AN INVESTIGATION INTO ATTITUDES TOWARDS COMPUTERS AND BIOLOGICAL PROBLEM SOLVING AMONG SCOTTISH SECONDARY SCHOOL PUPILS

BY

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ABSTRACT

A survey of the relevant literature was carried out. This covered a large number of topics relating to the different areas covered by this work: computer use in schools, attitudes of girls and boys to computers, pupil attitudes in general, problem solving skills, areas of difficulty in Biology, perception and memory.

The role of the computer in the classroom was investigated. Pupil attitudes to the microcomputer and its use in the classroom were investigated using a questionnaire. The areas investigated were: general expectation of use, mode of use within the classroom, links with other subjects and the world outside, expectations of boys and girls. The survey was also linked to questions about the use of home computers. The attitude survey made use of two different measurement techniques (Likert and Semantic - Differential). Pupil attitudes were measured at the beginning of first and third year secondary schooling. The same pupils were questioned a year later at the beginning of second and fourth year respectively.

Concurrently with the attitude survey, an investigation of an area of difficulty within the Biology syllabus was carried out. The area chosen was that of the construction of biological keys. The aim of this part of the work was to make a computer program to improve the learning of this topic. As a result of the design exercise necessary to construct the computer program, further work on the analysis of key making skills was carried out.

Analysis of the skills needed to make a biological key showed that these skills were divided into two main areas. The choosing of the correct biological features and the mechanics of key construction. Initially, each of these areas was investigated separately. Hypotheses concerning these skills and the influence of the psychological factors of working memory and ability to disembed were formulated. The key making skills were tested using written material developed during the course of the work.

The psychological factors were investigated using standard tests. All three tests were completed by two hundred and eighty five third year biology pupils from a range of schools in the West of Scotland.

Both the attitude questionnaire and the key-making test material were developed through a series of pilot studies. The data collected was analysed and underwent statistical analysis. Relevant conclusions were drawn.

Finally, conclusions drawn from the results have been summarised, recommendations made and further work suggested.

INTRODUCTION

Since the introduction of a significant number of microcomputers into schools in the early 1980's, a large number of official bodies including the Scottish Examination Board and Her Majesty's Inspectorate have actively encouraged teachers to use computers in their classrooms. Amongst the new Standard Grade subjects, the arrangements for Biology (1) lay before us an impressive range of benefits to be gained from the use of computers:

"The development of microcomputing in schools provides opportunities for their use as aids to learning and experimentation which should help motivate pupils and lead to greater understanding".

The starting point for this piece of research work is therefore the computer in the classroom, its use, the software available and pupil attitudes to it. If the computer is to be an aid to learning then knowledge of pupil attitudes towards computers and their use in school is important. This knowledge was obtained using an attitude survey carried out amongst first and third year secondary pupils. The survey set out to investigate the following hypotheses concerning the attitudes of such pupils to microcomputers.

1 Pupils find using computers in school exciting, interesting and enjoyable.

2 Pupils think computers are important and time well spent.

3 Pupils use computers at school.

4 Pupils like to use a computer because it individualises their learning.

5 Pupils like to play games on the computer.

6 Pupils think they need abilities in other subjects to use a computer.

7 Pupils think that using a computer in school will help their job opportunities.

8 Girls and boys have similar attitudes to computers.

The survey also followed these pupils as they moved into second and fourth years respectively. The survey results give us an insight into what pupil attitudes are and how they change during their time at school. If attitudes are negative, then using a computer in class will not help a pupil's learning. Conversely, positive attitudes may improve pupil motivation and learning.

Many pupils have their own computers at home. This type of use, together with the software they experience, may influence their feelings towards microcomputer use in school. For this reason, pupils were also asked questions about the frequency of home use and the type of software they used.

It was also felt to be important that the attitudes of boys and girls should be investigated separately. It was already known that differences existed in relation to science due to differences in interests and expectations between boys and girls.

One area in which the computer might be able to aid learning is topics of special pupil difficulty. A number of these areas of difficulty were identified in Biology and it was hoped that a computer program could be written to improve learning in a particular area.

The area of difficulty chosen was Biological Keys. Keys are used and made by both first and third year pupils as part of their Integrated Science, Ordinary or Standard Grade Biology courses. The use of keys to identify living organisms gives pupils few problems, but their construction either as family trees or as paired statements can cause major difficulties.

The design of the computer program needed an analysis of the skills required to construct a key successfully. This led to the development not of the computer program, which was felt to be inappropriate at this time, but to the identification of the specific skills needed by pupils to make a key.

The necessary skills were initially divided into two main areas. The first part of the work laid emphasis on the mechanics of key making and the influence of a variety of factors such as course content and question type. The second part of the work looked at the choosing of attributes and the factors that might affect this, for example the type of object and the amount of information given. To collect this information, a number of techniques were used including written and interview items.

This work was also linked to the study of two psychological factors, working memory capacity and the ability to disembed, which might also affect the successful completion of a key. These investigations culminated in the production of test material to investigate the skills needed to make a biological key in two distinct areas.

1 Choosing suitable biological attributes
2 Mechanics of making the key

Within the area of choosing attributes, the following skills were investigated:

1 the ability to distinguish features
2 the ability to name these features
3 the ability to choose biologically significant features and to disregard unsuitable differences
4 the ability to know when there are enough suitable features so that all the organisms within the given group

can be identified.

Within the area of making the key, the following skills were investigated:

1 the ability to sort or set objects
2 the making of a family tree key
3 the making of a paired statement key

The following hypotheses were investigated. That:

1 the skills needed to construct a biological key are related to a pupil's working memory capacity; and
2 the skills are related to a pupil's ability to disembed.

It was hoped that a better understanding of these skills and the factors which influence them would lead to better teaching and improved learning of a complex problem solving skill.

OVERALL PLAN OF WORK CARRIED OUT 1985 TO 1989

Time	Project
1985-86	Initial Literature Review
1986	Attitude Survey (Pilot Study) Year 1
1987	Computer Program Design
1987	Attitude Survey (Pilot Study) Year 2
1987	Attitude Survey (Main Study) Year 1
1987-88	"Key Problem" (Pilot 1)
1988	Attitude Survey (Main Study) Year 2
1988	"What Pupils See" (Pilot 2)
1988-89	Biological Keys (Main Study)

CHAPTER 1

COMPUTER USE IN SCHOOLS AND SOME FEATURES OF PROGRAM DESIGN

1.1 History of Computing in British Schools

The first major attempt to introduce computing into schools was the five year National Development Programme in Computer Assisted Learning (NDPCAL). In 1977 its final report Hooper (2) argued that Computer Assisted Learning (CAL) can only be considered effective if it can demonstrate both "institutionalisation" and "transferability". Institutionalisation was used to indicate acceptance by a school or college, including commitment of both staff and resources and availability to students or pupils. Transferability was defined as "the systematic attempt to promote the spread of experience, new ideas and teaching materials". In other words, if CAL was to be in any way successful in an educational institution, it required the total commitment of that institution.

In the following ten years, Hooper "saw a steady and evolutionary growth as likely and desirable", this period of growth "would be geared to finances, teacher commitment, changing curriculum and technology". He also emphasised the support CAL and CML (computer managed learning) could provide for new teaching techniques such as Resource Based Learning (RBL). The computer was also seen in the assistancé of teaching such skills as problem-solving and decision making rather than a mere transmitter of facts.

During the period of NDPCAL changes in the hardware available, from large central computers with data terminals to the first generation of microcomputers, accelerated the pace of change and allowed individuals in schools and colleges to become involved.

In Scotland, the Scottish Microelectronics Development Programme (SMDP) (3) was set up in 1980 as a major initiative to introduce microelectronics into schools and colleges. During its four year programme, its main aims were: to raise general awareness of microelectronics in education; to develop a software library, information service and in-service training; to foster liaison between interested parties and to provide programming support.

In 1982 the progress of SMDP was evaluated by Odor & Entwhistle (4) as patchy but computer awareness levels had risen in Scottish schools. A software library was being built up, but the high cost of developing good high quality software was now appreciated. Programming assistance had been given but was of a limited nature. To be more effective it was felt that changes in financing and control would be needed. Attention was also drawn to the important issue of teacher support which would be needed if the initiative was to be maintained and extended.

In the same year, the Education Committee of COSLA (Council of Scottish Local Authorities) issued a discussion document "Microelectronics in Scottish Schools - A National Plan" (5). Its objective was to co-ordinate rather than generate change. As a result of this and other discussions, by 1984 SMDP had become integrated within SCET (Scottish Council for Educational Technology) to act as the executive arm of the Scottish Microelectronics in Education Committee (MEC). This Committee had now become the main focus for the production of software and for the development of computing within Scottish Schools.

In 1985 MEC, although responsible for all microelectronics, saw the implementation of the "National Plan for the Use of Microcomputers in Scottish Schools" as their most important and immediate task over the next decade. The National Plan saw the main argument for the general use of microcomputers in schools, with only a minority of pupils acquiring specialist technical knowledge. The Plan emphasised the increasing use of computers in everyday life and industry and the need for schools to reflect the society they serve. It suggested that educational benefits from the use of computers include: growth of problem-solving capacities; independence of the learning process and hopes that this will lead to a capacity to make choices and cope with their consequences.

Later discussion will suggest that, as with many introductions of the last 20 years, the computer is not the answer to all our problems. It can be of assistance, but must be carefully used in the best possible way so as to complement the thinking, learning and teaching being carried out in the classroom.

1.2 Computer Use in Schools

A large number of uses for microcomputers in school have been suggested. A committee of the American Association for the Education of Teachers in Science [Sherwood (6)] listed six main areas:

1. Learning from computers (drill & practice, tutorials)
2. Learning with computers (simulations, games)
3. Learning about computers (computer studies)
4. Learning to think with computers (logo, problem-solving)
5. Managing learning with computers (records, testing, remediation)
6. Training of teachers to work with and use computers.

While this list may not be exhaustive, it provides a basis to work from. When considering use within the classroom, the emphasis will be on areas of learning from, learning with and learning to think with, computers.

1.3 Why Use a Computer in the Classroom?

When considering the specific use of a microcomputer in the classroom, an important question must be answered:

Is the computer necessary?

This is, of course, a matter of professional judgement by the teacher, but like many new developments the microcomputer has been seen by many as a panacea for all educational problems. To quote Alfred Bork (7)

"There is . nothing magical about computers, like all technological developments the computer itself is not good or evil, rather it is the way it is used by humans which is the critical factor."

The microcomputer is good at certain things; it can individualise learning, handle large amounts of data quickly and efficiently and run simulations.

Individualised learning can provide the pupil with material specially tailored for his or her needs and abilities. It is able to interact with the user and can provide relevant and frequent feedback (section 1.6). Unlike the teacher, it does not have the demands of other pupils to cope with. It can be infinitely patient. It may also be seen by the pupil as providing a less critical and more understanding approach.

The microcomputer can store large quantities of information which can be searched easily and quickly and is readily accessible to all members of a class. It can also handle numerical data, do calculations, draw graphs and tables neatly and easily. The microcomputer, when used as a word processor, can provide all pupils whatever their language abilities with a neat, correctly spelt and well presented piece of work.

All the tasks mentioned before could be carried out by more traditional, time consuming methods, individual learning by book, feedback from the teacher, pencil and paper graphs.

What about tasks which cannot be done within a conventional classroom situation? Simulations (section 1.7) allow the possibility of carrying out experiments not normally possible because of the constraints of time, equipment or safety. Individuals or groups can see and be involved in experiments they would previously have not done or seen by demonstration or more probably only read about.

Interfacing or the use of the computer to collect experimental data and to control on equipment is a vast field mentioned here, but outside the scope of this particular piece of research work.

A large number of authors suggest that one important role of the computer is in the field of problem-solving [Hooper (2), Hartley (8), Ridgeway et al (9)]. Cabinol et al (10) describe "George - heuristic problem solver". George uses heuristic rules to discover a solution to a problem. Using chemistry problems of mass, volume and number of moles the program shows students how to solve their own problems. If the student does not supply enough data he or she is asked to provide the missing information. When the data supplied is sufficient, the program supplies the answer but more importantly explains how the answer was reached. Ganiel & Idar (11) hope that by using computer simulations students will become "involved" in the problem solving and that this will lead to meaningful learning.

Whether general problem solving skills such as prediction, checking and monitoring can be taught using a variety of computer programs is not as yet proved. Most problem solving is knowledge-based and lacks transferability so that ideas of computer teaching problem solving per se may be premature (Sections 6.15, 6.16, 6.17), the computer then is just another way (like experimental work or group discussion or paper & pencil exercises) of solving problems in science.

Ganiel & Idar also see computer problem solving as a way of overcoming student misconceptions (Section 5.29). The computer being able to test the validity of predictions against the students' own interpretations, thus helping the student to build correct models of the Natural World.

The computer also allows the exploration of micro worlds such as Logo. Seymour Papert (12) describes Logo as a language for learning, a philosophy of education. Logo hopes to foster the skill of learning itself, to allow the building of mental models, the more a child learns the better the model, the more able he or she becomes as a learner.

Improved motivation is often stated as a good reason for the use of microcomputers [(1), (9), Rogers (13)]. In a study of 9-11 year olds classificatory abilities, Underwood (14) decided that the main reason for an improvement in scores with the computer was motivation and suggested that the learners felt more in control when using a computer. Interestingly, Holmes et al (15) in another study found that learner control with advice gave the best results in a computer study of Maths work.

1.4 Software Available for Use in Schools

There is a general feeling, including that of the author, that software aimed at schools leaves a lot to be desired (7), (8), (16). Many authors give exhaustive lists of criteria for evaluation and suggestions for improvement

(7), (16), (17), (18). Chandler (19) considers content, presentation and documentation of a program by asking a large number of pertinent questions, among which are:

Does the learner have the required prerequisites, in both knowledge and skills?

What are the stated aims and objectives of the program?

Is the program based on sound pedagogical design?

Is the content relevant, interesting and stimulating?

Is it user friendly to both sexes?

The use of these questions, together with consideration of the presentation, instructions, use of type, graphics, sound and colour give a useful basis on which to assess a piece of software for classroom use.

In general, the types of software available for use in schools fall into six main categories: drill and practice, simulations, databases and handling, games, interfacing and testing. The majority of programs fall into the drill and practice tutorial group. Bialo and Erickson (16) found that in 1985 in all of the software available to US schools (some 4,500 programs), 49.4% were drill and practice, 18.9% tutorial, 12.3% games, 5.4% simulations. A similar British study is not available but an analysis of lists of programs available to schools show similar trends. In view of the special abilities of the computer, this seems a waste of a lot of potential, allowing the computer to do something that could be done, possibly better, by other means such as a text-book or paper & pencil.

It would appear that the early drill & practice programs, which were little more than page turning exercises, still exist. They are perhaps being emulated and are certainly not the best use of the capabilities of the classroom microcomputer.

1.5 Who Controls the Computer?

When computer programs first appeared in schools, most programs were of the drill & practice or tutorial type. The control of pupils' learning was by the computer who merely followed the instructions of the program's author.

During the last decade ideas concerning who controls the program have changed. These changes have, of course, been linked to improvements and developments in both computer expertise and technology.

Hartley et al (20) have investigated the problem of learner control in CAL. Programs available at the time were very limited when compared with a teacher-pupil dialogue. To improve the situation, they created a number of different programs which included tutorials, simulations and problem banks. These programs could be used in a number of different ways, also the user could receive help in a number of different ways: regulation of the size of steps in problem-solving; goals and strategies; summarising; information and feedback. Evaluation of the material was carried out with a number of different groups. One group of chemistry students used a program on experimental planning. The students were assigned either to a controlled route regulated by individual performance (A) or to a learner controlled group (B). Initially, treatment A did better in post-tests but treatment B was preferred by the students. When the materials were extended into further related topics, the two treatments performed equally well, with Group B needing a shorter study time.

Similarly, Biological Science and Physiology students preferred a method which allowed learner control. Lewis (21) reporting on behalf of the Chelsea College group producing software for use in schools and colleges, also saw the need for more flexibility, program adaptability and learner control. Another study in 1985 by Holmes (15) using a school mathematics program, reported that learner control, with advice, produced the best results followed by learner and adaptive control with the random control group doing worst.

It would appear that the learner does better and prefers to be in charge, but with the proviso that some guidance is given as to the right decision to be taken perhaps analogous to the guided discovery method of carrying out practical work.

1.6 Feedback

Interaction is regarded by Bork (7) as the most important advantage of the computer in that it can provide frequent and highly relevant feedback.

Roper (22) found the best results when feedback (right or wrong) with the correct answer was given, suggesting that the most important feature of immediate feedback is to correct wrong information, so that the user can progress. Tait (23) also states that it is the informational aspect of feedback which is its most important feature.

Lassoff (24) also found similar results. He gave an enriched form of feedback which included praise and personalisation, but the informational feedback still gave the best results. The extra items hindered rather than enhanced the retention of information.

Gaynor (25) studied the effect of feedback delay on the retention of maths material. She found that end of session (after 15/20 minutes) feedback helped high ability students and helped the learning of more abstract and conceptional material. A short delay of 30 seconds frustrated high ability students and reduced their Knowledge and Application scores.

The consensus of opinion is that feedback should only be used immediately to correct errors and is used to best advantage at the end of a topic or session - in other words, it should be flexible.

1.7 Simulations

A simulation is like a well run demonstration of a real experiment. Simulations can be seen as one of the tasks that a computer can do where the actual experiment is too difficult, dangerous, time-consuming or expensive to do in the laboratory [Masterton & Chaundry (26), Moore & Thomas (27), Mulvey (28), Murphy (29), Wellington (30)]. Simulations can also be used in conjunction with practical work [Bender (31), Tritz (32)] to provide previewing facilities, ideal experimental conditions and the removal of the "noise" of experimentation.

The computer can teach the principles of the experiment and can help in the planning of experimental strategies, if used in conjunction with an actual experiment, it allows a comparison of results. Criticisms have been levelled at simulations in that they may be boring and can cause confusion with reality. Another problem is over simplification, often to provide a usable simulation too much simplification can be made thus rendering the program unrealistic.

1.8 Effectiveness and Evaluation of Computer Assisted Learning (CAL)

What effect does CAL have on pupils' learning and attitudes? There is a lack of research comparing CAL with conventional methods of teaching, highlighted by Moore & Thomas (27); Roblyer (33).

Some researchers feel it is not possible or appropriate to compare CAL with other methods [Walker (34), Clark (35)]. Many of the studies carried out do not control important variables so it is difficult to make an objective assessment of the effectiveness of CAL. The major problem seems to be the complexity of investigating different methods of instruction. Ideally, if the computer is to be compared with any other method the only variable should be the use of the computer. In practice, this is not always possible, but a small number of studies have tried to fulfil the criteria for a controlled comparison of CAL with another more traditional method of teaching.

Hartley & Bostrom (36) studied Mathematics pupils using the same content and teaching sequence and found no significant difference between CAL and control groups:

CAL Group	mean score 17.9/25	8.8 st. dev	n = 182
Control Group	mean score 16.7	7.7 st. dev	n = 132

The material provided was similar so that any differences between the groups was not due to differing cognitive demands, but other factors. The CAL form of instruction gave the teacher more opportunities to interact with small groups so that the differences in scores may in fact be due to increased pupil/teacher interactions and not directly due to the use of the computer.

An earlier study by Kenny & Schmulian (37) with medical students investigated the management of self-poisoning and burns using CAL and tutorial groups. Each student group did 1 tutorial and 1 CAL topic, both CAL units showed improved scores when compared with the tutorial, the burns unit more than the poisoning.

Moore, Smith, Avner (38) considered the effectiveness of the interaction provided by the computer when investigating the acquisition of chemistry laboratory skills. The materials were presented as an interactive computer simulation or as a tape/slide sequence. After working through either set of the materials, the students were observed in the laboratory and the errors they made in certain procedures were noted. Students in the tape/ slide sequence made twice as many mistakes as the interactive computer group.

Many claim that computer-based discovery methods such as Logo provide greater achievement than traditional CAL [Papert (12)]. The computer does make possible unique learning conditions but studies on problem-solving and critical thinking skills [Bass & Perkins (39)] have not provided consistent evidence of measurable achievement.

Studies by Clyde (40), Diem (41) and Lovelace (42) have compared CAL with traditional methods and found no difference in performance between groups. In fact, Wainwright (43) comparing CAL (chemistry; formulae and balancing equations) with traditional pencil and paper methods showed that the latter did better.

The evidence so far accumulated could support either side of the argument as to whether computers improve learning or not. Those in favour are enthusiastic in their praise of the use of the machine and one wonders if improvements shown by the use of computers are because of the increased enthusiasm and motivation of the teacher concerned, not the machine. A number of other reasons could be set forward for improved learning in computer groups, the computer itself could interest and motivate the pupils, when using the computer especially if the program is interactive the pupil becomes an active learner rather than passively watching slides or listening to the teacher.

The other side of the argument is that pupils have a high expectation of computers because of their games experience (Section 1.10) and may find school programs dull and uninteresting so "turning them off" from any learning process.

1.9 Differences between Boys and Girls

The differences in interest and attitude between girls and boys is also discussed in Section 2.6.

If the computer is to be used in the most effective manner in the classroom, then it is most important that any differences between the sexes must be taken into account.

In their studies of 9-10 year old girls, Turkle (44) and Griffiths (45) showed that they had less interest in computing and the type of problem-solving tasks associated with educational software.

Siann & MacLeod (46) suggest that this lack of interest promotes self-selection away from opportunities to study computing at school. Two studies Schwerm & Benedict (47) in the USA and Newbould (48) in England showed that more boys than girls opt for computer studies as a school subject. Newbould investigated entries to both CSE (Certificate of Secondary Education) and GCE (General Certificate of Education) Ordinary level examinations, in Computer Studies. He estimated that 70% of 'O' level and 60% of CSE examinees were male. Only Physics was a more male dominated subject. In 1987 Scottish Examination Board figures (49) for 'O' grade Computing showed twice as many boys than girls taking the subject. Although there is an element of self-selection in the girls who take computer studies, boys still out-performed the girls in the examinations.

Fife-Schaw et al (50) in their survey of 1747 school pupils, showed that in all years from Secondary 4 to 6 (Scottish S3 to S6), at all levels of use, girls used computers less than boys. These differences could be explained by different subjects choice, not just computer studies, since other subjects have different computer inputs. It could be due to different use within the classroom or to membership of interest clubs. Fife-Schaw (50) also showed that girls, when they use the computer, are not as keen on playing games as boys. This may be due to the nature of these games which are usually aggressive and competitive.

1.10 Computer use at Home

Homes with boys are much more likely to have a computer than those with only girls [Fife-Schaw (50), Glyn-Jones (51)]. Glyn-Jones' study in South Devon covered the whole population rather than just school-children. Fife-Schaw showed that 61% of homes with boys and 39% of homes with girls had home-computers.

Both studies showed that arcade-type games were usually played in the machine. Educational packages coming a poor second. Hoyles (52) also estimated that 80% of home computers were bought for boys. This study (Sections 4.8, 4.9) shows similar trends in ownership. Gloom is often expressed in educational circles over this type of use as many people in education see programming as a more important skill to be learnt. However, in Fife-Schaw's (50) study, more than 80% of pupils went on from games use to some other computer activity. Over half the pupils went on to learn a computer language and to program a computer. They added to their games use rather than replaced it with these other activities.

Moore (53) also showed that like the other studies the main use of home computers was games playing and that more boys than girls used computers at home. Home use of a computer reduced the anxiety level of pupils, even those who had been taking a computer studies course for over a year. Could this be a valuable contribution of home computers?

1.11 Summary

Computers in classrooms started life as electronic versions of resources already available to the teacher, mainly as boring text-books with no pictures. The main pupil input being to respond to the command "Press Space Bar when you are ready for the next page".

Over the last 10 years, the realisation has dawned that computers can do more then simply page turning and could possibly be used to develop higher order skills such as problem-solving.

Computers can be used for a wide range of purposes within the school, but one of the main purposes of this study was to look at their use within the classroom. If effective use is to be made of the computer resources now coming into schools, then the computer must be utilised to do tasks it can do uniquely or can do better than existing resources and techniques allow. To do this, good, relevant software must be developed, since much of the software now available in schools is still of the drill & practice variety.

One advantage of the computer is its ability to interact, albeit in a limited fashion, with the user. Features of program design such as learner control, with guidance, and use of a range of feedbacks could help to improve learning with a computer.

One important feature of computer use is the running of simulations. These range from quite simple experiments allowing a range of normal laboratory experiments to be run more quickly and efficiently, to very sophisticated experiments which would be too dangerous or expensive to carry out in the classroom.

No clear statements can be made as to the effectiveness of CAL as compared to other methods of teaching. The studies that have been carried out show a range of results. The most important factor may be the type of program and the context in which it is used. Any increase in learning could be attributed to a novelty or newness effect. As more computers appear in the school and become a more regular component of the lesson, this effect could well disappear.

It is also essential that all those involved in computer use in schools must be aware of the different responses of girls and boys. It is obvious that they have different interests and expectations of the machine and this could quite well influence their reaction to learning from or with microcomputers.

Finally, it must be remembered that computer use in school does not take place in isolation and that many other factors including home use and parental attitudes and expectations will influence pupils.

CHAPTER 2

ATTITUDE THEORY AND PUPIL ATTITUDES IN SECONDARY SCHOOLS

2.1 Attitude Theory

For the last 55 years, the concept of attitude has been the subject of extended debate. In 1935 Allport (54) proposed the following definition:

"an attitude is a mental and neural state of readiness, organised through experience, exerting a directive or dynamic influence upon the individuals response to all objects and situations with which it is related."

In spite of other attempts this definition has remained the best available. Allport suggested a list of factors, perception, learning, personality, social environment and general behaviour which contribute towards attitudes. In 1946 Krech (55) further suggested that attitudes should be regarded as aspects of learning, in particular problem-solving. This was following up in 1947 by Doob (56) who also suggested that theories of learning could be applied to attitude development. He defined an attitude in terms of "an implicit drive producing response" that does not change the phenomena to which it refers, but which draws attention to the heterogeneous nature of human behaviour.

In 1959 Katz & Stotland (57) proposed that attitudes while complex could be divided into 3 major areas:

a) cognitive - related to knowledge
b) affective - related to feelings
c) action - associated to a physical response

Eysenck (58) in 1953 proposed the organisation of attitudes into four main layers:

a) lowest level attitude - very specific in content or determined by a specific feature of a situation

b) next level attitude - a statement of attitude repeated on several occasions "repeat reliability" these are often defined as opinions

c) third level attitude - opinions correlated together giving an attitude level measurement

d) highest level attitude - these attitudes are inter-correlated giving rise to high-order general concepts or ideology.

At school, opinions (level b) relate to one teacher, one subject, one class, the computer, etc. Third level attitudes relate to all computers, all teachers, all classes.

In 1964 Cook and Sellitz (59) drew the conclusion that attitudes did not control behaviour but contributed along with other factors to an individual's behaviour.

2.2 Measurement of Attitudes

Attitudes are complex and difficult to measure. Many proposals as to how measurements should take place have been put forward. Cook and Sellitz (59) put forward five groups of techniques:

a) self reports, written or verbal
b) observation of overt behaviour
c) reaction to partially structured material
d) performance on objective tasks
e) physiological reactions

Many of the techniques listed are not suitable for use in schools or are too time-consuming. Major reservations were also cast by Brown (60) on the validity of observations in b & d. The techniques of attitude assessment finally decided upon were based on those successfully used by Hadden (61) in his attitude assessment of secondary school pupils.

2.3 Attitude Scales

An attitude scale allows the comparison of the attitudes of different groups or the study of a group's attitudes over time. A scale gives an indication of an individual's or group's position along an attitude continuum. It is particularly relevant that an attitude scale can be used also to assess the effects of a school curriculum on pupils' attitudes (Brown, 60).

The main purpose of this work was to compare attitudes between year groups and to follow an individual year group over a period of time (longitudinal study). In this work two scales - the Likert and Semantic-differential - were used.

1 **Likert Scale**

The Likert Scale uses a 5-point scale between two opposing opinions on a particular statement, eg: strongly agree/strongly disagree. Likert (62) considered the selection of the statements to be very important. Some of the most important criteria are:

a) statements must be of desired behaviour not fact
b) statements must be clear, concise & straightforward
c) statements should be worded so that a mixture of responses is obtained
d) a large selection of statements should be prepared before the final selection is made.

A number is assigned to each attitude. This is an ordinal not a cardinal number and any summations would be invalid. The scale that was used in this study is as follows:

1 strong agree
2 agree
3 neither agree nor disagree
4 disagree
5 strongly disagree

To ensure that the items were valid questions, they were compared with previous surveys (Hadden, 61) who studied a similar group of pupils. The questions in Hadden's survey had been correlated in two pre-tests samples to ensure reliability. In addition to using some of the questions used in Hadden's survey, pupils were asked to volunteer their own questions about computers. A selection of suitable questions were then pre-tested with a small group of pupils and unsuitable ones discarded. On a larger scale, the first group of pupils tested were considered to be a pilot group. After they had completed the questionnaire, further questions were changed before the final survey was constructed.

2 Semantic-Differential Scale

Osgood (63) developed another important method of attitude measurement called the Semantic-Differential. This method provides a combination of controlled association and scaling procedures. The pupil is provided with a concept to be differentiated and a set of bi-polar adjectival scales against which to do it, in practice a word pair such as Exciting/Boring. The pupil then has to indicate the direction and intensity of association on a 6-point scale:

eg: Exciting 1 2 3 4 5 6 Boring

An example is given to the pupil indicating the meaning of the scale, eg: 1 - very; 3 - quite (Hadden, 61).

It is assumed that these instructions persist throughout the test. According to Osgood (63), it does not matter which way round the word pair is written. The procedure is simple, but complex behaviourally. The place chosen on the scale by the pupil is dependent on the dominance of the word pair, the distance from the ends on the intensity of the response.

This semantic-differential technique is reported to have test reliability, ie: test/retest of around 0.91 by several reporters. Heise (64) has reviewed the use of Osgood's method and has found it suitable in terms of sample type, design, reliability, validity and administration when compared with other methods.

2.4 Theories of Attitude Change

According to Hadden (61), there are a large number of models to account for attitude change:

1 Behaviourist-learning Approach:
the definition of attitudes in behavioural terms, eg: Doob (56) who saw attitudes as intervening between stimulus and response.

2 Social-judgement Approach:
the implications of judgements on attitude chosen was first considered by Hovland (65). Opinions already held influence further opinions.

3 Cognitive-dissonance Approach:
internal consistency is the desired personality state. Attitude change moves the balance point, which accommodates inconsistencies, within the individual.

4 Functional Approach:
this was developed by Katz (57) and is based on the psycho-analytical approach. It views attitudes

as serving functions of adjustment and ego defence.

Other considerations that are particularly relevant to pupils attitudes within the school are the influence of the teacher and of the child's peer group.

2.5 Statistical Tests

For each question asked, the relationship between two sets of data was examined. A null hypotheses was set up that the 2 sets of data were not statistically different. This was tested using the chi-squared (X^2) test.

$$X^2 = \sum \frac{(\text{actual frequency} - \text{expected frequency})^2}{\text{expected frequency}}$$

The expected frequencies were calculated by combining the observed frequencies to produce a weighted value to which both sets of observed data can be compared.

If the individual data in each cell of the contingency table fell below 10%, then adjoining groups of data were accumulated until a 10% value was reached. This 10% rule was applied to achieve a corrected X^2 test.

This method is applicable to comparisons between symmetrical data from 2 sets of different individuals or from 2 sets of data from the same individuals. As the differences between the actual and the expected frequencies becomes larger, X^2 gets larger. The probability of a relationship appearing by chance is shown in terms of significance. Significance is calculated from tables by knowing the degrees of freedom which operate.

A probability of 0.001 indicates that a relationship exists and that there is only a 1 in 1000 chance that it could have occurred by chance, ie: X^2 is statistically significant at the 0.001 level or 0.1% level. For the purposes of this study, a significance level of 0.02 was noted, but significances of 0.01 and less were considered more important. This imposes a high level of rigour on the results which is considered to be essential in attitude assessment.

To ensure the validity of all X^2 calculations:

a) X^2 values were calculated from raw data for each of the distributions being compared.

b) categories which contained less than 10% of the total sample were amalgamated with adjacent groups until the 10% level was reached.

The reason for this is that any change, however small, in small groups of data will have a disproportionate effect on the X^2. High values of X^2 give greater significance so these changes could produce invalid results.

The tables of data which appear in later chapters contain X^2 values calculated from raw data where the numbers of responses for each category are greater than 10% of the total sample.

Corrected values can be safely compared with uncorrected values where the significance is 0.01, since amalgamation of these much larger groups of data would only increase the X^2 and thus the significance.

Previous studies (Hadden, 61) have shown that the analysis of data from attitude questionnaires must be carefully considered so that important information from both Likert & Semantic-Differential scales is not lost.

It is important to note that the numbers used on these attitude scales denote a position on that scale not a quantity. They are not to be regarded as cardinal numbers and no arithmetic operations will be done on them, eg: averaging.

2.6 Pupil Attitudes to Computers and Science - Previous Studies

Studies into pupil attitudes are isolated. Many commentators state that pupil attitudes are improved by computer use, but there seems to be only a small number of detailed studies in this area.

In the early 1980's Moore (66) tested a sample of 1274 English 14 year old pupils (end of Scottish second year). He investigated their attitudes with a computer and robot attitude questionnaire (CARAQ) which assessed 7 separate areas using 64 Likert type items. The areas studied were:

a) school: learning and use in school.
b) leisure: home use, tv programmes.
c) career: computer career satisfying/worthwhile
d) employment: use of computers and robots in commerce and industry
e) social: benefits, social costs of computers
f) threat: computers take over/blow up the world
g) future: computers part of life.

The scores in these areas were investigated as a function of pupils sex, Piagetian stage, course of study and CAL classroom experience. Pupils were also tested a year later. The results indicate that boys have more favourable attitudes to computers than girls. There is no clear-cut correlation between Piagetian stage and attitude, but pupils with higher Piagetian levels have better attitudes. This correlation is better for boys than girls.

When considering change in attitude during the year and attitude itself, pupils choosing computer studies showed more favourable attitudes and less decline in these attitudes. In general all groups showed a decline in attitudes, but this was less marked in pupils who had a high use of home computers and those who had CAL experience in other school subjects.

It is important not to look at computers in isolation, but as part of the whole school curriculum since their use impinges on all subjects. Studies of attitudes to other subjects are therefore useful and informative. In view of this, Hadden's (61) study of over 1000 Scottish pupils gives valuable insight into the attitudes of Scottish pupils (Primary 7 to Secondary 2) to other subjects including Science. Pupils prior to secondary transfer showed enthusiasm and a high degree of interest in Science and had high expectations of secondary school Science. As pupils progressed through S1 these highly favourable and polarised attitudes to Science changed. This erosion of positive attitudes was also found in Geography, Arithmetic and Mathematics but was more pronounced in Science and less so in Maths. It would appear that the most important factor in this decline was the change in girls attitudes. In second year this deterioration of attitudes continued, but appears to be a more complex situation and it is difficult to detect specific factors which account for the change. Hadden feels that the most important factor may be the pupils view of the teacher and/or department.

Another study by Kelly in 1986 (67) investigated pupils attitudes to the image of Science and science curiosity. Pupils also completed tests on sex-stereotyping, cognitive skills and background. These pupils were also tested three years later. Kelly also shows a significant overall decline in attitudes. Interest in Physical Science declined but interest in Human Biology increased, especially amongst girls - an interesting exception. More able pupils exhibited a greater interest in science and were less likely to see it as a male subject, and throughout the study older pupils saw science as less male orientated. Initial attitudes are strongly related to final attitudes, so that many of the sex differences were well established by age 11, emphasising the importance of the Primary school in developing attitudes to a subject whose teaching is often patchy or non-existent at this level. Other factors such as social class and IQ appear to have a weaker effect on attitudes, but individual schools do have an important effect. Hadden, (61) also showed the importance of individual schools and departments on pupil attitudes to Science.

In an earlier study, Kelly (68) noted that although parents were just as ambitious for girls to include a study of science in their curriculum, their expectations outside school were different and they had traditional aspirations for their children.

Pupils perceptions of computers are important in determining whether they take up computer studies at school. Their experiences at home and in both primary and secondary school will affect their choice of subjects. Studies in both USA and the UK show that uptake of computer studies courses by girls is significantly lower than boys [Schwerm & Benedict (47), Newbould (48)]. If a knowledge of micro-electronics applications, etc are necessary for good career prospects in this field, it would seem that girls are ruling themselves out of this sector of the employment market. Only a fraction of computer scientists are women (Simons, 69).

How computers are used by pupils outside the classroom obviously has an important influence in their classroom attitude. Fife-Schaw <u>et al</u> (50) surveyed teenage computer use and found that games playing is the most important out-of-school computer activity. This must have significance for school use where games would come fairly low down on a teacher's list of possible uses. The hope is put forward that games may facilitate the move into more complex tasks such as the learning of programming languages. Their study also showed that girls play fewer games and have less interest in doing so.

Glyn-Jones study (51) [Sect 1.10] also showed that homes with boys are more likely to have computers and that like the Fife-Schaw study, the preferred use for computers outside school is games playing.

2.7 Summary

In the study of pupils attitudes to computers there is, along with other aspects of the curriculum, a decline in positive attitudes, especially amongst girls. All the studies show the importance of other factors such as home computer use and influence of the primary school in determining pupils attitudes to computers.

CHAPTER 3

ATTITUDE SURVEY - MAIN AND PILOT STUDY RESULTS

3.1 Attitude Survey - Aims and Objectives

During the mid 1980's a large number of microcomputers were introduced into Scottish secondary schools. The authorities hoped that all pupils would be exposed to computers, either in specialist computing and computer studies courses or in individual subject areas.

In the light of this massive hardware investment, the researcher felt it was important to investigate the attitudes of the pupils who would use the machines. If computers are to be used successfully in the classroom, pupil attitudes are important since they could well affect their learning.

At this time there was also an expansion of the home computer market. A better understanding of the nature of pupil computer use at home could give insights into pupil attitudes to school computers and hence on their learning.

The aims of the survey were to:

1) Investigate the attitudes of first (S1) and third (S3) year secondary pupils to microcomputers.

2) Compare the attitudes of S1 and S3 pupils.

3) Investigate the change of attitudes as first year moved into second (S2) year and third year became fourth (S4) year.

4) Compare the attitudes of S2 and S4 pupils.

5) Investigate pupils use of computers at home.

The survey was conducted in two parts; an initial pilot study followed by the main study. Both studies were carried out in the same Ayrshire comprehensive secondary school. The pilot study (Group A) involved 147 first year pupils and 60 third year pupils. This consisted of the total 1986 first year intake and all third year pupils who were studying Biology.

The main study (Group B) consisted of 123 first year and 153 third year pupils. These were the total numbers of pupils in each of the year groups at the beginning of the 1987 session. All the year groups contained both boys and girls of mixed ability and from a range of social backgrounds.

Composition of Groups:

GROUP A (Pilot Study)

S1	part 1	(n = 146)	73 girls	73 boys
	part 2	(n = 147)	73 girls	74 boys
S2		(n = 151)	74 girls	77 boys
S3	part 1	(n = 61)	33 girls	28 boys
	part 2	(n = 60)	33 girls	27 boys
S4		(n = 59)	31 girls	28 boys

GROUP B (Main Study)

S1		(n = 123)	56 girls	67 boys
S2		(n = 127)	57 girls	70 boys
S3	part 1	(n = 153)	56 girls	97 boys
	part 2	(n = 152)	57 girls	95 boys
S4	part 1	(n = 153)	59 girls	94 boys
	part 2	(n = 152)	59 girls	93 boys

3.2 The Survey

The survey consisted of a mixture of Likert and Semantic-Differential type questions. The questions used in the survey were selected in a number of different ways. Some had already been used successfully in Hadden's survey of pupils' attitudes to Science (61). A large number of questions were tried out in the researcher's own school, including questions suggested by pupils. From this bank of questions, the Group A survey (Appendix IIIA) was drawn up, in the light of the results from this pilot group the survey was modified into its final form for Group B.

The survey questionnaire for the main study (Group B) was made up of nineteen Likert (part 1) and nine Semantic-Differential (part 2) type questions (see Appendix IIIB). To make it as easy as possible for pupils to answer the questions, the two types were put into separate sections, each with clear instructions as to how to answer that type of question.

The survey set out to investigate the following hypotheses:

Pupils find using computers in school exciting, interesting and enjoyable;

Pupils think computers are important and time well spent;

Pupils like to use a computer because it individualises their learning;

Pupils like to play games on the computer;

Pupils think they need abilities in other subjects to use a computer;

Pupils think that using a computer in school will help their job opportunities;

Girls and boys have similar attitudes to computers.

Four areas were investigated by the attitude survey, these were:

1 General expectation of computer use.

2 Mode of computer use within the classroom.

3 Computer links with other subjects and their relevance to the world outside school.

4 Sex differences in attitudes to computers.

The following sections show the questions selected to investigate the attitudes in each area. Some questions relate to more than one area (D6). The letter and number for each question refer to the section and order respectively.

3.2.1 General Expectation of Computer Use in School

This section included the overall general attitudes pupils might have to computers and their expectation of how much use of computers they might have in school.

C1 Using a computer in school has been really exciting.

C2 I expected to use the computer a lot in secondary school.

C3 Computers should only be used by the teacher.

C14 I like to use the computer as part of my lessons.

Using a Computer in School is:

D1 Exciting/Boring.

D2 Interesting/Dull.

D4 Frightening/Friendly.

D5 Enjoyable/Hateful.

D6 Unimportant/Important.

D8 Time well spent/Waste of time.

D9 Difficult to use/Easy to use.

3.2.2 Mode of Computer Use Within the Classroom

This area covered more specific questions about the type of use, such as individualised learning (C6, C10, C13, C19) and use by the teacher.

C3 Computers should only be used by the teacher.

C4 I like to play games on the computer.

C5 Computers make a boring subject more enjoyable.

C6 I prefer to use the computer by myself in class.

C9 I prefer the teacher to explain things to me rather than the computer.

C10 I like to work with the computer because it works at my own speed.

C13 I find it is easier to answer the computer than the teacher.

C14 I like to use the computer as part of my lessons.

C15 Only clever people can learn from a computer.

C17 You must be good at arithmetic to learn from a computer.

C19 I think the computer should mark my work.

Using a Computer in School is:
D9 Difficult to use/Easy to use.

3.2.3 Link with Other Subjects and the World Outside School

This area explored the ideas that abilities in other subjects such as Mathematics influence the ability to benefit from using a computer. Also, that school use might influence job opportunities.

C4 I like to play games on the computer.

C7 To get the best out of a computer you need to know about programming.

C12 Learning to work with computers will help me to get a job when I leave school.

C15 Only clever people can learn from a computer.

C17 You must be good at arithmetic to learn from a computer.

Using a Computer in School is:
D6 Unimportant/Important.

3.2.4 Sex Differences

An important area of concern amongst educators is the image of computers and computing to the different sexes. It is important to know if the computer is seen as equally relevant to both boys and girls. Specific questions about boys and girls were asked but also investigated were boys and girls' attitudes to all the questions.

C8 Boys and girls are equally good at working with computers.

C11 Girls find it much easier to work with computers.

C16 Boys are better at giving answers to the computer.

C18 If I work with a partner of the opposite sex, I sit back and let her/him work the computer.

Using a Computer in School is:
D3 Useful for boys/Useless for boys.

D7 Useless for girls/Useful for girls.

In the light of the results from year 1 of the pilot (Group A), the questionnaire (Appendix IIIA) used was modified for the main study (Group B) (Appendix IIIB). In the pilot study, there was more emphasis of the mechanics of using the computer and the relationship to job opportunities. Questions on the use of the keyboard, ease of seeing the monitor and taking jobs from people were dropped. In the Group B study more emphasis was put on general expectations, mode of use within the classroom and differences between boys and girls.

Other minor revisions were made. These included changing the order of questions so that those in the same area were not grouped together and reversing the semantic-differential questions so that the positive words did not all appear on one side.

3.3 Method and Treatment of Results

All the questionnaires were given to pupils at the beginning of the relevant Autumn term. In this way the first year pupils results were effectively those of primary pupils anticipating secondary school. The filling in of the survey was administered by the form teacher.

The results from each pupil's questionnaire were collected and scored according to question and attitude stated. The results were collated into the following sub-groups:

	Totals	Girls	Boys
GROUP A	S1 (1986)	S1	S1
(Pilot Study)	S2 (1987)	S2	S2
	S3 (1986)	S3	S3
	S4 (1987)	S4	S4
GROUP B	S1 (1987)	S1	S1
(Main Study)	S2 (1988)	S2	S2
	S3 (1987)	S3	S3
	S4 (1988)	S4	S4

The raw results and results expressed as a percentage of the sub-groups can be found in Appendix IIIC for Group A and Appendix IIID for Group B.

Chi-squared tests were carried out on the results. If individual results were less than 10% of the total, adjoining columns were amalgamated and a corrected X^2 calculated (Section 2.5).

3.4 Survey of Home Computer Use

The main body of the survey of secondary pupils was an investigation into their attitudes towards computers in schools. Work in school does not stand in isolation from the influences of both the primary school and the home. Obviously possession and use of a home computer will influence the attitudes of pupils within school.

The aims of the home computer survey were to investigate:

1 the level of use
2 the frequency of use
3 the social groupings associated with use
4 the type of software used

All first and third year pupils who completed the attitude survey also completed the questions on home computer use. Appendix IIIA shows the questions given to Group A. In the light of the results from Group A, modifications to the questions were made. The main difference was the addition of two questions about computer use within school given to third year Group B pupils. First year pupils received an appropriate form of the questions (Appendix IIIB). For results and discussion see Sections 4.7, 4.8, 4.9 and 4.10.

3.5 Group A: Pilot Study - Discussion of Results

(see Appendix IIIE for further discussion and more detailed results)

3.5.1 First Year Pupils

First year secondary pupils arrive from their primary schools with different experiences of computers. These experiences include both those in the classroom and at home. In general, their attitudes are very positive (Tables 3.1, 3.2). Pupils enjoy computers and they think computers are interesting, useful and well worth spending time with (B2, B7, B8, B9, A1). Pupils have high expectations of using and enjoying computers when they get to secondary school (A1, A2, B1).

Table 3.1 Summary of attitudes expressed as % of total group. First Year Pupils (pilot study).

Question		Positive	Neutral	Negative
A1	Exciting	77.4	19.9	2.7
A2	Use a lot	56.9	35.6	7.5
A3	Use by teacher	1.4	2.7	95.9
A4	Individual use	37.0	35.6	27.4
A5	Keyboard difficult	15.8	17.1	67.1
A6	Blackboard easier	15.0	33.6	51.4
A7	Know programming	64.4	19.2	16.5
A8	Teacher to explain	46.6	33.6	19.9
A9	Expts. easier	6.8	30.1	63.0
A10	Help for job	50.7	36.3	13.1
A11	Take jobs	37.7	30.8	31.5
A12	Important	41.8	29.5	28.8
A13	Programming/job	84.3	6.9	8.9
A14	Need to be clever	1.4	5.5	93.2
A15	Good at arith.	3.5	13.0	83.6
A16	Easy for girls	6.1	34.3	59.6
A17	Boys better	15.7	31.5	52.8

Table 3.2 Summary of attitudes expressed as % of the whole group. First Year Pupils (pilot study).

