evaluation

Bureaucratic evaluation is an unconditional service to those government agencies which have major control over the allocation of educational resources. The evaluator accepts the values of those who hold office, and offers information which will help them to accomplish their policy objectives. He acts as a management consultant, and his criterion of success is client satisfaction. His techniques of study must be credible to the policy-makers and not lay them open to public criticism. He has no independence, no control over the use that is made of his information, and no court of appeal. The report is owned by the bureaucracy and lodged in its files. The key concepts of bureaucratic evaluation are 'service', 'utility' and 'efficiency'. Its key justificatory concept is 'the reality of power'.

Autocratic evaluation

Autocratic evaluation is a conditional service to those government agencies which have major control over the allocation of educational resources. It offers external validation of policy in exchange for compliance with its recommendations. Its values are derived from the evaluator's perception of the constitutional and moral obligation of the bureaucracy. He focuses upon issues of educational merit, and acts as expert adviser. His techniques of study must yield scientific proofs, because his power base is the academic research community. His contractual arrangements guarantee non-interference by the client, and he retains ownership of the study. His report is lodged in the files of the bureaucracy, but is also published in academic journals. If his recommendations are rejected, policy is not validated. His court of appeal is the research community, and high levels in the bureaucracy. The key concepts of the autocratic evaluator are

'principle' and 'objectivity'. His key justificatory concept is 'the responsibility of office'.

Democratic evaluation

Democratic evaluation is an information service to the whole community about the characteristics of an educational programme. Sponsorship of the evaluation study does not in itself confer a special claim upon this service. The democratic evaluator recognizes value pluralism and seeks to represent a range of interests in his issue formulation. The basic value is an informed citizenry, and the evaluator acts as broker in exchanges of information between groups who want knowledge of each other. His techniques of data-gathering and presentation must be accessible to non-specialist audiences. His main activity is the collection of definitions of, and reactions to, the programme. He offers confidentiality to informants and gives them control over his use of the information they provide. The report is non-recommendatory, and the evaluator has no concept of information misuse. He engages in periodic negotiation of his relationships with sponsors and programme participants. The criterion of success is the range of audiences served. The report aspires to 'best-seller' status. The key concepts of democratic evaluation are 'confidentiality', 'negotiation' and 'accessibility'. The key justificatory concept is 'the right to know'.

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The 11–14 Mixed Ability Project in Science

Draft report for criticism and amendment

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