Question			Neutral		
B1	Exciting	66.0	32.6	1.4	Boring
B2	Interesting	81.0	17.7	1.4	Dull
B3	Important	50.3	44.3	5.5	Unimportant
B4	Enjoyable	77.5	22.4	0.0	Hateful
B5	Friendly	43.6	53.7	2.8	Frightening
B6	Difficult	16.4	36.0	47.6	Easy
B7	Time well spent	63.3	34.1	2.7	Waste of Time
B8	Useful/Girls	53.0	38.8	8.2	Useless/Girls
B9	Useful/Boys	63.3	33.3	3.4	Useless/Boys

Girls and boys show similar attitudes but there is a slight favouring of the usefulness of computers for boys as opposed to girls (B8, B9). Both girls and boys see the need for computers in their future life and that knowledge of them will be important in their jobs (A10, A12).

3.5.2 Third Year Pupils

Third year pupils have already had two years of secondary schooling. In these two years they appear to have had only a small amount of contact with computers. Pupils still have positive attitudes (Tables 3.3, 3.4) to using computers. Computers are enjoyable, interesting and time is well spent with them. Pupil attitudes fall in the middle area of the scale; Important/Unimportant (B3) and Exciting/Boring (B1). Pupils feel strongly that there is no need to be clever or good at arithmetic to use a computer (A14, A15). When considering the attitudes of boys and girls, the group as a whole sees the computer as more useful to boys than to girls (B8, B9).

Table 3.3 Summary of attitudes expressed as % of total group. Third Year Pupils (pilot study).

Question		Positive	Neutral	Negative
A1	Exciting	42.7	49.2	8.2
A2	Use a lot	9.8	11.5	78.7
A3	Use by teacher	3.3	4.9	91.8
A4	Individual use	49.2	32.8	18.0
A5	Keyboard difficult	4.9	21.3	73.8
A6	Blackboard easier	21.3	39.3	39.4
A7	Know programming	52.5	31.2	16.4
A8	Teacher to explain	49.2	31.2	19.7
A9	Expts. easier	13.1	32.8	54.1
A10	Help for job	45.9	40.9	13.1
A11	Take jobs	45.9	32.8	21.3
A12	Important	36.1	42.6	21.3
A13	Programming/job	80.3	11.5	8.2
A14	Need to be clever	1.6	1.6	96.7
A15	Good at arith.	3.2	16.4	80.3
A16	Easy for girls	3.3	37.7	59.0
A17	Boys better	11.5	39.3	49.2

Table 3.4 Summary of attitudes expressed as % of the whole group. Third Year Pupils (pilot study).

Question			Neutral		
B1	Exciting	40.0	55.0	5.0	Boring
B2	Interesting	73.3	23.3	3.3	Dull
B3	Important	36.7	56.7	6.7	Unimportant
B4	Enjoyable	70.0	28.4	1.7	Hateful
B5	Friendly	41.6	55.0	3.3	Frightening
B6	Difficult	8.4	48.3	43.4	Easy
B7	Time well spent	66.7	28.3	5.0	Waste of Time
B8	Useful/Girls	48.3	43.3	8.3	Useless/Girls
B9	Useful/Boys	56.7	40.0	3.3	Useless/Boys

3.5.3 Differences between Girls and Boys

In the first year there are some differences between girls and boys (Tables 3.5, IIIE.1, IIIE.2). Boys think computers are more important in finding a job and their use is time well spent. They also think they are useful for boys and that boys are better at using them (A17, B9). Are boys already thinking about possible uses of computers for themselves as adults? Girls find this aspect of computers less important. They also feel that computers take jobs away from people (A11). Some trends continue on into second year, eg: Boys think boys are better (A17), they have a high opinion of their own abilities. In the complementary question (A16) girls did not think that computing was easier for them. Some attitude differences appear only in one year group (A7, B6, B7). Some differences appear later, eg: The need to know about programming (A7). Third and fourth year pupils show similar trends. Some of the differences from S1 and S2 remaining, some disappearing and some appearing. Third year girls found computers less exciting, expected to use computers less than the boys and saw it as time less well spent (A1, A2, B1, B7).

Table 3.5

% Significance of X^2 Test
Group A Girl/Boy comparison within each year.

Question	S1	S2	S3	S4
A1	-	-	1.0	1.0
A2	-	2.0	-	-
A3	-	-	-	-
A4	-	-	-	-
A5	-	-	-	-
A6	-	-	-	-
A7	-	1.0	-	-
A8	-	-	-	-
A9	-	-	-	-
A10	2.0	-	-	-
A11	-	-	-	-
A12	-	-	-	-
A13	-	-	-	-
A14	-	-	-	-
A15	-	-	-	-
A16	-	-	-	-
A17	1.0	0.1	-	-
B1	-	-	2.0	-
B2	-	-	-	-
B3	2.0	-	-	-
B4	-	-	-	-
B5	-	-	-	-
B6	-	1.0	-	-
B7	2.0	-	1.0	-
B8	-	-	-	-
B9	1.0	-	-	-

3.5.4 Comparison between First and Third Years

Discussion and Summary

In the pilot study third year pupils, when compared with first years (Tables 3.6, IIIE.3, IIIE.4), find computers less exciting and use them far less than they expected (A1, A2). A quick, informal survey of subject computer use at this time revealed little use, although hardware was available in the computer room and as mobile units.

Table 3.6

% Significance of X^2 Test
Group A Comparison of First and Third Years

Question	Totals	Girls	Boys
A1	0.1	0.1	-
A2	0.1	0.1	1.0
A3	-	-	-
A4	-	-	-
A5	-	-	-
A6	-	-	-
A7	-	-	-
A8	-	-	-
A9	-	-	-
A10	-	-	-
A11	-	-	-
A12	-	-	-
A13	-	-	-
A14	-	-	-
A15	-	-	-
A16	-	-	-
A17	-	-	-
B1	1.0	0.1	-
B2	-	-	-
B3	-	-	-
B4	-	-	-
B5	-	-	-
B6	-	-	-
B7	-	-	-
B8	-	-	-
B9	-	-	-

Girls and boys attitudes were already different when they arrived in first year. Although both changed by third year, there was a more significant change in the girls' attitudes (A1, B1). It must be remembered that the third year pupils used were not the whole cohort so that it is quite possible that the girls in the group, because of the subjects they had chosen, showed a less positive attitude to computers than the general third year population.

The other problem is that this comparison is of two different populations, not the same population over a period of time. The third year group would have entered secondary school two years earlier when there were even fewer computing facilities. However when new facilities are on offer third year pupils, at the beginning of their Ordinary Grade courses, are usually the most likely group to benefit.

3.5.5 Comparison between Second and Fourth Years

Discussion and Summary

The comparison between second and fourth year pupils was carried out in the second year of the survey. First year had become second and third become fourth (Appendix IIIE for further analysis and results).

Fourth year pupils find computers less exciting, duller and less enjoyable than second year pupils (A1, B1, B2, B4). Where significant differences occurred between second and fourth year pupils (Tables IIIE.5, IIIE.6) these were due to differences in the girls' attitudes not the boys' (B4, B1, A1, A2). In looking at other differences between second and fourth year pupils, fourth years prefer the blackboard to the computer monitor (A6). This may reflect lack of computer use or use as a class electronic blackboard which can be difficult to see. It is also possible that older pupils prefer to remain with the familiar. Fourth years also preferred the teacher to use the computer (A8). This may also reflect pupils' classroom experience. Many of the attitudes of second and fourth year pupils remained remarkably constant. The main areas of change seem to be in the lack of use (A2) and that computers "lose their gloss", they become less exciting, duller and more boring (A1, B1, B2, B4). In most cases, the difference in attitudes can be attributed to differences between the girls. This may be due, as stated before, to the sample of girls used (B1, B2, B4, A1, A2).

3.6 Group A: Pilot Study - Overall Summary

Group A was used as a pilot study to try out the questionnaire, which had not been used before. It was also used to see if the proposed hypotheses were substantiated or not. The nature of this type of investigation means that no test instrument exists, but has to be constructed by the researcher. This means that is is absolutely essential to pilot the questions before embarking on the main study.

The pilot study set out to investigate the following hypotheses (see Appendix IIIA):

Pupils find computer use in school exciting and enjoyable;
Pupils use computers in school;
Pupils see computer use in school as important in relation to future jobs;
Pupils find a computer easy to operate;
Pupils like to use a computer because it individualises learning;
Pupils think they need a knowledge of mathematics and programming to use a computer in school;
Boys and girls have similar attitudes to computers.

Pupils enter secondary school with high expectations of computer use and with positive attitudes towards them. Pupils see them as interesting, exciting and of help in their future careers. The computer itself holds no fears for them, although they still prefer the teacher to explain things. They do not see major benefits from computers individualising their learning. Interestingly even at this stage, although seen as being useful for both girls and boys, the computer was thought to be more useful to boys.

Third year pupils still found the computer exciting, but less than the first year. They used computers less than they expected, when they did they had few problems with the mechanics. They also saw computers as important in helping with jobs and as more useful for boys.

When comparing first year with third year and second year with fourth, remembering these are two separate populations, the common trends are a dropping off of enthusiasm and less use than expected. Boys and girls show different attitudes, the change in the girls' attitudes is far more marked than that of the boys'. In fact, many of the significant differences between groups are due to girls only.

3.7 Main Attitude Survey - Group B

(see Appendix IIIB for results)

The main study of pupil attitudes to computers and computing took place in 1987 and 1988. All pupils who entered the school in the August of 1987 together with the whole of the third year were surveyed using the final form of the questionnaire.

3.8 Comparison between First and Third Year Pupils (Group B)

The results from the first and third year sub-groups were collated and chi-squared tests carried out on the data for the totals and for the girls and boys (Tables 3.7, 3.8).

Table 3.7

Group B (1987) - Comparison of First and Third Year.

Chi-squared Test

	Totals	Girls	Boys
C1 Computer Exciting	77.9 *** S1+ S3-	26.1 *** S3- S1+	47.9 *** S3- S1+
C2 Use a Lot	11.1 ** S1+ S3-	9.4 ** S3- S1+	3.3
C3 Teacher use	3.8	0.9	1.6
C4 Play games	14.4 *** S3+ S1-	8.1 ** S3+ S1-	4.9
C5 Boring Subject Enjoyable	1.8	0.4	5.0
C6 Individual Use	11.6 ** S1- S3+	5.1	3.7
C7 Know Programming	2.7	5.0	2.6
C8 Boy/Girl Comparison	1.0	3.4	0.1
C9 Teacher to Explain	2.3	3.3	0.6
C10 Work at own Speed	1.1	0.2	1.4

Level of Significance *** .1%
** 1%
* 2%

Direction of Difference
on attitude Scale: 5 → 1 = + (→ agree) 1 → 5 = - (→ disagree)

Table 3.7 (cont.)

Group B (1987) S1/S3 Comparison

Chi-squared Test

	Totals	Girls	Boys
C11 Easy for Girls	* 8.3 S1- S3+	4.1	6.7
C12 Help for Job	3.5	0.7	4.8
C13 Easier to Answer	7.2	4.9	3.1
C14 Use in Lesson	*** 14.6 S2+ S3-	** 12.7 S1+ S3-	4.6
C15 Need to be Clever	0.4	0.0	0.9
C16 Boys Better	* 8.20 S1+ S3-	5.7	9.3 S1+ S3-
C17 Good at Arithmetic	* 8.9 S1+ S3-	0.7	** 13.6 S1+ S3-
C18 Sit Back When Work with Opp. Sex	* 8.8 S1- S3+	5.7	4.3
C19 Mark Work Explain	*** 21.0 S3+ S1-	*** 17.5 S1+ S3-	7.7

Level of Significance *** .1%
** 1%
* 2%

Direction of Difference 5 → 1 = +
1 → 5 = -

Table 3.8

Group B (1987) - Comparison of First and Third Years

Chi-squared Test

		Totals	Girls	Boys
D1	Exciting/Boring	32.0 *** S3- S1+	14.8 *** S3- S1+	21.1 *** S3- S1+
D2	Interesting/Dull	3.1	0.7	2.4
D3	Useful/Useless for Boys	0.8	2.3	0.0
D4	Frightening/Friendly	0.9	0.4	2.6
D5	Enjoyable/Hateful	0.6	0.9	0.2
D6	Unimportant/Important	6.3	3.1	5.5
D7	Useless/Useful for Girls	2.3	4.3	3.7
D8	Time Well Spent/ Waste of Time	13.9 *** S3- S1+	11.9 ** S3- S1+	4.3
D9	Difficult/ Easy	11.2 *	4.7	7.0

Level of Significance *** .1%
** 1%
* 2%

Direction of Difference
on attitude scale 1 → 6 = - 6 → 1 = +

3.8.1 General Expectation of Use

(Graph 3.1, Tables 3.7, 3.8)

Survey Questions:

C1 Using a computer in school should be really exciting.

C2 I expect to use the computer a lot in secondary school.

C3 Computers should only be used by the teacher.

C14 I would like to use the computer as part of my lessons.

Using Computers in School is:

D1 Exciting/Boring

D2 Interesting/Dull

D4 Friendly/Frightening

D5 Enjoyable/Hateful

D6 Important/Unimportant

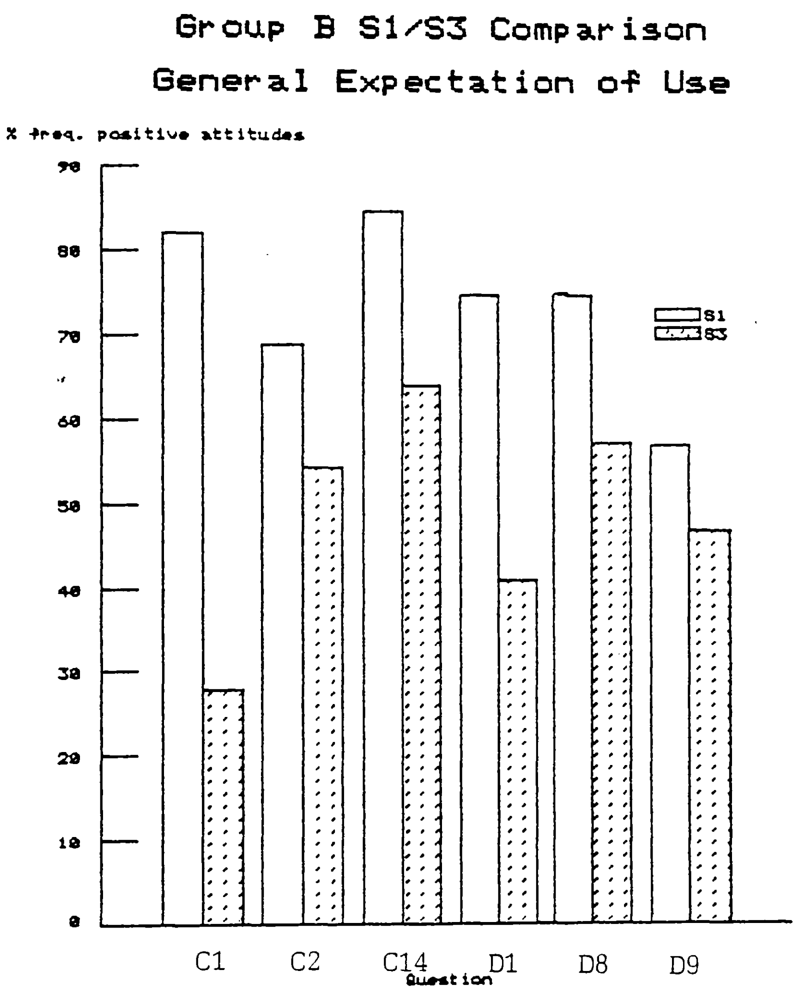
D8 Time well spent/Waste of Time

D9 Difficult/Easy

Third year pupils when compared with first year found the computer significantly (0.1% level) less exciting but still more exciting than boring. Third year felt that computers were more a waste of time than did first year (significant at 0.1% level), but still thought it was time better spent than wasted. First year expected and wanted to use the computer a lot while third year appear to find the computer significantly easier, when examining the actual data the trend is not so clear cut. While first year pupils find the computer easy, pupils in third year show a much wider range of opinion.

Attitudes to questions D2, Interesting/Dull; D4, Frightening /Friendly; D5, Enjoyable/Hateful remain the same in both first and third years. Both years feel that computers should not only be used by the teacher.

GRAPH 3.1


Group B S1/S3 Comparison
General Expectation of Use
% freq. positive attitudes
90
80
70
60
50
40
30
20
10
0
S1
S3
C1
C2
C14
D1
D8
D9
Question

3.8.2 Mode of Use in the Classroom

(Graph 3.2, Tables 3.7, 3.8)

Survey Questions:

C3 Computers should only be used by the teacher.

C4 I Like to play games on the computer.

C5 Computers make a boring subject more enjoyable.

C9 I prefer the teacher to explain things to me rather than the computer.

C10 I like to work with the computer because it works at my own speed.

C13 I find it easier to answer the computer than the teacher.

C14 I like to use the computer as part of my lessons.

C15 Only clever people can learn from a computer.

C17 You must be good at arithmetic to learn from a computer.

C19 I think the computer should mark my work.

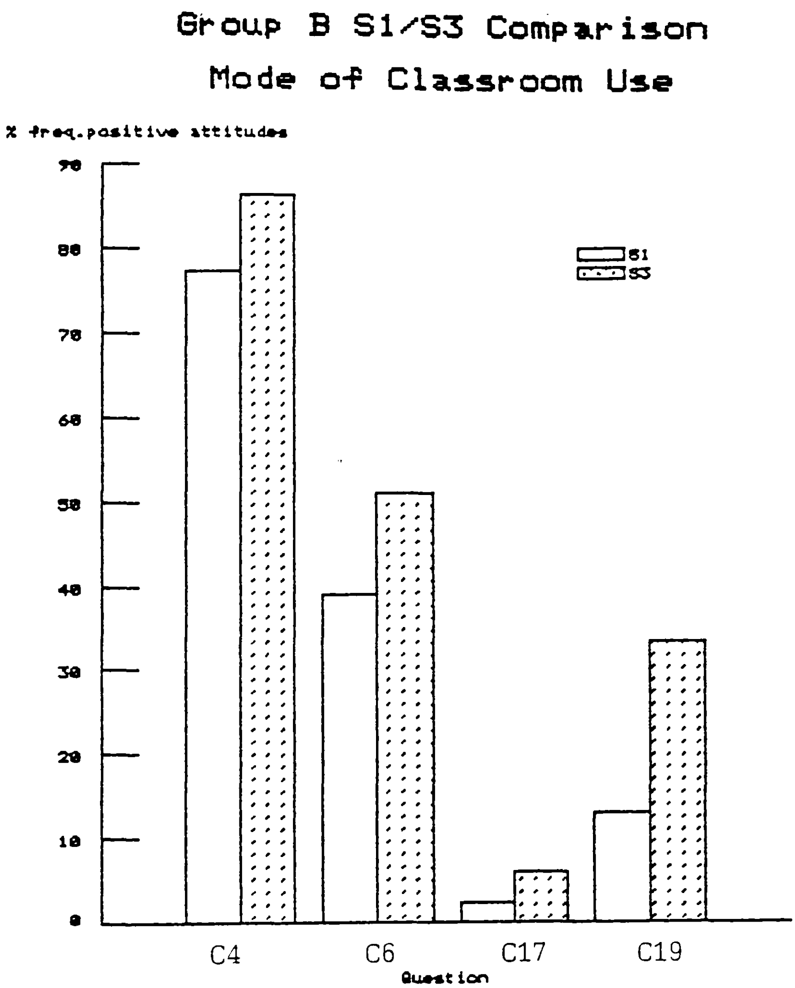
Using a Computer in School is:

D9 Difficult/Easy

Third year pupils when compared to first year prefer to play games on the computer. This is significant at the 0.1% level. Third year also show a trend towards individualised use. This is significant at the 1% level.

There is a significant difference (0.1% level) in attitudes to the computer marking work, but attitudes in third year are considerably diversified. First year think that being good at arithmetic is a necessary prerequisite to using a computer, while third year differ significantly (2% level).

GRAPH 3.2



Group B S1/S3 Comparison
Mode of Classroom Use
% freq.positive attitudes
90
80
70
60
50
40
30
20
10
0
S1
S3
C4
C6
C17
C19
Question

3.8.3 Expectations of Girls and Boys

(Graphs 3.3, 3.4, 3.5, Tables 3.7, 3.8)

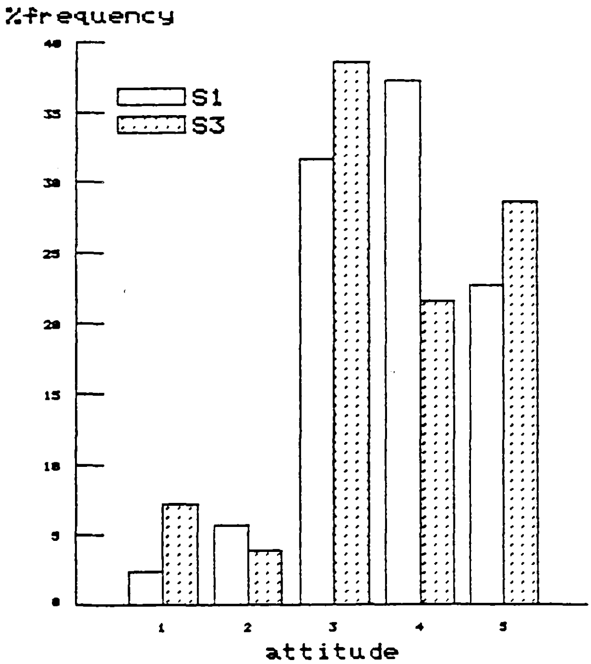
This section involves specific questions asked about girls and boys (C8, C11, C16, C18, D3, D7) attitudes to computers, but also looks at the responses of the two groups to all the questions.

There are significant differences between first and third year in q C11, C16, C18. The direction of the change in attitudes is difficult to determine.

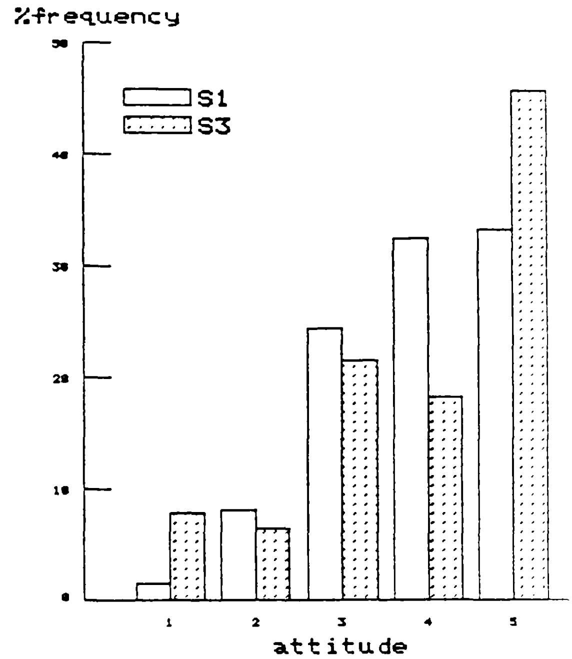
In question C11 (graph 3.3) third year differ significantly from first year (2% level) but show more diversity of opinion. In questions C16 and C18 (graphs 3.4, 3.5) there is also a significant difference (2% level) between first and third years, with the trend in third year pupils towards the strongly disagreeing end of the attitude scale.

When comparing first and third year results (Tables 3.7, 3.8) some other differences in attitudes appear if the boys and girls are considered as separate sub-groups. Most of the significant differences (all at 1% level) in attitudes are between the first and third year girls. Third year girls disagree more strongly that they use computers a lot and that they would like to use computers as part of their lessons (C2, C14). Third year girls also prefer to play games on the computer and to have it mark their work (C4, C19). These girls when compared with the first year see the computer as more of a waste of time (D8). The only significant difference between third and first year boys is that third year disagree more strongly that you must be good at arithmetic to learn from a computer (C17).

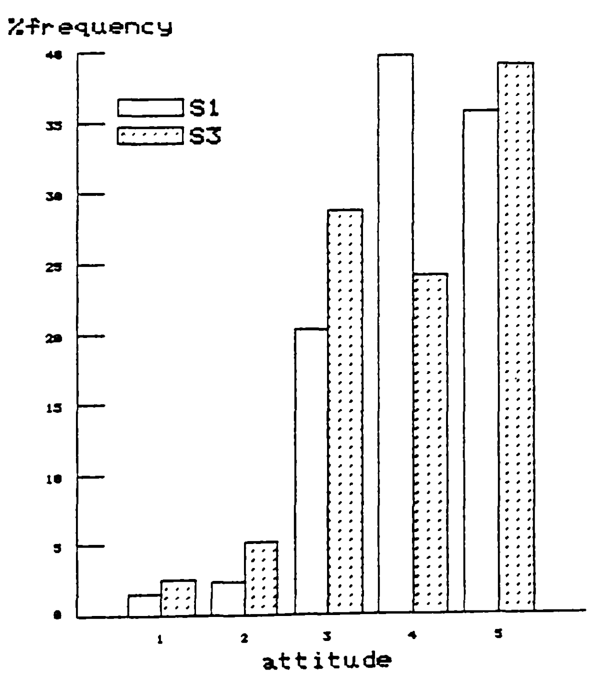
Graph 3.3
Group B S1/S3 Comparison
Q C11 Easy for Girls



Graph 3.4
Group B S1/S3 Comparison
Q C16 Boys Better



Graph 3.5
Group B S1/S3 Comparison
Q C18 Sit back/work opp.sex



3.9 Comparison of Girls and Boys within each Year Sub-Group

Within each year, the results obtained for girls and boys were compared using chi-squared tests (Tables 3.9, 3.10).

Table 3.9

Group B (1987) - Comparison of Girls and Boys Within Year Group.

Chi-squared Test

	S1	S3
C1 Computer Exciting	0.4	0.0
C2 Use a Lot	0.7	2.9
C3 Teacher use	2.8	3.7
C4 Play games	4.3	0.4
C5 Boring Subject Enjoyable	5.1	0.3
C6 Individual Use	3.6	2.2
C7 Know Programming	3.5	0.9
C8 Boy/Girl Comparison	5.7	*** 17.5 G+ B-
C9 Teacher to Explain	2.6	0.0
C10 Work at own Speed	1.2	0.5

Level of Significance *** .1%
** 1%
* 2%

Direction of Difference on attitude Scale: 5 → 1 = + (→ agree)
1 → 5 = - (→ disagree)

Table 3.9 (cont.)

Group B (1987) Comparison of Girls and Boys within Year Group

Chi-squared Test

	S1	S3
C11 Easy for Girls	*** 17.3 G+ B-	*** 17.7 G+ B-
C12 Help for Job	1.8	0.9
C13 Easier to Answer	3.4	1.5
C14 Use in Lesson	1.8	2.9
C15 Need to be Clever	0.7	0.0
C16 Boys Better	** 10.2 G- B+	*** 24.5 G- B+
C17 Good at Arithmetic	3.3	3.1
C18 Sit Back When Work with Opp. Sex	** 9.2 G- B+	2.7
C19 Mark Work	2.6	2.1

Level of Significance *** .1%
** 1%
* 2%

Direction of Attitude Difference
5 → 1 = +
1 → 5 = -

Table 3.10
Group B (1987) - Comparison of Girls and Boys
within each Years Group.

Chi-squared Test

		S1	S3
D1	Exciting/Boring	3.5	3.7
D2	Interesting/Dull	0.1	0.2
D3	Useful/Useless for Boys	4.1	7.6 ** G- B+
D4	Frightening/Friendly	0.3	7.3
D5	Enjoyable/Hateful	1.0	0.2
D6	Unimportant/Important	4.8	3.1
D7	Useless/Useful for Girls	1.2	8.7
D8	Time Well Spent/ Waste of Time	0.2	2.6
D9	Difficult/Easy	2.6	1.0

Level of Significance *** .1%
** 1%
* 2%

Direction of Difference
on attitude scale: 1 → 6 = - 6 → 1 = +

3.9.1 <u>First Year</u>

(Graph 3.6, Tables 3.9, 3.10)

Survey Questions:

C11 Girls find it much easier to work with computers.

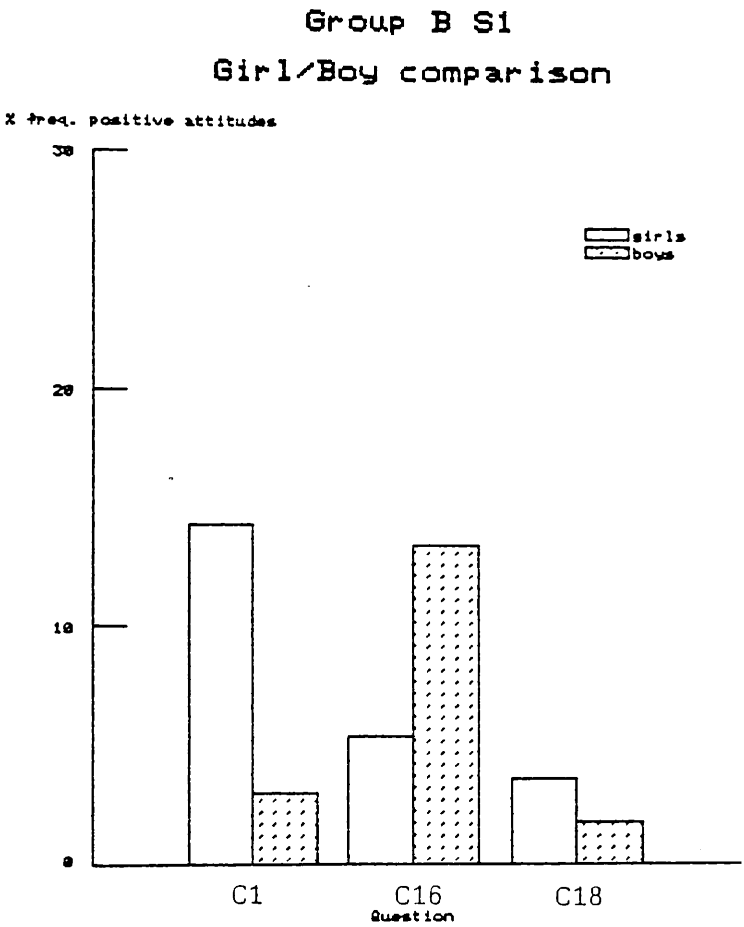
C16 Boys are better at giving answers to the computer.

C18 If I work with a partner of the opposite sex, I sit back and let her/him work the computer.

C8 Boys and girls are equally good at working with computers.

Questions on general expectations and use within the classroom show little differences between girls and boys. The questions that show significant differences are those that contain a specific reference to boys or girls (C8, C16, C18). Girls think that girls are better and similarly boys think that boys are better. Girls disagree more strongly than boys that they will sit back when working with a partner of the opposite sex (positive attitudes are 1 & 2 on scale, strongly agree and agree).

Graph 3.6


Group B S1
Girl/Boy comparison
% freq. positive attitudes
30
20
10
0
girls
boys
C1
C16
C18
Question

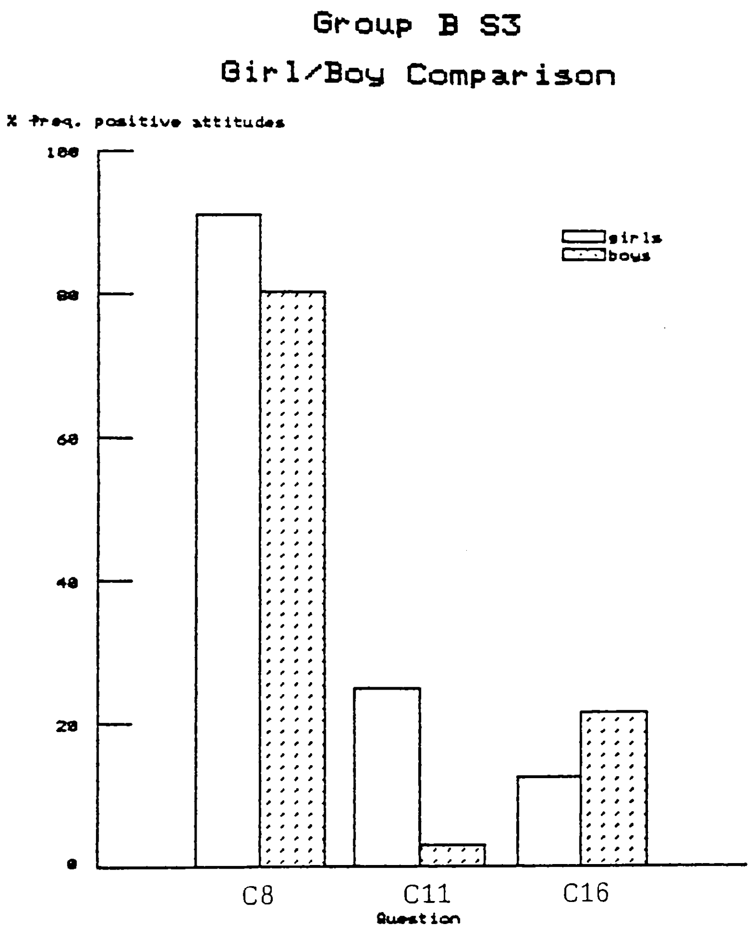
3.9.2 Third Year

(Graph 3.7, Tables 3.9, 3.10)

(Positive attitudes 1 & 2 on scale, strongly agree & agree).

Questions C11 and C16 still show significant differences (0.1%). The differences in question C18 have disappeared, boys are no longer more likely than girls to sit back when working with a partner of the opposite sex. In question C8, girls agree very strongly that boys and girls are equally good at working with computers, but boys have less strong positive attitudes. Boys more than girls think computers are more useful for boys (significant at 1% level). In the complementary question (D7), although girls more than boys think computers are useful for girls, the difference is not significant.

GRAPH 3.7


Group B S3
Girl/Boy Comparison
% freq. positive attitudes
100
80
60
40
20
0
girls
boys
C8
C11
C16
Question

3.10 Summary

In general, third year pupils find computers less exciting and have less expectation of using them in the classroom. There are some trends in third year towards attitudes which might favour a more individualised approach which computers can offer. Third year girls have a greater decline in interest than boys, which is a worrying trend if opportunities are to be equal. Girls in third year prefer to play more computer games than in first year. This may be that they played fewer in the first place, especially since fewer of them have home computers. The main activity on home computers is the playing of games (Sects 4.8, 4.9, 4.10).

In both years, girls and boys have a higher opinion of their own sex. Third year boys do not agree that computers are equally useful for boys and girls, but think computers are more useful to boys.

3.11 Comparison of Second Year with Fourth Year

(Tables IIIF.1, IIIF.2, IIIF.3, IIIF.4, Appendix F).

Fourth year, in general, find computers less exciting, interesting etc, but their attitudes are still in the positive and neutral end of the scale. The trends in fourth year are often diverse and difficult to interpret. Differences in the boys' attitudes contribute most to the overall differences between second and fourth years.

Within each year group, girls' and boys' attitudes can be compared. Apart from large differences in attitudes to playing computer games, the majority of differences relate to the questions about boys and girls.

3.12 Profiles of Years

(for detailed profiles see Appendix IIIG)

It is very important to be aware of pupils' attitudes towards computers and to note the changes that occur in these attitudes as they progress through secondary school. It must be remembered that pupils enter secondary school with a highly developed set of their own attitudes. If they are to learn to the best of their abilities, then these attitudes must be taken into consideration.

To help to understand the set of attitudes possessed by a group of pupils, it is possible to draw up a profile based on the distribution of results obtained from the attitude survey. The profile has been drawn up using the point on the attitude scale which obtained the maximum score. If this score is high, then there is a better chance of this being the attitude of the majority of the group. Often the maximum score is < 40%, showing a much greater diversity of opinion. The following profiles give indications of trends and, together with any changes, give useful insights into the attitudes of our secondary pupils to computers and computing.

First year pupils have a lot of positive attitudes about computers. They are interesting, enjoyable and important. They will help in school lessons and in finding a job. Overall, first year attitudes to individualised learning are neutral. Pupils also feel that you do not have to be clever to use a computer, but that a knowledge of programming is important. Very importantly, first years want to use the computer, not just watch the teacher demonstrate.

Most of the attitudes of first year boys and girls are similar. They differ in a few areas; boys strongly agree that a knowledge of programming is necessary to get the best out of a computer (C7) while girls only agree. Girls think computers are very important, while boys only important. Again, there are differences in the questions which refer to their own or the opposite sex (C16, C11, C18, D3, D7). In general, pupils have a more positive attitude towards their own sex's abilities.

Third year pupils find computers less exciting, interesting and time well spent but still very enjoyable, friendly and important. Pupils feel that using a computer in school will help with finding a job and should make a boring subject more enjoyable (C5, C12). Pupils strongly agree that they need to know about programming to get the best out of the computer and that boys and girls are equally good at working with the computer (C7, C8). The questions on pupils' attitudes to individualised learning (C6, C10, C13, C19) show a wide range of responses.

Boys have more positive attitudes than girls to the playing of games (C4), and liking to use the computer (C14). Girls are more likely to feel that using a computer will help with a job and they also agree that it is easier to answer the computer than the teacher (C13). Boys have stronger attitudes about the equality of girls and boys; girls have slightly more mixed responses (C11, C16, C18).

CHAPTER 3 APPENDICES

IIIA Attitude Questionnaire - Group A (pilot study)

IIIB Attitude Questionnaire - Group B (main study)

IIIC Group A Results

IIID Group B Results

IIIE Group A - Analysis of Results

IIIF Group B - Analysis of Results

IIIG Group B - Pupil Profiles

APPENDIX IIIA

ATTITUDE QUESTIONNAIRE - GROUP A (pilot study)

A 1 Hypotheses

A 2 Analysis of Questionnaire

A 3 Questionnaire

A 4 Validity

A1 Hypotheses

The questionnaire for the pilot survey set out to investigate the following hypotheses:

Pupils find computer use in school exciting and enjoyable;

Pupils use computers in school;

Pupils see computer use in school as important in relation to future jobs;

Pupils find a computer easy to operate;

Pupils like to use a computer because it individualises learning;

Pupils think they need a knowledge of mathematics and programming to use a computer in school;

Boys and Girls have similar attitudes to computers.

A2 Analysis of Group A Questionnaire

The following six areas of pupil attitudes were investigated:

1 **General Expectation of Use**

Questions:

A1 Using a computer has been really exciting

A2 I have used the computer a lot in secondary school

Using computers in school is:

B1 Exciting/Boring

B2 Interesting/Dull

B3 Important/Unimportant

B4 Enjoyable/Hateful

B7 Time Well Spent/Waste of Time

2 **Mode of Computer Use with the Classroom**

Questions:

A3 Computers should only be used by the teacher

A4 I prefer to use the computer by myself in class

A8 I prefer the teacher to explain things to me rather than the computer

A9 Experiments are easier to do on the computer than in the Science room

B6 Using a computer in school: Difficult to Use/Easy to Use.

3 **Use of Machine Itself** (mechanics)

Questions:

A5 The keyboard on a computer is difficult to use

A6 A blackboard is easier to read than a computer monitor

Using a computer in school is:

B3 Important/Unimportant

B6 Difficult to use/Easy to Use

4 **Link with Other Subjects**

Questions:

A7 To get the best out of a computer you need to know about programming

A14 Only clever people can learn from a computer

A15 You must be good at arithmetic to learn from a computer

5 **World of Work/Links Outside School**

Questions:

A10 Learning to work with a computer will help me get a job when I leave school

A11 Computers take jobs away from people

A12 Even if my job does not use a computer they will be important to me in my everyday life

A13 To have a job working with computers I must know how to program

Using a computer in school is:

B3 Important/Unimportant

B7 Time well spent/Waste of time

6 **Expectations of Boys and Girls**

Questions:

A16 Girls find it much easier to work with computers

A17 Boys are better at giving answers to the computer

Using a computer in school is:

B8 Useful/Useless for girls

B9 Useful/Useless for boys

GROUP A (Pilot) - Survey

University of Glasgow

Science Education Group

Your Name ....

Age in Years ....

Boy or Girl ....

Register Class ....

FOR FIRST YEAR ONLY:
  Primary School ....

  Primary 7 Teacher ....

FOR THIRD YEAR ONLY:
  List the subjects you are taking this year.

There's no "pass" or "fail" for your answers, so take plenty of time.

Thankyou for taking part.

(Note: First Year Pupils: q A1, A2 were worded so that they were appropriate).

Part 1

Below are some statements. Read each one carefully and decide whether you agree or disagree with it. At the end of each statement is an empty box, put a number 1 to 5 in each box to show what you think about each statement.

1 means: you STRONGLY AGREE with the statement.

2 means: you AGREE with the statement.

3 means: you NEITHER agree or disagree with the statement.

4 means: you DISAGREE with the statement.

5 means: you STRONGLY DISAGREE with the statement.

A1 Using a computer has been really exciting.

A2 I have used the computer a lot in secondary school.

A3 Computers should only be used by the teacher.

A4 I prefer to use the computer by myself in class.

A5 The keyboard is easier to read than a computer monitor.

A6 A blackboard is easier to read than a computer monitor.

A7 To get the best out of a computer you need to know about programming.

A8 I prefer the teacher to explain things to me rather than the computer.

A9 Experiments are easier to do on the computer than in the science room.

A10 Learning to work with a computer will help me get a job when I leave school.

A11 Computers take jobs away from people.

A12 Even if my job does not use a computer they will be important to me in my everyday life.

A13 To have a job working with computers I must know how to program.

A14 Only clever people can learn from a computer.

A15 You must be good at arithmetic to learn from a computer.

A16 Girls find it easier to work with computers.

A17 Boys are better at giving answers to the computer.

If you want, finish this sentence:

Using computers is

Part 2

If you had to describe "Going into Space", you could do it like this:

Safe	1	2	3	4	5	6	Dangerous
Important	1	2	3	4	5	6	Unimportant
Fast	1	2	3	4	5	6	Slow

The positions of the circles between the word pairs show that you think it is quite dangerous, slightly more important than unimportant and very fast.

Use the same method of circling numbers to describe "**Using Computers in School**".

B1	Exciting	1	2	3	4	5	6	Boring
B2	Interesting	1	2	3	4	5	6	Dull
B3	Important	1	2	3	4	5	6	Unimportant
B4	Enjoyable	1	2	3	4	5	6	Hateful
B5	Friendly	1	2	3	4	5	6	Frightening
B6	Difficult to Use	1	2	3	4	5	6	Easy to Use
B7	Time Well Spent	1	2	3	4	5	6	Waste of Time
B8	Useful for Girls	1	2	3	4	5	6	Useless for Girls
B9	Useful for Boys	1	2	3	4	5	6	Useless for Boys

Part 3

Answer these questions briefly in the space provided. Write an answer on every line even if it is just "YES" or "NO".

1 Do you have a computer at home? ....

(If your answer to this question is "YES" go straight to Question 3 now. If your answer is "NO" go to Question 2).

2 Do you use a computer owned by someone else? ....

(If you answer to this question is "YES" go on to Question 4. If you answer is "NO" hand back all of these sheets to your teacher now).

3 Is the computer:
Your own machine? ....
Shared with the family? ....
(parents, brothers, sisters)

4 What make is the computer you use? ....

5 Do you use the computer:
every day?
2/3 times a week? ....
about once a week? ....
about once a month? ....
less than once a month? ....

6 Have you used any extras like paddles, joystick, turtle?
If so, say which: ....

7 Do you use the computer:
on your own? ....
with brother/sister? ....
with parents? ....
with friends? ....

8 Do you play games on your computer? ....

9 Do you use programs based on schoolwork? ....

10 Do you write your own programs? ....

11 Write down the names of 2 favourite programs.

....

12 Do you have any computer books or magazines? ....

Validity of Questionnaire

The questionnaire used in the attitude testing is not a standardised test. This means that the validity of the questions have to be checked.

A random sample of questions were taken from parts 1 & 2. The pupils tested in first year were divided into 2 groups. The boys and girls within that year were also divided into 2 groups. For each of the groups, the results for each question were compared using a X^2 test. None of the questions tested in this manner had a significance of less than 2%. The majority had significances of more than 10%, therefore the test is valid.

The test also has to show internal consistency. Questions A1 and B1 both refer to the computer as being exciting. If the test has internal consistency, then the responses to these questions should be similar.

Questions B3 (important/unimportant) and B7 (time well spent/waste of time) also show similar consistency.

APPENDIX IIIB

ATTITUDE QUESTIONNAIRE - GROUP B (main study)

B 1 Validity of Questionnaire

B 2 Questionnaire

B1 Validity of Group B Questionnaire

The questionnaire used in the attitude testing was not a standard test. This means that the validity of the questions have to be checked.

A random sample of questions were taken from both parts 1 & 2. The pupils tested were divided into 2 groups and the results for each of the questions were compared using a X^2 test. None of these questions tested in this manner had a significance of less than 2%, the majority had a significance of more than 10%, so the test is valid showing that differences in attitude are due to the pupils not the questions.

The test also has to show internal consistency, eg: q C1 and D1 both refer to the computer being exciting. If the test has internal consistency then the responses to these questions should be similar. The responses are similar (see raw results Appendix IIID). Also questions B2 & B4 or D2 & D5 (interesting/dull; enjoyable/hateful) should also show similar results.

Group B (Main Study) - Survey

University of Glasgow

Science Education Group

Your Name	....
Age in Years	....
Boy or Girl	....
Register Class	....

FOR FIRST YEAR ONLY:
Primary School ....

FOR THIRD/FOURTH YEAR ONLY:

Science subjects:	Physics	YES/NO
	Biology	YES/NO
	Chemistry	YES/NO
	Computer Studies	YES/NO

There's no "pass" or "fail" for your answers, so take plenty of time.

Thankyou for taking part.

Some questions need to be worded slightly differently, eg: C1. C2 for different years.

For S1: Using a computer in school should be really exciting.
For S3: Using a computer in school has been really exciting.

Part 1

Below are some statements. Read each one carefully and decide whether you agree or disagree with it. At the end of each statement is an empty box, put a number 1 to 5 in each box to show what you think about each statement.

1 means: you STRONGLY AGREE with the statement.

2 means: you AGREE with the statement.

3 means: you NEITHER agree or disagree with the statement.

4 means: you DISAGREE with the statement.

5 means: you STRONGLY DISAGREE with the statement.

C1 Using a computer in school should be really exciting.

C2 I expect to use the computer a lot in secondary school.

C3 Computers should only be used by the teacher.

C4 I like to play games on the computer.

C5 Computers should make a boring subject more enjoyable.

C6 I would prefer to use the computer by myself in class.

C7 To get the best out of a computer you need to know about programming.

C8 Boys and girls are equally good at working with computers.

C9 I would prefer the teacher to explain things to me rather than the computer.

C10 I would like to work with the computer because it works at my own speed.

C11 Girls find it much easier to work with computers.

C12 Learning to work with computers will help me to get a job when I leave school.

C13 I find it easier to answer the computer than the teacher.

C14 I would like to use the computer as part of my lessons.

C15 Only clever people can learn from a computer.

C16 Boys are better at giving answers to the computer.

C17 You must be good at arithmetic to learn from a computer.

C18 If I work with a partner of the opposite sex, I would sit back and let her/him work the computer.

C19 I think the computer should mark my work.

Part 2

If you had to describe "Going into Space", you could do it like this:

Safe	1	2	3	4	5	6	Dangerous
Important	1	2	3	4	5	6	Unimportant
Fast	1	2	3	4	5	6	Slow

The positions of the circles between the word pairs show that you think it is quite dangerous, slightly more important than unimportant and very fast.

Use the same method of circling numbers to describe "**Using Computers in School**".

D1	Exciting	1	2	3	4	5	6	Boring
D2	Interesting	1	2	3	4	5	6	Dull
D3	Useful for Boys	1	2	3	4	5	6	Useless for Boys
D4	Frightening	1	2	3	4	5	6	Friendly
D5	Enjoyable	1	2	3	4	5	6	Hateful
D6	Unimportant	1	2	3	4	5	6	Important
D7	Useless for Girls	1	2	3	4	5	6	Useful for Girls
D8	Time Well Spent	1	2	3	4	5	6	Waste of Time
D9	Difficult to Use	1	2	3	4	5	6	Easy to Use

Part 3

Answer these questions YES or NO.

F1 Do you have a computer at home? ....

(If your answer is "NO" go to Question F2
If you answer is "YES" go to Question F3)

F2 Do you use a computer owned by someone else? ....

(If you answer is "NO" you have finished THANK YOU. If your answer is "YES" go to Question F3).

F3 Do you use the computer:
every day?
2/3 times a week? ....
about once a week? ....
about once a month? ....
less than once a month? ....

F4 Do you use the computer:
on your own? ....
with brother/sister? ....
with parents? ....
with friends? ....

F5 Do you play games on your computer? ....

F6 Do you use programs based on schoolwork? ....

F7 Do you write your own programs? ....

You have finished THANK YOU.

APPENDIX IIIC - GROUP A (Pilot Study)

Results and Results Expressed as % of Group

Table IIIC.1	Group A	(1986)	S1	Totals	q A1-A17
IIIC.2	Group A	(1986)	S1	Girls	q A1-A17
IIIC.3	Group A	(1986)	S1	Boys	q A1-A17
IIIC.4	Group A	(1987)	S2	Totals	q A1-A17
IIIC.5	Group A	(1987)	S2	Girls	q A1-A17
IIIC.6	Group A	(1987)	S2	Boys	q A1-A17
IIIC.7	Group A	(1986)	S3	Totals	q A1-A17
IIIC.8	Group A	(1986)	S3	Girls	q A1-A17
IIIC.9	Group A	(1986)	S3	Boys	q A1-A17
IIIC.10	Group A	(1987)	S4	Totals	q A1-A17
IIIC.11	Group A	(1987)	S4	Girls	q A1-A17
IIIC.12	Group A	(1987)	S4	Boys	q A1-A17
IIIC.13	Group A	(1986)	S1	Totals	q B1-B9
IIIC.14	Group A	(1986)	S1	Girls	q B1-B9
IIIC.15	Group A	(1986)	S1	Boys	q B1-B9
IIIC.16	Group A	(1987)	S2	Totals	q B1-B9
IIIC.17	Group A	(1987)	S2	Girls	q B1-B9
IIIC.18	Group A	(1987)	S2	Boys	q B1-B9
IIIC.19	Group A	(1986)	S3	Totals	q B1-B9
IIIC.20	Group A	(1986)	S3	Girls	q B1-B9
IIIC.21	Group A	(1986)	S3	Boys	q B1-B9
IIIC.22	Group A	(1987)	S4	Totals	q B1-B9
IIIC.23	Group A	(1987)	S4	Girls	q B1-B9
IIIC.24	Group A	(1987)	S4	Boys	q B1-B9

Table IIIC.1

Group A (1986) S1 Totals (n = 146)
(% Result)

	ATTITUDE 1	2	3	4	5
A1 Exciting	34 (23.3)	79 (54.1)	29 (19.9)	4 (2.7)	0
A2 Use a Lot	21 (14.4)	62 (42.5)	52 (35.6)	11 (7.5)	0
A3 Use by Teacher	1 (0.7)	1 (0.7)	4 (2.7)	39 (26.7)	101 (69.2)
A4 Individual Use	16 (11.0)	38 (26.0)	52 (35.6)	35 (24.0)	5 (3.4)
A5 Keyboard Difficult	2 (1.4)	21 (14.4)	25 (17.1)	53 (36.3)	45 (30.8)
A6 Blackboard Easier Than Monitor	5 (3.4)	17 (11.6)	49 (33.6)	41 (28.1)	34 (23.3)
A7 Know Programming	40 (27.4)	54 (37.0)	28 (19.2)	22 (15.1)	2 (1.4)
A8 Teacher to Explain	19 (13.0)	49 (33.6)	49 (33.6)	22 (15.1)	7 (4.8)
A9 Expts. Easier on Computer	4 (2.7)	6 (4.1)	44 (30.1)	47 (32.2)	45 (30.8)
A10 Help for Job	35 (24.0)	39 (26.7)	53 (36.3)	9 (6.2)	10 (6.9)
A11 Take Jobs From People	22 (15.1)	33 (22.6)	45 (30.8)	25 (17.1)	21 (14.4)
A12 Important in Everyday Life	20 (13.7)	41 (28.1)	43 (29.5)	33 (22.6)	9 (6.2)

Group A (1986) S1 Totals (146) cont..

	1	2	3	4	5
A13 Know Programming for Job	68 (46.6)	55 (37.7)	10 (6.9)	9 (6.2)	4 (2.7)
A14 Need to be Clever	2 (1.4)	0	8 (5.5)	36 (24.7)	100 (68.5)
A15 Good at Arithmetic	3 (2.1)	2 (1.4)	19 (13.0)	49 (33.6)	73 (50.0)
A16 Easy for Girls	5 (3.4)	4 (2.7)	50 (34.3)	32 (21.9)	55 (37.7)
A17 Boys Better	18 (12.3)	5 (3.4)	46 (31.5)	29 (19.9)	48 (32.9)

TABLE IIIC.2

Results Group A (1986) S1 Girls (73)
(%)

	1	2	3	4	5
A1 Exciting	19 (26.1)	37 (50.7)	15 (20.6)	2 (2.7)	0
A2 Use a Lot	6 (8.2)	34 (46.6)	29 (39.7)	4 (5.5)	0
A3 Use by Teacher	0	0	2 (2.7)	27 (37.0)	44 (60.3)
A4 Individual Use	8 (11.0)	15 (20.6)	27 (37.0)	19 (26.0)	4 (5.5)
A5 Keyboard Difficult	1 (1.4)	12 (16.4)	10 (13.7)	29 (39.7)	21 (28.8)
A6 Blackboard Easier Than Monitor	2 (2.7)	6 (8.2)	30 (41.1)	18 (24.7)	17 (23.3)
A7 Know Programming	18 (24.7)	30 (41.1)	13 (17.8)	12 (16.4)	0
A8 Teacher to Explain	7 (9.6)	26 (35.6)	27 (37.0)	12 (16.4)	1 (1.4)
A9 Expts. Easier on Computer	3 (4.1)	2 (2.7)	26 (35.6)	22 (30.1)	20 (27.4)
A10 Help for Job	10 (13.7)	19 (26.1)	34 (46.6)	7 (9.6)	3 (4.1)
A11 Take Jobs From People	10 (13.7)	19 (26.1)	28 (38.4)	11 (15.1)	5 (6.8)
A12 Important in Everyday Life	4 (5.5)	19 (26.1)	24 (32.9)	20 (27.4)	6 (8.2)

Group A (1986) S1 Girls (73) cont..

	1	2	3	4	5
A13 Know Programming for Job	33 (45.2)	29 (39.7)	6 (8.2)	2 (2.7)	3 (4.1)
A14 Need to be Clever	1 (1.4)	0	5 (6.9)	14 (19.2)	53 (72.6)
A15 Good at Arithmetic	2 (2.7)	0	8 (11.0)	28 (38.4)	35 (47.9)
A16 Easy for Girls	3 (4.1)	3 (4.1)	29 (39.7)	16 (21.9)	22 (30.1)
A17 Boys Better	2 (2.7)	1 (1.4)	22 (30.1)	16 (21.9)	32 (43.8)

Table IIIC.3

Results Group A (1986) S1 Boys (73)
(%)

	1	2	3	4	5
A1 Exciting	15 (20.6)	42 (57.5)	14 (19.2)	2 (2.7)	0
A2 Use a Lot	15 (20.6)	28 (38.4)	23 (31.5)	7 (9.6)	0
A3 Use by Teacher	1 (1.4)	1 (1.4)	2 (2.7)	12 (16.4)	57 (78.1)
A4 Individual Use	8 (11.0)	23 (31.5)	25 (34.3)	16 (21.9)	1 (1.4)
A5 Keyboard Difficult	1 (1.4)	9 (12.3)	15 (20.6)	24 (32.9)	24 (32.9)
A6 Blackboard Easier Than Monitor	3 (4.1)	11 (15.1)	19 (26.0)	23 (31.5)	17 (23.3)
A7 Know Programming	22 (30.1)	24 (32.9)	15 (20.6)	10 (13.7)	2 (2.7)
A8 Teacher to Explain	12 (16.4)	23 (31.5)	22 (30.1)	10 (13.7)	6 (8.2)
A9 Expts. Easier on Computer	1 (1.4)	4 (5.5)	18 (24.7)	25 (34.2)	25 (34.2)
A10 Help for Job	25 (34.2)	20 (27.4)	19 (26.0)	2 (2.7)	7 (9.6)
A11 Take Jobs From People	12 (16.4)	14 (19.2)	17 (23.3)	14 (19.2)	16 (21.9)
A12 Important in Everyday Life	16 (21.9)	22 (30.1)	19 (26.0)	13 (17.8)	3 (4.1)

Group A (1986) S1 Boys (73) cont..

	1	2	3	4	5
A13 Know Programming for Job	35 (47.9)	26 (35.6)	4 (5.5)	7 (9.6)	1 (1.4)
A14 Need to be Clever	1 (1.4)	0	3 (4.1)	22 (30.1)	47 (64.4)
A15 Good at Arithmetic	1 (1.4)	2 (2.7)	11 (15.1)	21 (28.8)	38 (52.1)
A16 Easy for Girls	2 (2.7)	1 (1.4)	21 (28.8)	16 (21.9)	33 (45.2)
A17 Boys Better	16 (21.9)	4 (5.5)	24 (32.9)	13 (17.8)	16 (21.9)

Table IIIC.4

Results Group A (1987) S2 Totals (151)
(%)

	1	2	3	4	5
A1 Exciting	37 (24.5)	58 (38.4)	44 (29.1)	10 (6.6)	2 (1.3)
A2 Use a Lot	6 (4.0)	28 (18.5)	29 (19.2)	56 (37.1)	32 (21.2)
A3 Use by Teacher	2 (1.3)	0	8 (5.3)	16 (10.6)	125 (82.8)
A4 Individual Use	58 (38.4)	40 (26.5)	41 (27.2)	6 (4.0)	6 (4.0)
A5 Keyboard Difficult	3 (2.0)	8 (5.3)	34 (22.5)	44 (29.1)	62 (41.1)
A6 Blackboard Easier Than Monitor	7 (4.6)	15 (9.9)	37 (24.5)	45 (29.8)	47 (31.1)
A7 Know Programming	41 (27.2)	44 (29.1)	37 (24.5)	17 (11.3)	12 (8.0)
A8 Teacher to Explain	35 (23.2)	30 (19.9)	50 (33.1)	15 (9.9)	21 (13.9)
A9 Expts. Easier on Computer	16 (10.6)	4 (2.7)	34 (22.5)	53 (35.1)	44 (29.1)
A10 Help for Job	29 (19.2)	38 (25.2)	54 (35.8)	17 (11.3)	13 (8.6)
A11 Take Jobs From People	38 (25.2)	29 (19.2)	48 (31.8)	19 (12.6)	17 (11.3)
A12 Important in Everyday Life	20 (13.3)	36 (23.8)	51 (33.8)	24 (15.9)	20 (13.3)

Group A (1987) S2 Totals (151) cont..

	1	2	3	4	5
A13 Know Programming for Job	84 (55.6)	44 (29.1)	15 (9.9)	3 (2.0)	5 (3.3)
A14 Need to be Clever	1 (0.7)	3 (2.0)	9 (6.0)	36 (23.8)	102 (67.6)
A15 Good at Arithmetic	1 (0.7)	4 (2.7)	13 (8.6)	35 (23.2)	98 (64.9)
A16 Easy for Girls	5 (3.3)	4 (2.7)	38 (25.2)	19 (12.6)	85 (56.3)
A17 Boys Better	26 (17.2)	7 (4.6)	41 (27.2)	16 (10.6)	61 (40.4)

Table IIIC.5

Results Group A (1987) S2 Girls (74)
(%)

	1	2	3	4	5
A1 Exciting	11 (14.9)	33 (44.6)	24 (32.4)	6 (8.1)	0
A2 Use a Lot	2 (2.7)	13 (17.6)	14 (18.9)	32 (43.2)	13 (17.6)
A3 Use by Teacher	1 (1.4)	0	4 (5.4)	9 (12.2)	60 (81.1)
A4 Individual Use	27 (36.5)	22 (29.7)	18 (24.3)	3 (4.1)	4 (5.4)
A5 Keyboard Difficult	2 (2.7)	5 (6.8)	16 (21.6)	27 (36.5)	24 (32.4)
A6 Blackboard Easier Than Monitor	2 (2.7)	7 (9.5)	22 (29.7)	22 (29.7)	21 (28.4)
A7 Know Programming	11 (14.9)	26 (35.1)	23 (31.0)	9 (12.2)	5 (6.8)
A8 Teacher to Explain	13 (17.6)	18 (24.3)	28 (37.8)	8 (10.8)	7 (9.5)
A9 Expts. Easier on Computer	6 (8.1)	3 (4.1)	21 (28.4)	25 (33.8)	19 (25.7)
A10 Help for Job	10 (13.5)	18 (24.3)	26 (35.1)	10 (13.5)	10 (13.5)
A11 Take Jobs From People	16 (21.6)	17 (23.0)	25 (33.8)	10 (13.5)	6 (8.1)
A12 Important in Everyday Life	8 (10.8)	15 (20.3)	24 (32.4)	18 (24.3)	9 (12.2)

Group A (1987) S2 Girls (74) cont..

	1	2	3	4	5
A13 Know Programming for Job	38 (51.4)	25 (33.8)	8 (10.8)	1 (1.4)	2 (2.7)
A14 Need to be Clever	1 (1.4)	0	4 (5.4)	17 (23.0)	52 (70.3)
A15 Good at Arithmetic	0	1 (1.4)	6 (8.1)	19 (25.7)	48 (64.9)
A16 Easy for Girls	4 (5.4)	4 (5.4)	17 (23.0)	11 (14.9)	38 (51.4)
A17 Boys Better	2 (2.7)	3 (4.1)	14 (18.9)	11 (14.9)	44 (59.5)

Table IIIC.6

Results Group A (1987) S2 Boys (77)
(%)

	1	2	3	4	5
A1 Exciting	26 (33.8)	25 (32.5)	20 (26.0)	4 (5.2)	2 (2.6)
A2 Use a Lot	4 (5.2)	15 (19.5)	15 (19.5)	24 (31.2)	19 (24.7)
A3 Use by Teacher	1 (1.3)	0	4 (5.2)	7 (9.1)	65 (84.4)
A4 Individual Use	31 (40.3)	18 (23.4)	23 (29.9)	3 (3.9)	2 (2.6)
A5 Keyboard Difficult	1 (1.3)	3 (3.9)	18 (23.4)	17 (22.1)	38 (49.4)
A6 Blackboard Easier Than Monitor	5 (6.5)	8 (10.4)	15 (19.5)	23 (29.9)	26 (33.8)
A7 Know Programming	30 (39.0)	18 (23.4)	14 (18.2)	8 (10.4)	7 (9.1)
A8 Teacher to Explain	22 (28.6)	12 (15.6)	22 (28.6)	7 (9.1)	14 (18.2)
A9 Expts. Easier on Computer	10 (13.0)	1 (1.3)	13 (16.9)	28 (36.4)	25 (32.5)
A10 Help for Job	19 (24.7)	20 (26.0)	28 (36.4)	7 (9.1)	3 (3.9)
A11 Take Jobs From People	22 (28.6)	12 (15.6)	23 (29.9)	9 (11.7)	11 (14.3)
A12 Important in Everyday Life	12 (15.6)	21 (27.3)	27 (35.1)	6 (7.8)	11 (14.3)

Group A (1987) S2 Boys (77) cont..

	1	2	3	4	5
A13 Know Programming for Job	46 (59.7)	19 (24.7)	7 (9.1)	2 (2.6)	3 (3.9)
A14 Need to be Clever	0	3 (3.9)	5 (6.5)	19 (24.7)	50 (64.9)
A15 Good at Arithmetic	1 (1.3)	3 (3.9)	7 (9.1)	16 (20.8)	50 (64.9)
A16 Easy for Girls	1 (1.3)	0	21 (27.3)	8 (10.4)	47 (61.0)
A17 Boys Better	24 (31.2)	4 (5.2)	27 (35.1)	5 (6.5)	17 (22.1)

Table IIIC.7

Results Group A (1986) S3 Totals (61)
(%)

	1	2	3	4	5
A1 Exciting	4 (6.6)	22 (36.1)	30 (49.2)	4 (6.6)	1 (1.6)
A2 Use a Lot	3 (4.9)	3 (4.9)	7 (11.5)	18 (29.5)	30 (49.2)
A3 Use by Teacher	2 (3.3)	0	3 (4.9)	10 (16.4)	46 (75.4)
A4 Individual Use	8 (13.1)	22 (36.1)	20 (32.8)	5 (8.2)	6 (9.8)
A5 Keyboard Difficult	0	3 (4.9)	13 (21.3)	30 (49.2)	15 (24.6)
A6 Blackboard Easier Than Monitor	2 (3.3)	11 (18.0)	24 (39.3)	10 (16.4)	14 (23.0)
A7 Know Programming	15 (24.6)	17 (27.9)	19 (31.2)	7 (11.5)	3 (4.9)
A8 Teacher to Explain	9 (14.8)	21 (34.4)	19 (31.2)	5 (8.2)	7 (11.5)
A9 Expts. Easier on Computer	3 (4.9)	5 (8.2)	20 (32.8)	20 (32.8)	13 (21.3)
A10 Help for Job	6 (9.8)	22 (36.1)	25 (40.9)	6 (9.8)	2 (3.3)
A11 Take Jobs From People	8 (13.1)	20 (32.8)	20 (32.8)	6 (9.8)	7 (11.5)
A12 Important in Everyday Life	5 (8.2)	17 (27.9)	26 (42.6)	11 (18.0)	2 (3.3)

Group A (1986) S3 Total (61) cont..

	1	2	3	4	5
A13 Know Programming for Job	26 (42.6)	23 (37.7)	7 (11.5)	4 (6.6)	1 (1.6)
A14 Need to be Clever	1 (1.6)	0	1 (1.6)	24 (39.3)	35 (57.4)
A15 Good at Arithmetic	1 (1.6)	1 (1.6)	10 (16.4)	29 (47.5)	20 (32.8)
A16 Easy for Girls	0	2 (3.3)	23 (37.7)	15 (24.6)	21 (34.4)
A17 Boys Better	2 (3.3)	5 (8.2)	24 (39.3)	10 (16.4)	20 (32.8)

Table IIIC.8

Results Group A (1986) S3 Girls (33)
(%)

	1	2	3	4	5
A1 Exciting	0	8 (24.2)	20 (60.6)	4 (12.1)	1 (3.0)
A2 Use a Lot	0	0	4 (12.1)	7 (21.2)	22 (66.7)
A3 Use by Teacher	0	0	3 (9.1)	7 (21.2)	23 (69.7)
A4 Individual Use	1 (3.0)	11 (33.3)	14 (42.4)	3 (9.1)	4 (12.1)
A5 Keyboard Difficult	0	1 (3.0)	8 (24.2)	18 (54.5)	6 (18.2)
A6 Blackboard Easier Than Monitor	2 (6.1)	8 (24.2)	14 (42.4)	5 (15.2)	4 (12.1)
A7 Know Programming	9 (27.3)	11 (33.3)	9 (27.3)	3 (9.1)	1 (3.0)
A8 Teacher to Explain	6 (18.2)	12 (36.4)	12 (36.4)	1 (3.0)	2 (6.1)
A9 Expts. Easier on Computer	0	2 (6.1)	14 (42.4)	12 (36.4)	5 (15.2)
A10 Help for Job	2 (6.1)	15 (45.5)	12 (36.4)	4 (12.1)	0
A11 Take Jobs From People	2 (6.1)	10 (30.3)	13 (39.4)	5 (15.2)	3 (9.1)
A12 Important in Everyday Life	3 (9.1)	9 (27.3)	13 (39.4)	7 (21.2)	1 (3.0)

Group A (1987) S3 Girls (33) cont..

	1	2	3	4	5
A13 Know Programming for Job	11 (33.3)	17 (51.5)	4 (12.1)	1 (3.0)	0
A14 Need to be Clever	0	0	0	13 (39.4)	20 (60.6)
A15 Good at Arithmetic	0	0	3 (9.1)	18 (54.5)	12 (36.4)
A16 Easy for Girls	0	2 (6.1)	14 (42.4)	8 (24.2)	9 (27.3)
A17 Boys Better	0	1 (3.0)	11 (33.3)	6 (18.2)	15 (45.5)

Table IIIC.9

Results Group A (1986) S3 Boys (28)
(%)

	1	2	3	4	5
A1 Exciting	4 (14.3)	14 (50.0)	10 (35.7)	0	0
A2 Use a Lot	3 (10.7)	3 (10.7)	3 (10.7)	11 (39.3)	8 (28.6)
A3 Use by Teacher	2 (7.1)	0	0	3 (10.7)	23 (82.1)
A4 Individual Use	7 (25.0)	11 (39.3)	6 (21.4)	2 (7.1)	2 (7.1)
A5 Keyboard Difficult	0	2 (7.1)	5 (17.9)	12 (42.9)	9 (32.1)
A6 Blackboard Easier Than Monitor	0	3 (10.7)	10 (35.7)	5 (17.9)	10 (35.7)
A7 Know Programming	6 (21.4)	6 (21.4)	10 (35.7)	4 (14.3)	2 (7.1)
A8 Teacher to Explain	3 (10.7)	9 (32.1)	7 (25.0)	4 (14.3)	5 (17.9)
A9 Expts. Easier on Computer	3 (10.7)	3 (10.7)	6 (21.4)	8 (28.6)	8 (28.6)
A10 Help for Job	4 (14.3)	7 (25.0)	13 (46.4)	2 (7.1)	2 (7.1)
A11 Take Jobs From People	6 (21.4)	10 (35.7)	7 (25.0)	1 (3.6)	4 (14.3)
A12 Important in Everyday Life	2 (7.1)	8 (28.6)	13 (46.4)	4 (14.3)	1 (3.6)

Group A (1986) S3 Boys (28) cont..

	1	2	3	4	5
A13 Know Programming for Job	15 (53.6)	6 (21.4)	3 (10.7)	3 (10.7)	1 (3.6)
A14 Need to be Clever	1 (3.6)	0	1 (3.6)	11 (39.3)	15 (53.6)
A15 Good at Arithmetic	1 (3.6)	1 (3.6)	7 (25.0)	11 (39.3)	8 (28.6)
A16 Easy for Girls	0	0	9 (32.1)	7 (25.0)	12 (42.9)
A17 Boys Better	2 (7.1)	4 (14.3)	13 (46.4)	4 (14.3)	5 (17.9)

Table IIIC.10

Results Group A (1987) S4 Totals (59)
(%)

	1	2	3	4	5
A1 Exciting	3 (5.1)	14 (23.7)	25 (42.4)	12 (20.3)	5 (8.5)
A2 Use a Lot	3 (5.1)	1 (1.7)	7 (11.9)	23 (39.0)	25 (42.4)
A3 Use by Teacher	1 (1.7)	0	6 (10.2)	17 (28.8)	35 (59.3)
A4 Individual Use	15 (25.4)	16 (27.1)	14 (23.7)	11 (18.6)	3 (5.1)
A5 Keyboard Difficult	0	4 (6.8)	16 (27.1)	22 (37.3)	17 (28.8)
A6 Blackboard Easier Than Monitor	3 (5.1)	9 (15.3)	24 (40.7)	15 (25.4)	8 (13.6)
A7 Know Programming	9 (15.3)	21 (35.6)	15 (25.4)	11 (18.6)	3 (5.1)
A8 Teacher to Explain	19 (32.2)	18 (30.5)	14 (23.7)	7 (11.8)	1 (1.7)
A9 Expts. Easier on Computer	3 (5.1)	8 (13.6)	20 (33.9)	18 (30.5)	10 (16.9)
A10 Help for Job	8 (13.6)	20 (33.9)	18 (30.5)	10 (16.9)	3 (5.1)
A11 Take Jobs From People	6 (10.2)	18 (30.5)	20 (33.9)	7 (11.8)	8 (13.6)
A12 Important in Everyday Life	4 (6.8)	13 (22.0)	22 (37.3)	14 (23.7)	6 (10.2)

Group A (1987) S4 Totals (59) cont..

	1	2	3	4	5
A13 Know Programming for Job	15 (25.4)	29 (49.2)	8 (13.6)	3 (5.1)	4 (6.8)
A14 Need to be Clever	0	1 (1.7)	2 (3.4)	18 (30.5)	38 (64.4)
A15 Good at Arithmetic	1 (1.7)	3 (5.1)	6 (10.2)	24 (40.7)	25 (42.4)
A16 Easy for Girls	0	0	18 (30.5)	6 (10.2)	35 (59.3)
A17 Boys Better	2 (3.4)	3 (5.1)	16 (27.1)	11 (18.6)	27 (45.8)

Table IIIC.11

Results Group A (1987) S4 Girls (31)
(%)

	1	2	3	4	5
A1 Exciting	0	5 (16.1)	12 (38.7)	10 (32.3)	4 (12.9)
A2 Use a Lot	0	0	4 (12.9)	11 (35.5)	16 (51.6)
A3 Use by Teacher	0	0	6 (19.4)	9 (29.0)	16 (51.6)
A4 Individual Use	6 (19.4)	7 (22.6)	8 (25.8)	9 (29.0)	1 (3.2)
A5 Keyboard Difficult	0	1 (3.2)	7 (22.6)	14 (45.2)	9 (29.0)
A6 Blackboard Easier Than Monitor	1 (3.2)	7 (22.6)	12 (38.7)	7 (22.6)	4 (12.9)
A7 Know Programming	2 (6.5)	12 (38.7)	9 (29.0)	7 (22.6)	1 (3.2)
A8 Teacher to Explain	11 (35.5)	8 (25.8)	9 (29.0)	3 (9.7)	0
A9 Expts. Easier on Computer	1 (3.2)	4 (12.9)	10 (32.3)	11 (35.5)	5 (16.1)
A10 Help for Job	4 (12.9)	10 (32.3)	11 (35.5)	5 (16.1)	1 (3.2)
A11 Take Jobs From People	2 (6.5)	8 (25.8)	12 (38.7)	5 (16.1)	4 (12.9)
A12 Important in Everyday Life	0	6 (19.4)	13 (41.9)	8 (25.8)	4 (12.9)

Group A (1987) S4 Girls (31) cont..

	1	2	3	4	5
A13 Know Programming for Job	6 (19.4)	20 (64.5)	3 (9.7)	2 (6.5)	0
A14 Need to be Clever	0	0	1 (3.2)	10 (32.3)	20 (64.5)
A15 Good at Arithmetic	0	0	2 (6.5)	15 (48.4)	14 (45.2)
A16 Easy for Girls	0	0	12 (38.7)	4 (12.9)	15 (48.4)
A17 Boys Better	0	0	7 (22.6)	6 (19.4)	18 (58.1)

Table IIIC.12

Results Group A (1987) S4 Boys (28)
(%)

	1	2	3	4	5
A1 Exciting	3 (10.7)	9 (32.1)	13 (46.4)	2 (7.1)	1 (3.6)
A2 Use a Lot	3 (10.7)	1 (3.6)	3 (10.7)	12 (42.9)	9 (32.1)
A3 Use by Teacher	1 (3.6)	0	0	8 (28.6)	19 (67.9)
A4 Individual Use	9 (32.1)	9 (32.1)	6 (21.4)	2 (7.1)	2 (7.1)
A5 Keyboard Difficult	0	3 (10.7)	9 (32.1)	8 (28.6)	8 (28.6)
A6 Blackboard Easier Than Monitor	2 (7.1)	2 (7.1)	12 (42.9)	8 (28.6)	4 (14.3)
A7 Know Programming	7 (25.0)	9 (32.1)	6 (21.4)	4 (14.3)	2 (7.1)
A8 Teacher to Explain	8 (28.6)	10 (35.7)	5 (17.9)	4 (14.3)	1 (3.6)
A9 Expts. Easier on Computer	2 (7.1)	4 (14.3)	10 (35.7)	7 (25.0)	5 (17.9)
A10 Help for Job	4 (14.3)	10 (35.7)	7 (25.0)	5 (17.9)	2 (7.1)
A11 Take Jobs From People	4 (14.3)	10 (35.7)	8 (28.6)	2 (7.1)	4 (14.3)
A12 Important in Everyday Life	4 (14.3)	7 (25.0)	9 (32.1)	6 (21.4)	2 (7.1)

Group A (1987) S4 Boys (28) cont..

	1	2	3	4	5
A13 Know Programming for Job	9 (32.1)	9 (32.1)	5 (17.9)	1 (3.6)	4 (14.3)
A14 Need to be Clever	0	1 (3.6)	1 (3.6)	8 (28.6)	18 (64.3)
A15 Good at Arithmetic	1 (3.6)	3 (10.7)	4 (14.3)	9 (32.1)	11 (39.3)
A16 Easy for Girls	0	0	6 (21.4)	2 (7.1)	20 (71.4)
A17 Boys Better	2 (7.1)	3 (10.7)	9 (32.1)	5 (17.9)	9 (32.1)

Table IIIC.13

Results Group A (1986) S1 Totals (147)
(%)

		1	2	3	4	5	6
B1	Exciting/ Boring	40 (27.2)	57 (38.8)	39 (26.5)	9 (6.1)	0	2 (1.4)
B2	Interesting/ Dull	67 (45.6)	52 (35.4)	21 (14.3)	5 (3.4)	2 (1.4)	0
B3	Important/ Unimportant	34 (23.1)	40 (27.2)	48 (32.7)	17 (11.6)	6 (4.1)	2 (1.4)
B4	Enjoyable/ Hateful	60 (40.8)	54 (36.7)	29 (19.7)	4 (2.7)	0	0
B5	Friendly/ Frightening	21 (14.3)	43 (29.3)	66 (44.9)	13 (8.8)	2 (1.4)	2 (1.4)
B6	Difficult/ Easy	7 (4.8)	17 (11.6)	25 (17.0)	28 (19.0)	47 (32.0)	23 (15.6)
B7	Time Well Spent/Waste of Time	36 (24.5)	57 (38.8)	43 (29.3)	7 (4.8)	3 (2.0)	1 (0.7)
B8	Girls, Useful/ Useless	44 (29.9)	34 (23.1)	40 (27.2)	17 (11.6)	5 (3.4)	7 (4.8)
B9	Useful/Useless for Boys	56 (38.1)	37 (25.2)	39 (26.5)	10 (6.8)	4 (2.7)	1 (0.7)

Table IIIC.14

Results Group A (1986) S1 Girls (73)
(%)

		1	2	3	4	5	6
B1	Exciting/ Boring	17 (23.3)	29 (39.7)	22 (30.1)	5 (6.8)	0	0
B2	Interesting/ Dull	34 (46.6)	23 (31.5)	11 (15.1)	4 (5.5)	1 (1.4)	0
B3	Important/ Unimportant	9 (12.3)	24 (32.9)	26 (35.6)	10 (13.7)	3 (4.1)	1 (1.4)
B4	Enjoyable/ Hateful	27 (37.0)	29 (39.7)	15 (20.5)	2 (2.7)	0	0
B5	Friendly/ Frightening	11 (15.1)	20 (27.4)	31 (42.5)	9 (12.3)	2 (2.7)	0
B6	Difficult/ Easy	3 (4.1)	12 (16.4)	8 (11.0)	16 (21.9)	26 (35.6)	8 (11.0)
B7	Time Well Spent/Waste of Time	11 (15.1)	28 (38.3)	26 (35.6)	5 (6.8)	2 (2.7)	1 (1.4)
B8	Girls, Useful/ Useless	23 (31.5)	16 (21.9)	24 (32.9)	7 (9.6)	3 (4.1)	0
B9	Useful/Useless for Boys	22 (30.1)	15 (20.5)	27 (37.0)	5 (6.8)	3 (4.1)	1 (1.4)

Table IIIC.15

Results Group A (1986) S1 Boys (74)
(%)

		1	2	3	4	5	6
B1	Exciting/ Boring	23 (31.1)	28 (37.8)	17 (23.0)	4 (5.4)	0	2 (2.7)
B2	Interesting/ Dull	33 (44.6)	29 (39.2)	10 (13.5)	1 (1.4)	1 (1.4)	0
B3	Important/ Unimportant	25 (33.8)	16 (21.6)	22 (29.7)	7 (9.5)	3 (4.1)	1 (1.4)
B4	Enjoyable/ Hateful	33 (44.6)	25 (33.8)	14 (18.9)	2 (2.7)	0	0
B5	Friendly/ Frightening	10 (13.5)	23 (31.1)	35 (47.3)	4 (5.4)	0	2 (2.7)
B6	Difficult/ Easy	4 (5.4)	5 (6.8)	17 (23.0)	12 (16.2)	21 (28.4)	15 (20.2)
B7	Time Well Spent/Waste of Time	25 (33.8)	29 (39.2)	17 (23.0)	2 (2.7)	1 (1.4)	0
B8	Girls, Useful/ Useless	21 (28.4)	18 (24.3)	16 (21.6)	10 (13.5)	2 (2.7)	7 (9.5)
B9	Useful/Useless for Boys	34 (45.9)	22 (29.7)	12 (16.2)	5 (6.8)	1 (1.4)	0

Table IIIC.16

Results Group A (1987) S2 Totals (151)
(%)

		1	2	3	4	5	6
B1	Exciting/ Boring	29 (19.2)	59 (39.1)	40 (26.5)	12 (8.0)	7 (4.6)	4 (2.7)
B2	Interesting/ Dull	58 (38.4)	42 (27.8)	31 (20.5)	11 (7.3)	6 (4.0)	3 (2.0)
B3	Important/ Unimportant	31 (20.5)	44 (29.1)	42 (27.8)	26 (17.2)	6 (4.0)	2 (1.3)
B4	Enjoyable/ Hateful	60 (39.7)	50 (33.1)	31 (20.5)	6 (4.0)	2 (1.3)	2 (1.3)
B5	Friendly/ Frightening	30 (19.9)	41 (27.2)	60 (39.7)	17 (11.3)	3 (2.0)	0
B6	Difficult/ Easy	5 (3.3)	22 (14.6)	24 (15.9)	24 (15.9)	31 (20.5)	45 (29.8)
B7	Time Well Spent/Waste of Time	43 (28.5)	40 (26.5)	43 (28.5)	20 (13.3)	3 (2.0)	2 (1.3)
B8	Girls, Useful/ Useless	60 (39.7)	24 (15.9)	38 (25.2)	12 (8.0)	6 (4.0)	11 (7.3)
B9	Useful/Useless for Boys	72 (47.7)	23 (15.2)	40 (26.5)	9 (6.0)	2 (1.3)	5 (3.3)

Table IIIC.17

Results Group A (1987) S2 Girls (74)
(%)

		1	2	3	4	5	6
B1	Exciting/ Boring	14 (18.9)	29 (39.2)	23 (31.0)	5 (6.8)	2 (2.7)	1 (1.4)
B2	Interesting/ Dull	29 (39.2)	21 (28.4)	14 (18.9)	8 (10.8)	1 (1.4)	1 (1.4)
B3	Important/ Unimportant	12 (16.2)	20 (27.0)	23 (31.0)	14 (18.9)	4 (5.4)	1 (1.4)
B4	Enjoyable/ Hateful	30 (40.5)	25 (33.8)	16 (21.6)	2 (2.7)	0	1 (1.4)
B5	Friendly/ Frightening	11 (14.9)	22 (29.7)	31 (41.9)	10 (13.5)	0	0
B6	Difficult/ Easy	5 (6.8)	12 (16.2)	12 (16.2)	13 (17.6)	21 (28.4)	11 (14.9)
B7	Time Well Spent/Waste of Time	17 (23.0)	26 (35.1)	19 (25.7)	11 (14.9)	0	1 (1.4)
B8	Girls, Useful/ Useless	31 (41.9)	12 (16.2)	24 (32.4)	4 (5.4)	3 (4.1)	0
B9	Useful/Useless for Boys	29 (39.2)	12 (16.2)	24 (32.4)	5 (6.8)	1 (1.4)	3 (4.1)

Table IIIC.18

Results Group A (1987) S2 Boys (77)
(%)

		1	2	3	4	5	6
B1	Exciting/ Boring	15 (19.5)	30 (39.0)	17 (22.1)	7 (9.1)	5 (6.5)	3 (3.9)
B2	Interesting/ Dull	29 (37.7)	21 (27.3)	17 (22.1)	3 (3.9)	5 (6.5)	2 (2.6)
B3	Important/ Unimportant	19 (24.7)	24 (31.2)	19 (24.7)	12 (15.6)	2 (2.6)	1 (1.3)
B4	Enjoyable/ Hateful	30 (39.0)	25 (32.5)	15 (19.5)	4 (5.2)	2 (2.6)	1 (1.3)
B5	Friendly/ Frightening	19 (24.7)	19 (24.7)	29 (37.7)	7 (9.1)	3 (3.9)	0
B6	Difficult/ Easy	0	10 (13.0)	12 (15.6)	11 (14.3)	10 (13.0)	34 (44.2)
B7	Time Well Spent/Waste of Time	26 (33.8)	14 (18.2)	24 (31.2)	9 (11.7)	3 (3.9)	1 (1.3)
B8	Girls, Useful/ Useless	29 (37.7)	12 (15.6)	14 (18.2)	8 (10.4)	3 (3.9)	11 (14.3)
B9	Useful/Useless for Boys	43 (55.8)	11 (14.3)	16 (20.8)	4 (5.2)	1 (1.3)	2 (2.6)

Table IIIC.19

Results Group A (1986) S3 Totals (60)
(%)

		1	2	3	4	5	6
B1	Exciting/ Boring	7 (11.7)	17 (28.3)	25 (41.7)	8 (13.3)	3 (5.0)	0 (0.0)
B2	Interesting/ Dull	15 (25.0)	29 (48.3)	11 (18.3)	3 (5.0)	2 (3.3)	0 (0.0)
B3	Important/ Unimportant	9 (15.0)	13 (21.7)	28 (46.7)	6 (10.0)	3 (5.0)	1 (1.7)
B4	Enjoyable/ Hateful	22 (36.7)	20 (33.3)	13 (21.7)	4 (6.7)	0 (0.0)	1 (1.7)
B5	Friendly/ Frightening	8 (13.3)	17 (28.3)	27 (45.0)	6 (10.0)	2 (3.3)	0 (0.0)
B6	Difficult/ Easy	1 (1.7)	4 (6.7)	18 (30.0)	11 (18.3)	16 (26.7)	10 (16.7)
B7	Time Well Spent/Waste of Time	16 (26.7)	24 (40.0)	15 (25.0)	2 (3.3)	3 (5.0)	0 (0.0)
B8	Girls, Useful/ Useless	17 (28.3)	12 (20.0)	23 (38.3)	3 (5.0)	3 (5.0)	2 (3.3)
B9	Useful/Useless for Boys	16 (26.7)	18 (30.0)	20 (33.3)	4 (6.7)	2 (3.3)	0 (0.0)

Table IIIC.20

Results Group A (1986) S3 Girls (33)
(%)

		1	2	3	4	5	6
B1	Exciting/ Boring	3 (9.1)	5 (15.2)	15 (45.5)	7 (21.2)	3 (9.1)	0
B2	Interesting/ Dull	7 (21.2)	14 (42.4)	7 (21.2)	3 (9.1)	2 (6.1)	0
B3	Important/ Unimportant	2 (6.1)	8 (24.2)	17 (51.5)	3 (19.1)	3 (9.1)	0
B4	Enjoyable/ Hateful	8 (24.2)	11 (33.3)	9 (27.3)	4 (12.1)	0 (0.0)	1 (3.0)
B5	Friendly/ Frightening	3 (9.1)	8 (24.2)	16 (48.5)	5 (15.2)	1 (3.0)	0
B6	Difficult/ Easy	1 (3.0)	2 (6.1)	14 (42.4)	5 (15.2)	10 (30.3)	1 (3.0)
B7	Time Well Spent/Waste of Time	4 (12.1)	14 (42.4)	11 (33.3)	2 (6.1)	2 (6.1)	0
B8	Girls, Useful/ Useless	5 (15.2)	10 (30.3)	13 (39.4)	2 (6.1)	2 (6.1)	1 (3.0)
B9	Useful/Useless for Boys	5 (15.2)	13 (39.4)	11 (33.3)	3 (9.1)	1 (3.0)	0

Table IIIC.21

Results Group A (1986) S3 Boys (27)
(%)

		1	2	3	4	5	6
B1	Exciting/ Boring	4 (14.8)	12 (44.4)	10 (37.0)	1 (3.7)	0 (0.0)	0 (0.0)
B2	Interesting/ Dull	8 (29.6)	15 (55.6)	4 (14.8)	0 (0.0)	0 (0.0)	0 (0.0)
B3	Important/ Unimportant	7 (25.9)	5 (18.5)	11 (40.7)	3 (11.1)	0 (0.0)	1 (3.7)
B4	Enjoyable/ Hateful	14 (51.9)	9 (33.3)	4 (14.8)	0 (0.0)	0 (0.0)	0 (0.0)
B5	Friendly/ Frightening	5 (18.5)	9 (33.3)	11 (40.7)	0 (0.0)	1 (3.7)	1 (3.7)
B6	Difficult/ Easy	0 (0.0)	2 (7.4)	4 (14.8)	6 (22.2)	6 (22.2)	9 (33.3)
B7	Time Well Spent/Waste of Time	12 (44.4)	10 (37.0)	4 (14.8)	0 (0.0)	1 (3.7)	0 (0.0)
B8	Girls, Useful/ Useless	12 (44.4)	2 (7.4)	10 (37.0)	1 (3.7)	1 (3.7)	1 (3.7)
B9	Useful/Useless for Boys	11 (40.7)	5 (18.5)	9 (33.3)	1 (3.7)	1 (3.7)	0 (0.0)

Table IIIC.22

Results Group A (1987) S4 Totals (59)
(%)

		1	2	3	4	5	6
B1	Exciting/ Boring	4 (6.8)	12 (20.3)	21 (35.6)	12 (20.3)	6 (10.2)	4 (6.8)
B2	Interesting/ Dull	12 (20.3)	20 (33.9)	10 (16.9)	10 (16.9)	3 (5.1)	4 (6.8)
B3	Important/ Unimportant	10 (16.9)	18 (30.5)	16 (27.1)	12 (20.3)	1 (1.7)	2 (3.4)
B4	Enjoyable/ Hateful	15 (25.4)	12 (20.3)	20 (33.9)	7 (11.9)	3 (5.1)	2 (3.4)
B5	Friendly/ Frightening	8 (13.6)	15 (25.4)	28 (47.5)	4 (6.8)	2 (3.4)	2 (3.4)
B6	Difficult/ Easy	0	7 (11.9)	16 (27.1)	13 (22.0)	14 (23.7)	9 (15.3)
B7	Time Well Spent/Waste of Time	16 (27.1)	12 (20.3)	15 (25.4)	10 (16.9)	5 (8.5)	1 (1.7)
B8	Girls, Useful/ Useless	23 (39.0)	9 (15.3)	19 (32.2)	3 (5.1)	1 (1.7)	4 (6.8)
B9	Useful/Useless for Boys	24 (40.7)	12 (20.3)	18 (30.5)	4 (6.8)	0	1 (1.7)

Table IIIC.23

Results Group A (1987) S4 Girls (31)
(%)

		1	2	3	4	5	6
B1	Exciting/ Boring	2 (6.5)	2 (6.5)	13 (41.9)	9 (29.0)	4 (12.9)	1 (3.2)
B2	Interesting/ Dull	4 (12.9)	8 (25.8)	7 (22.6)	9 (29.0)	2 (6.5)	1 (3.2)
B3	Important/ Unimportant	4 (12.9)	10 (32.3)	11 (35.5)	5 (16.1)	1 (3.2)	0
B4	Enjoyable/ Hateful	4 (12.9)	6 (19.4)	14 (45.2)	4 (12.9)	3 (9.7)	0
B5	Friendly/ Frightening	4 (12.9)	7 (22.6)	15 (48.4)	3 (9.7)	2 (6.5)	0
B6	Difficult/ Easy	0	2 (6.5)	6 (19.4)	10 (32.3)	9 (29.0)	4 (12.9)
B7	Time Well Spent/Waste of Time	5 (16.1)	9 (29.0)	11 (35.5)	3 (9.7)	3 (9.7)	0
B8	Girls, Useful/ Useless	12 (38.7)	6 (19.4)	12 (38.7)	1 (3.2)	0	0
B9	Useful/Useless for Boys	12 (38.7)	6 (19.4)	12 (38.7)	1 (3.2)	0	0

Table IIIC.24

Results Group A (1987) S4 Boys (28)
(%)

		1	2	3	4	5	6
B1	Exciting/ Boring	2 (7.1)	10 (35.7)	8 (28.6)	3 (10.7)	2 (7.1)	3 (10.7)
B2	Interesting/ Dull	8 (28.6)	12 (42.9)	3 (10.7)	1 (3.6)	1 (3.6)	3 (10.7)
B3	Important/ Unimportant	6 (21.4)	8 (28.6)	5 (17.9)	7 (25.0)	0	2 (7.1)
B4	Enjoyable/ Hateful	11 (39.3)	6 (21.4)	6 (21.4)	3 (10.7)	0	2 (7.1)
B5	Friendly/ Frightening	4 (14.3)	8 (28.6)	13 (46.4)	1 (3.6)	0	2 (7.1)
B6	Difficult/ Easy	0	5 (17.9)	10 (35.7)	3 (10.7)	5 (17.9)	5 (17.9)
B7	Time Well Spent/Waste of Time	11 (39.3)	3 (10.7)	4 (14.3)	7 (25.0)	2 (7.1)	1 (3.6)
B8	Girls, Useful/ Useless	11 (39.3)	3 (10.7)	7 (25.0)	2 (7.1)	1 (3.6)	4 (14.3)
B9	Useful/Useless for Boys	12 (42.9)	6 (21.4)	6 (21.4)	3 (10.7)	0	1 (3.6)

APPENDIX IIID - GROUP B (Main Study)

Results and Results Expressed as % of Group

Table IIID.1	Group B (1987)	S1 Totals	q C1-C19
IIID.2	Group B (1987)	S1 Girls	q C1-C19
IIID.3	Group B (1987)	S1 Boys	q C1-C19
IIID.4	Group B (1988)	S2 Totals	q C1-C19
IIID.5	Group B (1988)	S2 Girls	q C1-C19
IIID.6	Group B (1988)	S2 Boys	q C1-C19
IIID.7	Group B (1987)	S3 Totals	q C1-C19
IIID.8	Group B (1987)	S3 Girls	q C1-C19
IIID.9	Group B (1987)	S3 Boys	q C1-C19
IIID.10	Group B (1988)	S4 Totals	q C1-C19
IIID.11	Group B (1988)	S4 Girls	q C1-C19
IIID.12	Group B (1988)	S4 Boys	q C1-C19
IIID.13	Group B (1987)	S1 Totals	q D1-D9
IIID.14	Group B (1987)	S1 Girls	q D1-D9
IIID.15	Group B (1987)	S1 Boys	q D1-D9
IIID.16	Group B (1988)	S2 Totals	q D1-D9
IIID.17	Group B (1988)	S2 Girls	q D1-D9
IIID.18	Group B (1988)	S2 Boys	q D1-D9
IIID.19	Group B (1987)	S3 Totals	q D1-D9
IIID.20	Group B (1987)	S3 Girls	q D1-D9
IIID.21	Group B (1987)	S3 Boys	q D1-D9
IIID.22	Group B (1988)	S4 Totals	q D1-D9
IIID.23	Group B (1988)	S4 Girls	q D1-D9
IIID.24	Group B (1988)	S4 Boys	q D1-D9

Table IIID.1

Results Group B (1987) S1 Totals (n = 123)
(%)

	1	2	3	4	5
C1 Computer Exciting	18 (14.6)	83 (67.5)	19 (15.4)	2 (1.6)	1 (0.8)
C2 Use a Lot	19 (15.4)	67 (54.5)	33 (26.8)	4 (3.3)	0
C3 Teacher Use	1 (0.8)	0	2 (1.6)	41 (33.3)	79 (64.2)
C4 Play Games	33 (26.8)	62 (50.4)	20 (16.3)	7 (5.7)	1 (0.8)
C5 Boring Subject Enjoyable	36 (29.3)	63 (51.2)	17 (13.8)	4 (3.3)	3 (2.4)
C6 Individual Use	15 (12.2)	33 (26.8)	45 (36.6)	26 (21.1)	4 (3.3)
C7 Know Programming	34 (27.6)	36 (29.3)	29 (23.6)	21 (17.1)	3 (2.4)
C8 Boy/Girl Comparison	61 (49.6)	41 (33.3)	16 (13.0)	2 (1.6)	3 (2.4)
C9 Teacher to Explain	8 (6.5)	34 (27.6)	53 (43.1)	20 (16.3)	8 (6.5)
C10 Work at own Speed	34 (27.6)	48 (39.0)	33 (26.8)	8 (6.5)	0
C11 Easy for Girls	3 (2.4)	7 (5.7)	39 (31.7)	46 (37.4)	28 (22.8)
C12 Help for Job	20 (16.3)	53 (43.1)	37 (30.1)	6 (4.9)	7 (5.7)

Group B (1987) S1 Totals (123) cont..

	1	2	3	4	5
C13 Easier to Answer	20 (16.3)	21 (17.1)	58 (47.2)	19 (15.4)	5 (4.1)
C14 Use in Lesson	44 (35.8)	60 (48.8)	14 (11.4)	3 (2.4)	2 (1.6)
C15 Need to be Clever	0	0	8 (6.5)	42 (34.1)	73 (59.3)
C16 Boys Better	2 (1.6)	10 (8.1)	30 (24.4)	40 (32.5)	41 (33.3)
C17 Good at Arithmetic	0	3 (2.4)	27 (22.0)	55 (44.7)	38 (30.9)
C18 Sit back when work with opp. sex	2 (1.6)	3 (2.4)	25 (20.3)	49 (39.8)	44 (35.8)
C19 Mark Work	7 (5.7)	9 (7.3)	52 (42.3)	29 (23.6)	26 (21.1)

Table IIID.2

Results Group B (1987) S1 Girls (56)
(%)

	1	2	3	4	5
C1 Computer Exciting	5 (8.9)	39 (69.6)	11 (19.6)	1 (1.8)	0
C2 Use a Lot	7 (12.5)	32 (57.1)	16 (28.6)	1 (1.8)	0
C3 Teacher Use	1 (1.8)	0	2 (3.6)	22 (39.3)	31 (55.4)
C4 Play Games	10 (17.9)	31 (55.4)	10 (17.9)	4 (7.1)	1 (1.8)
C5 Boring Subject Enjoyable	18 (32.1)	23 (41.1)	9 (16.1)	4 (7.1)	2 (3.6)
C6 Individual Use	3 (5.4)	14 (25.0)	22 (39.3)	17 (30.4)	0
C7 Know Programming	11 (19.6)	19 (33.9)	15 (26.8)	10 (17.9)	1 (1.8)
C8 Boy/Girl Comparison	34 (60.7)	16 (28.6)	5 (8.9)	1 (1.8)	0
C9 Teacher to Explain	2 (3.6)	13 (23.2)	26 (46.4)	10 (17.9)	5 (8.9)
C10 Work at own Speed	13 (23.2)	22 (39.3)	16 (28.6)	5 (8.9)	0
C11 Easy for Girls	1 (1.8)	7 (12.5)	25 (44.6)	17 (30.4)	6 (10.7)
C12 Help for Job	9 (16.1)	21 (37.5)	20 (35.7)	3 (5.4)	3 (5.4)

Group B (1987) S1 Girls (56) cont..

	1	2	3	4	5
C13 Easier to Answer	6 (10.7)	12 (21.4)	28 (50.0)	9 (16.1)	1 (1.8)
C14 Use in Lesson	17 (30.4)	31 (55.4)	5 (8.9)	2 (3.6)	1 (1.8)
C15 Need to be Clever	0	0	4 (7.1)	16 (28.6)	36 (64.3)
C16 Boys Better	0	3 (5.4)	12 (21.4)	14 (25.0)	27 (48.2)
C17 Good at Arithmetic	0	1 (1.8)	11 (19.6)	22 (39.3)	22 (39.3)
C18 Sit back when work with opp. sex	1 (1.8)	1 (1.8)	5 (8.9)	23 (41.1)	26 (46.4)
C19 Mark Work	2 (3.6)	5 (8.9)	28 (50.0)	15 (26.8)	6 (10.7)

Table IIID.3

Results Group B (1987) S1 Boys (67)
(%)

		1	2	3	4	5
C1	Computer Exciting	13 (19.4)	44 (65.7)	8 (11.9)	1 (1.5)	1 (1.5)
C2	Use a Lot	12 (17.9)	35 (52.2)	17 (25.4)	3 (4.5)	0
C3	Teacher Use	0	0	0	19 (28.4)	48 (71.6)
C4	Play Games	23 (34.3)	31 (46.3)	10 (14.9)	3 (4.5)	0
C5	Boring Subject Enjoyable	18 (26.9)	40 (59.7)	8 (11.9)	0	1 (1.5)
C6	Individual Use	12 (17.9)	19 (28.4)	23 (34.3)	9 (13.4)	4 (6.0)
C7	Know Programming	23 (34.3)	17 (25.4)	14 (20.9)	11 (16.4)	2 (3.0)
C8	Boy/Girl Comparison	27 (40.3)	25 (37.3)	11 (16.4)	1 (1.5)	3 (4.5)
C9	Teacher to Explain	6 (9.0)	21 (31.3)	27 (40.3)	10 (14.9)	3 (4.5)
C10	Work at own Speed	21 (31.3)	26 (38.8)	17 (25.4)	3 (4.5)	0
C11	Easy for Girls	2 (3.0)	0	14 (20.9)	29 (43.3)	22 (32.8)
C12	Help for Job	11 (16.4)	32 (47.8)	17 (25.4)	3 (4.5)	4 (6.0)

Group B (1987) S1 Boys (67) cont..

	1	2	3	4	5
C13 Easier to Answer	14 (20.9)	9 (13.4)	30 (44.8)	10 (14.9)	4 (6.0)
C14 Use in Lesson	27 (40.3)	29 (43.3)	9 (13.4)	1 (1.5)	1 (1.5)
C15 Need to be Clever	0	0	4 (6.0)	26 (38.8)	37 (55.2)
C16 Boys Better	2 (3.0)	7 (10.4)	18 (26.9)	26 (38.8)	14 (20.9)
C17 Good at Arithmetic	0	2 (3.0)	16 (23.9)	33 (49.3)	16 (23.9)
C18 Sit back when work with opp. sex	1 (1.5)	2 (3.0)	20 (29.9)	26 (38.8)	18 (26.9)
C19 Mark Work	5 (7.5)	4 (6.0)	24 (35.8)	14 (20.9)	20 (29.9)

Table IIID.4

Results Group B (1988) S2 Totals (127)
(%)

		1	2	3	4	5
C1	Computer Exciting	20 (15.7)	62 (48.8)	36 (28.3)	9 (7.1)	0
C2	Use a Lot	21 (16.5)	56 (44.1)	42 (33.1)	8 (6.3)	0
C3	Teacher Use	3 (2.4)	0	0	23 (18.1)	101 (79.5)
C4	Play Games	59 (46.5)	55 (43.3)	12 (9.4)	1 (0.8)	0
C5	Boring Subject Enjoyable	34 (26.8)	56 (44.1)	31 (24.4)	4 (3.1)	2 (1.6)
C6	Individual Use	27 (21.3)	33 (26.0)	48 (37.8)	14 (11.0)	5 (3.9)
C7	Know Programming	24 (18.9)	33 (26.0)	36 (28.3)	25 (19.7)	9 (7.1)
C8	Boy/Girl Comparison	50 (39.4)	46 (36.2)	18 (14.2)	7 (5.5)	6 (4.7)
C9	Teacher to Explain	21 (16.5)	28 (22.0)	44 (34.6)	16 (12.6)	18 (14.2)
C10	Work at own Speed	49 (38.6)	52 (40.9)	23 (18.1)	3 (2.4)	0
C11	Easy for Girls	7 (5.5)	0	43 (33.9)	33 (26.0)	44 (34.6)
C12	Help for Job	27 (21.3)	38 (29.9)	53 (41.7)	8 (6.3)	1 (0.8)

Group B (1988) S2 Totals (127) cont..

	1	2	3	4	5
C13 Easier to Answer	23 (18.1)	46 (36.2)	41 (32.3)	15 (11.8)	2 (1.6)
C14 Use in Lesson	45 (35.4)	57 (44.9)	22 (17.3)	2 (1.6)	1 (0.8)
C15 Need to be Clever	2 (1.6)	1 (0.8)	7 (5.5)	35 (27.6)	82 (64.6)
C16 Boys Better	5 (3.9)	2 (1.6)	31 (24.4)	31 (24.4)	58 (45.7)
C17 Good at Arithmetic	2 (1.6)	5 (3.9)	16 (12.6)	56 (44.1)	48 (37.8)
C18 Sit back when work with opp. sex	4 (3.1)	4 (3.1)	31 (24.4)	38 (29.9)	50 (39.4)
C19 Mark Work	16 (12.6)	15 (11.8)	54 (42.5)	26 (20.5)	16 (12.6)

Table IIID.5

Results Group B (1988) S2 Girls (57)
(%)

	1	2	3	4	5
C1 Computer Exciting	6 (10.5)	25 (43.9)	23 (40.4)	3 (5.3)	0
C2 Use a Lot	6 (10.5)	28 (49.1)	17 (29.8)	6 (10.5)	0
C3 Teacher Use	1 (1.8)	0	0	17 (29.8)	39 (68.4)
C4 Play Games	17 (29.8)	32 (56.1)	8 (14.0)	0	0
C5 Boring Subject Enjoyable	20 (35.1)	26 (45.6)	10 (17.5)	1 (1.8)	0
C6 Individual Use	14 (24.6)	15 (26.3)	19 (33.3)	6 (10.5)	3 (5.3)
C7 Know Programming	10 (17.5)	13 (22.8)	23 (40.4)	9 (15.8)	2 (3.5)
C8 Boy/Girl Comparison	33 (57.9)	16 (28.1)	4 (7.0)	2 (3.5)	2 (3.5)
C9 Teacher to Explain	5 (8.8)	18 (31.6)	24 (42.1)	6 (10.5)	4 (7.0)
C10 Work at own Speed	18 (31.6)	28 (49.1)	10 (17.5)	1 (1.8)	0
C11 Easy for Girls	5 (8.8)	0	26 (45.6)	15 (26.3)	11 (19.3)
C12 Help for Job	12 (21.1)	11 (19.3)	30 (52.6)	4 (7.0)	0

Group B (1988) S2 Girls (57) cont..

	1	2	3	4	5
C13 Easier to Answer	9 (15.8)	22 (38.6)	19 (33.3)	6 (10.5)	1 (1.8)
C14 Use in Lesson	18 (31.6)	22 (38.6)	15 (26.3)	1 (1.8)	1 (1.8)
C15 Need to be Clever	1 (1.8)	0	3 (5.3)	12 (21.1)	41 (71.9)
C16 Boys Better	0	0	4 (7.0)	14 (24.6)	39 (68.4)
C17 Good at Arithmetic	2 (3.5)	0	7 (12.3)	27 (47.4)	21 (36.8)
C18 Sit back when work with opp. sex	1 (1.8)	2 (3.5)	8 (14.0)	19 (33.3)	27 (47.4)
C19 Mark Work	5 (8.8)	6 (10.5)	27 (47.4)	13 (22.8)	6 (10.5)

Table IIID.6

Results Group B (1988) S2 Boys (70)
(%)

		1	2	3	4	5
C1	Computer Exciting	14 (20.0)	37 (52.9)	13 (18.6)	6 (8.6)	0
C2	Use a Lot	15 (21.4)	28 (40.0)	25 (35.7)	2 (2.9)	0
C3	Teacher Use	2 (2.9)	0	0	6 (8.6)	62 (88.6)
C4	Play Games	42 (60.0)	23 (32.9)	4 (5.7)	1 (1.4)	0
C5	Boring Subject Enjoyable	14 (20.0)	30 (42.9)	21 (30.0)	3 (4.3)	2 (2.9)
C6	Individual Use	13 (18.6)	18 (25.7)	29 (41.4)	8 (11.4)	2 (2.9)
C7	Know Programming	14 (20.0)	20 (28.6)	13 (18.6)	16 (22.9)	7 (10.0)
C8	Boy/Girl Comparison	17 (24.3)	30 (42.9)	14 (20.0)	5 (7.1)	4 (5.7)
C9	Teacher to Explain	16 (22.9)	10 (14.3)	20 (28.6)	10 (14.3)	14 (20.0)
C10	Work at own Speed	31 (44.3)	24 (34.3)	13 (18.6)	2 (2.9)	0
C11	Easy for Girls	2 (2.9)	0	17 (24.3)	18 (25.7)	33 (47.1)
C12	Help for Job	15 (21.4)	27 (38.6)	23 (32.9)	4 (5.7)	1 (1.4)

Group B (1988) S2 Boys (70) cont..

	1	2	3	4	5
C13 Easier to Answer	14 (20.0)	24 (34.3)	22 (31.4)	9 (12.8)	1 (1.4)
C14 Use in Lesson	27 (38.6)	35 (50.0)	7 (10.0)	1 (1.4)	0
C15 Need to be Clever	1 (1.4)	1 (1.4)	4 (5.7)	23 (32.9)	41 (58.6)
C16 Boys Better	5 (7.1)	2 (2.9)	27 (38.6)	17 (24.3)	19 (27.1)
C17 Good at Arithmetic	0	5 (7.1)	9 (12.8)	29 (41.4)	27 (38.6)
C18 Sit back when work with opp. sex	3 (4.3)	2 (2.9)	23 (32.9)	19 (27.1)	23 (32.9)
C19 Mark Work	11 (15.7)	9 (12.8)	27 (38.6)	13 (18.6)	10 (14.3)

Table IIID.7

Results Group B (1987) S3 Totals (153)
(%)

	1	2	3	4	5
C1 Computer Exciting	6 (3.9)	38 (24.8)	98 (64.1)	7 (4.6)	4 (2.6)
C2 Use a Lot	30 (19.6)	53 (34.6)	32 (20.9)	32 (20.9)	6 (3.9)
C3 Teacher Use	2 (1.3)	1 (0.7)	1 (0.7)	33 (21.6)	116 (75.8)
C4 Play Games	75 (49.0)	57 (37.3)	16 (10.5)	3 (2.0)	2 (1.3)
C5 Boring Subject Enjoyable	51 (33.3)	66 (43.1)	29 (19.0)	2 (1.3)	5 (3.3)
C6 Individual Use	44 (28.8)	34 (22.2)	49 (32.1)	17 (11.1)	9 (5.9)
C7 Know Programming	54 (35.3)	45 (29.4)	26 (17.0)	16 (10.5)	12 (7.8)
C8 Boy/Girl Comparison	85 (55.6)	44 (28.8)	17 (11.1)	3 (2.0)	4 (2.6)
C9 Teacher to Explain	30 (19.6)	34 (22.2)	53 (34.6)	15 (9.8)	21 (13.7)
C10 Work at own Speed	35 (22.9)	59 (38.6)	47 (30.7)	5 (3.3)	7 (4.6)
C11 Easy for Girls	11 (7.2)	6 (3.9)	59 (38.6)	33 (21.6)	44 (28.8)
C12 Help for Job	19 (12.4)	56 (36.6)	53 (34.6)	15 (9.8)	10 (6.5)

Group B (1987) S3 Totals (153) cont..

	1	2	3	4	5
C13 Easier to Answer	22 (14.4)	47 (30.7)	56 (36.6)	23 (15.0)	5 (3.3)
C14 Use in Lesson	43 (28.1)	55 (36.0)	40 (26.1)	7 (4.6)	8 (5.2)
C15 Need to be Clever	2 (1.3)	2 (1.3)	13 (8.5)	38 (24.8)	98 (64.1)
C16 Boys Better	12 (7.8)	10 (6.5)	33 (21.6)	28 (18.3)	70 (45.8)
C17 Good at Arithmetic	1 (0.7)	8 (5.2)	38 (24.8)	42 (27.5)	64 (41.8)
C18 Sit back when work with opp. sex	4 (2.6)	8 (5.2)	44 (28.8)	37 (24.2)	60 (39.2)
C19 Mark Work	27 (17.7)	24 (15.7)	34 (22.2)	31 (20.3)	37 (24.2)

Table IIID.8

Results Group B (1987) S3 Girls (56)
(%)

	1	2	3	4	5
C1 Computer Exciting	1 (1.8)	15 (26.8)	39 (69.6)	1 (1.8)	0
C2 Use a Lot	10 (17.9)	16 (28.6)	12 (21.4)	15 (26.8)	3 (5.4)
C3 Teacher Use	0	0	0	19 (33.9)	37 (66.1)
C4 Play Games	25 (44.6)	26 (46.4)	4 (7.1)	1 (1.8)	0
C5 Boring Subject Enjoyable	20 (35.7)	24 (42.9)	10 (17.9)	1 (1.8)	1 (1.8)
C6 Individual Use	14 (25.0)	12 (21.4)	22 (39.3)	5 (8.9)	3 (5.4)
C7 Know Programming	21 (37.5)	18 (32.1)	14 (25.0)	2 (3.6)	1 (1.8)
C8 Boy/Girl Comparison	44 (78.6)	7 (12.5)	5 (8.9)	0	0
C9 Teacher to Explain	11 (19.6)	13 (23.2)	19 (33.9)	7 (12.5)	6 (10.7)
C10 Work at own Speed	11 (19.6)	23 (41.1)	18 (32.1)	2 (3.6)	2 (3.6)
C11 Easy for Girls	9 (16.1)	5 (8.9)	26 (46.4)	9 (16.1)	7 (12.5)
C12 Help for Job	6 (10.7)	23 (41.1)	20 (35.7)	3 (5.4)	4 (7.1)

Group B (1987) S3 Girls (56) cont..

	1	2	3	4	5
C13 Easier to Answer	5 (8.9)	23 (41.1)	17 (30.4)	10 (17.9)	1 (1.8)
C14 Use in Lesson	13 (23.2)	18 (32.1)	21 (37.5)	1 (1.8)	3 (5.4)
C15 Need to be Clever	0	0	3 (5.4)	17 (30.4)	36 (64.3)
C16 Boys Better	1 (1.8)	0	6 (10.7)	10 (17.9)	39 (69.6)
C17 Good at Arithmetic	0	1 (1.8)	15 (26.8)	20 (35.7)	20 (35.7)
C18 Sit back when work with opp. sex	2 (3.6)	3 (5.4)	11 (19.6)	14 (25.0)	26 (46.4)
C19 Mark Work	9 (16.1)	11 (19.6)	10 (17.9)	13 (23.2)	13 (23.2)

Table IIID.9

Results Group B (1987) S3 Boys (97)
(%)

	1	2	3	4	5
C1 Computer Exciting	5 (5.2)	23 (23.7)	59 (60.8)	6 (6.2)	4 (4.1)
C2 Use a Lot	20 (20.6)	37 (38.1)	20 (20.6)	17 (17.5)	3 (3.1)
C3 Teacher Use	2 (2.1)	1 (1.0)	1 (1.0)	14 (14.4)	79 (81.4)
C4 Play Games	50 (51.5)	31 (32.0)	12 (12.4)	2 (2.1)	2 (2.1)
C5 Boring Subject Enjoyable	31 (32.0)	42 (43.3)	19 (19.6)	1 (1.0)	4 (4.1)
C6 Individual Use	30 (30.9)	22 (22.7)	27 (27.8)	12 (12.4)	6 (6.2)
C7 Know Programming	33 (34.0)	27 (27.8)	12 (12.4)	14 (14.4)	11 (11.3)
C8 Boy/Girl Comparison	41 (42.3)	37 (38.1)	12 (12.4)	3 (3.1)	4 (4.1)
C9 Teacher to Explain	19 (19.6)	21 (21.6)	34 (35.1)	8 (8.3)	15 (15.5)
C10 Work at own Speed	24 (24.7)	36 (37.1)	29 (29.9)	3 (3.1)	5 (5.2)
C11 Easy for Girls	2 (2.1)	1 (1.0)	33 (34.0)	24 (24.7)	37 (38.1)
C12 Help for Job	13 (13.4)	33 (34.0)	33 (34.0)	12 (12.4)	6 (6.2)

Group B (1987) S3 Boys (97) cont..

	1	2	3	4	5
C13 Easier to Answer	17 (17.5)	24 (24.7)	39 (40.2)	13 (13.4)	4 (4.1)
C14 Use in Lesson	30 (30.9)	37 (38.1)	19 (19.6)	6 (6.2)	5 (5.2)
C15 Need to be Clever	2 (2.1)	2 (2.1)	10 (10.3)	21 (21.7)	62 (63.9)
C16 Boys Better	11 (11.3)	10 (10.3)	27 (27.8)	18 (18.6)	31 (32.0)
C17 Good at Arithmetic	1 (1.0)	7 (7.2)	23 (23.7)	22 (22.7)	44 (45.4)
C18 Sit back when work with opp. sex	2 (2.1)	5 (5.2)	33 (34.0)	23 (23.7)	34 (35.1)
C19 Mark Work	18 (18.6)	13 (13.4)	24 (24.7)	18 (18.6)	24 (24.7)

Table IIID.10

Results Group B (1988) S4 Totals (153)
(%)

	1	2	3	4	5
C1 Computer Exciting	4 (2.6)	28 (18.3)	87 (56.9)	26 (17.0)	8 (5.2)
C2 Use a Lot	32 (20.9)	62 (40.5)	32 (20.9)	19 (12.4)	8 (5.2)
C3 Teacher Use	3 (2.0)	2 (1.3)	9 (5.9)	27 (17.6)	112 (73.2)
C4 Play Games	54 (35.3)	62 (40.5)	28 (18.3)	6 (3.9)	3 (2.0)
C5 Boring Subject Enjoyable	38 (24.8)	60 (39.2)	44 (28.8)	7 (4.6)	4 (2.6)
C6 Individual Use	36 (23.5)	38 (24.8)	49 (32.0)	24 (15.7)	6 (3.9)
C7 Know Programming	33 (21.6)	54 (35.3)	40 (26.1)	17 (11.1)	9 (5.9)
C8 Boy/Girl Comparison	78 (51.0)	42 (27.5)	24 (15.7)	1 (0.7)	8 (5.2)
C9 Teacher to Explain	19 (12.4)	39 (25.5)	62 (40.5)	20 (13.1)	13 (8.5)
C10 Work at own Speed	33 (21.6)	59 (38.6)	46 (30.1)	12 (7.8)	3 (2.0)
C11 Easy for Girls	5 (3.3)	3 (2.0)	62 (40.5)	38 (24.8)	45 (29.4)
C12 Help for Job	20 (13.1)	41 (26.8)	63 (41.2)	12 (7.8)	17 (11.1)

Group B (1988) S4 Totals (153) cont..

	1	2	3	4	5
C13 Easier to Answer	17 (11.1)	44 (28.8)	70 (45.8)	13 (8.5)	9 (5.9)
C14 Use in Lesson	34 (22.2)	66 (43.1)	42 (27.5)	7 (4.6)	4 (2.6)
C15 Need to be Clever	1 (0.7)	7 (4.6)	18 (11.8)	46 (30.1)	81 (52.9)
C16 Boys Better	7 (4.6)	7 (4.6)	42 (27.5)	34 (22.2)	63 (41.2)
C17 Good at Arithmetic	5 (3.3)	7 (4.6)	35 (22.9)	46 (30.1)	60 (39.2)
C18 Sit back when work with opp. sex	9 (5.9)	11 (7.2)	42 (27.5)	41 (26.8)	50 (32.7)
C19 Mark Work	20 (13.1)	22 (14.4)	42 (27.5)	25 (16.3)	44 (28.8)

Table IIID.11

Results Group B (1988) S4 Girls (59)
(%)

	1	2	3	4	5
C1 Computer Exciting	1 (1.7)	14 (23.7)	36 (61.0)	7 (11.9)	1 (1.7)
C2 Use a Lot	16 (27.1)	24 (40.7)	13 (22.0)	5 (8.5)	1 (1.7)
C3 Teacher Use	2 (3.4)	0	4 (6.8)	10 (16.9)	43 (72.9)
C4 Play Games	23 (39.0)	21 (35.6)	10 (16.9)	2 (3.4)	3 (5.1)
C5 Boring Subject Enjoyable	20 (33.9)	24 (40.7)	12 (20.3)	3 (5.1)	0
C6 Individual Use	11 (18.6)	13 (22.0)	18 (30.5)	14 (23.7)	3 (5.1)
C7 Know Programming	13 (22.0)	24 (40.7)	17 (28.8)	5 (8.5)	0
C8 Boy/Girl Comparison	42 (71.2)	10 (16.9)	5 (8.5)	0	2 (3.4)
C9 Teacher to Explain	8 (13.6)	13 (22.0)	23 (39.0)	11 (18.6)	4 (6.8)
C10 Work at own Speed	13 (22.0)	23 (39.0)	20 (33.9)	3 (5.1)	0
C11 Easy for Girls	5 (8.5)	2 (3.4)	28 (47.5)	17 (28.8)	7 (11.9)
C12 Help for Job	14 (23.7)	16 (27.1)	25 (42.4)	3 (5.1)	1 (1.7)

Group B (1988) S4 Girls (59) cont..

	1	2	3	4	5
C13 Easier to Answer	7 (11.9)	16 (27.1)	25 (42.4)	7 (11.9)	4 (6.8)
C14 Use in Lesson	19 (32.2)	22 (37.3)	14 (23.7)	2 (3.4)	2 (3.4)
C15 Need to be Clever	1 (1.7)	3 (5.1)	3 (5.1)	17 (28.8)	35 (59.3)
C16 Boys Better	1 (1.7)	1 (1.7)	7 (11.9)	12 (20.3)	38 (64.4)
C17 Good at Arithmetic	3 (5.1)	0	13 (22.0)	22 (37.3)	21 (35.6)
C18 Sit back when work with opp. sex	4 (6.8)	3 (5.1)	9 (15.3)	19 (32.2)	24 (40.7)
C19 Mark Work	10 (16.9)	8 (13.6)	16 (27.1)	10 (16.9)	15 (25.4)

Table IIID.12

Results Group B (1988) S4 Boys (94)
(%)

	1	2	3	4	5
C1 Computer Exciting	3 (3.2)	14 (14.9)	51 (54.3)	19 (20.2)	7 (7.4)
C2 Use a Lot	16 (17.0)	38 (40.4)	19 (20.2)	14 (14.9)	7 (7.4)
C3 Teacher Use	1 (1.1)	2 (2.1)	5 (5.3)	17 (18.1)	69 (73.4)
C4 Play Games	31 (33.0)	41 (43.6)	18 (19.1)	4 (4.3)	0
C5 Boring Subject Enjoyable	18 (19.1)	36 (38.3)	32 (34.0)	4 (4.3)	4 (4.3)
C6 Individual Use	25 (26.6)	25 (26.6)	31 (33.0)	10 (10.6)	3 (3.2)
C7 Know Programming	20 (21.3)	30 (31.9)	23 (24.5)	12 (12.8)	9 (9.6)
C8 Boy/Girl Comparison	36 (38.3)	32 (34.0)	19 (20.2)	1 (1.1)	6 (6.4)
C9 Teacher to Explain	11 (11.7)	26 (27.7)	39 (41.5)	9 (9.6)	9 (9.6)
C10 Work at own Speed	20 (21.3)	36 (38.3)	26 (27.7)	9 (9.6)	3 (3.2)
C11 Easy for Girls	0	1 (1.1)	34 (36.2)	21 (22.3)	38 (40.4)
C12 Help for Job	6 (6.4)	25 (26.6)	38 (40.4)	9 (9.6)	16 (17.0)

Group B (1988) S4 Boys (94) cont..

	1	2	3	4	5
C13 Easier to Answer	10 (10.6)	28 (29.8)	45 (47.9)	6 (6.4)	5 (5.3)
C14 Use in Lesson	15 (16.0)	44 (46.8)	28 (29.8)	5 (5.3)	2 (2.1)
C15 Need to be Clever	0	4 (4.3)	15 (16.0)	29 (30.9)	46 (48.9)
C16 Boys Better	6 (6.4)	6 (6.4)	35 (37.2)	22 (23.4)	25 (26.6)
C17 Good at Arithmetic	2 (2.1)	7 (7.4)	22 (23.4)	24 (25.5)	39 (41.5)
C18 Sit back when work with opp. sex	5 (5.3)	8 (8.5)	33 (35.1)	22 (23.4)	26 (27.7)
C19 Mark Work	10 (10.6)	14 (14.9)	26 (27.7)	15 (16.0)	29 (30.9)

Table IIID.13

Results Group B (1987) S1 Totals (123)

(%)

		1	2	3	4	5	6
D1	Exciting/ Boring	29 (23.6)	63 (51.2)	23 (18.7)	8 (6.5)	0	0
D2	Interesting/ Dull	42 (34.1)	53 (43.1)	26 (21.1)	2 (1.6)	0	0
D3	Useful/Useless for Boys	22 (17.9)	29 (23.6)	53 (43.1)	14 (11.4)	1 (0.8)	4 (3.3)
D4	Frightening/ Friendly	0	2 (1.6)	5 (4.1)	19 (15.4)	41 (33.3)	56 (45.5)
D5	Enjoyable/ Hateful	66 (53.7)	36 (29.3)	18 (14.6)	2 (1.6)	1 (0.8)	0
D6	Unimportant/ Important	1 (0.8)	3 (2.4)	11 (8.9)	24 (19.5)	45 (36.6)	39 (31.7)
D7	Girls, Useless/ Useful	4 (3.3)	4 (3.3)	22 (17.9)	34 (27.6)	22 (17.9)	37 (30.1)
D8	Time Well Spent/Waste of Time	38 (30.9)	54 (43.9)	22 (17.9)	3 (2.4)	5 (4.1)	1 (0.8)
D9	Difficult/ Easy	2 (1.6)	5 (4.1)	18 (14.6)	28 (22.8)	45 (36.6)	25 (20.3)

Table IIID.14

Results Group B (1987) S1 Girls (56)

(%)

		1	2	3	4	5	6
D1	Exciting/ Boring	17 (30.4)	24 (42.9)	14 (25.0)	1 (1.8)	0	0
D2	Interesting/ Dull	20 (35.7)	23 (41.1)	12 (21.4)	1 (1.8)	0	0
D3	Useful/Useless for Boys	9 (16.1)	9 (16.1)	23 (41.1)	11 (19.6)	0	4 (7.1)
D4	Frightening/ Friendly	0	0	1 (1.8)	12 (21.4)	19 (33.9)	24 (42.9)
D5	Enjoyable/ Hateful	28 (50.0)	19 (33.9)	8 (14.3)	1 (1.8)	0	0
D6	Unimportant/ Important	0	0	7 (12.5)	14 (25.0)	15 (26.8)	20 (35.7)
D7	Girls, Useless /Useful	3 (5.4)	2 (3.6)	7 (12.5)	16 (28.6)	12 (21.4)	16 (28.6)
D8	Time Well Spent/Waste of Time	18 (32.1)	25 (44.6)	11 (19.6)	1 (1.8)	1 (1.8)	
D9	Difficult/ Easy	1 (1.8)	1 (1.8)	6 (10.7)	15 (26.8)	21 (37.5)	12 (21.4)

Table IIID.15

Results Group B (1987) S1 Boys (67)

(%)

		1	2	3	4	5	6
D1	Exciting/ Boring	12 (17.9)	39 (58.2)	9 (13.4)	7 (10.4)	0	0
D2	Interesting/ Dull	22 (32.8)	30 (44.8)	14 (20.9)	1 (1.5)	0	0
D3	Useful/Useless for Boys	13 (19.4)	20 (29.9)	30 (44.8)	3 (4.5)	1 (1.5)	0
D4	Frightening/ Friendly	0	2 (3.0)	4 (6.0)	7 (10.4)	22 (32.8)	32 (47.8)
D5	Enjoyable/ Hateful	38 (56.7)	17 (25.4)	10 (14.9)	1 (1.5)	1 (1.5)	0
D6	Unimportant /Important	1 (1.5)	3 (4.5)	4 (6.0)	10 (14.9)	30 (44.8)	19 (28.4)
D7	Girls, Useless /Useful	1 (1.5)	2 (3.0)	15 (22.4)	18 (26.9)	10 (14.9)	21 (31.3)
D8	Time Well Spent/Waste of Time	20 (29.9)	29 (43.3)	11 (16.4)	2 (3.0)	4 (6.0)	1 (1.5)
D9	Difficult/ Easy	1 (1.5)	4 (6.0)	12 (17.9)	13 (19.4)	24 (35.8)	13 (19.4)

Table IIID.16

Results Group B (1988) S2 Totals (127)

(%)

		1	2	3	4	5	6
D1	Exciting/ Boring	22 (17.3)	54 (42.5)	42 (33.1)	6 (4.7)	1 (0.8)	2 (1.6)
D2	Interesting/ Dull	43 (33.9)	49 (38.6)	25 (19.7)	9 (7.1)	0	1 (1.8)
D3	Useful/Useless for Boys	32 (25.2)	31 (24.4)	40 (31.5)	16 (12.6)	6 (4.7)	2 (1.6)
D4	Frightening/ Friendly	0	2 (1.6)	2 (1.6)	11 (8.7)	32 (25.2)	80 (63.0)
D5	Enjoyable/ Hateful	63 (49.6)	40 (31.5)	16 (12.6)	6 (4.7)	2 (1.6)	0
D6	Unimportant /Important	2 (1.6)	4 (3.1)	8 (6.3)	16 (12.6)	52 (40.9)	45 (35.4)
D7	Girls, Useless /Useful	9 (7.1)	4 (3.1)	15 (11.8)	32 (25.2)	24 (18.9)	43 (33.9)
D8	Time Well Spent/Waste of Time	49 (38.6)	48 (37.8)	20 (15.7)	8 (6.3)	1 (0.8)	1 (0.8)
D9	Difficult/ Easy	2 (1.6)	7 (5.5)	9 (7.1)	31 (24.4)	45 (35.4)	33 (26.0)

Table IIID.17

Results Group B (1988) S2 Girls (57)

(%)

		1	2	3	4	5	6
D1	Exciting/ Boring	9 (15.8)	20 (35.1)	24 (42.1)	2 (3.5)	1 (1.8)	1 (1.8)
D2	Interesting/ Dull	22 (38.6)	19 (33.3)	10 (17.5)	6 (10.5)	0	0
D3	Useful/Useless for Boys	12 (21.1)	5 (8.8)	19 (33.3)	13 (22.8)	6 (10.5)	2 (3.5)
D4	Frightening/ Friendly	0	1 (1.8)	1 (1.8)	4 (7.0)	21 (36.8)	30 (52.6)
D5	Enjoyable/ Hateful	29 (50.9)	18 (31.6)	6 (10.5)	3 (5.3)	1 (1.8)	0
D6	Unimportant /Important	1 (1.8)	0	4 (7.0)	11 (19.3)	19 (33.3)	22 (38.6)
D7	Girls, Useless /Useful	3 (5.3)	0	3 (5.3)	19 (33.3)	10 (17.5)	22 (38.6)
D8	Time Well Spent/Waste of Time	23 (40.4)	17 (29.8)	11 (19.3)	4 (7.0)	1 (1.8)	1 (1.8)
D9	Difficult/ Easy	0	2 (3.5)	1 (1.8)	12 (21.1)	22 (38.6)	20 (35.1)

Table IIID.18

Results Group B (1988) S2 Boys (70)

(%)

		1	2	3	4	5	6
D1	Exciting/ Boring	13 (18.6)	34 (48.6)	18 (25.7)	4 (5.7)	0	1 (1.4)
D2	Interesting/ Dull	21 (30.0)	30 (42.9)	15 (21.4)	3 (4.3)	0	1 (1.4)
D3	Useful/Useless for Boys	20 (28.6)	26 (37.1)	21 (30.0)	3 (4.3)	0	0
D4	Frightening /Friendly	0	1 (1.4)	1 (1.4)	7 (10.0)	11 (15.7)	50 (71.4)
D5	Enjoyable/ Hateful	34 (48.6)	22 (31.4)	10 (14.3)	3 (4.3)	1 (1.4)	0
D6	Unimportant /Important	1 (1.4)	4 (5.7)	4 (5.7)	5 (7.1)	33 (47.1)	23 (32.9)
D7	Girls, Useless /Useful	6 (8.6)	4 (5.7)	12 (17.1)	13 (18.6)	14 (20.0)	21 (30.0)
D8	Time Well Spent/Waste of Time	26 (37.1)	31 (44.3)	9 (12.9)	4 (5.7)	0	0
D9	Difficult/ Easy	2 (2.9)	5 (7.1)	8 (11.4)	19 (27.1)	23 (32.9)	13 (18.6)

Table IIID.19

Results Group B (1987) S3 Totals (152)

(%)

		1	2	3	4	5	6
D1	Exciting/ Boring	18 (11.8)	44 (29.0)	64 (42.1)	18 (11.8)	2 (1.3)	6 (4.0)
D2	Interesting/ Dull	43 (28.3)	60 (39.5)	41 (27.0)	4 (2.6)	2 (1.3)	2 (1.3)
D3	Useful/Useless for Boys	22 (14.5)	41 (27.0)	65 (42.8)	15 (9.9)	3 (2.0)	6 (4.0)
D4	Frightening/ Friendly	1 (0.7)	3 (2.0)	8 (5.3)	20 (13.2)	43 (28.3)	77 (50.7)
D5	Enjoyable/ Hateful	78 (51.3)	42 (27.6)	22 (14.5)	3 (2.0)	5 (3.3)	2 (1.3)
D6	Unimportant /Important	6 (4.0)	8 (5.3)	17 (11.2)	20 (13.2)	44 (29.0)	57 (37.5)
D7	Girls, Useless /Useful	3 (2.0)	3 (2.0)	25 (16.5)	35 (23.0)	36 (23.7)	50 (32.9)
D8	Time Well Spent/Waste of Time	50 (32.9)	37 (24.3)	52 (34.2)	4 (2.6)	1 (0.7)	8 (5.3)
D9	Difficult/ Easy	3 (2.0)	7 (4.6)	37 (24.3)	34 (22.4)	30 (19.7)	41 (27.0)

Table IIID.20

Results Group B (1987) S3 Girls (57)

(%)

		1	2	3	4	5	6
D1	Exciting/ Boring	6 (10.5)	16 (28.1)	21 (36.8)	12 (21.1)	1 (1.8)	1 (1.8)
D2	Interesting/ Dull	17 (29.8)	23 (40.4)	13 (22.8)	3 (5.3)	1 (1.8)	0
D3	Useful/Useless for Boys	4 (7.0)	11 (19.3)	25 (43.9)	10 (17.5)	3 (5.3)	4 (7.0)
D4	Frightening /Friendly	0	1 (1.8)	1 (1.8)	12 (21.1)	22 (38.6)	21 (36.8)
D5	Enjoyable/ Hateful	28 (49.1)	16 (28.1)	8 (14.0)	1 (1.8)	2 (3.5)	2 (3.5)
D6	Unimportant /Important	3 (5.3)	2 (3.5)	9 (15.8)	10 (17.5)	15 (26.3)	18 (31.6)
D7	Girls, Useless /Useful	1 (1.8)	1 (1.8)	7 (12.3)	11 (19.3)	10 (17.5)	27 (47.4)
D8	Time Well Spent/Waste of Time	19 (33.3)	10 (17.5)	23 (40.4)	2 (3.5)	0	3 (5.3)
D9	Difficult/ Easy	2 (3.5)	4 (7.0)	10 (17.5)	14 (24.6)	13 (22.8)	14 (24.6)

Table IIID.21

Results Group B (1987) S3 Boys (95)

(%)

		1	2	3	4	5	6
D1	Exciting/ Boring	12 (12.6)	28 (29.5)	43 (45.3)	6 (6.3)	1 (1.1)	5 (5.3)
D2	Interesting/ Dull	26 (27.4)	37 (38.9)	28 (29.5)	1 (1.1)	1 (1.1)	2 (2.1)
D3	Useful/Useless for Boys	18 (18.9)	30 (31.6)	40 (42.1)	5 (5.3)	0	2 (2.1)
D4	Frightening /Friendly	1 (1.1)	2 (2.1)	7 (7.4)	8 (8.4)	21 (22.1)	56 (59.0)
D5	Enjoyable/ Hateful	50 (52.6)	26 (27.4)	14 (14.7)	2 (2.1)	3 (3.2)	0
D6	Unimportant /Important	3 (3.2)	6 (6.3)	8 (8.4)	10 (10.5)	29 (30.5)	39 (41.1)
D7	Girls, Useless /Useful	2 (2.1)	2 (2.1)	18 (18.9)	24 (25.3)	26 (27.4)	23 (24.2)
D8	Time Well Spent/Waste of Time	31 (32.6)	27 (28.4)	29 (30.5)	2 (2.1)	1 (1.1)	5 (5.3)
D9	Difficult/ Easy	1 (1.1)	3 (3.2)	27 (28.4)	20 (21.1)	17 (17.9)	27 (28.4)

Table IIID.22

Results Group B (1988) S4 Totals (152)

(%)

		1	2	3	4	5	6
D1	Exciting/ Boring	5 (3.3)	40 (26.3)	75 (49.3)	20 (13.2)	8 (5.3)	4 (2.6)
D2	Interesting/ Dull	18 (11.8)	57 (37.5)	60 (39.5)	13 (8.6)	1 (0.7)	3 (2.0)
D3	Useful/Useless for Boys	26 (17.1)	30 (19.7)	61 (40.1)	24 (15.8)	8 (5.3)	3 (2.0)
D4	Frightening /Friendly	1 (0.7)	5 (3.3)	9 (5.9)	24 (15.8)	49 (32.2)	64 (42.1)
D5	Enjoyable/ Hateful	40 (26.3)	58 (38.2)	35 (23.0)	10 (6.6)	7 (4.6)	2 (1.3)
D6	Unimportant /Important	5 (3.3)	4 (2.6)	12 (7.9)	35 (23.0)	57 (37.5)	39 (25.7)
D7	Girls, Useless /Useful	2 (1.3)	2 (1.3)	18 (11.8)	49 (32.2)	37 (24.3)	44 (28.9)
D8	Time Well Spent/Waste of Time	36 (23.7)	37 (24.3)	46 (30.3)	25 (16.4)	6 (3.9)	2 (1.3)
D9	Difficult/ Easy	3 (2.0)	5 (3.3)	18 (11.8)	45 (29.6)	52 (34.2)	29 (19.1)

Table IIID.23

Results Group B (1988) S4 Girls (59)

(%)

		1	2	3	4	5	6
D1	Exciting/ Boring	3 (5.1)	20 (33.9)	28 (47.5)	4 (6.8)	3 (5.1)	1 (1.7)
D2	Interesting/ Dull	10 (16.9)	27 (45.8)	15 (25.4)	7 (11.9)	0	0
D3	Useful/Useless for Boys	13 (22.0)	13 (22.0)	15 (25.4)	9 (15.3)	7 (11.9)	2 (3.4)
D4	Frightening /Friendly	0	3 (5.1)	2 (3.4)	6 (10.2)	21 (35.6)	27 (45.8)
D5	Enjoyable/ Hateful	19 (32.2)	23 (39.0)	10 (16.9)	4 (6.8)	2 (3.4)	1 (1.7)
D6	Unimportant /Important	3 (5.1)	1 (1.7)	2 (3.4)	9 (15.3)	22 (37.3)	22 (37.3)
D7	Girls, Useless /Useful	0	0	6 (10.2)	11 (18.6)	14 (23.7)	28 (47.5)
D8	Time Well Spent/Waste of Time	23 (39.0)	16 (27.1)	15 (25.4)	4 (6.8)	1 (1.7)	0
D9	Difficult/ Easy	1 (1.7)	2 (3.4)	4 (6.8)	18 (30.5)	23 (39.0)	11 (18.6)

Table IIID.24

Results Group B (1988) S4 Boys (93)

(%)

		1	2	3	4	5	6
D1	Exciting/ Boring	2 (2.2)	20 (21.5)	47 (50.5)	16 (17.2)	5 (5.4)	3 (3.2)
D2	Interesting/ Dull	8 (8.6)	30 (32.3)	45 (48.4)	6 (6.5)	1 (1.1)	3 (3.2)
D3	Useful/Useless for Boys	13 (14.0)	11 (18.3)	46 (49.5)	15 (16.1)	1 (1.1)	1 (1.1)
D4	Frightening /Friendly	1 (1.1)	2 (2.2)	7 (7.5)	18 (19.4)	28 (30.1)	37 (39.8)
D5	Enjoyable/ Hateful	21 (22.6)	35 (37.6)	25 (26.9)	6 (6.5)	5 (5.4)	1 (1.1)
D6	Unimportant /Important	2 (2.2)	3 (3.2)	10 (10.8)	26 (28.0)	35 (37.6)	17 (18.3)
D7	Girls, Useless /Useful	2 (2.2)	2 (2.2)	12 (12.9)	38 (40.9)	23 (24.7)	16 (17.2)
D8	Time Well Spent/Waste of Time	13 (14.0)	21 (22.6)	31 (33.3)	21 (22.6)	5 (5.4)	2 (2.2)
D9	Difficult/ Easy	2 (2.2)	3 (3.2)	14 (15.1)	27 (29.0)	29 (31.2)	18 (19.4)

APPENDIX IIIE

FURTHER ANALYSIS OF GROUP A RESULTS

E1 First Year Results

E2 Third Year Results

E3 Girl and Boy Comparison within Years.

Table IIIE.1 X^2 test, Group A, G/B Comparison, S1, S2, S3, S4 q A1-A17.

Table IIIE.2 X^2 test, Group A, G/B Comparison, S1, S2, S3, S4 q B1-B9.

E4 Comparison of First and Third Years

Table IIIE.3 X^2 test, Group A (1986), S1/S3 Comparison, q A1-A17.

Table IIIE.4 X^2 test, Group A (1986), S1/S3 Comparison, q B1-B9.

E5 Comparison of Second and Fourth Years

Table IIIE.5 X^2 test, Group A (1987), S2/S4 Comparison, q A1-A17.

Table IIIE.6 X^2 test, Group A (1987), S2/S4 Comparison, q B1-B9.

E1 First Year Results

(Details of questions, see Appendix IIIA, results see Appendix IIIC & Section 3.5.1)

1 **Mode of Use** (q A3, A4, A8, A9)

Pupils strongly disagree that the teacher only should use the computer (A3). Attitudes on using the computer by themselves (A4) and the balance between teacher and computer (A8) show a wide range of opinion. Pupils disagree that experiments would be easier to do on the computer (A9).

2 **Expectations of Girls and Boys** (q A16, A17, B8, B9)

Pupils slightly disagree or are neutral in stating that boys are better at giving answers to the computer or that girls find it easier to work with computers (A16, A17). They all agree on the usefulness of computers to both girls and boys, but feel that they are slightly more useful for boys (B8, B9).

3 **Expectations of Use** (q A1, A2, B1, B2, B3, B4, B7)

All pupils have high expectations of computer use, all have positive attitudes to computers. They are exciting, interesting, important and enjoyable.

4 **World of Work** (q A10, A11, A12, A13, B3, B7)

Pupils strongly agree that programming knowledge is necessary to get a job with computers. Not as strong but positive are the attitudes that knowledge about computers will help in the search for a job, but also that the job might be replaced by a computer. Also important was time spent with computers. Pupils were more divided as to the importance of computers to them in everyday life, even if they did not work with such machines.

5 **Machine Use** (q A5, A6, B3, B6)

Most pupils disagree or are neutral in their attitudes to monitor or keyboard difficulties. The machine is interesting and easy to use, no machine phobia here.

E2 Third Year Results (Section 3.5.2)

1 Expectation of Use (A1, A2, B1, B2, B3, B4, B7)

Computers are still exciting to S3 pupils but attitudes are in the positive/neutral area. They are still fairly enjoyable and interesting, but not very important. All S3 pupils agree that they do not use the computer a lot in school.

2 Expectations of Girls and Boys (A16, A17, B8, B9)

S3 pupils disagree that computers are easy for girls and that boys are better. All agree that computers are useful for both boys & girls although more useful for boys.

3 World of Work (A10, A11, A12, A13)

S3 have positive/neutral attitudes about computers helping them with a job and being important in future life, but they feel that computers will take jobs away from people and very strongly agree that to work with computers you must know programming.

E3 Girl and Boy Comparison with Years

(Tables E.1 and E.2)

S3, S4 girls find computers less exciting than the boys (A1, B1). Time less well spent (B7). In S1, boys more likely to think computers will help them get a job. Boys in S1 and S2 think "boys are better" at using computers.

Table IIIE.1

Group A Comparison of Girls with Boys for Each Year
Chi-squared Test

	S1	S3	S2	S4
A1 Exciting	0.8	*** 8.3 G+ B-	7.4	** 9.9 G- B+
A2 Use a Lot	0.1	* 9.0 G- B+	2.7	2.6
A3 Use by Teacher	4.6	0.6	0.1	1.0
A4 Individual Use	2.6	4.8	0.7	3.5
A5 Keyboard Difficult	2.0	1.6	5.4	2.3
A6 Blackboard Easier Than Monitor	4.7	6.6	2.5	1.2
A7 Know Programming	1.2	2.1	** 12.4 G- B+	0.8
A8 Teacher to Explain	0.8	1.0	5.1	0.7
A9 Expts. Easier on Computer	1.9	1.6	3.0	0.8
A10 Help for Job	* 10.7 G- B+	0.9	6.2	0.8
A11 Take Jobs From People	7.8 G- B+	2.6	2.2	1.9
A12 Important in Everyday Life	6.6	0.4	4.1	2.8

	S1	S3	S2	S4
A13 Know Programming for Job	0.2	5.8	1.5	6.3
A14 Need to be Clever	0.7	0.0	0.2	0.0
A15 Good at Arithmetic	1.7	0.1	0.0	0.0
A16 Easy for Girls	4.2	2.0	1.5	1.3
A17 Boys Better	** 10.8 G- B+	6.6	*** 29.8 G- B+	5.2

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference $1 \rightarrow 5$ = -
$5 \rightarrow 1$ = +

Table IIIE.2

Group A - Comparison of Girls with Boys for Each Year

Chi-squared Test

		S1	S2	S3	S4
B1	Exciting/ Boring	1.2	3.0	* 6.2 G- B+	8.0 B+ G-
B2	Interesting/ Dull	1.2	0.2	3.5	6.4 B+ G-
B3	Important/ Unimportant	* 9.8 G- B+	2.7	1.2	3.3
B4	Enjoyable/ Hateful	0.9	0.1	6.8 G- B+	6.6 B+ G-
B5	Friendly/ Frightening	0.2	2.3	1.4	0.5
B6	Difficult/ Easy	7.9	** 17.5 B- G+	5.4	7.0 B+ G-
B7	Time Well Spent/Waste of Time	* 9.0 G- B+	6.0	** 9.1 G- B+	9.9 B+ G-
B8	Girls, Useful/ Useless	4.6	0.3	0.3	0.9
B9	Useful/Useless for Boys	** 9.8 G- B+	4.4	5.8 G- B+	0.2

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference 6 → 1 = +
1 → 6 = -

E4 Comparison of First and Third Years (S1/S3)
(ref Tables E.3, E.4, Appendix IIIC)

1 **Use of Computer Exciting** (q A1, B1)

In S1 the majority opinion lies in the agree/strongly agree categories, but have shifted in S3 to neutral/disagree, ie: less positive attitudes. These differences are significant at 1% level.

2 **Use of Computers Exciting/Boys & Girls**

S1 boys show more positive attitudes than S1 girls, eg: attitude 1 - strongly agree 31% B, 23% G, similar trend in attitude 2 but with girls favouring the more neutral attitude 3 30% G, 23% B. By S3 there has been a change in both girls' and boys' attitudes, but significantly so (.1% level) in the girls. Boys, for the most part, remaining in the positive and neutral area and girls moving into neutral and negative attitudes.

3 **Use of Computer** (q A2)

Pupils enter from primary school with a high expectation of use of computers. They appear to be sadly disillusioned since there is a dramatic change in attitude towards usage from S1 to S3. For both boys and girls the difference is significant at .1% level. By S3 girls strongly disagree that they will use the computer, reflecting lack of use within the classroom. S3 boys are a little more hopeful that they will use a computer as part of their lessons.

Table IIIE.3

Group A (1986) - Comparison of First & Third Years

Chi-squared Test

	Totals	Girls	Boys
A1 Computer Exciting	*** 22.0 S3 -	*** 24.0 S3 -	2.1
A2 Use a Lot	*** 36.9 S3 -	*** 77.7 S3 -	** 11.6 S3 -
A3 Use by Teacher	3.5	0.5	0.0
A4 Individual Use	3.3	1.1	4.9
A5 Keyboard Difficult	2.9	2.2	1.1
A6 Blackboard Easier than Monitor	3.7	7.3	4.0
A7 Know Programming	3.8	1.6	3.6
A8 Teacher to Explain	0.1	0.4	1.4
A9 Expts. Easier on Computer	3.4	1.9	1.1
A10 Help for Job	5.8	1.3	5.5
A11 Take Jobs From People	3.7	0.1	5.7

Table IIIE.3 cont...

Group A (1986) S1/S3 Comparison

Chi-squared Test

	Totals	Girls	Boys
A12 Important in Everyday Life	3.4	1.3	3.9
A13 Know Programming for Job	0.5	1.5	2.2
A14 Need to be Clever	1.8	1.0	0.5
A15 Good at Arithmetic	5.3	0.8	4.6
A16 Easy for Girls	0.2	0.1	0.1
A17 Boys Better	1.6	0.2	1.6

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference $1 \rightarrow 5 = - \rightarrow$ disagree
$5 \rightarrow 1 = + \rightarrow$ agree

Table IIIE.4

Group A (1986) - Comparison of First & Third Years

Chi-squared Test

		Totals	Girls	Boys
B1	Exciting/ Boring	** 12.7 S3 -	*** 12.1 S3 -	2.7
B2	Interesting/ Dull	7.5 S3 -	6.3 S3 -	2.3
B3	Important/ Unimportant	4.2	1.5	1.2
B4	Enjoyable/ Hateful	1.3	4.2	0.6
B5	Friendly/ Frightening	0.1	0.4	0.5
B6	Difficult/ Easy	0.7	3.8	3.1
B7	Time Well Spent/ Waste of Time	0.2	0.3	1.2
B8	Girls Useful/ Useless	2.9	3.2	8.1 S3 +
B9	Useful/Useless for Boys	2.6	5.1 S3 -	2.9

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference 6 → 1 = +
1 → 6 = -

E5 Comparison of Second and Fourth Years (S2/S4)
(Tables E.5, E.6)

The following pages give further analysis of the comparison of second and fourth year pupils in the pilot study (Section 3.5.5).

1 **Question B4 Enjoyable/Hateful**
Fourth year pupils found the computer less enjoyable, the comparison is significant at the 1% level (Table E.5). The girls contributed the majority of the difference.

2 **Question B1 Exciting/Boring**
Fourth year pupils again found the computer less exciting (significant at .1% level) and again the girls contribute most of the differences between second and fourth year. Within the fourth year, boys and girls show different attitudes, eg: boys show 82.2% and girls 61.3% positive attitudes when considering question B1.

3 **Questions A1, B1**
Fourth year pupils find computers less exciting. They expect to use the computer a lot in school and find out that they do not.

S4 also find computers duller (B2) and less enjoyable (B4).

In all 4 questions, the change in attitude is due to changes in the girls', not the boys', attitudes.

Table IIIE.5

Group A (1987) - Comparison of Second & Fourth Years

Chi-squared Test

	Totals	Girls	Boys
A1 Computer Exciting	*** 18.4 S4 -	*** 14.7 S4 -	4.8
A2 Use a Lot	** 13.4 S4 -	*** 14.2 S4 -	3.1
A3 Use by Teacher	*** 11.6 S4 +	** 8.0 S4 +	2.5
A4 Individual Use	3.7	5.5	0.9
A5 Keyboard Difficult	2.8	0.7	3.6
A6 Blackboard Easier than Monitor	* 9.9 S4 +	5.6	7.1
A7 Know Programming	3.5	0.6	1.9
A8 Teacher to Explain	6.8	5.0	5.6
A9 Expts. Easier on Computer	5.6	1.2	6.3
A10 Help for Job	2.3	1.0	4.3
A11 Take Jobs From People	7.2	1.4	5.8

Table IIIE.5 cont...

Group A (1987) S2/S4 Comparison

Chi-squared Test

	Totals	Girls	Boys
A12 Important in Everyday Life	2.7	1.6	0.4
A13 Know Programming for Job	*** 15.5 S4 -	** 10.1 S4 -	7.3
A14 Need to be Clever	0.0	0.1	0.0
A15 Good at Arithmetic	* 9.1 S4 +	2.7	5.7
A16 Easy for Girls	0.2	0.2	0.5
A17 Boys Better	4.1	0.3	5.0

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference 1 → 5 = - → disagree
5 → 1 = + → agree

Table IIIE.6

Group A (1987) - Comparison of Second & Fourth Years

Chi-squared Test

		Totals	Girls	Boys
B1	Exciting/ Boring	*** 19.1 S4 -	*** 23.0 S4 -	2.0
B2	Interesting/ Dull	* 10.8 S4 -	** 11.6 S4 -	3.8
B3	Important/ Unimportant	0.4	0.8	2.0
B4	Enjoyable/ Hateful	** 13.7 S4 -	*** 16.8 S4 -	1.6
B5	Friendly/ Frightening	1.5	0.7	1.6
B6	Difficult/ Easy	8.3	3.3	8.6
B7	Time Well Spent/ Waste of Time	3.2	1.5	6.4
B8	Girls Useful/ Useless	1.5	0.1	0.9
B9	Useful/Useless for Boys	1.1	0.1	1.5

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference 6 > 1 = +
1 > 6 = -

APPENDIX IIIF

GROUP B: ANALYSIS OF RESULTS

F1 Comparison of S2 with S4

Table IIIF.1 X^2 Group B (1988) S2/S4 Comparison q C1-C19
Table IIIF.2 X^2 Group B (1988) S2/S4 Comparison q D1-D9

F2 Comparison of Girls with Boys in S2 & S4

Table IIIF.3 X^2 Group B (1988) G/B Comparison q C1-C19
Table IIIF.4 X^2 Group B (1988) G/B Comparison q D1-D9

F1 Comparison of S2 with S4

(ref Tables IIIF.1, IIIF.2, Section 3.11)

S4 pupils again find the computer less exciting (C1 sign .1%) and like to use the computer less in class (C14 sign 1%) than S2 pupils. In S4 computers are less interesting, less friendly, less enjoyable and time less well spent (all significant at .1% level). Although these attitudes all show a change from S2 they still remain in the positive/neutral sectors of the attitude scale.

S2 pupils, especially boys, prefer to play games on the computer, but both years still enjoy playing games. S4 pupils agree less with using a computer because it works at their pace. There are also differences of attitude between S2 and S4 in the need to be good at arithmetic to learn from a computer (C17) and whether the computer should mark pupils' work (C19). The results seem to indicate that S4 think arithmetic is not so necessary and they prefer the computer to mark their work, but the trends are difficult to interpret since attitudes have become more diverse in S4.

Table IIIF.1

Group B (1988) - Comparison of Second & Fourth Years

Chi-squared Test

	Totals	Girls	Boys
C1 Computer Exciting	*** 55.6 S4-	** 8.9 S4-	*** 47.3 S4-
C2 Use a Lot	0.9	5.3	0.5
C3 Teacher Use	1.2	0.1	4.8
C4 Play Games	** 9.8 S4-	5.2	* 10.7 S4-
C5 Boring Subject Enjoyable	1.4	0.6	0.5
C6 Individual Use	1.7	2.9	1.9
C7 Know Programming	5.4	6.2	2.4
C8 Boy/Girl Comparison	3.9	2.5	3.6
C9 Teacher to Explain	2.5	0.8	** 11.7
C10 Work at Own Speed	** 15.3 S4-	5.5	** 11.4 S4-

Table IIIF.1 cont...

Group B (1988) - Comparison of Second & Fourth Years

Chi-squared Test

	Totals	Girls	Boys
C11 Easy for Girls	1.2	1.2	1.8
C12 Help for Job	4.6	1.4	** 10.7 S4-
C13 Easier to Answer	6.8	2.8	5.5
C14 Use in Lesson	** 9.9 S4-	0.0	** 18.2 S4-
C15 Need to be Clever	3.3	1.5	1.1
C16 Boys Better	1.3	0.0	0.3
C17 Good at Arithmetic	* 8.2 S4-	2.4	5.6
C18 Sit Back When Work with Opp. Sex	2.9	1.0	1.3
C19 Mark Work	** 14.0 S4+	8.0	7.1

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference $1 \rightarrow 5$ = - $\rightarrow$ disagree
$5 \rightarrow 1$ = + $\rightarrow$ agree

Table IIIF.2

Group B (1988) - Comparison of Second & Fourth Years

Chi-squared Test

		Totals	Girls	Boys
D1	Exciting/ Boring	*** 24.5 S4-	1.2	*** 29.1 S4-
D2	Interesting/ Dull	*** 24.5 S4-	6.9	*** 15.2 S4-
D3	Useful/Usless for Boys	4.8	3.1	*** 17.9 S4-
D4	Frightening /Friendly	*** 13.8 S4+	1.5	*** 16.1 S4+
D5	Enjoyable/ Hateful	*** 17.8 S4-	4.4	** 13.4 S4+
D6	Unimportant /Important	6.9	0.2	** 11.1 S4+
D7	Girls, Useful/ Useless	4.8	3.4	** 13.0 S4+
D8	Time Well Spent/ Waste of Time	*** 23.3 S4-	0.2	*** 33.0 S4-
D9	Difficult/ Easy	2.5	5.1	0.1

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference $6 \rightarrow 1$ = +
$1 \rightarrow 6$ = -

F2 Comparison of Girls with Boys Within S2 and S4 Year Groups

(Tables IIIF.3, IIIF.4)

Boys do not think girls & boys are equally good, computers are easier for girls but they do think boys are better than girls. These differences are present in S2 & S4, more significant in S4 in questions C8 and C11.

S2 girls find computers more useless for boys and more useful for girls (nearly significant .02). Conversely, S2 boys find computers more useful for boys and less useful for girls. The majority of their attitudes still in the positive and neutral sectors of the scale.

Table IIIF.3

Group B (1988)
Comparison of Girls with Boys Within Each Year

Chi-squared Test

	S2	S4
C1 Computer Exciting	5.3	4.4
C2 Use a Lot	2.8	4.8
C3 Teacher Use	6.6	0.0
C4 Play Games	** 10.3 B+ G-	1.0
C5 Boring Subject Enjoyable	6.1	6.1
C6 Individual Use	1.1	5.5
C7 Know Programming	7.9	1.5
C8 Boy/Girl Comparison	** 15.4 B- G+	*** 15.7 B- G+
C9 Teacher to Explain	5.0	1.2
C10 Work at Own Speed	3.0	0.0

Table IIIF.3 cont...

Group B (1988) - Comparison of Second & Fourth Years

Chi-squared Test

	S2	S4
C11 Easy for Girls	** 12.9 B- G+	*** 14.5 B- G+
C12 Help for Job	6.3	4.1
C13 Easier to Answer	0.6	1.5
C14 Use in Lesson	6.7	5.5
C15 Need to be Clever	1.9	2.2
C16 Boys Better	*** 19.9 G- B+	*** 24.7 G- B+
C17 Good at Arithmetic	0.5	2.3
C18 Sit Back When Work with Opp. Sex	6.4	8.2
C19 Mark Work	2.3	1.5

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference 1 → 5 = - (→ disagree)
5 → 1 = + (→ agree)

Table IIIF.4

Group B (1988)
Comparison of Girls with Boys Within Each Year

Chi-squared Test

		S2	S4
D1	Exciting/ Boring	3.5	5.5
D2	Interesting/ Dull	1.4	* 8.3 G+ B-
D3	Useful/Usless for Boys	*** 14.7 B+ G-	9.1
D4	Frightening /Friendly	7.4	2.4
D5	Enjoyable/ Hateful	0.1	2.8
D6	Unimportant /Important	2.6	8.5
D7	Girls, Useful/ Useless	9.7	*** 18.1 G- B+
D8	Time Well Spent/ Waste of Time	3.5	** 15.9 G+ B-
D9	Difficult/ Easy	7.6 G- B+	2.2

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference 6 > 1 = +
1 > 6 = -

APPENDIX IIIG

Table G.1 S1 Profiles (Group B 1987)

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
boys & girls equally good at working with computers.	using a computer in school should be really exciting. expect to use computer a lot in secondary school. like to play games on the computer. should make a boring subject more enjoyable. like to work with computers because it works at my own speed. help with job when leave school. would like to use computer as part of my lessons. best out of computer need to know about programming.	prefer to use computer by myself. prefer teacher to explain. easier to answer computer than the teacher. computer should mark my work.	girls find it much easier to work with computers. must be good at arithmetic to learn from a computer. work with partner of opp. sex, sit back & allow them to do work.	computers should only be used by the teacher. only clever people can learn from a computer. boys are better at giving answers to the computer.

Table G.2

S1 Girls Profile (Group B 1987)

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
boys & girls equally good at working with computers.	using a computer should be exciting. expect to use the computer a lot. play games on the computer. should make a boring subject more enjoyable. need to know about programming to get best out of computer. like to work with computer, works at own (pupils) speed. help with job when leave school. like to use as part of lessons.	use computer by myself. prefer teacher to explain. girls find it easier to work with computers. computer should mark my work.	good at arith-metic to learn from computer.	computer only used by the teacher. only clever people can learn from a computer. boys are better at giving answers to the computer. good at arithmetic to learn from computer.

Table G.3

S1 Boys Profile: (Group B 1987)

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
best out of computer need to know programming. boys & girls equally good at working with computers.	using a computer should be exciting. expect to use the computer a lot. play games on the computer. should make a boring subject more enjoyable. like computer because it works at own (pupils) speed. work with computers will help get job. like to use computer as part of my lessons.	use computer by myself in class. prefer teacher to explain. easier to answer the computer than teacher. computer should mark my work.	girls find it easier to work with computers. boys are better at giving answers to computers. work with a girl, let her do the work.	computer only used by the teacher. only clever people can learn from a computer.

Table G.4

S3 Profile (Group B 1987)

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
like to play games on the computer. best out of computer need to know about programming. boys & girls equally good at working with computers.	expect to use computer a lot. computers should make a boring subject more enjoyable. computer works at own (pupils) speed. help with job. like to use computer as part of lessons.	using computer should be really exciting. prefer to use computer on own. prefer teacher to explain. girls find it easier. easier to answer computer than teacher.		computer only used by the teacher. only clever people can learn from a computer. boys better at giving answers. good at arithmetic. partner of opp. sex, sit back. computer should mark work.

Table G.5

S3 Girls Profile (Group B 1987)

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
need to know programming to get best out of computer.	expect to use computer a lot.	using computer should be really exciting.	good at arith-metic to learn from computers.	computer only used by the teacher.
boys & girls equally good at working with computers.	like to play games on computer.	prefer to use computer on own.	computer to mark work.	only the clever can learn from computer
	computer makes boring subject more enjoyable.	prefer teacher to explain things.		boys are better at giving answers to the computer.
	computer works at pupils' speed.	girls find it easier to work with computers.		good at arithmetic to learn from the computer.
	using a computer will help with a job.	like to use the computer.		work with a boy, let him work computer.
	easier to answer computer than teacher.			computer should mark work.

Table G.6

S3 Boys Profile (Group B 1987)

Strongly Agree	Agree	Neither Agree or Disagree	Mixed Response	Strongly Disagree
play games on the computer. use computer by myself. need to know about programming to get best out of computers. boys & girls equally good at computers.	expect to use computer a lot. computers should make a boring subject more enjoyable. computer works at own (pupils) speed. like to use computer.	using computer should be really exciting. prefer teacher to explain. easier to answer the computer.	using computers will help in finding a job. computer to mark work.	computer only used by the teacher. girls find it easier to work with computers. only the clever can learn from computer boys are better at answering the computer. good at arithmetic to learn from computer. work with a girl, sit back and allow her to do work.

CHAPTER 4

ATTITUDE SURVEY: LONGITUDINAL STUDY AND HOME COMPUTER USE

4.1 Longitudinal Study

(Detailed results can be found in Appendix IVA)

The attitude survey was carried out with two separate populations at the beginning of two subsequent years of schooling. It is therefore possible to look at the development of attitudes to computers in four different years of secondary school. It is also possible to look at the changes in attitudes as first year move into second year and third into fourth year.

For this purposes of this study the two populations (S1 and S3) of pupils have been assumed to have similar attitudes. This assumption is based on a comparison of the attitudes of the two first year populations who were surveyed (first year group A and first year group B). All the results from the questions that were the same in both surveys (19 questions) were compared using X^2 test. 80% of the questions showed no significant differences between the two sets of results.

Graphs 4.1 to 4.10, 4.14, 4.15 show the positive attitudes of pupils over four years of secondary school. Positive attitudes were taken as "strongly agree" and "agree" categories on the Likert Scale. On the Semantic-Differential scale, positive attitudes were taken as the two scale points nearest the positive word, eg:

(i) Unimportant 1 2 3 4 5 6 Important
Scale points 5 & 6 would be positive attitudes.

(ii) Exciting 1 2 3 4 5 6 Boring
Scale points 1 & 2 would be positive attitudes.

Graphs 4.11 to 4.13 show negative attitudes of the same groups of pupils. Negative attitudes are the "disagree" and "strongly disagree" areas of the Likert scale and the two scale points nearest the negative word in the Semantic-Differential Scale.

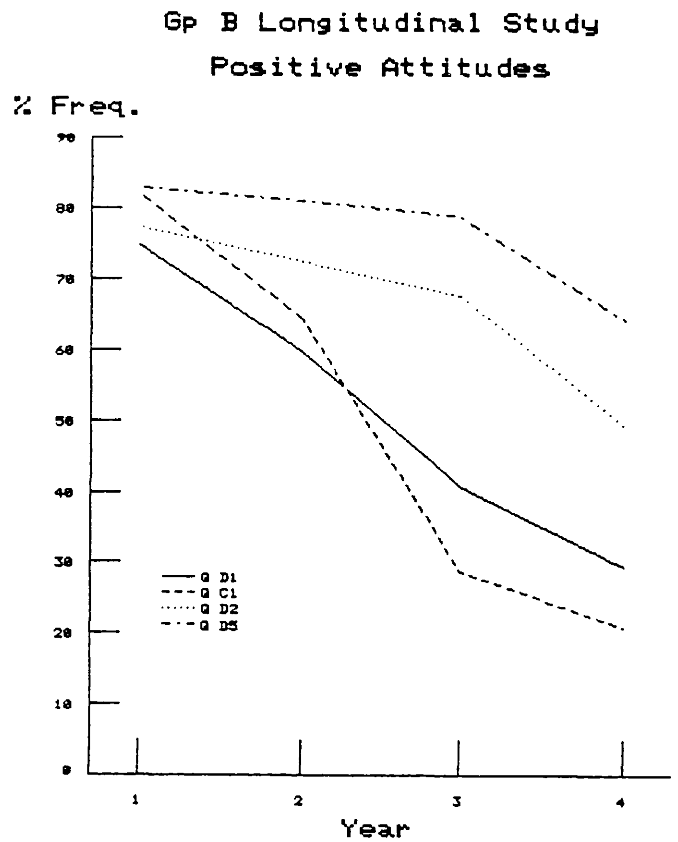
Table 4.1

% Significance of X^2 Test
Group B Comparisons of Pupils in Different Years

Question	S1/S2	S1/S3	S2/S4	S3/S4
C1	1.0	0.1	0.1	-
C2	-	1.0	-	-
C3	-	-	-	-
C4	1.0	0.1	1.0	-
C5	-	-	-	-
C6	-	1.0	-	-
C7	-	-	-	-
C8	-	-	-	-
C9	-	-	-	-
C10	-	-	1.0	-
C11	-	-	-	-
C12	-	-	-	-
C13	1.0	-	-	-
C14	-	0.1	1.0	-
C15	-	-	-	-
C16	-	2.0	-	-
C17	-	2.0	2.0	-
C18	-	2.0	-	-
C19	-	0.1	1.0	-
D1	-	0.1	-	0.1
D2	-	-	0.1	1.0
D3	-	-	-	-
D4	-	-	-	0.1
D5	-	-	0.1	0.1
D6	-	-	2.0	-
D7	-	-	-	-
D8	-	0.1	1.0	0.1
D9	-	2.0	1.0	-

4.2 Expectation of Use
(ref Table 4.1)

Graph 4.1

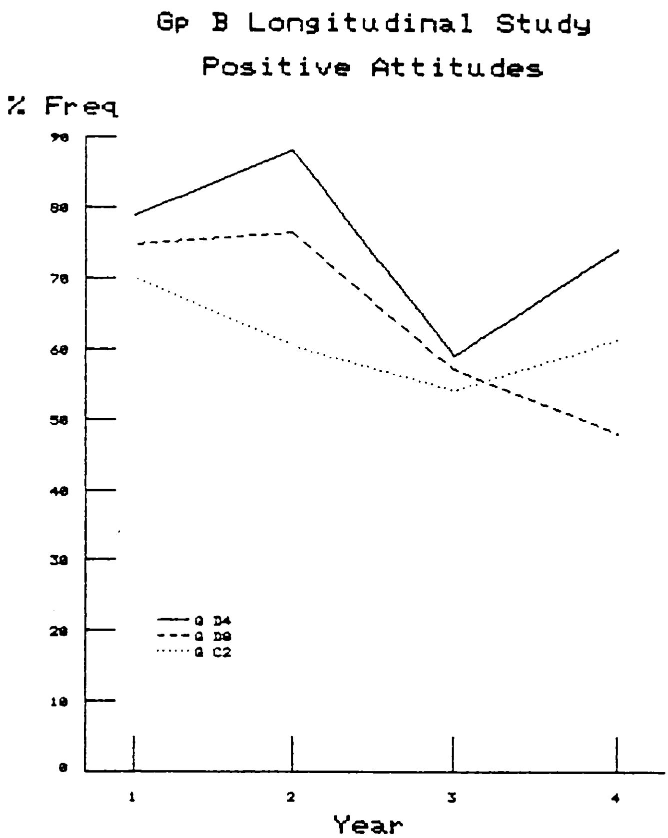


Question D2 "Interesting/Dull" (Graph 4.1)
The trends is towards "dull" end of the scale with small drops from first to third year and a significant (0.1%) drop from third to fourth year.

Questions D1 "Exciting/Boring" and C1 "Computer Exciting" (Graph 4.1)
There is a steady change in attitude towards "less exciting", the third and fourth years finding the computer less exciting.

Question D5 "Enjoyable/Hateful" (Graph 4.1)
The change in attitude seems to occur in fourth year, the change is significant between both second or third and fourth years. The computer is less enjoyable, but still not hateful in fourth year.

Graph 4.2



Question D4 "Frightening/Friendly" (Graph 4.2)
The trends in these responses are not so clear. Third year pupils have the least positive responses, they think the computer is less friendly. Fourth years attitudes are significantly more positive than third years and similar to first year.

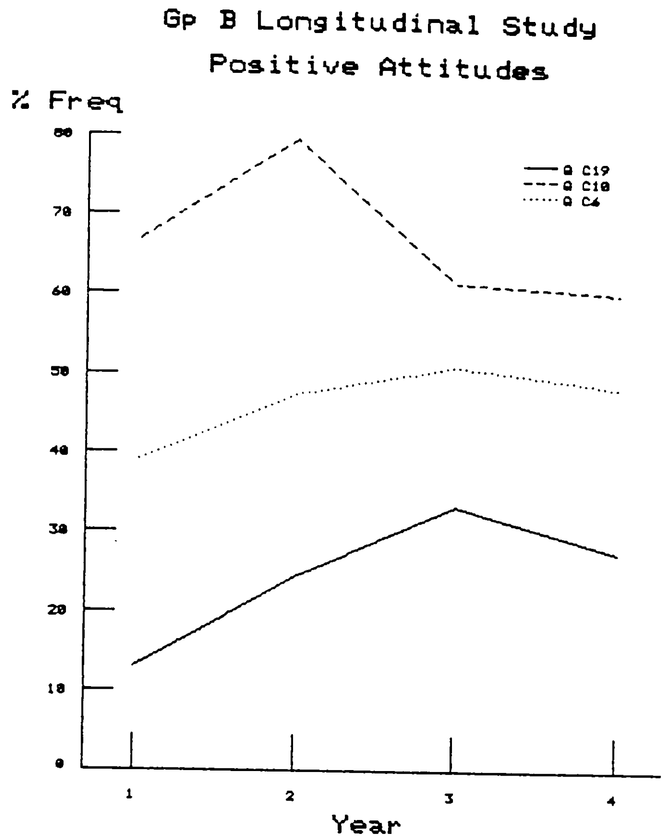
Question D8 "Time well spent/Waste of Time" (Graph 4.2)
First and second years show similar positive attitudes. There is a significant decline in these attitudes in third and fourth years, moving towards the "waste of time" end of the scale.

Question C2 "Use Computers a Lot" (Graph 4.2)
There is a steady decline in attitude from "agree" towards the "disagree and strongly disagree" end of the scale in years one to three. The change is only significant at the 1% level between first and third years. Fourth years show similar results to second years and therefore an increase from third year.

4.3

Mode of Use
(ref Table 4.1)

Graph 4.3



One of the attributes of computer use is the ability to individualise learning. How do pupil attitudes view this aspect of computers?

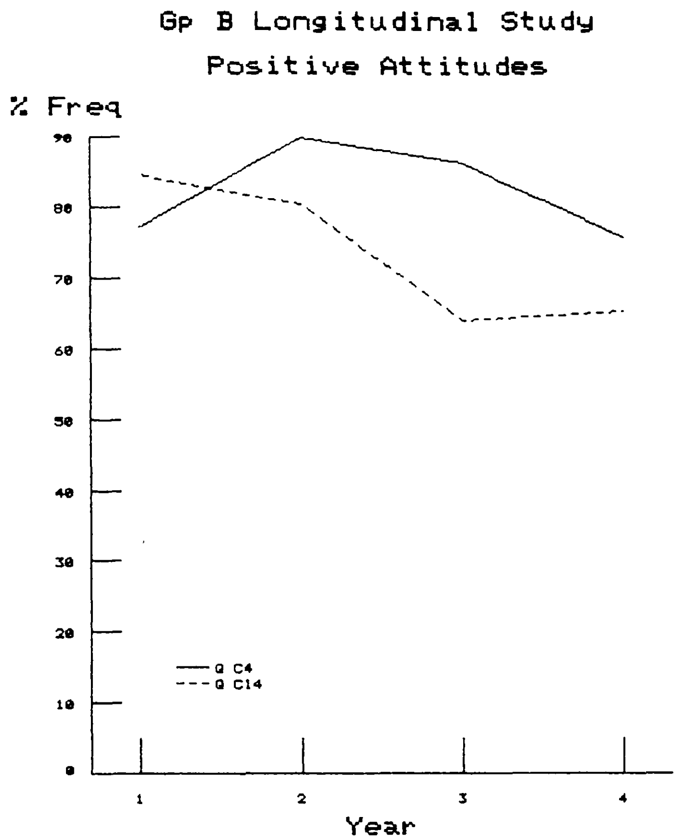
Question C6 "Individual Use" (Graph 4.3)
Attitudes for all years lie in the positive and neutral areas of the scale. Third years prefer to use the computer on their own when compared with first years, this is significant at the 1% level.

Question C10 "Work at Own Speed" (Graph 4.3)
Second year pupils are more positive in agreeing that they like to work with the computer because it works at their pace. The other years have slightly less positive attitudes, giving a significant change between second and fourth years (1% level).

Question C19 "Mark Work" (Graph 4.3)

Negative attitudes are in the majority in all four years. First and second years show similar attitudes in the neutral area of the scale. Instead of seeing the computer as a fair arbitrator of work and less critical of their mistakes, a large number of pupils prefer the computer not to mark their work.

Graph 4.4



Questions C14 "Use in Lesson" and C4 "Play Games" (Graph 4.4)
All pupils agree that they would like to use the computer as part of their lessons, but there are significant differences between both first and third years and between second and fourth years.

Older pupils are less likely to want to use the computer.

All pupils also agree that they like to play games on the computer.

4.4 Differences Between Boys and Girls

Table 4.2

% Significance of X^2 Test
Group B Year Comparison - Boys and Girls

Question	S1/S2		S1/S3		S2/S4		S3/S4	
	G	B	G	B	G	B	G	B
C1	-	-	0.1	0.1	1.0	0.1	-	-
C2	-	-	1.0	-	-	-	-	-
C3	-	-	-	-	-	-	-	-
C4	-	1.0	1.0	-	-	2.0	-	-
C5	-	1.0	-	-	-	-	-	-
C6	-	-	-	-	-	-	-	-
C7	-	-	-	-	-	-	-	-
C8	-	-	-	-	-	-	-	-
C9	-	-	-	-	-	1.0	-	-
C10	-	-	-	-	-	1.0	-	-
C11	-	-	-	-	-	-	-	-
C12	-	-	-	-	-	1.0	-	-
C13	-	-	-	-	-	-	-	-
C14	-	-	1.0	-	-	1.0	-	-
C15	-	-	-	-	-	-	-	-
C16	-	-	-	-	-	-	-	-
C17	-	-	-	1.0	-	-	-	-
C18	-	-	-	-	-	-	-	-
C19	-	-	-	-	-	-	-	-
D1	-	-	0.1	0.1	-	0.1	-	1.0
D2	-	-	-	-	-	0.1	-	0.1
D3	-	-	-	-	-	0.1	-	-
D4	-	-	-	-	-	0.1	-	-
D5	-	-	-	-	-	1.0	-	0.1
D6	-	-	-	-	-	1.0	-	0.1
D7	-	-	-	-	-	1.0	-	-
D8	-	-	1.0	-	-	0.1	-	1.0
D9	-	-	-	-	-	-	-	-

Questions C1 "Computer Exciting" and D8 "Time well Spent/Waste of Time" (Graphs 4.5, 4.6)

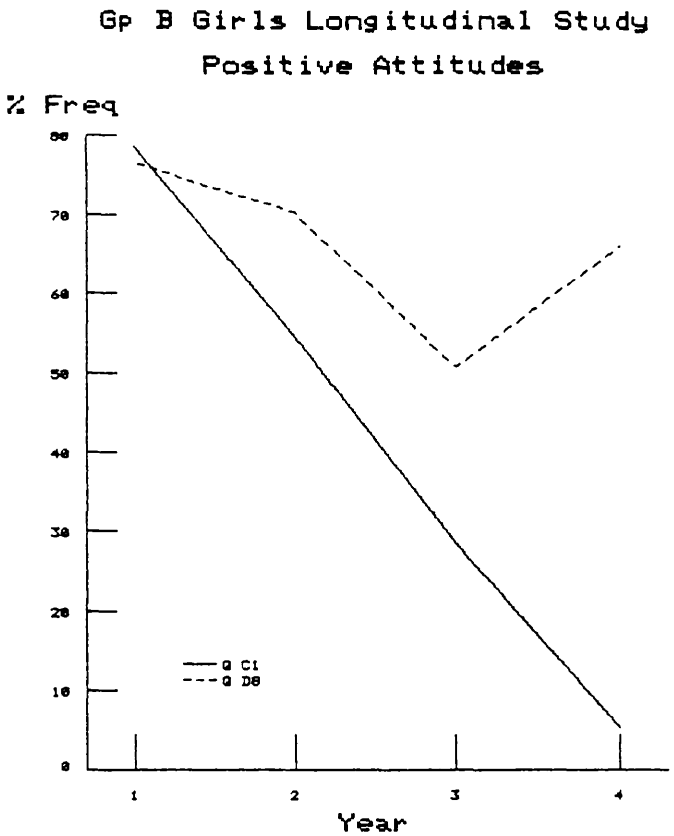
Both boys and girls contribute to the decline in positive attitudes concerning the excitement of using a computer. In some of the attitude changes, girls and boys contribute at different stages. When considering attitudes to the amount of time spent with the computer, girls show significant change between first and third years (1% level). The boys between second and fourth years (0.1% level) and the third and fourth years (1% level).

Questions D5 "Enjoyable/Hateful"; D2 "Interesting/Dull"; D4 "Frightening/Friendly" (Graphs 4.7, 4.8)

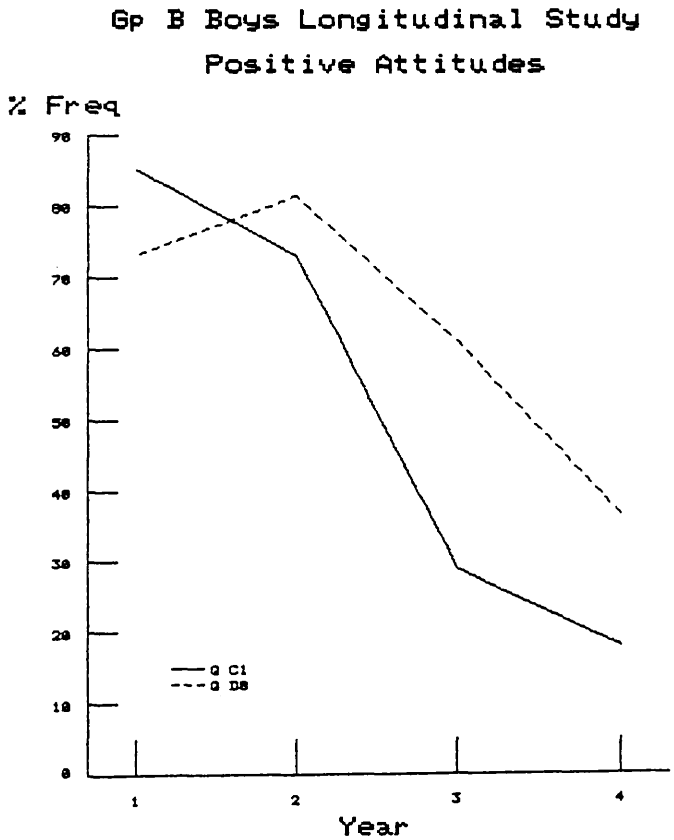
In both boys and girls, there is a lowering of positive attitudes from S1 to S4. The significant changes in attitude in these questions are all contributed by differences between second and fourth year boys.

In question **C10 "Work at Own Speed"** trends were similar in boys and girls. First year boys show more positive attitudes than girls (70% compared with 63%). In question **C14 "Use in Lesson"** boys and girls show different trends. In this question fourth year girls show an increase in positive attitudes which is counter to the general downward trend from S1 to S4.

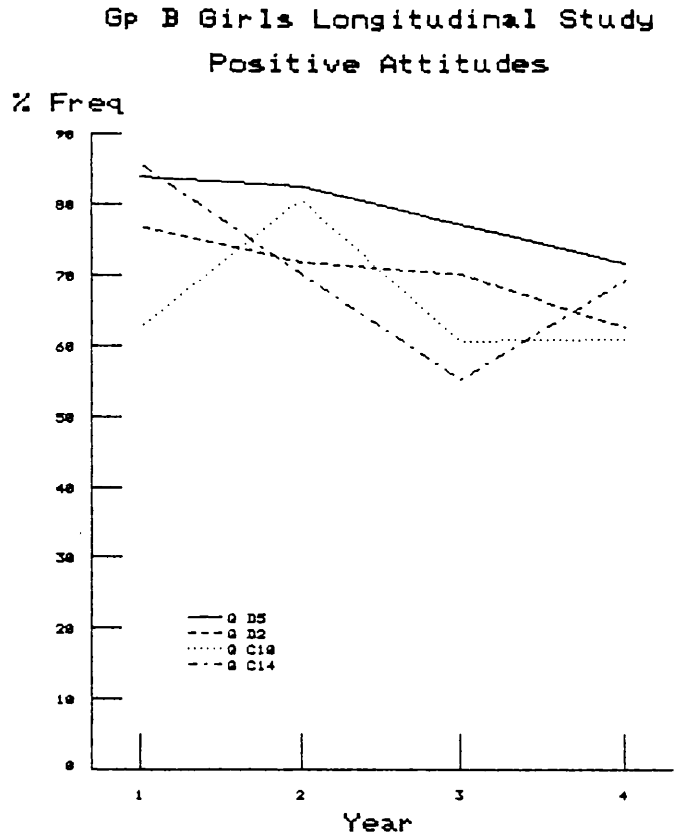
Graph 4.5



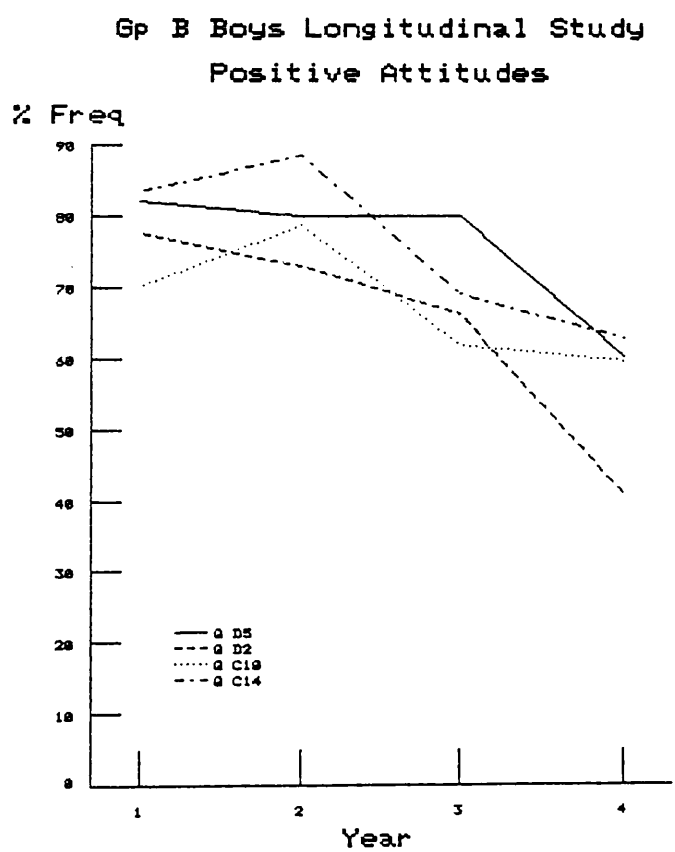
Graph 4.6



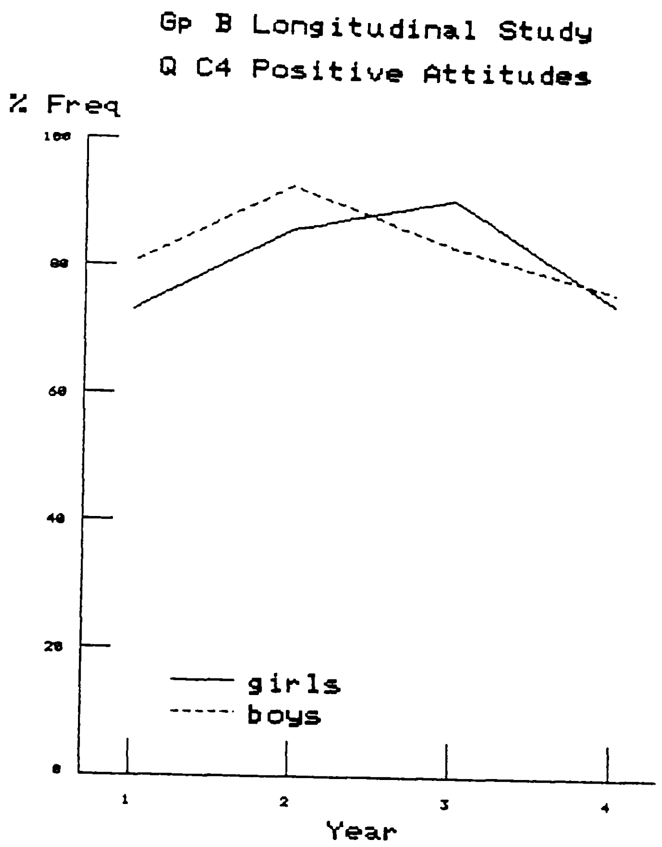
Graph 4.7



Graph 4.8



Graph 4.9



Question C4 "Play Games" (graph 4.9)

The change in attitude to playing games on the computer exemplifies the difference between boys and girls, significant differences are found between first and third year girls (1% level). Differences are found between first and second year boys (1% level) and between second and fourth year boys (2% level).

4.5 Expectations of Girls and Boys

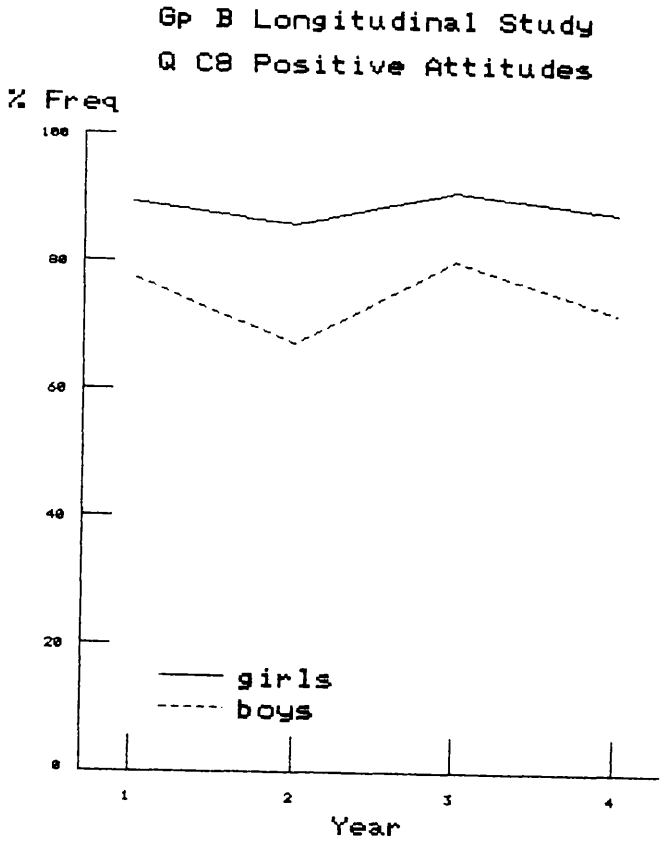
(ref Table 4.3)

In this section, questions relating to the differences between boys and girls will be considered. The questions used investigate the attitudes of pupils to computer use by their own and the opposite sex.

Table 4.3

% Significance of X^2 Test
Group B Comparison of Girls and Boys within Year

Question	S1	S2	S3	S4
C1	-	-	-	-
C2	-	-	-	-
C3	-	-	-	-
C4	-	1.0	-	-
C5	-	-	-	-
C6	-	-	-	-
C7	-	-	-	-
C8	-	1.0	0.1	0.1
C9	-	-	-	-
C10	-	-	-	-
C11	0.1	1.0	0.1	0.1
C12	-	-	-	-
C13	-	-	-	-
C14	-	-	-	-
C15	-	-	-	-
C16	1.0	0.1	0.1	0.1
C17	-	-	-	-
C18	1.0	-	-	-
C19	-	-	-	-
D1	-	-	-	-
D2	-	-	-	2.0
D3	-	0.1	1.0	-
D4	-	-	-	-
D5	-	-	-	-
D6	-	-	-	-
D7	-	-	-	0.1
D8	-	-	-	1.0
D9	-	-	-	-

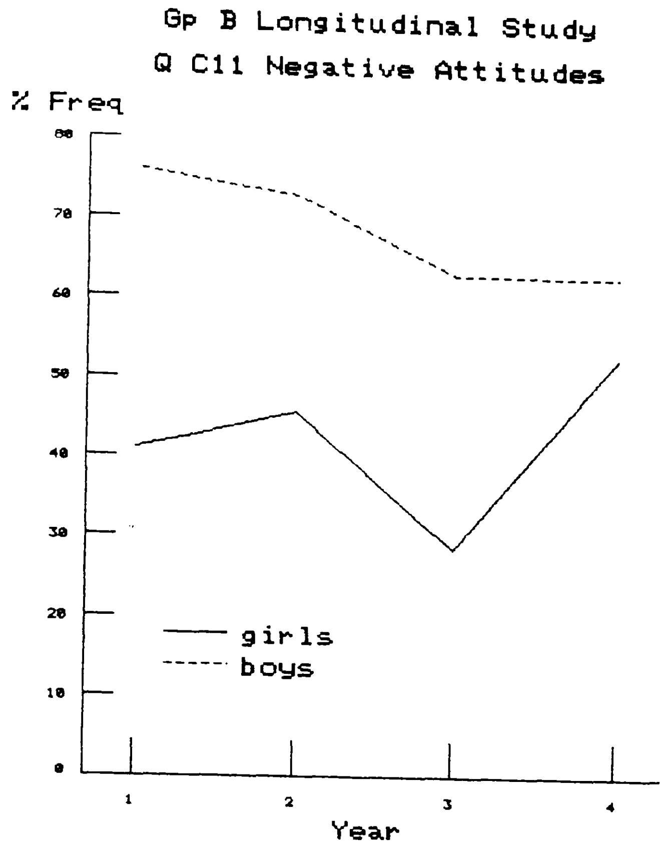


Graph 4.10

Question C8 "Boys & Girls are Equally Good" (Graph 4.10)

First year boys and girls show no significant differences, all the other years do. Third and fourth years (0.1% level) show more significant differences than second year (1.0% level). Once again girls' attitudes in all years are similar and positive, while boys' attitudes are more diverse and not so positive.

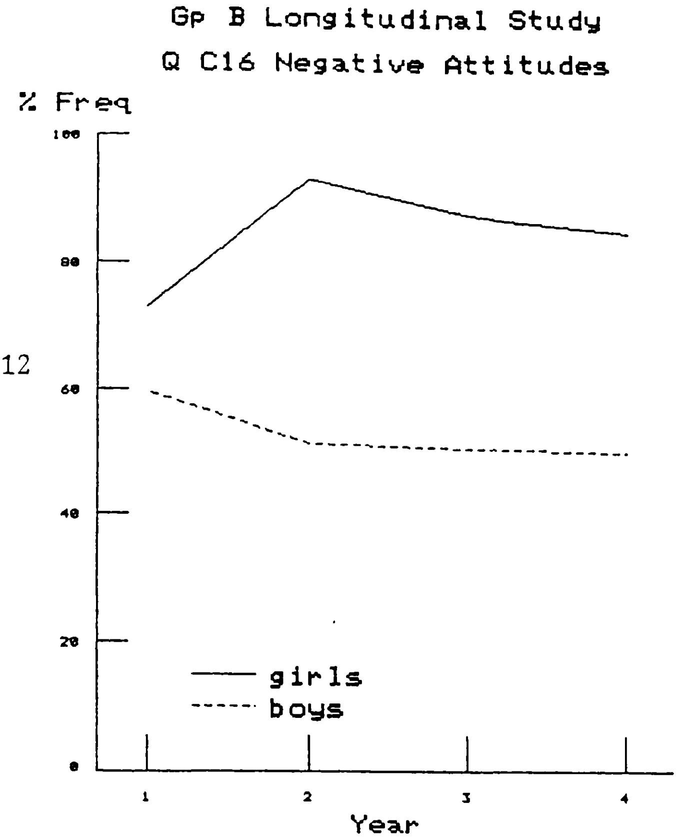
Graph 4.11



Question C11 "Easy for Girls" (Graph 4.11)
All years show significant differences between girls and boys. Boys in all years show more consistently negative (disagree + strongly disagree) attitudes than girls.

Over the four years, the negative attitudes show a slight decline in the boys. The girls show less consistent attitudes over the four years. In all years, the girls have less negative attitudes towards the statement that "Computers are Easy for Girls".

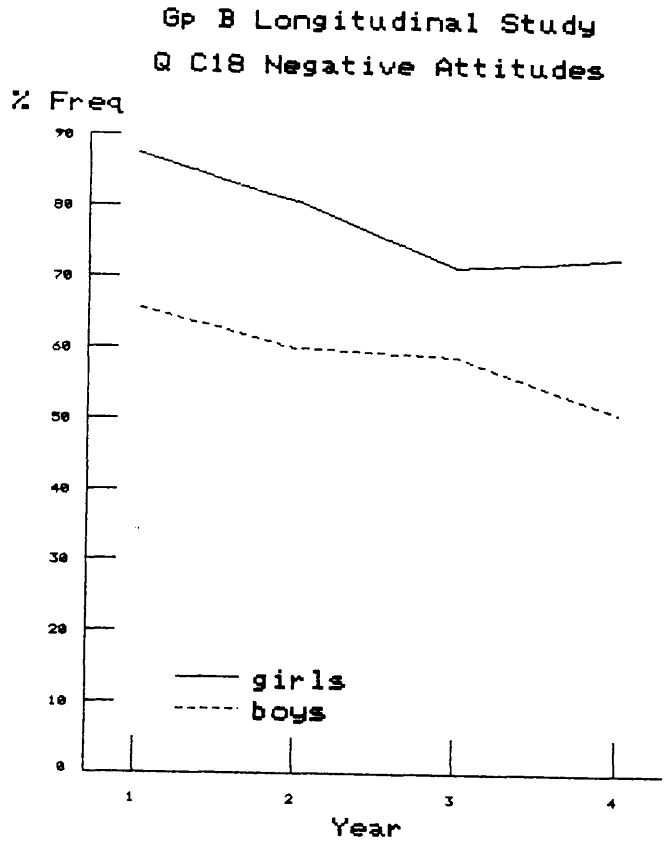
Graph 4.12



Question C16 "Boys Better" (Graph 4.12)

Again, as in the previous question (C11), boys show similar attitudes in all years and girls show a greater spread of opinion. Both boys and girls disagree that boys are better. Girls in all years have stronger negative attitudes than the boys.

Graph 4.13



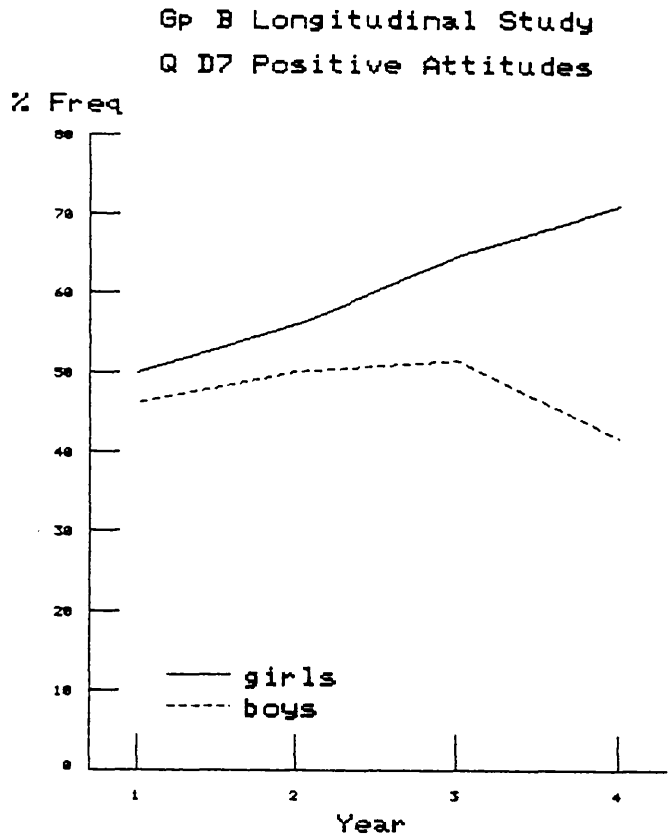
Question C18 "Sitting Back when Working with a Member of the Opposite Sex" (Graph 4.13)

Only first year boys and girls show any significant differences (1% level). Girls in all years show a less positive and more negative (strongly disagree end of attitude scale) attitudes to sitting back when working with a boy. Boys show less differences from first to fourth year than the girls, but although the trend is downwards there is not an enormous difference in attitude between S1 and S4.

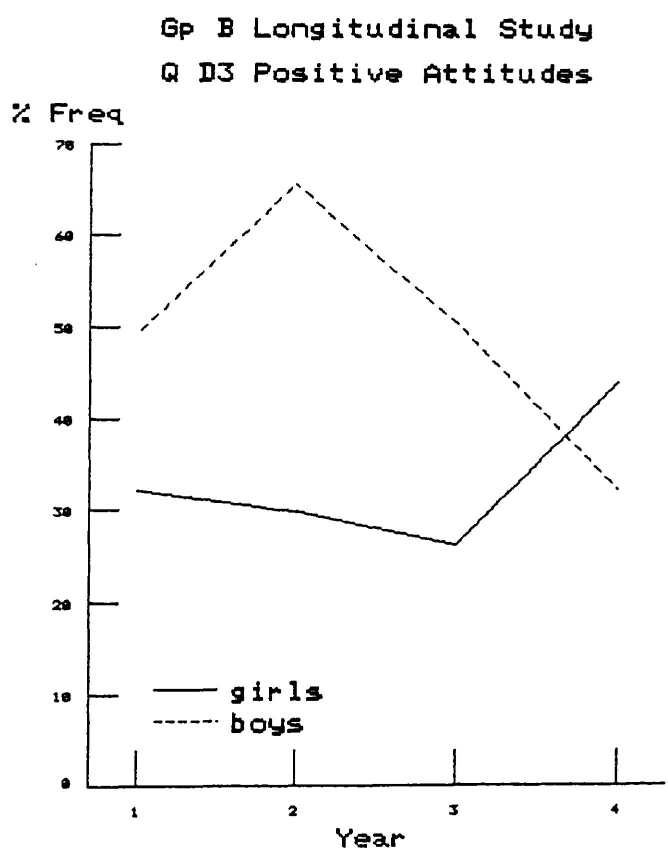
Question D7 "Useless/Useful for Girls" (Graph 4.14)
All years show positive attitudes. The only significant difference is between fourth year girls and boys (0.1% level). Girls feel more positively that computers are useful for girls.

Question D3 "Useful/Useless for Boys" (Graph 4.15)
There are significant differences between second (0.1% level) and third year (1% level) girls and boys. Over the four years boys and girls show very different trends in their responses to this question. Boys have more positive attitudes than girls in years one, two and three. In fourth year, these attitudes become less positive than those of the girls.

Graph 4.14



Graph 4.15



4.6 Summary - Longitudinal Study

In general, there is a lowering of expectation of use from first to fourth year, but the attitudes of the majority of pupils in all years remain in the positive and neutral sectors of the scale. No attitude to any of the questions remained absolutely constant. Some questions showed very similar trends of responses in all years and in both boys and girls, eg: C15 "Only Clever People can Learn from a Computer".

One of the attributes of the computer is its ability to individualise learning. There is no overwhelming evidence from the attitude survey that pupils favour this method of use. Pupils in all years like to play games on the computer.

Boys and girls do not show the same attitudes to all questions. Change in attitudes are sometimes due to boys, sometimes due to girls and sometimes due to both boys and girls.

Boys and girls do have different views of their own and the opposite sexes' capabilities with an expectation of computers. In questions C11, C16, C18 and D7, boys seem to have more cohesive attitudes and show more similarities between years. Girls show a greater spread of attitudes in these questions. First year girls and boys show less diversity in attitude than other years, but in all years each sex sees itself in a better light than the opposite one.

4.7 Home Computer Use

The main body of the survey of secondary pupils was an investigation into their attitudes towards computers in schools. Work in school does not stand in isolation from the influences of both the primary school and the home. Obviously possession and use of a home computer will influence the attitudes of pupils within school.

The aims of the home computer survey were to investigate:

1 the level of use
2 the frequency of use
3 social groupings associated with use
4 the type of software used

Table 4.4

Home Computer Survey Questions

Answer these questions YES or NO.

F1 Do you have a computer at home? ....
if your answer is NO go to Q. F2
if your answer is YES go to Q. F3

F2 Do you use a computer owned by someone else? ....
if your answer is NO go to Q. F8
if your answer is YES go to Q. F3

F3 Do you use the computer:
every day? ....
2/3 times a week? ....
about 1/week? ....
about 1/month? ....
less than 1/month? ....

F4 Do you use the computer:
on your own? ....
with brother/sister? ....
with parents? ....
with friends? ....

F5 Do you play games on your computer? ....

F6 Do you use programs based on school work? ....

F7 Do you write your own programs? ....

The home computer surveys were very similar in both the pilot and main studies. The pilot study pupils were asked two other questions about the type of machine they had and whether they bought computing magazines. These questions were dropped in the later main study.

Home computer survey questions for pilot (Group A) study can be seen in Appendix.

4.8 Group A Home Computer Survey - Results/ Discussion

The survey shows that over half of the pupils who took part have a computer at home (Table 4.5). The pattern of ownership is similar in both first and third year pupils. If use with friends is included then about three-quarters of all pupils use a computer out of school. The results show slightly more usage in first year than in third year.

Table 4.5

Home Computer Usage - % of Total Group

	First Year			Third Year		
	Total	Boys	Girls	Total	Boys	Girls
n	146	73	73	61	28	33
Own Home Computers	62%	75%	48%	57%	79%	39%
Use Friend's	19%	18%	21%	16%	11%	21%
Total Use	81%	93%	69%	74%	89%	61%

Over 70% of pupils use a computer at home at least once a week. They use the computer either on their own or with friends. About one third use the computer with a sibling and one fifth with their parents (Table 4.6).

Table 4.6

Home Computer Usage - Results Shown as % of Users

Use of Computer:	First Year Total	First Year Boys	First Year Girls	Third Year Total	Third Year Boys	Third Year Girls
Daily	9	15	0	20	28	10
2/3 per week	40	46	32	33	40	25
1 per week	23	27	18	27	24	30
1 per month	17	7	30	16	4	30
less than 1/month	11	4	20	11	8	15
own	63	68	56	67	72	60
with sibling	33	29	38	36	20	55
with parents	20	18	22	24	20	30
with friends	59	63	52	71	76	65

The predominant use for home computers is for playing games. Less than one fifth of pupils do school work and only 33% of first year program using their own computer, although this rises to 42% in third year (Table 4.7).

Table 4.7

Type of Program Used - Results as % of Users

Use of Computer:	First Year Total	First Year Boys	First Year Girls	Third Year Total	Third Year Boys	Third Year Girls
Games	93	88	98	100	100	100
Schoolwork	16	9	26	13	8	20
Program	33	38	26	42	60	20

A large number of pupils displayed interest beyond using the machine by buying magazines or books dealing with computing. In both first and third years, more boys have home computers than girls and in both years girls are more likely to use them with friends (Table 4.5). This could reflect the more social nature of girls or the fact that they have fewer machines so must share with friends if they are to have access.

The fact that more boys have computers may reflect the interests and prejudices of their parents, not those of the pupils. Parents may feel that it is more important for boys to have a computer than for girls. The survey does not indicate whether girls who have a home computer also share it with a brother.

Another survey carried out by Glyn-Jones (51) indicated that homes with boys are more likely to contain a home computer. Boys who have home computers certainly use them more frequently than the girls (Table 4.6). Apart from playing games, boys are more likely to program than girls. Girls are more likely than boys to use commercial programs based on school work (Table 4.7).

4.9 Group B - Home Computer Survey

Group B, surveyed a year later than Group A, showed similar computer ownership patterns in first and third years (Table 4.8). In both years, boys had more home computers than girls, the difference being greater in third year.

Table 4.8

Home Computer Usage - % of Total Group

	First Year			Third Year		
	Total	Boys	Girls	Total	Boys	Girls
n	122	67	55	155	97	58
Own Home Computers	59%	63%	55%	65%	74%	50%
Use Friend's	16%	18%	13%	14%	13%	14%
Total Use	75%	81%	68%	79%	87%	64%

First year pupils use the computer more often, 75% of first years use their computer at least once a week, while only 60% of third year do (Table 4.9). If usage of less than once a month is considered as not using the machine, then 10% of those who have a home computer do not use it in first year, in third year this figure rises to 25%. This would seem to reflect a general decline in use from first to third year. In both years over 50% of pupils (boys and girls) used the computer on their own. A large % of pupils also use the computer with their friends (36% in S3 and 47% in S1). In this group, slightly more girls used the computer on their own.

Table 4.9

Home Computer Usage - Results Shown as % of Users

	First Year			Third Year		
Use of Computer:	Total	Boys	Girls	Total	Boys	Girls
Daily	13	19	5	14	19	3
2/3 per week	40	41	39	24	25	22
1 per week	22	19	27	22	20	27
1 per month	13	9	19	11	11	14
less than 1/month	10	9	11	25	21	35
own	54	52	57	58	56	62
with sibling	38	31	49	23	20	30
with parents	14	13	16	10	5	22
with friends	47	50	43	36	36	35

Nearly all the pupils in both years played games on their computer (Table 4.10). In first year more pupils were likely to use programs based on school work. In both years, girls were more likely to use this type of program. In first year, both boys and girls programmed their computer, but in third year boys were far more likely to program.

Table 4.10

Type of Program Used - Results as % of Users

Use of Computer:	First Year			Third Year		
	Total	Boys	Girls	Total	Boys	Girls
Games	97	94	100	93	89	100
Schoolwork	24	22	27	16	12	27
Program	30	28	32	36	40	27

4.10 Summary of Both Home Computer Surveys (Group A & B)

About 60% of all the pupils surveyed have a home computer, and of those who do not many use a friends. In all the year groups, more boys own computers than girls; whether this reflects pupils' or parents' expectations is uncertain. At least 60% of the pupils who have access to a machine use it at least once a week, either on their own or with friends.

The major use of all home computers is to play games, this probably reflects pupils' interests but many home computers are only games' machines and will not run other types of software or are not programmable. Some machines, eg: BBC series, will run a range of software and can be programmed. Only a small number of pupils either use other software based on school work or program their machines. Girls are more likely to use school work programs and boys to program, especially in third year. This is also reflected by the lack of girls on computer studies courses (Section 1.9).

Results in both groups are similar for first years, but third years in Group A show greater enthusiasm for using their home computers than Group B. It must be remembered that Group A third year were only part of the total year group and this may have influenced the results.

When trying to link home and school computer use, there are a number of difficulties. The major of which is how the machines are viewed by the pupils. Many home computers are merely seen as toys and bear little resemblance to the hardware found in schools. If, as the survey shows, expectation of school use is similar to home, ie: games, then pupils will be sadly disappointed. Even the small numbers of games-type programs used in school are often inferior, with poorer graphics and less sophistication. Other school software (non-games type) is also less sophisticated, with poorer graphics and slow response times.

Pupils who have home computers use them a lot and so they will therefore be disappointed at the comparative lack of use in school. Pupils obviously enjoy and have great expectations of computers if their home experience is anything to go by. This enjoyment and enthusiasm must surely be harnessed so that computers in school can be used to their full potential.

4.11 Main Study - Overall Summary

Group B was the main study investigating pupil attitudes towards computers and their use in school. The survey set out to investigate the following hypotheses:

Pupils find using computers in school exciting, interesting and enjoyable;

Pupils think computers are important and time well spent;

Pupils use computers in school;

Pupils like to use a computer because it individualises their learning;

Pupils like to play games on the computer;

Pupils think that using a computer in school will help their job opportunities;

Girls and boys have similar attitudes to computers.

In Group B, third year pupils were also asked questions about frequency of computer use in the classroom. When investigating pupils' attitudes to computer classroom use, any interpretation of the results must be affected by the low level of use within the classroom. This effect was unforeseen by the researcher who thought that there would be, by this time, significant computer use in the classroom. Table 4.11 shows the frequency of use in the third year pupils who were surveyed.

Table 4.11

Classroom Use Expressed as % of Pupils in Year

	Total (n = 155)	Girls (n = 58)	Boys (n = 97)
used 2-3/week	6	0	9
used 1/week	5	5	4
used 1/month	7	9	6
used less than 1/month	41	31	46
never used	41	55	35

Table 4.12

Type of Use in Classroom Expressed as % of Total Year Group

	Total (n = 155)	Girls (n = 58)	Boys (n = 97)
pupil use only	15	12	16
teacher use only	21	19	22
pupil + teacher	17	12	21

Table 4.11 only shows the results from one year group (S3) and includes fourteen boys who did Computer Studies. It would appear that over 80% of the year group never used a computer or used it less than once a month. Not all pupils who had used the computer responded to the question, but only 15% of use was by pupils on their own and 21% by teacher demonstration (Table 4.12). Boys appeared to use the computer more often but this might be a reflection of the usage in the Computer Studies course not general classroom use. Fife-Schaw (50) in her study reported that 58% of pupils said they had never used the

school computer this figure rose to 80% of pupils if less than monthly use was included. Also that females were less likely to use school computers than males.

Pupils enter secondary school with an initial excitement and anticipation about computers and their use in school. This initial enthusiasm is followed by a general decline in attitudes which do, for the most part, stay in the positive and neutral sectors of the attitude scale. Hadden's (61) survey of pupils' attitudes to Science show a similar decline.

Girls and boys show a varied response to a wide variety of questions, both generally about computers and specifically about boys and girls use of them. In general, changes in attitudes occur earlier in girls than boys, but this is not always the case. Each sex has a higher opinion of its own sex, this is more marked in the boys than the girls. Kelly <u>et al</u> (68) study of attitudes to science also showed that boys and girls valued their own sex and despised the other. Girls and boys contribute to the changes in attitudes in different ways, therefore it is important to take this into account when designing any teaching programme using computers.

The predominant use of computers outside school is as a games machine. More boys have home computers than girls. Fife-Schaw (50) in her survey also found the predominance of games use, more so by boys than girls. Home computer use does not reflect use within school. These two types of use may not, in fact, be connected by the majority of pupils who only see their computer as a games machine with no other capabilities.

Pupils would like to use the computer on their own and not watch the teacher demonstrate. At the moment, there does not seem to be any indications that pupils prefer the computer to the teacher. There seems to be no strong trends amongst pupils concerning the benefit of the computer individualising learning. If the computer is to be an effective learning tool within the classroom, then pupils must have positive attitudes. School use must also take into account the differences between boys and girls.

What of the future? Since the initial pilot study in 1986 and the final main study survey in 1988, more hardware has entered the school. Teachers have gained more expertise and confidence. Standard grades, with their emphasis on new methods, have been introduced. It would be very interesting to see if these advances have led to more classroom use of computers and less of a decline in pupil attitudes towards them.

APPENDIX IV

LONGITUDINAL STUDY - GROUP B

Tables

IVA.1	(q C1-C19)	X^2 Comparison of Year Groups
IVA.2	(q D1-D9)	S1/S2, S1/S3, S2/S4, S3/S4
IVA.3	(q C1-C19)	X^2 Comparison of Year Groups - Girls
IVA.4	(q D1-D9)	X^2 Comparison of Year Groups - Girls
IVA.5	(q C1-C19)	X^2 Comparison of Year Groups - Boys
IVA.6	(q D1-D9)	X^2 Comparison of Year Groups - Boys
IVA.7	(q C1-C19)	X^2 G/B Comparison within Year
IVA.8	(q D1-D9)	X^2 G/B Comparison within Year

Table IVA.1

Longitudinal Study Group B
Comparison of Year Groups

Chi-squared Test

	S1/S2	S1/S3	S2/S4	S3/S4
C1 Computer Exciting	** 10.9 S2-	*** 77.9 S3-	*** 55.6 S4-	2.1
C2 Use a Lot	2.9	11.1 S3-	0.9	2.6
C3 Teacher Use	* 6.5 S2-	3.8	1.2	0.1
C4 Play Games	** 13.1 S2+	*** 14.4 S3+	** 9.8 S4-	8.0
C5 Boring Subject Enjoyable	3.1	1.8	1.4	6.1
C6 Individual Use	5.9	** 11.6 S3+	1.7	1.3
C7 Know Programming	4.2	2.7	5.4	8.9
C8 Boy/Girl Comparison	3.2	1.0	3.9	1.7
C9 Teacher to Explain	1.8	2.3	2.5	3.6
C10 Work at Own Speed	6.1	1.1	** 15.3 S4-	0.0

Table IVA.1 cont...

Chi-squared Test

	S1/S2	S1/S3	S2/S4	S3/S4
C11 Easy for Girls	5.6	* 8.3 S3+	1.2	0.6
C12 Help for Job	4.7	3.5	4.6	3.5
C13 Easier to Answer	** 13.5 S2+	7.2	6.8	3.0
C14 Use in Lesson	0.8	*** 14.6 S3-	** 9.9 S4-	2.0
C15 Need to be Clever	0.5	0.4	3.3	4.2
C16 Boys Better	4.2	* 8.2 S3-	1.3	3.8
C17 Good at Arithmetic	2.0	* 8.9 S3-	* 8.2 S4-	0.3
C18 Sit Back When Work with Opp. Sex	2.8	* 8.8 S3+	2.9	1.4
C19 Mark Work	4.3	*** 21.0 S3+	** 14.0 S4+	3.2

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference 1 → 5 = - → disagree
5 → 1 = + → agree

Table IVA.2

Longitudinal Study Group B
Comparison of Year Groups

Chi-squared Test

		S1/S2	S1/S3	S3/S4	S2/S4
D1	Exciting/ Boring	6.4	*** 32.0 S3-	4.1	*** 24.5 S4-
D2	Interesting/ Dull	0.8	3.1	*** 16.5 S4-	*** 24.5 S4-
D3	Useful/Usless for Boys	4.2	0.8	4.2	4.8
D4	Frightening /Friendly	8.2	0.9	2.2	*** 13.8 S4-
D5	Enjoyable/ Hateful	0.4	0.6	*** 20.4 S4-	*** 17.8 S4-
D6	Unimportant /Important	2.5	6.3	* 11.0	6.9
D7	Girls, Useful/ Useless	0.6	2.3	4.2	4.8
D8	Time Well Spent/ Waste of Time	1.7	*** 13.9 S3-	** 11.3 S4-	*** 23.3 S4-
D9	Difficult/ Easy	2.3	* 11.2 S3+	** 15.5 S4+	2.5

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference 6 → 1 = +
1 → 6 = -

Table IVA.3

Longitudinal Study Group B
Comparison of Year Groups - Girls Only

Chi-squared Test

	S1/S2	S1/S3	S2/S4	S3/S4
C1 Computer Exciting	6.3	*** 26.1 S3-	** 8.9 S4-	0.0
C2 Use a Lot	1.2	** 9.4 S3-	5.3	8.9
C3 Teacher Use	1.5	0.9	0.1	0.3
C4 Play Games	3.9	** 8.1 S3+	5.2	5.5
C5 Boring Subject Enjoyable	0.9	0.4	0.6	0.2
C6 Individual Use	5.8	5.1	2.9	3.9
C7 Know Programming	2.8	5.0	6.2	3.3
C8 Boy/Girl Comparison	0.2	3.4	2.5	0.4
C9 Teacher to Explain	2.7	3.3	0.8	0.9
C10 Work at Own Speed	4.6	0.2	5.0	0.1

Table IVA.3 cont...

Chi-squared Test

	S1/S2	S1/S3	S2/S4	S3/S4
C11 Easy for Girls	1.6	4.1	1.2	4.7
C12 Help for Job	4.6	0.7	1.4	4.4
C13 Easier to Answer	5.7	4.9	2.8	1.9
C14 Use in Lesson	4.7	** 12.7 S3-	0.0	2.5
C15 Need to be Clever	0.4	0.0	1.5	0.1
C16 Boys Better	3.9	5.7	0.0	0.3
C17 Good at Arithmetic	0.9	0.7	2.4	0.0
C18 Sit Back When Work with Opp. Sex	1.2	5.7	1.0	0.7
C19 Mark Work	0.2	*** 17.5 S3-	8.0	2.3

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference 1 → 5 = - → disagree
5 → 1 = + → agree

Table IVA.4

Longitudinal Study Group B
Comparison of Year Groups - Girls

Chi-squared Test

		S1/S2	S1/S3	S3/S4	S2/S4
D1	Exciting/ Boring	6.7	*** 14.8 S3-	1.2	2.6
D2	Interesting/ Dull	0.7	0.7	6.9	2.7
D3	Useful/Usless for Boys	2.9	2.3	3.1	5.7
D4	Frightening /Friendly	3.3	0.4	1.5	1.1
D5	Enjoyable/ Hateful	0.0	0.0	4.4	3.4
D6	Unimportant /Important	1.2	3.1	0.2	4.9
D7	Girls, Useful/ Useless	3.3	4.3	3.4	1.2
D8	Time Well Spent/ Waste of Time	2.6	** 11.9 S3-	0.2	3.0
D9	Difficult/ Easy	3.7	4.7	5.1	7.1

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference $6 \rightarrow 1$ = +
$1 \rightarrow 6$ = -

Table IVA.5

Longitudinal Study Group B
Comparison of Year Groups - Boys

Chi-squared Test

		S1/S2	S1/S3	S2/S4	S3/S4
C1	Computer Exciting	3.3	*** 47.9 S3-	*** 47.3 S4-	10.3
C2	Use a Lot	2.0	3.3	0.5	0.4
C3	Teacher Use	5.1	1.6	4.8	1.3
C4	Play Games	** 10.2 S2+	4.9	* 10.7 S4-	6.7
C5	Boring Subject Enjoyable	** 10.1 S2+	5.0	0.5	7.8
C6	Individual Use	1.0	3.7	1.9	1.6
C7	Know Programming	5.1	2.6	2.4	7.1
C8	Boy/Girl Comparison	4.3	0.1	3.6	1.7
C9	Teacher to Explain	4.2	0.6	** 11.7	3.5
C10	Work at Own Speed	2.6	1.4	** 11.4 S4-	0.3

Table IVA.5 cont...

Chi-squared Test

	S1/S2	S1/S3	S2/S4	S3/S4
C11 Easy for Girls	4.9	6.7	1.8	0.1
C12 Help for Job	1.2	4.8	** 10.7 S4-	4.3
C13 Easier to Answer	8.6	3.1	5.5	3.7
C14 Use in Lesson	0.9	4.6	** 18.2 S4-	5.9
C15 Need to be Clever	0.0	0.9	1.1	4.3
C16 Boys Better	4.6	9.3	0.3	4.4
C17 Good at Arithmetic	3.5	** 13.6 S3-	5.6	0.3
C18 Sit Back When Work with Opp. Sex	2.1	4.3	1.3	1.4
C19 Mark Work	7.6	7.7	7.1	3.1

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference 1 → 5 = - → disagree
5 → 1 = + → agree

Table IVA.6

Longitudinal Study Group B
Comparison of Year Groups - Boys

Chi-squared Test

		S1/S2	S1/S3	S3/S4	S2/S4
D1	Exciting/ Boring	3.6	*** 21.1 S3-	*** 29.1 S4-	** 9.3 S4-
D2	Interesting/ Dull	0.4	2.4	*** 15.2 S4-	*** 11.2 S4-
D3	Useful/Usless for Boys	3.9	0.0	*** 17.9 S4-	6.7
D4	Frightening /Friendly	8.2	2.6	*** 16.1 S4+	8.7
D5	Enjoyable/ Hateful	0.9	0.2	** 13.4 S4-	*** 18.9 S4-
D6	Unimportant /Important	2.1	5.5	** 11.1 S4+	*** 16.4 S4+
D7	Girls, Useful/ Useless	1.8	3.7	** 13.0 S4+	5.5
D8	Time Well Spent/ Waste of Time	1.5	4.3	*** 33.0 S4-	** 13.1 S4-
D9	Difficult/ Easy	2.2	7.0	0.1	8.8

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference $6 \rightarrow 1$ = +
$1 \rightarrow 6$ = -

Table IVA.7

Longitudinal Study Group B
Comparison of Girl/Boy

Chi-squared Test

		S1/S2	S1/S3	S2/S4	S3/S4
C1	Computer Exciting	0.4	5.3	0.0	4.4
C2	Use a Lot	0.7	2.8	2.9	4.8
C3	Teacher Use	2.8	6.6	3.7	0.0
C4	Play Games	4.3	** 10.3 B+ G-	0.4	1.0
C5	Boring Subject Enjoyable	5.1	6.1	0.3	6.1
C6	Individual Use	3.6	1.1	2.2	5.5
C7	Know Programming	3.5	7.9	0.9	1.5
C8	Boy/Girl Comparison	5.7	** 15.4 B- G+	*** 17.5 G+ B-	*** 15.7 B- G+
C9	Teacher to Explain	2.6	5.0	0.0	1.2
C10	Work at Own Speed	1.2	3.0	0.5	0.0

Table IVA.7 cont...

PART 1 - CHI SQUARED TEST

	S1/S2	S1/S3	S2/S4	S3/S4
C11 Easy for Girls	*** 17.3 G+ B-	** 12.9 B- G+	*** 17.7 G+ B-	*** 14.5 B- G+
C12 Help for Job	1.8	6.3	0.9	4.1
C13 Easier to Answer	3.4	0.6	1.5	1.5
C14 Use in Lesson	1.8	6.7	2.9	5.5
C15 Need to be Clever	0.7	1.9	0.0	2.2
C16 Boys Better	*** 10.2 G- B+	*** 19.9 G- B+	*** 24.5 G- B+	*** 24.7 G- B+
C17 Good at Arithmetic	3.3	0.5	3.1	2.3
C18 Sit Back When Work with Opp. Sex	** 9.2 G- B+	6.4	2.7	8.2
C19 Mark Work	2.6	2.3	2.1	1.5

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference 1 → 5 = - → disagree
5 → 1 = + → agree

Table IVA.8

Longitudinal Study Group B
Comparison of Girl/Boy

Chi-squared Test

		S1/S2	S1/S3	S3/S4	S2/S4
D1	Exciting/ Boring	3.5	3.5	3.7	5.5
D2	Interesting/ Dull	0.1	1.4	0.2	* 8.3 G+ B-
D3	Useful/Usless for Boys	4.1	*** 14.7 B+ G-	** 7.6 G- B+	9.1
D4	Frightening /Friendly	0.3	7.4	** 7.3 G+ B-	2.4
D5	Enjoyable/ Hateful	1.0	0.1	0.2	2.8
D6	Unimportant /Important	4.8	2.6	3.1	8.5
D7	Girls, Useful/ Useless	1.2	9.7	8.7	*** 18.1 G- B+
D8	Time Well Spent/ Waste of Time	0.2	3.5	2.6	** 15.9 G+ B-
D9	Difficult/ Easy	2.6	7.6	1.0	2.2

Level of Significance *** = .1%
** = 1%
* = 2%

Direction of Attitude Difference 6 > 1 = +
1 > 6 = -

CHAPTER 5

"KEY PROBLEM"

DESIGNING A COMPUTER PROGRAM AND ANALYSIS OF
SKILLS NEED TO MAKE A BIOLOGICAL KEY.

5.1 Introduction

Many people claim that computers help pupils to learn, that they will aid learning, help motivation and aid understanding (1, 7, 13). The most important factor when thinking of using a computer in the classroom is to choose something that the computer can make a unique contribution towards. There is no point in using the computer to do a task that can be done better by another method or with other resources. At the time of this research, the available software was limited and mostly of the "Drill and Practice" type.

By this time, the survey of pupil attitudes had been carried out with the pilot group and the main study had just begun. The pilot study had shown a decrease of initially very positive attitudes. In spite of the decline, the majority of pupil attitudes to computers had stayed in the positive and neutral areas of the scale. These were also linked to a small amount of school computer use by pupils.

With all this in mind, the researcher set out to identify a topic within the secondary school Biology syllabi which could benefit from the production of some relevant software.

5.2 Areas of Difficulty in Biology

Biology contains a number of areas which cause pupils difficulties. Johnstone and Mahmound (70) investigated senior school pupils and first year university students to produce a long list of topics which gave difficulty to pupils. Arnold & Simpson (71, 72, 73) have studied in depth the problems associated with the Ordinary Grade topics of Photosynthesis and Osmosis. There are many other areas which can still be identified, including the construction of Biological Keys. The making of keys is a very different exercise to using keys. Their use seems to cause little difficulty, even to junior pupils. Keys are used and made in S1 as part of the section of work on Living Things and in the Ordinary and Standard Grade Biology examinations. The new Standard Grade Biology Syllabus (1) contains problem solving skills such as key making:

"Candidates should be able to demonstrate their abilities in problem solving by handling and processing information".

"At General level the candidate should be able to present information as simple branched (family tree) keys".

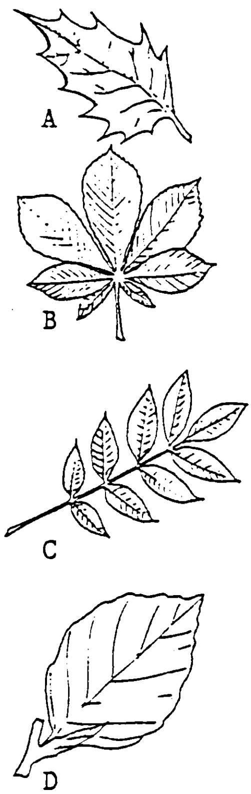
"At Credit level the candidate should be able to present information as paired statement keys".

In both years groups a large number of pupils have difficulties in constructing both Family Tree and Paired Statement types of keys. One of the aims of this piece of research was to aid the learning of key construction using a computer program.

5.3 Biological Keys

A biological key is a method of classifying and identifying living organisms. It is based on characteristics which are of significance in an organism. These characteristics are used in a system on the basis of the presence or absence of a succession of these characteristics. Usually keys are dichotomous, ie: at each step there is a choice between two possibilities. In schools the "Key" is found in two basic forms. The branched or family tree type and the paired statement type. The usual method of key use is to name an organism from a living specimen, picture or drawing. Pupils are also asked to make their own key from either living materials, pictures, drawings or tables of information.

Figure 5.1 shows both types of key used to identify the leaves from four common trees.



branching tree

leaves
- single leaf
  - prickles — HOLLY
  - no prickles — BEECH
- leaflets
  - fan shape — HORSE CHESTNUT
  - not fan shape — ASH

paired statement

1.	single leaf: leaflets:	go to 2 go to 3
2.	prickles: no prickles:	Holly Beech
3.	fan shape: not fan shape:	Horse chestnut Ash

5.4 Writing the Computer Program

The construction of biological keys can be divided into two major tasks:

1 The collection of a suitable number of biological characteristics or attributes;

2 Presenting this information in either a family tree or paired statement form (see Fig 5.1).

At this point, the researcher felt that the major pupil difficulties lay in task 2 and that the computer program could contribute most in this area. The aims of the program were:

1 to break down the task into simple steps;
2 to develop a strategy which pupils could apply to the making of any key;
3 to allow pupils to learn at their own pace;
4 to give pupils appropriate remediation.

Since the program was to develop a strategy for task 2, the starting point of the program would be a table of information which would be changed into a suitable key.

The program also had to be made within the constraints of the non-professional programming and the hardware available.

Part 1 - The Changing of a Table of Information into a Family Tree Key.

The program started by using a worked example. The biological information from which the key was to be drawn was presented as an attribute table.

Table of Attributes

Name of Bird	Beak	Webbed Feet	Stripes
Snipe	Straight	No	Yes
Whimbrel	Curved	No	Yes
Avocet	Curved	Yes	No
Knot	Straight	No	No

The information in the table was to be redrawn on the screen as a family tree. The program was to be designed to allow the pupil the facility of moving backwards and forwards between frames.

It was felt that the example might be too complex since it was biological and that the names and characteristics of unknown birds might introduce unnecessary "noise". It was therefore decided that the initial worked example would be better done using more familiar geometric shapes rather than organisms (details of the frames drawn by Prof A Smith are to be found in Appendix VA).

The program was to include worked examples with both shapes and organisms. After viewing the worked examples, pupils would be asked to complete some test items. The following are examples of the format of possible test items for the pupil to complete after doing the worked examples.

1 computer does the first part of the key, the pupil completes.
2 computer presents a completed key and the pupil has to indicate whether it is right or wrong.

At this stage, the form of the program would be worked examples using:

1 Geometric shapes.
2 Green men (an intermediate stage to help with the transition to biological items).
3 Organisms.

To complete the program optional pre-test and post tests were to be made. The post test would also be used to diagnose particular difficulties. This would allow remediation to be carried out by a further computer program or by the teacher.

Part 2 - The Making of an Attribute Table.

Having produced a suitable format for the construction of a key from a table of information, the next step was to make a table of attributes from a collection of objects. The pupil would see a group of shapes and using a series of structured questions would make a yes/no table of attributes (for details of program frames see Appendix VB).

The form of the program would now be as follows:

1 Pre-test.
2a Making of attribute table using geometric shapes.
2b Making of family tree from attribute table.
3a Making of attribute table for little green men (an intermediate stage to help with the transition to biological items).
3b Making of a family tree type key.
4a Making of an attribute table using biological items.
4b Making a family tree.
5 Post test.

Part 3 - The Conversion of a Family Tree Key into a Paired Statement.

Further development of the stage from family tree to paired statement was felt to be necessary. This detailed examination resulted in the identification of a large number of steps: (see also Appendix VC)

1 letter statements A->
2 write them down in order
3 number pairs of statements
4 add GOTO
5 write in names of objects/organisms
6 remove letters

All three parts could now be combined to produce a piece of software suitable for use in the classroom.

5.5 Discussion

At this stage of the program design, a number of problems came to light. Screen space was very limited. Even with a small number of items, the screen was not big enough to draw more than a simple key. Each frame of the program allowed the processing of only one piece of information. This meant that a lot of frames had to be written to do even a fairly simple step. To convert a table of information about four geometric shapes, which differed by colour and shape, into a family tree key took seventeen frames. If the presentation of simple information caused such problems, how would the problem of using pictures or live organisms, with much more information, be overcome. Although the making of a family tree key and its conversion into a paired statement key needs a large number of frames a program could be made provided a small number of objects are used. Using pictures a table of attributes could be drawn up by the computer asking yes/no questions. The answers given by the pupils could be added into the table. Having completed a suitable table this could then be converted into a family tree key and then into a paired statement key or direct into a paired statement without the family tree stage.

The aim of preparing this computer program was to help pupils overcome difficulties they had with the making of biological keys. It would seem obvious from the analysis carried out so far that the making of a key involves far more processing than was previously thought. The detailed analysis necessary for the designing of the program gave considerable insight into the possible causes of the difficulties that pupils have with this topic.

Pupils need to be able, not only to select suitable biological attributes from a wide range of material but also to turn this information into the correct form. In view of this and the limitations of programmers and hardware, the computer program was abandoned at the design stage and analysis of the "Key Problem" became the focus of attention.

5.6 Further Analysis of the "Key Problem"

The investigation continued by carrying out a further analysis of the task "Making a Key". The investigation was divided into a number of sections, allowing different aspects of the problem to be examined.

Table 5.1

An Overall View of the "Making a Key" Studies

Time	**Project**	**Test Material**	**Pupils Used**
87-88	Pilot 1		
	"Key Problem"	Test 1	S1, S3 School A
			S1, S3 School B
			S1, S3 School C
88	Pilot 2		
	"What Pupils See"	Test 2	S2 School A
		Test 3 (HFT)	S1, S3 School A
		Test 4 (DBT)	S1, S3 School B
		Interviews	S1, S3 School C
88-89	Main Study	Tests 5a, 5b	S3 School 1
		Test 3	S3 School 2
		Test 6 (FIT)	S3 School 3
			S3 School 4
			S3 School 5

HFT - Hidden Figures Test measuring disembedding ability.
FIT - Figure Intersection Test and DBT - Digit Backwards Test, measuring working memory capacity (Appendix VF).

As a result of the design work on the computer program, it was already clear that the mechanics of key making required a large number of steps and might be more difficult than previously thought. Therefore the Pilot 1 test concentrated on the mechanics of key production rather than the identification of suitable attributes.

The aims of Pilot 1 were to investigate:

1 the ability of pupils to make a paired statement key from drawings, tables of information and family tree keys;

2 the ability of pupils to make a family tree key from tables of information;

3 the ability of pupils to choose and record suitable biological attributes from drawings;

4 the effect of the presentation of material, eg: drawings or tables on the ability of pupils to make a key;

5 the effect of different amounts of information on the ability of pupils to, make a key;

6 the effect of teaching strategy on the ability of pupils to complete a key.

5.7 Pupils Tested

In the school session 1987-1988, pupils from three local schools completed the test material. In the researcher's own school (School A) all first year science and third year Biology classes took part. The first year classes were divided into two groups, those who followed the existing course and those who followed a modified course. The modified course set out a specific teaching strategy and provided extra worksheets (see Appendix VC). The three first year classes following the modified course were taught by a chemist, a physicist and a biologist.

The remaining first year pupils followed the existing course based on the Heinneman worksheets (74).

In School A all the third year "O" Grade Biology classes followed the new teaching strategy and completed the extra worksheets.

Two other local six-year comprehensives were asked to provide first year science and third year biology pupils to complete the test material. In both these schools the first year course was based on Curriculum Paper No. 7 (75) using school produced worksheets. The emphasis being on using keys and the construction of family tree type keys. In the third year all pupils were taught to use and make both types of keys. In all, 338 first year and 171 third year pupils took part in Pilot 1.

Figure 5.2

Summary of Pupils Taking Part in Pilot 1 Study

School A	First Year	60
	First Year: Modified Course	30
	Third Year Biologists: Modified Course	73
School B	First Year	72
	Third Year Biologists	34
School C	First Year	176
	Third Year Biologists	64

5.8 Organisation of Test Material

Two tests were prepared because pupils could not do both questions 9a and 9b. Information given in question 9b would have enabled pupils to complete question 9a. Test 1a contained choosing attribute item (q 9a) and test 1b the identify and record item (q 9b). All other questions were common to both tests. The items were arranged so that the most difficult task, ie: choosing attributes, making paired statement key came first.

The tests were administered by the class teacher. First year pupils completed the test material after they had finished the section of work on Living Things. Third year pupils did the test material after they had completed the section of work on classification.

Both tests were marked according to a marking scheme (Appendix VD).

5.9 Modified Course

As a result of the computer program design exercise and in response to requests from non-biologists colleagues, a strategy for teaching keys was drawn up. In conjunction with this strategy, a set of pupil worksheets was also made (Appendix VC).

The work was divided into three sections:

1. choosing suitable attributes;
2. sorting/setting to allow the making of a family tree key;
3. the changing of a family tree into a paired statement key.

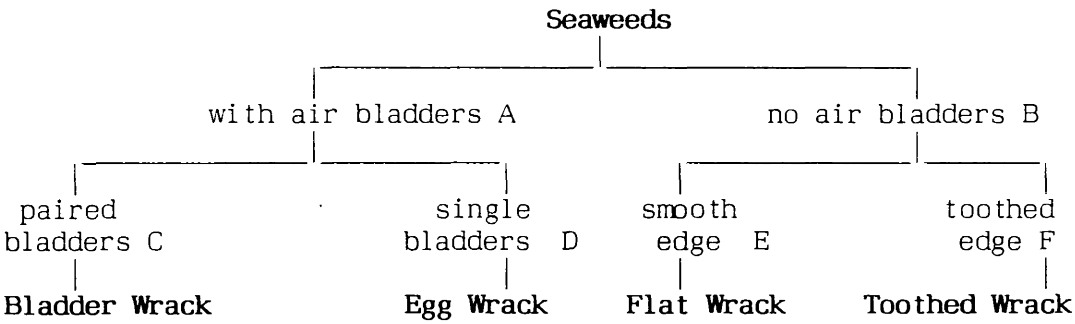
The new worksheets (Fig 5.3) were intended to supplement existing first year sheets (74).

Figure 5.3

Supplementary Worksheets for Modified S1 Course (part only) Showing Conversion of Family Tree Key into Paired Statement Key

5. Making a Paired Statement Key.

a) letter statements.



b) Write down the statements in order.

1 A ....

B ....

2 C ....

D ....

3 E ....

F ....

c) Add GOTO

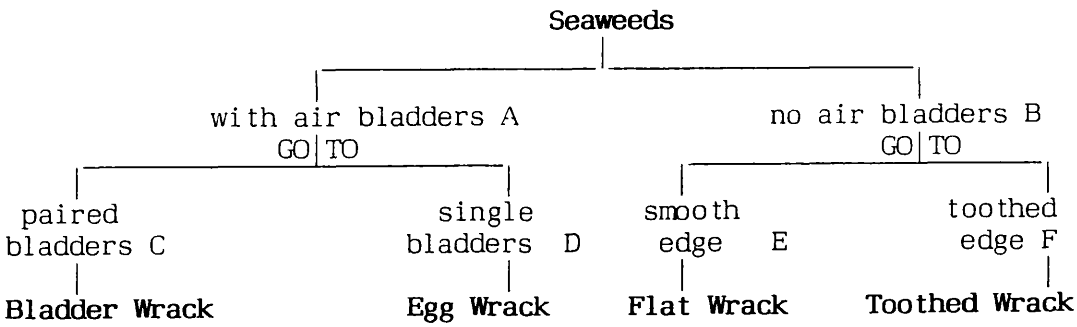


Figure 5.3 cont...

1	A	....	GO TO 2
	B	....	GO TO ....
2	C	....	
	D	....	
3	E	....	
	F	....	

d) Add names of seaweeds.

1	A	....	GO TO ....
	B	....	GO TO ....
2	C	....	Bladder Wrack
	D	....	....
3	E	....	....
	F	....	....

Finally rub out A-F.

5.10 Pilot 1: The Test Material (see Appendix VD)

Test was designed to begin by testing a pupils' ability to complete the whole task of selecting attributes and constructing a paired statement key. The items then became easier by either reducing the amount of information or by removing a step from the process. The final items looked at the selection of attributes. All the questions contained information which was biologically correct, so that a pupil with a knowledge say of wild flowers would not be confused by inaccurate information.

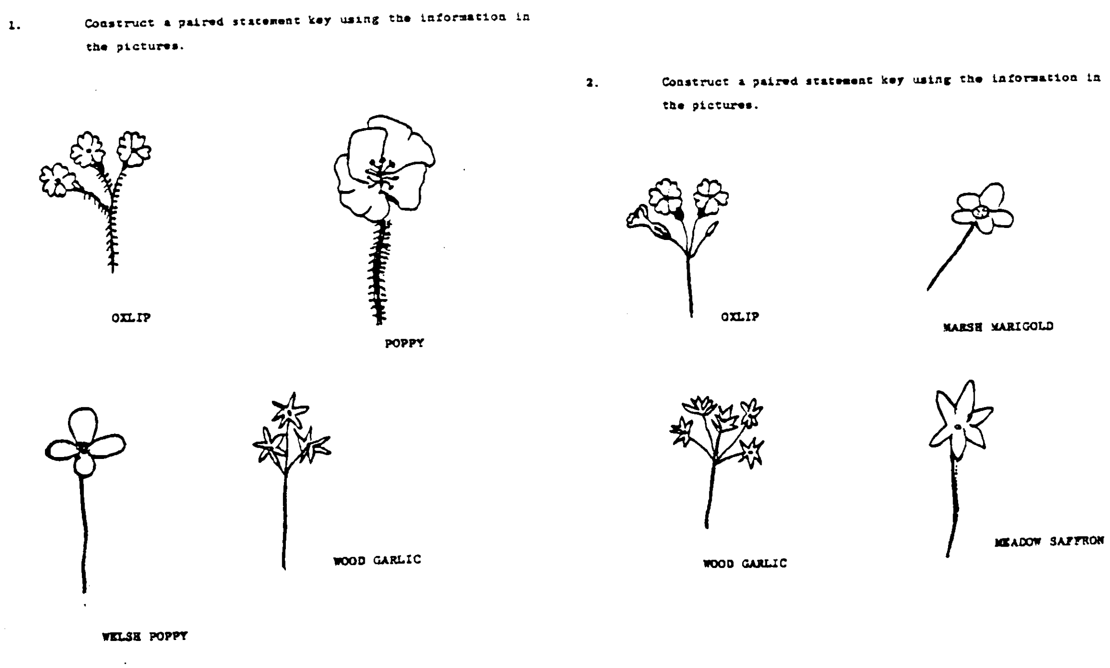
Q1 making a paired statement key from drawings, 4 sets of information.

Q2 making a paired statement key from drawings, 2 sets of information.

Questions 1 & 2 (Fig 5.4) asked pupils to make a paired statement key from line drawings of flowers. Question 1 tested all the processes, the choosing of the correct attributes and the construction of a paired statement key. It also gave pupils more information than they needed to complete the task. This type of question would be similar to the actual task a pupil would be expected to carry out after completing the section of work on keys. Question 2 contained less information, with two differences; the number of petals and the number of flowers between the drawings.

Figure 5.4

Test 1: Questions 1 & 2



Q3 making a paired statement key using a table of 2 sets or groups of information.

Q4 making a paired statement key using a table of 3 sets of information.

Q5 making a family tree key using a table of 2 sets of information.

Q6 making a family tree key using a table of 3 sets of information.

Questions 5 & 6 (Fig 5.5) used information about varieties of dogs, question 6 having one more set of information. Questions 3 & 4 (Fig 5.5) used information about pupils and other vertebrates, again the second of the pair of questions gave an additional set of information. In all four questions, the pupils were given a table of the necessary attributes so that the mechanics of making a family tree could be tested. The second question of each pair allowed the researcher to investigate the effect of giving pupils more information to process.

Figure 5.5

Test 1: Questions 3, 4, 5 & 6

3 Using the information in the table make a paired statement key.

Name	Boy/Girl	Hair Colour
John	Boy	Brown
Scott	Boy	Blonde
Kirsty	Girl	Blonde
Sara	Girl	Brown

4 Make a paired statement key from the information in the table.

Name	With Legs/ No Legs	Body Covering	With Fins/ No Fins
Horse	Legs	Hair	No Fins
Frog	Legs	Skin	No Fins
Adder	No Legs	Scales	No Fins
Goldfish	No Legs	Scales	Fins

5 Using the information in the table make a family tree type key.

Name	Length of Coat	Length of Legs
Greyhound	Short Coat	Long
Bulldog	Short Coat	Short
Alsatian	Long Coat	Long
Toy Poodle	Long Coat	Short

6 Construct a family tree type key from the information in the table.

Name	Length of Coat	Type of Ears	Length of Legs
Greyhound	Short Coat	Hang Down	Long
Bulldog	Short Coat	Hang Down	Short
Alsatian	Long Coat	Stand Up	Long
Retriever	Long Coat	Hang Down	Long

Q9a choosing suitable attributes.

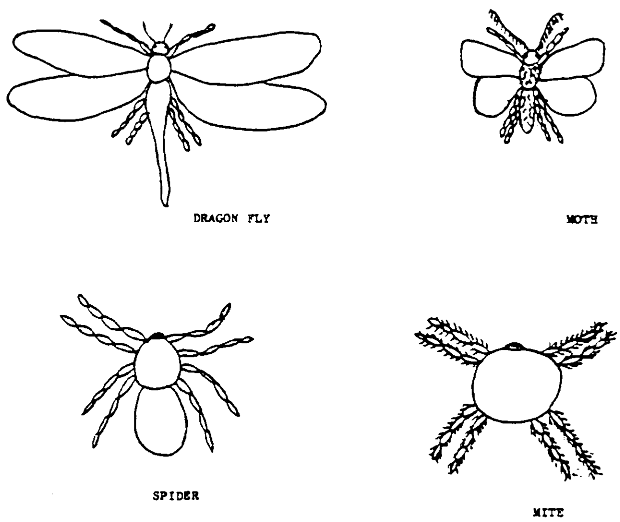
Q9b identification and recording of suitable attributes.

In question 9a (Fig 5.6) pupils were given line drawings of four common arthropods and asked to choose three characteristics which varied between the animals. The drawings were simplified so that as much extraneous information as possible was excluded. The animals were all shown as a similar size and the number of leg segments was kept the same. The drawings offered pupils four very obvious differences (number of legs, wings, hairiness, number of body parts).

Question 9b (Fig 5.6) used the same pictures but asked pupils to complete the table which already contained three suitable attributes.

Figure 5.6

Test 1: Questions 9a, 9b



9a. Look at the pictures, choose 3 things which vary (not the same) between the animals. Fill in the table below, writing down the names of the things you have chosen.

	Thing 1	Thing 2	Thing 3 ....
SPIDER			
MOTH			
DRAGONFLY			
MITE			

9b. Look at the pictures, using the properties listed fill in the table below.

	Number of Legs	With Wings/ No Wings	With Hair/ No Hair
SPIDER			
MOTH			
DRAGONFLY			
MITE			

Q7 (Fig 5.7) making a paired statement key from a family tree key, 2 sets of information.

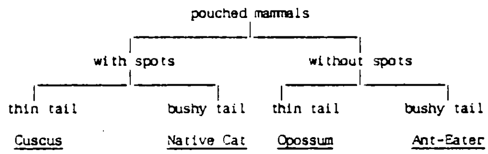
Q8 (Fig 5.7) making a paired statement key from a family tree key, 3 sets of information.

Paired statement keys can be taught by making a family tree key then converting it into a paired statement key. These four questions investigated this strategy which is often successful with pupils who have previously failed to make a paired statement key. As before, the first question of each pair contained less information than the second. The final two questions looked at the additional effect of making the family tree key asymmetric.

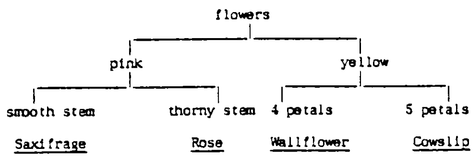
Figure 5.7

Test 1: Questions 7 & 8

7 The following is a tree key about 4 pouched mammals.



8 The following is a tree key about some common flowers.

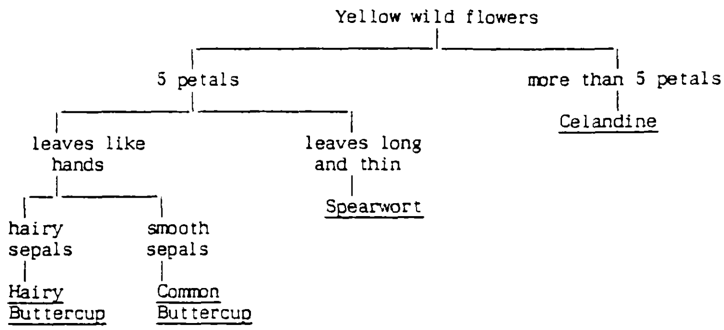


From this information, make a paired statement key.

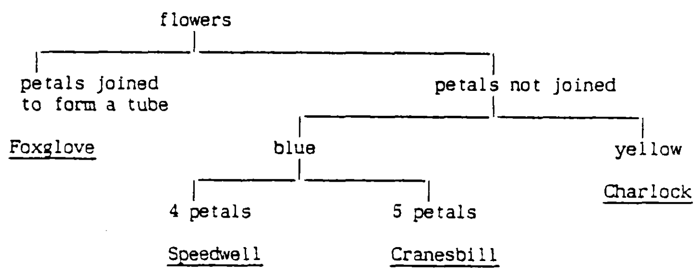
Figure 5.7

Test 1: Questions 10 & 11

10



11



Change the tree key into a paired statement key.

5.11 Teacher Strategy

Each class teacher was asked to complete a short questionnaire about the strategies they used in the teaching of keys (Appendix VE). The results of this survey showed that although the teaching of paired statement keys was part of the first year syllabi in all the schools, in two of the schools only the Biologists taught this type of key.

In all three schools the third year Biology pupils were taught to make both types of keys. The analysis of the results had therefore to take this information into account.

5.12 Analysis of First Year Results

As a consequence of the analysis of the teacher strategy sheets, it was decided that overall results would be meaningless because pupils had been taught different things.

Pupils were divided into two groups according to the type of key they had been taught. Group I contained pupils who had made both types of key (family tree and paired statement). Group II contained pupils who had only made family tree keys. Group I was further divided into those pupils who had done the modified course (Sect 5.9) and those who had not.

Table 5.2

Organisation of First Year Groups

	GROUP I (1)	GROUP I (2)	GROUP II
Type of Key Made	Family Tree Paired Statement	Paired Statement	Family Tree
Type of Course	Unmodified	Modified	Unmodified
No of Pupils	133	30	175

Table 5.3

Test 1: Percentage Scores of First Year Pupils

Question No.	Group I (1)	Group 1 (2)	Group II
1	24	57	34
2	25	63	37
3	44	80	57
4	33	60	40
5	56	93	69
6	40	63	44
7	42	80	53
8	43	83	51
9a	26	58	28
9b	54	73	47
10	40	70	60
11	38	77	63

Table 5.4

X^2 Test: Percentage Significance

	Groups Compared	
Question	Gp I (1) with Gp I (2)	Gp I (1) with Gp II
1	0.1	-
2	0.1	-
3	0.1	-
4	0.1	-
5	0.1	-
6	1.0	-
7	0.1	-
8	0.1	-
9a	0.1	-
9b	1.0	-
10	0.1	1.0
11	0.1	0.1

Except for pupils following the modified course, one third or less of pupils tested could construct a paired statement key from pictures (q 1 & 2). In both groups, more pupils could make a paired statement key if given the attributes in the form of a table (q 3 & 4). Pupils found a family tree key easier to make than a paired statement key (q 5 compared with q 3).

Overall, the making of paired statement keys does not improve the performance of S1 pupils in making either type of key from tables of information or drawings (Group I [1] compared with Group II). The only significant differences between the two groups are in questions 10 & 11, the conversion of a skewed family tree key into a paired statement key.

The score of all pupils was affected by the amount of information presented, the more information the lower the score. This difference was greatest in the questions which used an attribute table (q 3, 4, 5, 6). In both questions 1 and 2 there is an overload of information, so the increase in information in question 1 makes little difference to pupil scores.

As the task of making a key is broken down into its constituent parts, pupils' scores improve suggesting that some of the problems of overload are being reduced.

Only a quarter of pupils could choose biological attributes from simple diagrams (q 9a) and given the specific attributes only half the pupils could identify and record the correct information (q 9b). Pupils are either unaware of biologically important features, or they do not understand the drawings.

In all the questions pupils following the modified course did better than the other groups. However, their scores were not perfect so that in spite of the improved course pupils are still having problems with keys.

5.13 Effect of Modified Course

The results from School A showing both groups, those following the normal first year course and those using the additional worksheets are shown in Table 5.5. The pupils following the modified course showed better scores in all questions when compared with the pupils who followed the normal course. These differences were significant at the 1% or less level for all questions, except for question 9b. Question 9b asked pupils to record given attributes from a set of diagrams. This improvement could have been the result of greater teacher enthusiasm and confidence. Many non-biologists say they find keys hard to teach and a precise structured strategy might have helped. The new worksheets also gave the pupils more practice in doing keys, but the main feature of these new sheets was to divide the task (the choosing of attributes and the mechanics of key making) into a number of clearly defined steps, ie: it was prepackaged. The advantage of this is that the strategies which have been practised are stored in the long term memory (Appendix VF). When needed they can be extracted from long term memory and used by the working memory (Appendix VF) in the most efficient way.

Table 5.5

Test 1: Percentage Scores of School A S1 Pupils
The Effect of the Type of Course on the Ability of
Pupils to make Keys and Choose Attributes

Question	**Pupils on normal course (n = 60)**	**Pupils on modified course (n = 40)**	**% Significance X^2 Test**
1	35	57	1.0
2	33	63	0.1
3	48	80	0.1
4	33	60	0.1
5	72	93	0.1
6	43	63	1.0
7	48	80	0.1
8	47	83	0.1
9a	21	58	0.1
9b	68	73	-
10	30	70	0.1
11	26	27	0.1

5.14 Effect of Making an Attribute Table

Table 5.6 shows the effect of making a biological attribute table on the key making skills. The making of an attribute table has no significant effect on the pupils' ability to make keys. In some cases not making a table gave better scores (q 1, 3, 4). Other scores were better in the group that made the attribute table. As might be expected in the question in which pupils had to choose attributes (q 9a), pupils did slightly better if they had already made a table. It would appear that at this stage this is not the most important factor affecting key making.

Table 5.6

Test 1: Percentage Scores of S1 Pupils
The Effect of Making a Table of Biological Attributes
on the Ability to Make Keys and Choose Attributes

Question	Pupils Making an Attribute Table (n = 141)	Pupils not Making an Attribute Table (n = 197)
1	32	40
2	36	36
3	54	58
4	40	44
5	73	70
6	53	39
7	52	59
8	54	56
9a	37	25
9b	54	62
10	47	42
11	45	42

5.15 Effect of Teacher Subject (Biologists Compared with Non-Biologists)

Table 5.7 shows the scores of pupils when grouped according to their teacher's subject. Classes who were taught by a biologist did slightly better in all questions except 1 & 2 (pictures into paired statement), and question 5 (table into family trees) where the scores were equal. There was no significant difference between the groups.

In both groups, fewer people can make a paired statement key than a family tree key. An increase in the amount of information given to pupils also causes a drop in score.

Table 5.7

Test 1: Percentage Scores of S1 Pupils
The Effect of Teacher Subject on a Pupils' Ability to Make Keys and Choose Suitable Attributes

Question	**Biologists (n = 85)**	**Non-Biologists (n = 253)**
1	32	35
2	35	37
3	64	50
4	47	39
5	71	71
6	56	45
7	58	53
8	60	51
9a	39	30
9b	69	54
10	49	39
11	51	38

5.16 Analysis of the Type of Pupil Errors

In an attempt to find out why pupils were not able to make a key correctly, the errors made by pupils in questions 1 & 2 were analysed. The errors were classified as either relating to attribute selection or to the mechanics of key making.

In questions 1 & 2 answers were wrong not because of failure to make the key, but due to an inability to choose the correct biological features (about 60% of the errors). The pupils did not know which features to use or they did not understand the drawings. In question 1 the number of biological errors made by pupils whether they had made paired statement keys or not were similar. In question 2 the group making paired statements keys had more biological errors (60% compared with 42%).

5.17 Analysis of Third Year Results

All the pupils in this group were following a Scottish Certificate of Education Ordinary Grade course in Biology (1). All pupils had been taught how to use and make both family tree and paired statement keys during their third year course. The third year results are shown in Table 5.8.

Table 5.8

Test 1: Percentage Scores of Third Year Pupils

Question	**All Pupils % Score (n = 171)**	**Pupils in School A (n = 73)**	**Pupils in Schools B & C (n = 98)**
1	67	88	50
2	68	90	48
3	80	92	70
4	74	89	60
5	82	89	71
6	73	77	63
7	85	99	73
8	85	99	73
9a	67	86	55
9b	80	95	69
10	82	93	72
11	81	92	70

Overall, there is an increase in score when information has been selected and presented in a table. Scores are similar when a table has to be changed into a key. The major factor here being the ability to sort or set the information, not the mechanics of making the paired statement. As the amount of information presented increases, the scores drop. In the later questions 7, 8, 10, 11 the increase in and change in the presentation of the information has little effect. This evidence again supports the suggestion that pupils' failure to obtain the correct answer may be due to an overload of the working memory.

Working memory (Appendix VF) has a limited capacity. When pupils first scan a set of pictures to obtain the correct attributes for their key, they are faced with a wide variety of information. The pictures or drawings present the pupil with a number of features. From these features pupils have to be able to choose the correct number of suitable attributes or characteristics. It would not be surprising if, at this stage, the pupils' working memory capacity was not overloaded with information. Working memory space has to be capable of holding both information and techniques to deal with that information (76, 77). If the space is filled with information, then there will be no space to process that information.

Only 67% of pupils could construct a paired statement key from pictures (q 1 & 2) and a similar number could choose the correct attributers from pictures (q 9a), suggesting that failure to answer questions 1 and 2 could be due to failure to identify the correct attributes.

5.18 Comparison of School A with the Other Schools

Table 5.8 also shows the comparison of School A with the others. Third year classes in School A followed a new course based upon the material prepared for first year classes (Appendix V). This course used the improved teacher strategy and the new worksheets, together with extra examples on all three sub-problems; choosing attributes, making family tree keys and paired statement keys. In all questions, pupils scores improved. In all questions except for question 6, there was a significant difference between the two groups (Table 5.9). A clear plan, the teaching of strategies for sub-problems and practice have worked in the classroom situation.

Table 5.9

% Significance X^2 Test: School A Compared with Schools B & C (S3 Pupils)

Q	1	2	3	4	5	6	7	8	9a	9b	10	11
%	0.1	0.1	0.1	0.1	1.0	-	0.1	0.1	0.1	0.1	0.1	0.1

5.19 Summary

Some important conclusions on pupil problems with keys can be drawn. Firstly, making a key is a complex task needing a clear plan. It also requires the ability to complete a number of complex sub-problems. The pupils must be able to solve all the sub-problems if a correct key is to be made.

All this processing is going to take a large amount of working memory. If the pupil does not have the capacity or the strategies to prevent overload, then the problem will not be solved. The overload problem is not helped if the pupil is uncertain or if the problem set contains a large amount of extraneous information, since all these will further overload the working memory.

5.20 Choosing Suitable Biological Features

From the results of the Pilot 1 tests (1a and 1b) it can be said that a specific strategy together with teacher awareness of pupil difficulties will help pupils to be more successful in making keys. There is still a problem if material is presented as pictures rather than as a table. If keys are to be made from living organisms, pictures or drawings it is essential that pupils can recognise and choose suitable biological attributes. Such attributes or characteristics are those which fall into distinct groups, ie: show discontinuous variation, eg: number of legs or petals, colour, hairiness, body covering. Pilot 2 which was the next part of the work, therefore concentrates on investigating "What Pupils See" and some of the factors that might influence this.

Pilot 2 investigated the following hypotheses, that the ability to choose suitable attributes is affected by:

1 the type of object (biological/non-biological)
2 the number of variables present in the object.

In addition to these hypotheses, each pupil's working memory capacity was measured. This was done in order to ascertain if there was any relationship between the amount of working memory (Appendix VF) and the ability to choose attributes. Another possible psychological factor affecting a pupil's ability to choose suitable attributes could be the ability to disembed, ie: to be able to see an object in its surroundings (Appendix VG). This ability could be important in recognising the characteristics which could be used in making a key.

5.21 Pupils Tested in Pilot 2

During the summer of 1988 48 first year, 16 second year and 53 third year pupils, from the same three schools used in Pilot 1, completed a range of test material (Table 5.10). Group 1 (S2) acted as a pre-pilot group for the test 2 material. The written test material consisted of:

Test 2 (Appendix VH)
- this tested types of objects and number of variables.

Test 3 (Appendix VG)
- Hidden Figures Test to measure disembedding.

Test 4 (Appendix VF)
- Digit Backwards Test to measure working memory capacity.

Table 5.10

Groups of Pupils Tested in Pilot 2

Group	Year	School	Number of Pupils	Tests Completed
1	S2	A	16	2
2	S1	A	15	2, 3, 4
3	S1	B	12	2
4	S1	B	3	2, 3, 4
5	S1	C	18	2, 3, 4
6	S3	A	18	2, 3, 4
7	S3	B	15	2
8	S3	B	3	2, 3, 4
9	S3	C	17	2, 3, 4

5.22 The Test Material for Pilot 2 (test 2 see Appendix VH)

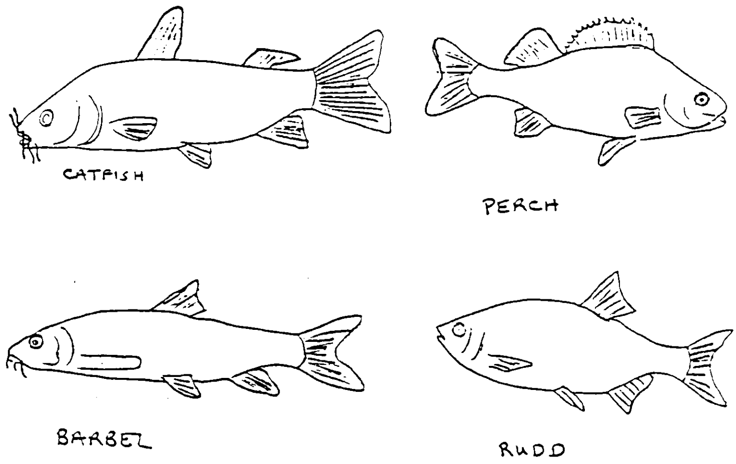
The aim of test 2 was to investigate the factors affecting the ability of pupils to choose suitable biological attributes. Questions 1 & 2 asked pupils to sort simple non-biological objects into groups. Pupils were asked to sort four objects into two groups and then into a further two groups so that the final groups contained one object only. At each sort, they were asked to draw the objects and to record the feature they had chosen. Question 1 used four geometric shapes (white & black square, white & black hexagon). Question 2 used four pieces of laboratory glassware (round bottomed & conical flask, beaker, test-tube).

In questions 3 & 4 (Fig 5.8) pupils were given four drawings of living organisms and asked to choose features which could be used to recognise differences which must be biologically significant. Question 3 used four fish (catfish, perch, barbel, rudd) and question 4 used four British birds (sparrow hawk, pheasant, avocet, moorhen).

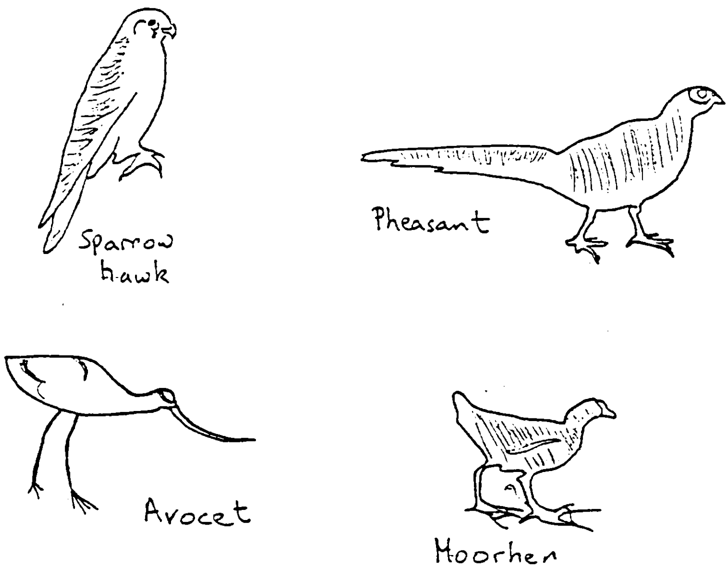
Figure 5.8

Test 2: Questions 3 & 4

3



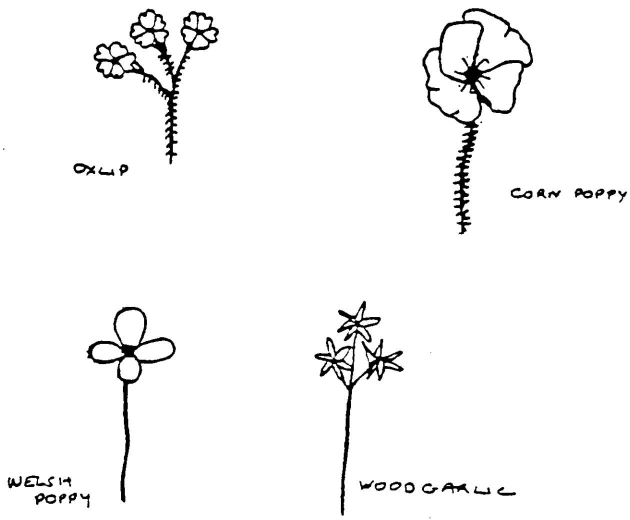
4



In question 5 (Fig 5.9) pupils were given drawings of four flowers (oxlip, corn poppy, welsh poppy, woodgarlic). The first part of the question asked them to describe the appearance of one flower using suitable biological words, eg: petals, hairs. The second part asked the pupils for similarities and differences between the flowers.

Figure 5.9

Test 2: Question 5



Use these pictures of common flowers to do the following:

1 You are asked to describe the corn poppy to someone over the 'phone. Write down at least four things you might mention about it.

2 Look at the other three flowers. Choose two of them which have something in common (the same) but different from the third one.

The two flowers chosen are .... and ....

What was the same about them? ....

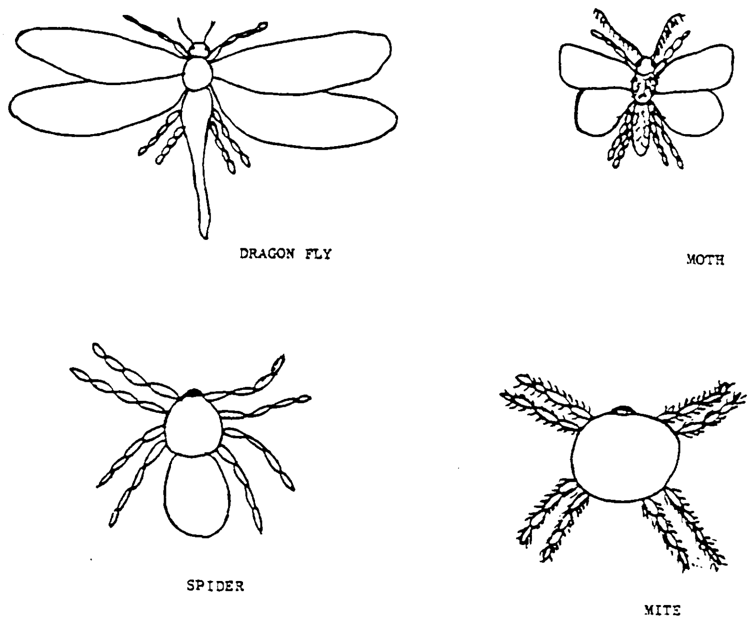
These flowers are not exactly the same. Can you find something that is different about them?

....

In question 6 (Fig 5.10) pupils were given drawings of four common arthropods (dragonfly, moth, spider, mite) and asked to complete an attribute table. The purpose of the question was to see if pupils could choose suitable features and record them in the table. Finally, pupils were asked if they had enough information in their table to make a key.

Figure 5.10

Test 2: Question 6



If you look at the pictures you will notice that the dragonfly and moth have feelers but the spider and mite do not. This has been written in the table for you. Now look for three other things which are different about these animals. Put these in the table.

	Thing 1 Feelers	Thing 2	Thing 3	Thing 4
SPIDER	No			
MOTH	Yes			
DRAGONFLY	Yes			
MITE	No			

Using this table, could you make a key?

5.23 Analysis of Test 2 Results

Many pupils seemed unaware that the main purpose of a biological key was to classify or separate objects and organisms. Each question was only marked correct if all the parts were correct. In general scores were not good (Table 5.9). No pupil answered all the questions correctly.

Table 5.11

Test 2: Percentage Scores

Question No	S1 Pupils	S3 Pupils
1	60	75
2	15	43
3	21	35
4	4	10
5	6	22
6	38	39

Errors pupils made included:

1 inappropriate use of size, eg: stem is long or stem is short, with no reference to actual size or in relation to other parts;

2 confusion between leaves and petals;

3 counting errors, eg: number of petals and fins;

4 using information not in the pictures, eg: colour of petals, habitat;

5 use of wrong vocabulary;

6 "spot the difference competition" type differences, eg: counted the lines on the fish's tail;

7 direction in which fish swam (see p268 q3, three fish swim one way, the fourth in the opposite direction). The direction of swimming was seen as a significant biological difference.

5.24 Discussion

To try to eliminate the effect of size, all the organisms were drawn to the same scale. This was done because pupils are often confused by the idea of scale even when given an indication of actual size, they assume all the organisms are the same size (Abercrombie's work in interpretation of X-rays, 78).

Small differences sometimes no more than those due to photocopying were noted before what would appear to be more major differences. Size was often the most important feature if not the only one mentioned.

Richards (79) found similar trends when asking pupils of various ages to describe earthworms. Below average ability pupils of ages 11, 13 and 16 all used words like "long, thin" to describe the worm. Average ability pupils of age 11 and 13 also used similar words, but above average ability pupils if they used such words qualified it with an actual measurement, eg: 7" long. As children got older and or were more able, their descriptions became more detailed and more informative.

5.25 Effect of the Amount of Information Presented

An attempt was made to investigate the effect of the amount of information presented to pupils. In order to do this, the number of variables present in each set of drawings was calculated (Table 5.12). This proved to be a difficult exercise.

Table 5.12

Question No	Type of Object	Variables
1	Shapes	No. of Sides Colour
2	Lab. equipment	Type of base Neck
3	Fish	Whiskers No. of Fins Type of Top Fin
4	Birds	Type of Tail Type of Beak Type of Feet Type of Legs
5	Flowers	No. of Flowers Hairiness Petal shape No. of Petals
6	Arthropods	Hairiness Wings No. of Body Parts No. of Legs Feelers

In questions 1 to 5, both S1 and S3 show a fall in performance as the number of variables increases (Table 5.13).

The drop in score between question 1 and 2 may reflect the less familiar nature of the laboratory equipment. The low score in the bird question may be due to the unclear nature of the drawing rather than anything else. Question 6 (arthropods) has a relatively high score, this could be due to the more specific type of questions asked, the more familiar nature of the organisms or that there were plenty of obvious differences to use.

It would appear that it is not only the amount of information, but its type and familiarity which influences whether pupils can extract it correctly from the pictures.

Table 5.13

Effect of the Number of Variables on Pupil Score

Question No	No of Variables	% Score S1 Pupils	% Score S3 Pupils
1	2	60	75
2	2	15	43
3	3	21	35
4	4	4	10
5	4	6	22
6	5	38	39

5.26 Interviews

In addition to the written test material, a number of pupils (30 out of 101) were interviewed by the researcher. The interviews were carried out in the hopes of obtaining further insight into pupil's thinking as they choose suitable attributes and sorted items into groups.

Table 5.14 shows the item sets used in the interviews in the order they were used. Pictures of the actual items used can be found in Appendix VJ. In Schools A and C the interviews were conducted with pairs of pupils who were in the same class and of similar ability. In School B pupils were interviewed separately because only one pupil of each ability was provided. Starting with the first set of items (wooden shapes), the pupils were asked to put them into groups using a particular attribute or feature. They were asked to think out loud and to say which feature they had chosen. When the item set had been successfully sorted or it was very obvious that they could not complete the sort, the next item set was produced and the exercise continued.

Table 5.14

Item Sets Used in Interviews

	Item Set	Objects	Variables
1	Wooden Shapes	Triangle, Rectangle Circle, Ellipse	No.of sides/angles
2	Non-biological Objects	3 nuts (different) 3 washers (different)	size/colour colour/spikiness
3	Non-biological Objects	wood screw, nail, tack, phillips bolt, bolt	thread/colour/ size
4	Biological Objects: Shells	mussel, cockle, winkle, whelk	twisted/colour/ no.of parts
5	Biological Objects: Leaves	beech, birch, elm, cherry	arrangement of veins/hairy/leaf margin
6	Birds: pictures	sparrow hawk, avocet pheasant, moorhen	type of beak/feet/ colour/type of legs
7	Flowers: pictures	chicory, nipplewort, sowthistle, cornflower	colour of flower/ hairs/colour of stem/type of leaves
8	Flowers: pictures	ox-eye daisy, birdweed dandelion, pansy, bugle, carot	colour/hairiness/ type of leaves/ roots/no of petals type of flower

The interviews were recorded as brief notes while the pupils talked, then written up in more detailed form immediately after the pupils left.

The choosing of the pupils for interview was left to individual class teachers. First year class teachers were asked to select two high ability pupils (scoring > 75% in class tests), two middle ability pupils (scoring 50-60% in class tests) and two low ability pupils (scoring < 40% in class tests). Third year class teachers were asked to select pupils on their predicted ability in the Ordinary

Grade Biology exam. Low ability pupils would be unlikely to obtain grade 3 "O" Biology. Middle ability pupils would be likely to gain a grade 3 and High ability pupils would obtain a grade 2 or above.

As a result of the interviews with group 1 (Table 5.10) and the pupil answers to the written material (test 2) pictures of birds were added to the original interview items. If the pupil problems with question 4 of the written test were due to bad drawings, then pupils would be expected to do better in the interviews if given good pictures.

5.27 Analysis of Interviews with First Year Pupils

Low Ability:

Pupils used size as the most important feature. Differences in size were often the first thing they mentioned. They often could not find any other differences.

Middle Ability:

When differences were obvious they had few problems. They often picked out useless information and found difficulty focusing on the important points, ie: they chose features which cannot be used to distinguish items and cannot be used to make a key.

High Ability:

This group did better but still reverted to size when there were a large number of variables. They seemed to be better at picking out relevant points, ie: separating signal from noise than the lower ability groups.

Generally, there was an improvement in ability to classify objects from low to high ability pupils. There was less emphasis on size and they found differences more easily. They rejected inappropriate answers and coped with more variables.

5.28 Analysis of Interviews with Third Year Pupils

Low Ability (unlikely to obtain grade 3 'O' Biology)
Size was the most common feature chosen. They did not always choose the most appropriate characteristics and some had trouble choosing the correct word.

Middle Ability (likely to be borderline grade 3)
These pupils still used size inappropriately but they coped with an increase in the number of variables better than the low ability group.

High Ability (likely to obtain grade 2 or above)
Size was still used, but the fact that it must be related to other features was also mentioned. The majority of this group correctly separated 5 out of 6 items.

5.29 Discussion

In general, there was inappropriate use of size throughout the ability range. It was used more frequently as a first feature, especially by the less able pupils. The more able reverted to it when they could not see any other obvious differences. The responses to the pictures of the birds were better than the drawings used in test 2, suggesting that the original drawings were unclear.

Size is often used to describe objects in everyday use. It is obviously important judging by pupils' responses. In Biology when a key is being constructed, the use of size is only acceptable in certain circumstances. When size is used it must be of a precise nature, ie: a specific value or scale. If the size of a part of an organism is used, then it must either have a numeric value or be related to the overall size or to the size of another part, eg: tail is the same length as the body. Because of the large number of possible pitfalls relating to the use of size, pupils constructing keys are told to use characteristics which show discontinuous variation (can be divided into discrete groups).

Ideas brought by children to the learning task have a significant influence on what children learn (Driver, 80). By the time children are taught Science in school, their expectations or beliefs about natural phenomena may be well developed. Sometimes these ideas are in keeping with the Science that is being taught in class. They can then provide a base for subsequent lessons. Sometimes these ideas are significantly different. They are then known as "Alternative Frameworks". They affect pupils interpretations of their practical experiences in Science lessons and also influence the observations they make. Faced with a novel situation, pupils search for familiar events to which they can relate the new experience, eg: the use of size when describing living organisms. Alternative Frameworks can persist in a range of situations and can be resistant to change. As well as influencing the investigation of irrelevant aspects of a system, they may also cause the neglect of relevant features, this seems to be especially important in the choosing of suitable attributes. In certain areas of Science there is evidence that pupils maintain aspects of their Alternative Frameworks, especially when faced with problems in new contexts. Lessons may change knowledge but other more fundamental aspects of their thinking are more difficult to change. Alternative Frameworks will not be rejected until there is something adequate and reliable to replace them with. Even experiences which conflict with expectations will not necessarily help to reconstruct Alternative Frameworks.

Simpson and Arnold (71, 72, 73) in their work on Osmosis and Photosynthesis state that concepts which are wrong but which are nevertheless meaningful to the learner, are highly resistant to the correct information. Formation of the wrong concepts may predate formal instruction or may arise during instruction as a result of the inappropriate use of subsuming information.

Johnstone and Mahmoud (81) when investigating pupils difficulties with water potential, found a large number of misconceptions which could easily become blocks to future learning.

Ausubel (82) also felt that children's preconceptions were very strong and difficult to change and that the unlearning of these preconceptions might be one of the most important factors in acquiring of knowledge.

5.30 Investigation of Other Factors

Other factors which might affect a pupil's ability to choose suitable biological attributes were investigated. In addition to the hypotheses already investigated (Sect 5.20) each pupil's working memory capacity and ability to disembed were also measured. Each pupil completed a Digit Backwards Test to assess their working memory capacity (see Appendix VF) and a Hidden Figures Test to measure their ability to disembed (see Appendix VG).

All the pupils who took part in Pilot 2 also completed Test 2 to assess their ability to choose suitable attributes.

5.31 Overall Analysis of Results

The detailed results from test 2 (choosing biological abilities), test 3 (measuring disembedding) and test 4 (measuring working memory) can be found in Appendix VK.

To see if there was any correlation between the ability to choose attributes (test 2), working memory capacity (DBT) and the ability to disembed (HFT) a Pearson correlation was carried out.

Table 5.15

Pilot 2: Correlations Carried out Between Tests 2, 3 & 4

Tests Correlated	First Year	Third Year
Choosing Attributes/ Disembedding	0.5, sign. 5%	0.0
Choosing Attributes/ Working Memory Capacity	0.0	-0.2
Working Memory Capacity/ Disembedding	-0.2	0.0

The results (Table 5.15) only show correlations in first year pupils between the score for written work and the ability to disembed. This is significant at the 5% level.

5.32 Summary

Interviews with pupils showed that size was one of the most important features that they use when classifying objects. This conflicts with features usually chosen for biological keys. These features show discontinuous variation, ie: they fall into distinct categories. Size can be used in keys, but is either related to other features or to the correct use of a scale. Many pupils see differences between organisms in terms of "Spot the Difference" competitions which look for very small differences between two pictures. They look for these minor differences and fail to recognise or ignore the major ones such as number of legs or petals. The ability to disembed, ie: to be Field Independent shows indications that it might be important in determining the ease with which pupils can see differences.

There is no correlation between working memory capacity and the ability to see differences. This may be due to problems administering the Backwards Digit Test so that a true measure of working memory capacity was not obtained. The exercise could have been within the capacity of some of the pupils and would therefore not discriminate for those individuals with a higher capacity. If the maximum number of variables in the test was five then the test would not discriminate for those pupils with a capacity of five or more.

To quote Ausubel (82):

"If I had to reduce all of educational psychology to just one principle I would say this: The most important single factor influencing learning is what the learner already knows".

APPENDIX V

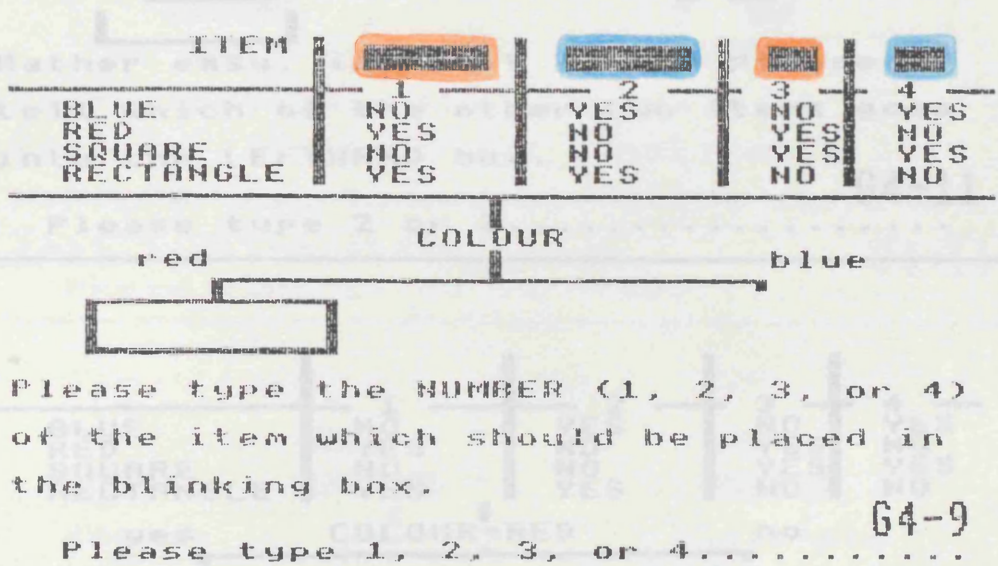
V A	Computer Program Frames
V B	Computer Program Frames
V C	Modified Course (Keys) TG + PS
V D	Pilot 1/Test 1a & 1b + Marking Scheme.
V E	Survey Sheet for Teachers of Pupils Completing Pilot 1/Test 1.
V F	Working Memory and its Measurement.
V G	Disembedding and its Measurement.
V H	Test 2 (Pilot 2) + Marking Scheme.
V J	Interview Items.
V K	Pilot 2 - Raw Results.

APPENDIX V A

Frames Created by Prof Alan Smith, visiting scholar from the University of Southern Maine, USA.

Task:
to convert a table of information about 4 geometric shapes (red rectangle, red square, blue rectangle, blue square) into a family tree key by asking the pupil which item should be placed in a particular box.

(The table to be in the YES/NO format).



G4-9

ITEM	1	2	3	4
BLUE	NO	YES	NO	YES
RED	YES	NO	YES	NO
SQUARE	NO	NO	YES	YES
RECTANGLE	YES	YES	NO	NO

COLOUR

red blue

GOOD! Now the other box is blinking: please type the number of the item which goes in it.

G4-10

Please type 1, 2, 3, or 4...........

ITEM	1	2	3	4
BLUE	NO	YES	NO	YES
RED	YES	NO	YES	NO
SQUARE	NO	NO	YES	YES
RECTANGLE	YES	YES	NO	NO

COLOUR=RED

yes no

Rather easy, isn't it ? Now please tell which of the other two items goes into the LEFTHAND box.

G4-11

Please type 2 or 3...................

	1	2	3	4
BLUE	NO	YES	NO	YES
RED	YES	NO	YES	NO
SQUARE	NO	NO	YES	YES
RECTANGLE	YES	YES	NO	NO

yes COLOUR=RED no

Right....I completed te Table for us. So far, we've sorted the original set of four into two Subsets of two each. Further work is needed.........

G4-12

Press <SPACE> to continue...........

MEM	1	2	3	4
BLUE	NO	YES	NO	YES
RED	YES	NO	YES	NO
SQUARE	NO	NO	YES	YES
RECTANGLE	YES	YES	NO	NO

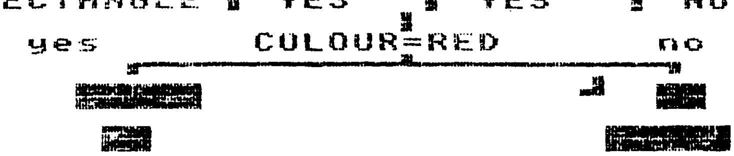
Next, we have to sort each group of two into its individual members.

We've used COLOUR to begin, now we'll use SHAPE. Let's see how......

G4-13

Press <SPACE> to continue...........

MEM	1	2	3	4
BLUE	NO	YES	NO	YES
RED	YES	NO	YES	NO
SQUARE	NO	NO	YES	YES
RECTANGLE	YES	YES	NO	NO

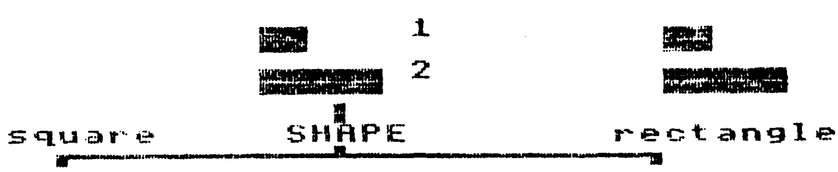


Each subset has the same pair of shapes: a SQUARE and a RECTANGLE.

Hence we can indeed use shape for the last sorting stage.

G4-14

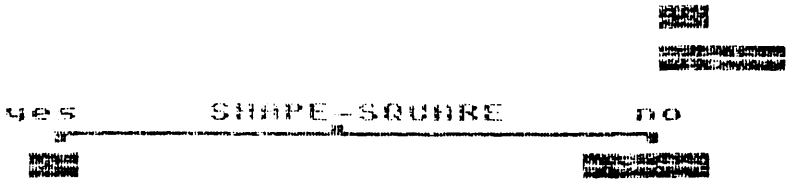
Press <SPACE> to continue...........



Which of the two red shapes belongs in the white box ?

G4-15

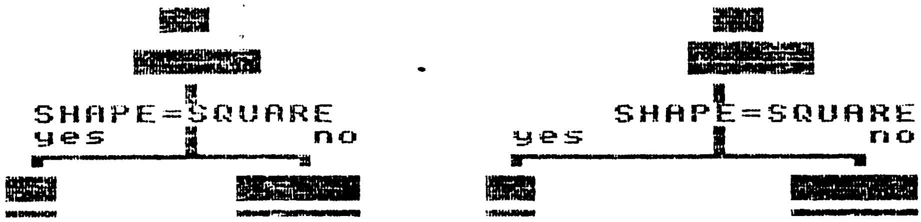
Please type 1 or 2 ....



Indeed it does, and I have put the other red item in the right-hand box. Clearly the same sorting process will apply to the blue items. I'll just go ahead and complete that one.

G4-16

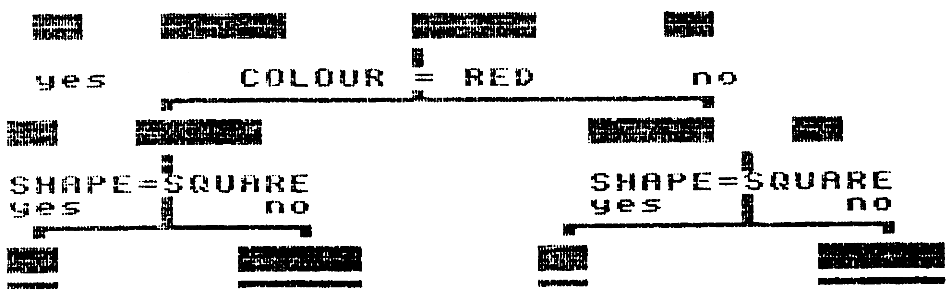
Press <SPACE> to continue...........



Thus: the original set of four items has been sorted---using two properties --into four subgroups of one item each. Let's examine the entire scheme, just to see it all on one display.

G4-17

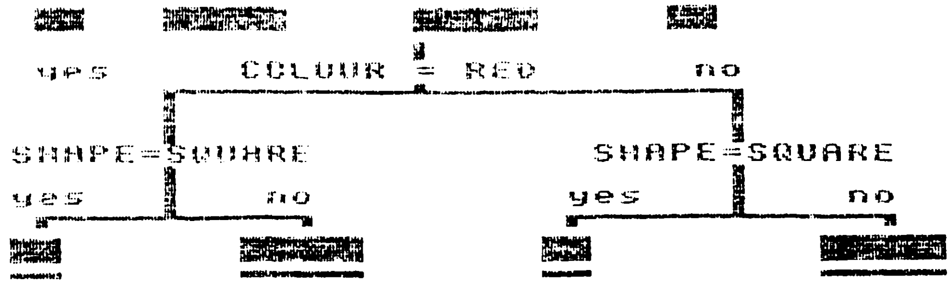
Press <SPACE> to continue...........



Here then is the complete table, which shows how the two properties can be used (one at a time) to sort or class-fy a group of items.

G4-18

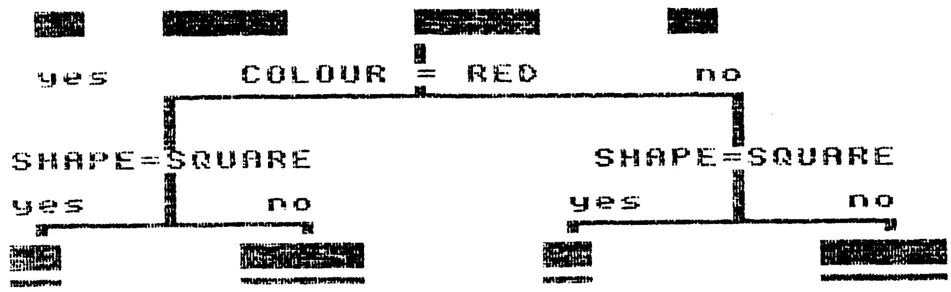
Press <SPACE> to continue...........



This table is slightly different from the last one. The items themselves do not appear until they have been completely separated.

G4-19

Press <SPACE> to continue...........

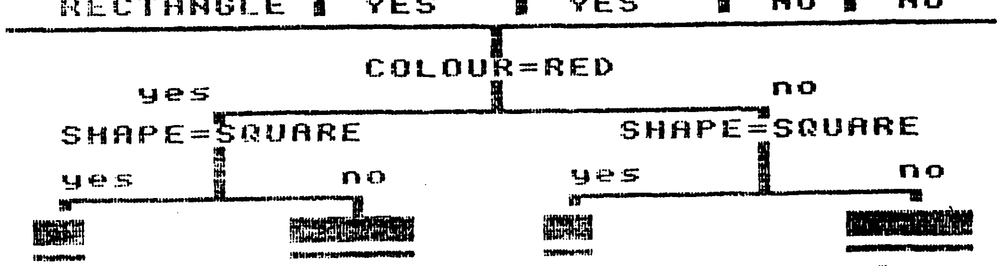


This convention is used in your text-book as well, so it seems like a good idea to do so here.

G4-20

Press <SPACE> to continue...........

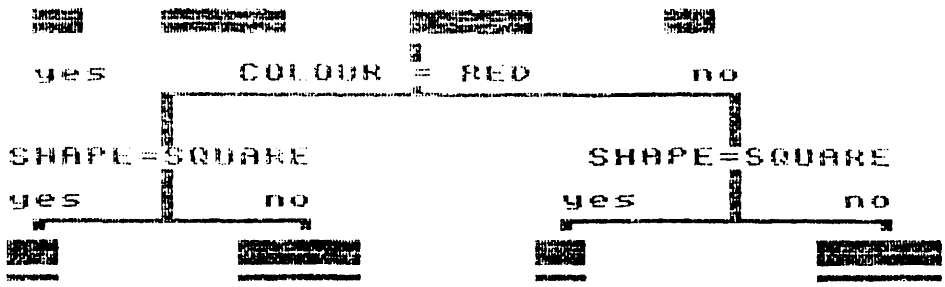
ITEM M				
BLUE	NO	YES	NO	YES
RED	YES	NO	YES	NO
SQUARE	NO	NO	YES	YES
RECTANGLE	YES	YES	NO	NO



This display shows how the original Table of properties is related to the form which we have been using.

G4-21

Press <SPACE> to continue...........



This table, which we saw just a few displays back, has a name which reflects its shape, at least to some extent.

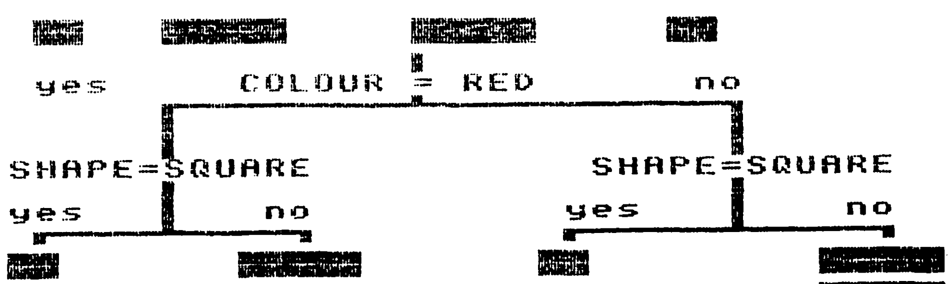
G4-22

Press <SPACE> to continue...........

If we erase all the small boxes which have words printed in them, what is left looks a bit like a tree, so we call it a TREE STRUCTURE.

G4-23

Press <SPACE> to continue...........



Here is the Tree Structure in its complete form. We will look at similar tables for other goups of objects. The central idea remains the same, however.

G4-24

Press <SPACE> to continue...........

APPENDIX V B

Frames Created by Prof A Smith.

Task:
To create an attribute table for 4 geometric shapes.

ITEM				
BLUE	***			
RED				
SQUARE				
RECTANGLE				

Here's the first entry:

Please type Y(es)

or N(o).

G4-7

Please type Y(es) or N(o)...........

ITEM	1	2	3	4
BLUE	NO	YES	NO	YES
RED	YES	NO	YES	NO
SQUARE	NO	NO	YES	YES
RECTANGLE	YES	YES	NO	NO

Now the Table is complete. We can now begin to sort the items by COLOUR as decided earlier. Notice that each item has a Number printed beneath it.

G4-8

Press <SPACE> to continue...........

APPENDIX V C

Modified Course

C1 Teachers Guide for Introductory Lesson.

C2 Pupil worksheets.

1 Table of Attributes/Characteristics

	Tail	Stripes	Spots
Cuscus	thin tail	no stripes	with spots
Opossum	thin tail	no stripes	no spots
Ant-eater	bushy tail	with stripes	no spots
Native Cat	bushy tail	no stripes	with spots

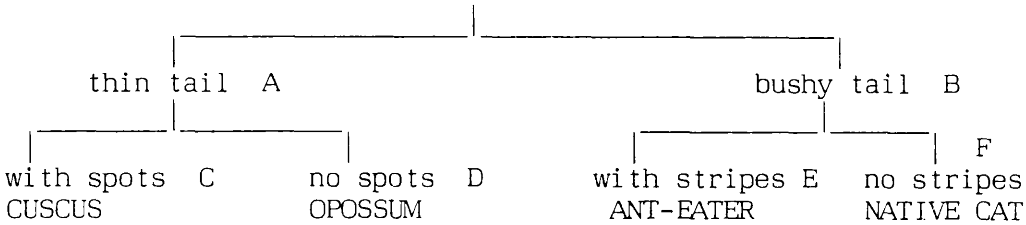
2 Family Tree/Branched Key from Table Above

- thin tails
  - with spots
    CUSCUS
  - no spots
    OPOSSUM
- bushy tails
  - with stripes
    ANT-EATER
  - no stripes
    NATIVE CAT

(split into 2 groups each time).

3 Conversion of Tree Structure into Paired Statement

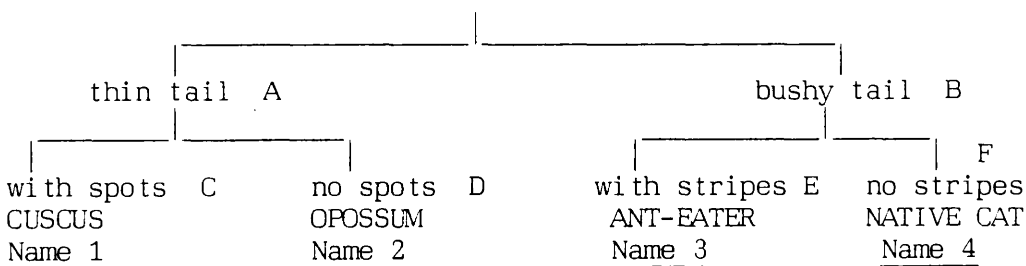
a) Letter statements A, B etc.



b) write down statements in pairs
c) number statements

1	thin tail	A
	bushy tail	B
2	with spots	C
	without spots	D
3	with stripes	E
	without stripes	F

d) add GOTO to tree key, then to paired statements.



1	thin tail	GOTO 2
	bushy tail	GOTO 3
2	with spots	
	without spots	
3	with stripes	
	without stripes	

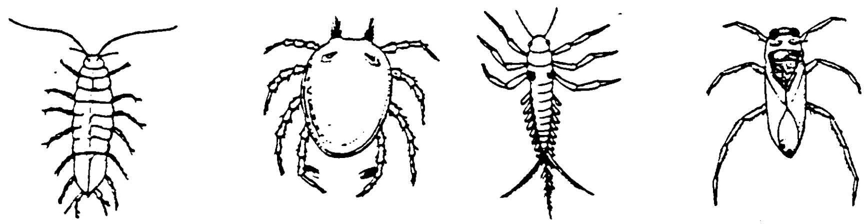
e) add in names of animals/plants.

1	thin tail	GOTO 2
	bushy tail	GOTO 3
2	with spots	Cuscus (name 1)
	without spots	Opossum (name 2)
3	with stripes	Ant-eater (name 3)
	without stripes	Native Cat (name 4)

MAKING KEYS

Pupil Sheet 1
(ref: based on S1 sheets, 74)

1

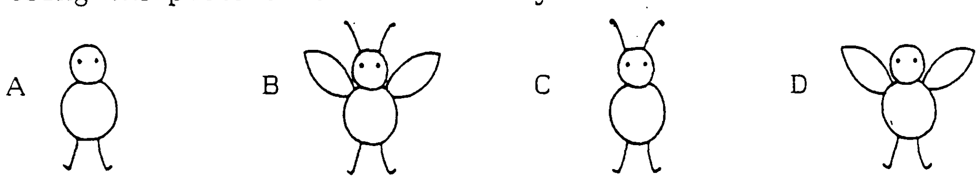


Water Louse Water Mite Mayfly Water Boatman

Look at the pictures of the pond animals. Fill in the table of attributes.

	Number of Legs	With/Without Hairy Legs	With/Without Antenna
Water Louse			
Water Mite			
May Fly			
Water Boatman			

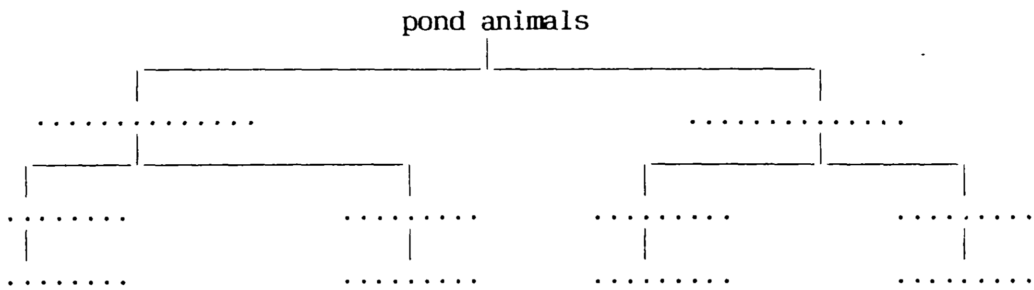
2 Using the pictures below fill in your own table.



Bugs				
A				
B				
C				
D				

Pupil Sheet 2

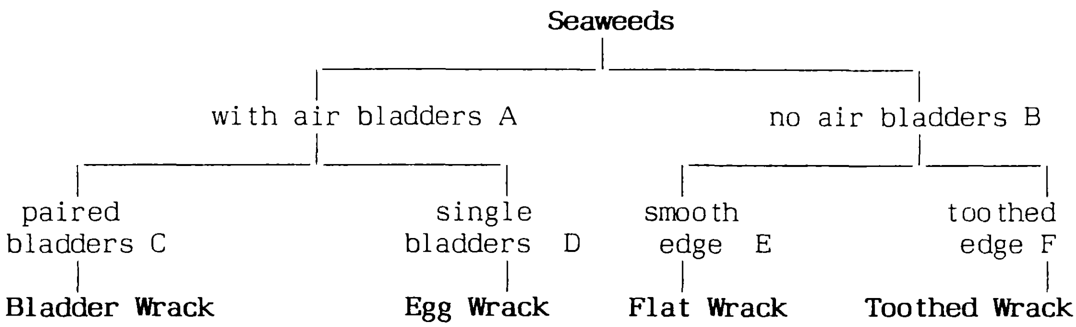
3 You are now going to turn the table 1 into a family tree or branched key.



4 Make a key from Table 2

5 Making a Paired Statement Key

a) letter statements



b) Write down the statements in order.

1 A ....

B ....

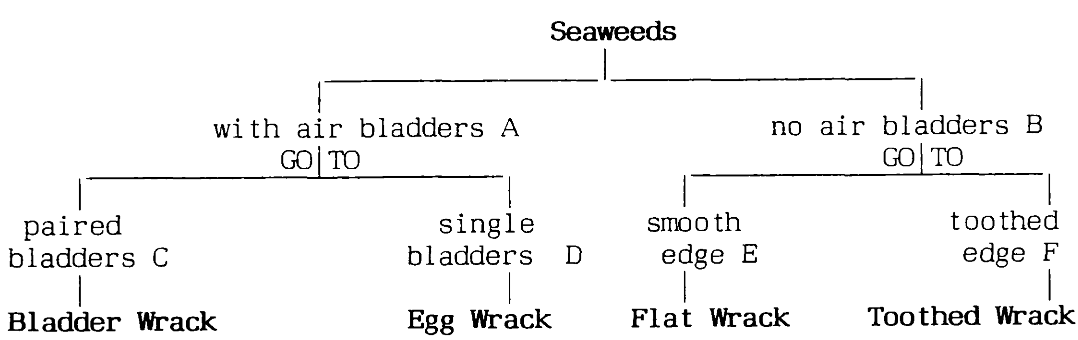
2 C ....

D ....

3 E ....

F ....

c) Add GOTO



Pupil Sheet 4

1 A .... GO TO 2

B .... GO TO ....

2 C ....

D ....

3 E ....

F ....

d) Add names of seaweeds.

1 A .... GO TO ....

B .... GO TO ....

2 C .... Bladder Wrack

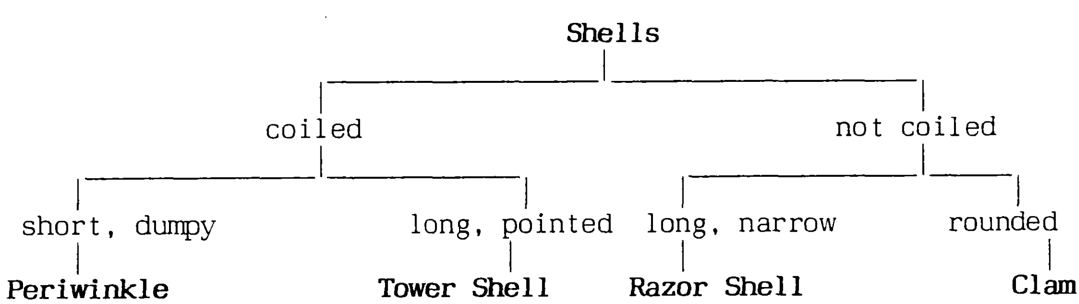
D ....

3 E ....

F ....

Finally rub out A-F.

6 Now make your own paired statement key.



APPENDIX V D

Tests 1a & 1b - Pilot 1

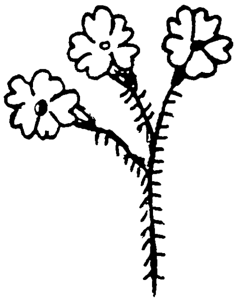
Introduction

There is no one correct answer to each question. Each answer the pupil wrote was checked against the following criteria:

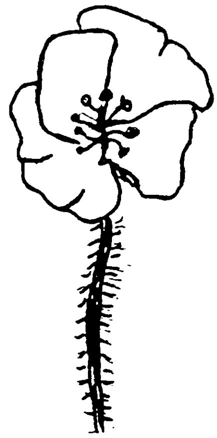
> Did the key work, could it be used to identify the organisms given in the question.

Each question has an example of a correct answer.

1 Construct a paired statement key using the information in the picture.

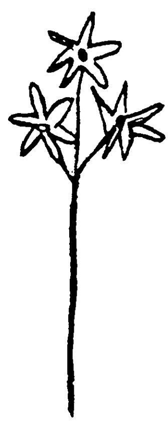


OXLIP



POPPY

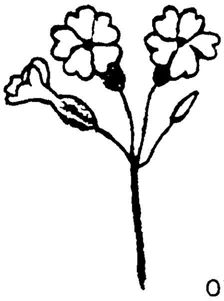
WELSH POPPY



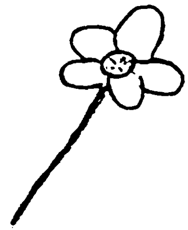
WOOD GARLIC

1	*Single flower*	*GOTO 2*
	Group of flowers	*GOTO 3*
2	*Hairs*	*Poppy*
	No Hairs	*Welsh Poppy*
3	*5 Petals*	*Oxlip*
	6 Petals	*Wood Garlic*

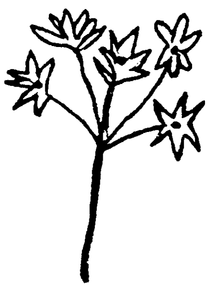
2 Construct a paired statement key using the information in the pictures.



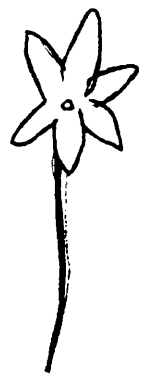
OXLIP



MARSH MARIGOLD



WOOD GARLIC



MEADOW SAFFRON

1	*5 petals*	*GOTO 2*
	6 petals	*GOTO 3*
2	*Single flower*	*Marsh Marigold*
	Group of flowers	*Oxlip*
3	*Single flower*	*Meadow Saffron*
	Group of flowers	*Wood Garlic*

3 Using the information in the table make a paired statement key.

Name	Boy/Girl	Hair Colour
John	Boy	Brown
Scott	Boy	Blonde
Kirsty	Girl	Blonde
Sara	Girl	Brown

1	*Boy*	*GOTO 2*
	Girl	*GOTO 3*
2	*Brown (Hair)*	*John*
	Blonde	*Scott*
3	*Blonde*	*Kirsty*
	Brown	*Sara*

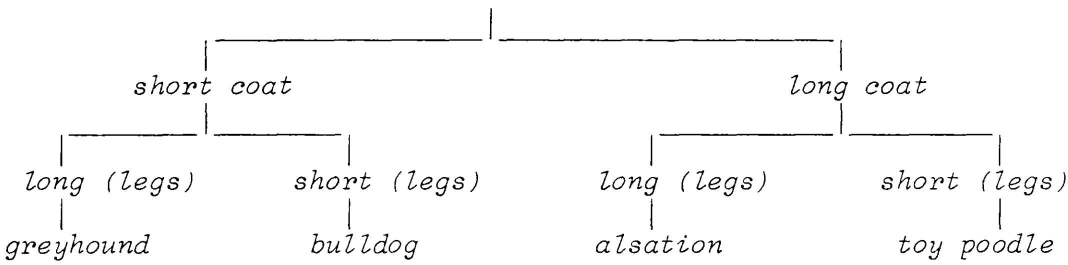
4 Make a paired statement key from the information in the table.

Name	With Legs/ No Legs	Body Covering	With Fins/ No Fins
Horse	Legs	Hair	No Fins
Frog	Legs	Skin	No Fins
Adder	No Legs	Scales	No Fins
Goldfish	No Legs	Scales	Fins

1	*Legs*	*GOTO 2*
	No Legs	*GOTO 3*
2	*Hair*	*Horse*
	Skin	*Frog*
3	*Fins*	*Goldfish*
	No Fins	*Adder*

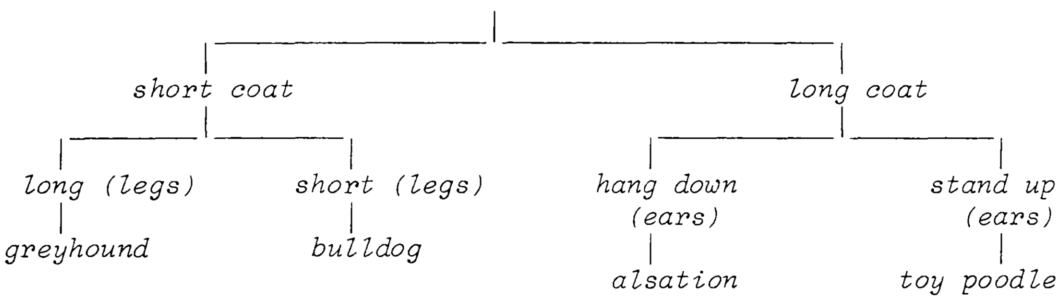
5 Using the information in the table make a family tree type key.

Name	Length of Coat	Length of Legs
Greyhound	Short Coat	Long
Bulldog	Short Coat	Short
Alsatian	Long Coat	Long
Toy Poodle	Long Coat	Short

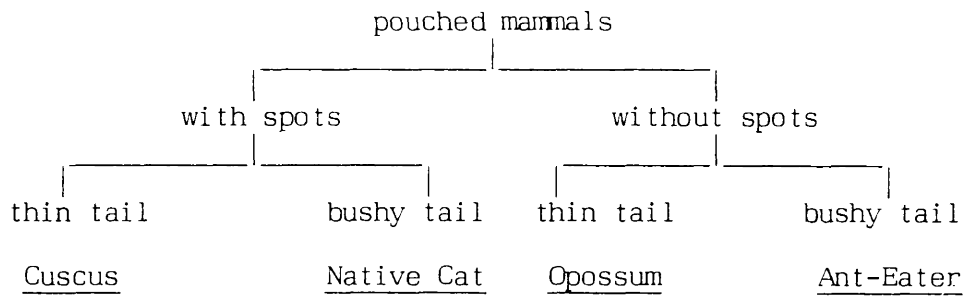


6 Construct a family tree type key from the information in the table.

Name	Length of Coat	Type of Ears	Length of Legs
Greyhound	Short Coat	Hang Down	Long
Bulldog	Short Coat	Hang Down	Short
Alsatian	Long Coat	Stand Up	Long
Retriever	Long Coat	Hang Down	Long



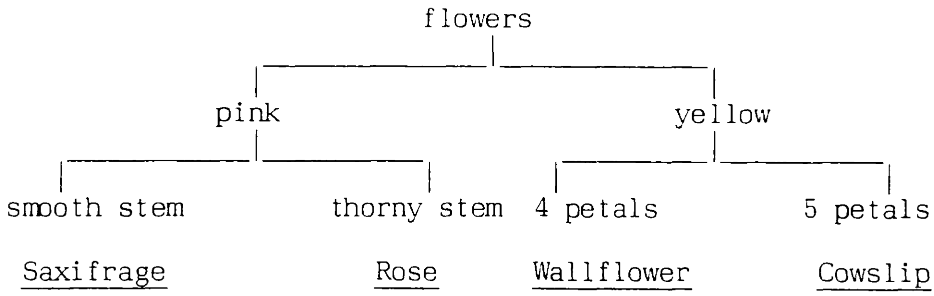
7 The following is a tree key about 4 pouched mammals.



From this information make a paired statement key.

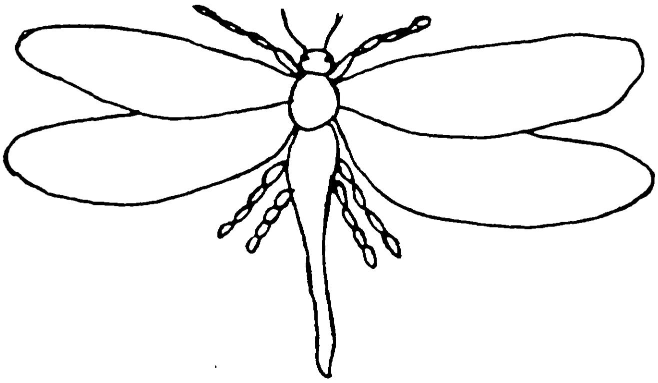
1	*With spots*	*GOTO 2*
	Without spots	*GOTO 3*
2	*Thin tail*	*Cuscus*
	Bushy tail	*Native Cat*
3	*Thin tail*	*Opossum*
	Bushy tail	*Ant-Eater*

8 The following is a tree key about some common flowers.

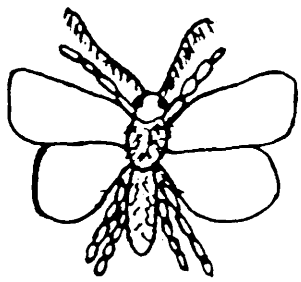


From this information, make a paired statement key.

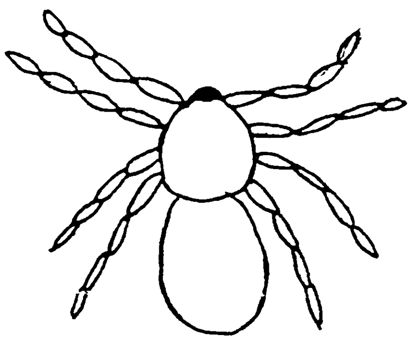
1	*Pink flowers*	*GOTO 2*
	Yellow flowers	*GOTO 3*
2	*Smooth stem*	*Saxifrage*
	Thorny stem	*Rose*
3	*4 petals*	*Wallflower*
	5 petals	*Cowslip*



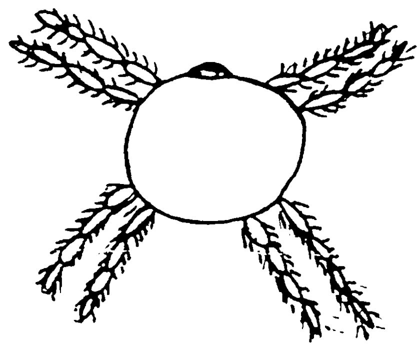
DRAGON FLY



MOTH



SPIDER

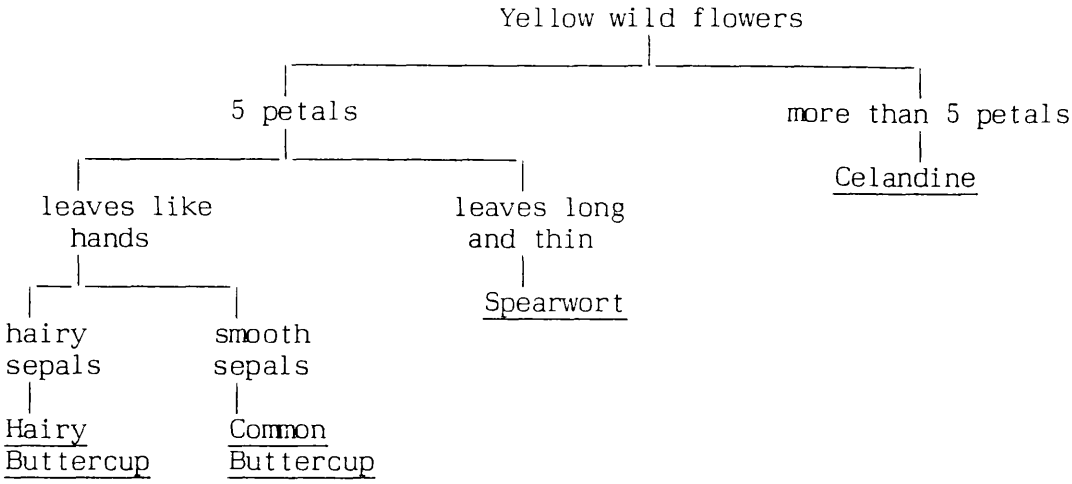


MITE

9a. Look at the pictures, choose 3 things which vary (not the same) between the animals. Fill in the table below, writing down the names of the things you have chosen.

	Thing 1 *feelers/antenna*	Thing 2 *legs*	Thing 3 *hairs*
SPIDER	*No*	*8*	*No*
MOTH	*Yes*	*6*	*Yes*
DRAGONFLY	*Yes*	*6*	*No*
MITE	*No*	*8*	*Yes*

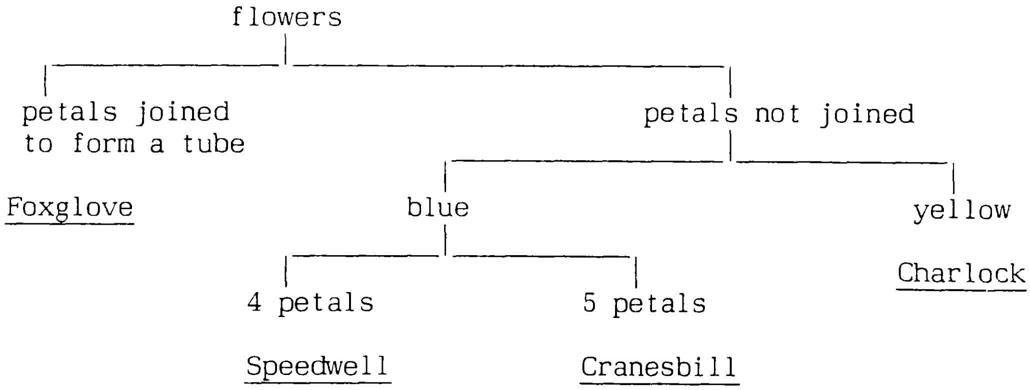
10



Change the tree key into a paired statement key.

1	*5 petals*	*GOTO 2*
	More than 5 petals	*Celandine*
2	*Leaves like hands*	*GOTO 3*
	Leaves long and thin	*Spearwort*
3	*Hairy sepals*	*Hairy Buttercup*
	Smooth sepals	*Common Buttercup*

11

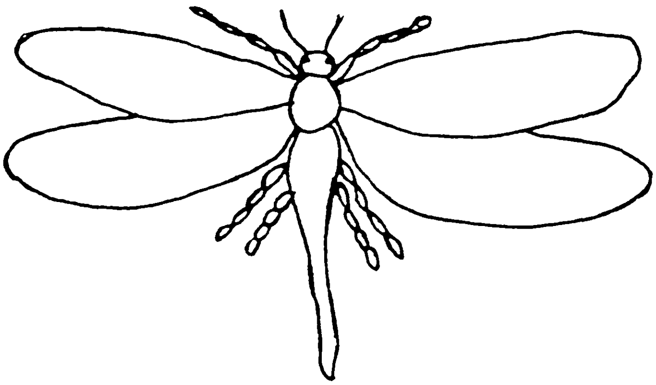


Change the tree key into a paired statement key.

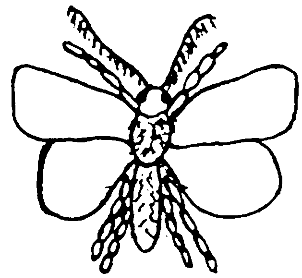
1	*Petals joined to form a tube*	*Foxglove*
	Petals not joined	*GOTO 2*
2	*Blue (petals)*	*GOTO 3*
	Yellow (petals)	*Charlock*
3	*4 petals*	*Speedwell*
	5 petals	*Cranesbil*

Test 1b

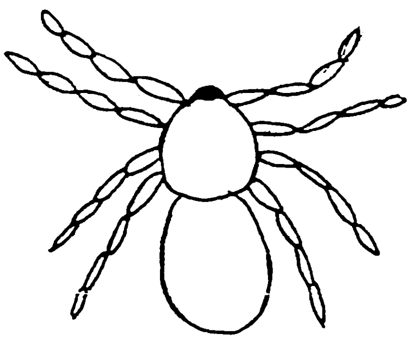
Same items as Test 1a, but question 9b is substituted for question 9a.



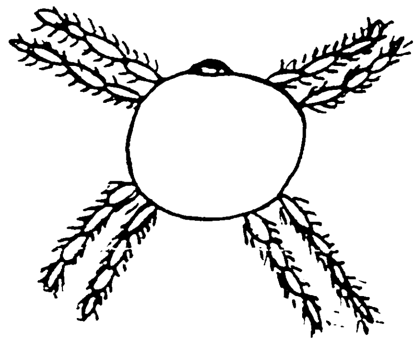
DRAGON FLY



MOTH



SPIDER



MITE

9b. Look at the pictures, using the properties listed fill in the table below.

	Number of Legs	With Wings/ No Wings	With Hair/ No Hair
SPIDER	*8*	*No Wings*	*No Hair*
MOTH	*6*	*Wings*	*Hair*
DRAGONFLY	*6*	*Wings*	*No Hair*
MITE	*8*	*No Wings*	*Hair*

APPENDIX V E

Survey - Teachers of Pilot 1 Pupils

Teacher Strategy

1 Do you teach:

a) how to use
   1) tree/branched key
   2) paired statement key

b) how to make
   1) tree key
   2) paired statement key

2 Do you teach the following operations:

a) making a table/list of attributes from pictures live material

b) making a tree key from table of attributes

c) making a paired statement key from table of attributes

d) making a tree key from pictures

e) making a paired statement key from pictures

f) making a paired statement key from a tree key

g) making a key from non-biological objects.

APPENDIX V F

F1 Memory

F2 Measurement of Working Memory Space

F3 Figure Intersection Test with Marking Scheme.

F1 <u>Memory</u>

"Memory is the repository where everything is stored that we need to know to interact with the environment" (84).

The idea of memory as an active process goes back a long way. As long ago as 1932 Bartlett (85) drew attention to the importance of concepts and expectancies called "schemas" which affect not only what we see but what we remember.

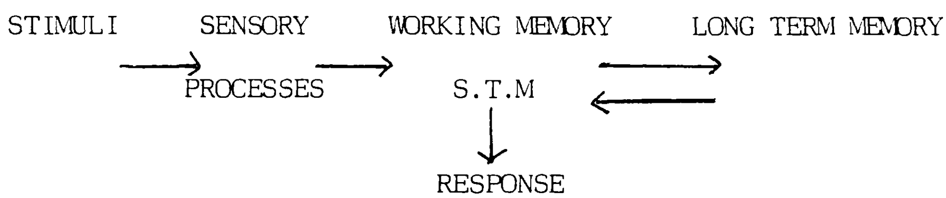
In the 1960's psychologists developed a multistore model to account for the ideas that different kinds of memory existed. One of these was formulated by Atkinson & Shiffrin (86).

$$\begin{tikzcd}
\text{STIMULUS INPUT} \arrow[r] & \text{SENSORY MEMORY} \arrow[r] & \text{SHORT TERM MEMORY} \arrow[r, shift left] \arrow[d] & \text{LONG TERM MEMORY} \arrow[l, shift left] \\
 & & \text{RESPONSE} &
\end{tikzcd}$$

Sensory processes are very short term and allow us to register briefly several inputs from the environment from which to select items for further storage. It acts as a sort of filter. Short term memory is of limited capacity and duration. Miller (87) in a very influential paper "The magical number seven plus or minus two" stated that people can process seven ($\pm$ 2) pieces or chunks of information. What constitutes a unit or chunk of information will depend on the subject's previous knowledge, experience and acquired skills.

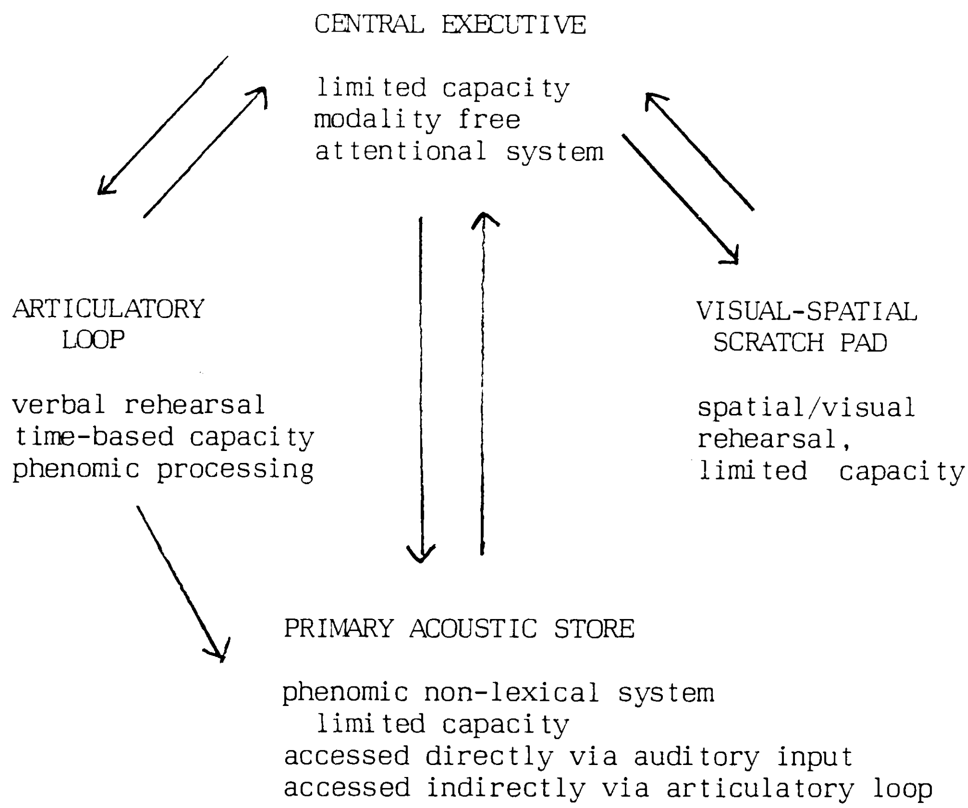
Tulving (88) introduced a distinction between two types of long term memory, episodic memory, which is memory for personal experiences and semantic memory, which contains general knowledge. In theory, the storage and duration of knowledge in the long term memory is unlimited, but retrieval of these memories is not always possible.

In the 1980's more functional models of memory have emerged, short term memory is looked at as an area where active processing goes on (Baddeley, 89) hence the concept of working memory.



Working memory combines both short term memory stores and processing of information. In this context, it can be thought of as a hierarchical system comprising a central processing executive and a number of short term stores, the articulary loop, the primary acoustic store and the visual-spatial scratch pad. Information can be held in these three areas for short periods of time without the involvement of the central executive.

The following diagram gives a summary of the present thinking concerning details of the working memory system (ref Eysenck based on Baddeley's model).



The Articulatory Loop is a sort of "inner voice" which holds the words we are going to say. It is also involved in any sort of verbal rehearsal, eg: saying a telephone number to ourselves while dialling. The Primary Acoustic Store is a sort of "inner ear" and records directly auditory information such as pitch and loudness. The third store is the Visual-Spatial Scratch Pad and is a sort of "inner eye". It deals with visual features such as size and shape, it is thought to encode more spatially than visually.

There is far more known about the stores than the Central Executive: obviously something is directing operations or there would be chaos within the system. The central executive appears to be a flexible processor of information using a variety of methods. Baddeley (89) suggests that "the central executive is becoming increasingly like a pure attentional system". It is able to allocate inputs and direct other parts of the short term memory system and is able to store information for a short period of time. This is obviously an area in which a large amount of work needs to be done.

To summarise, the working memory is composed of several independent but related processing mechanisms. Attentional process are part of the same system, in fact the central executive may only be "attention". In fact in everyday life we use both these (attention and short term storage) together so it also seems useful to treat them as parts of the same working memory system. Each component of the system is used in a wide variety of tasks, eg: it has been shown that the articulatory loop is involved in memory span tasks and mental arithmetic and to a lesser extent in verbal reasoning and reading.

So far, only short term memory has been considered. What about the influence of long-term memory? The two types of memory are obviously closely related. Problems cannot be solved unless the working memory can retrieve information and strategies from the long-term memory.

Craik and Lockheart (91) investigating long-term memory suggest that memory is a by-product of the depth of processing, the deeper the processing the better the retention. The crucial theoretical assumption they make is that the depth or level of processing determines the persistence of a memory trace in the long-term memory. They state "Trace persistence is a function of depth of analysis, with deeper levels of analysis associated with more elaborate, longer lasting and stronger traces". Other experimental evidence supports the basic assumptions of the level of processing theory. Processing activities at the time of learning do have a major impact on the subsequent retention of material in the long-term memory. Eysenck (90) has recently argued that the original theory focused too narrowly on processing activities occurring at acquisition and that learning and memory are affected by many other factors. He lists four major ones: the nature of the task, the kind of stimulus materials, the existing knowledge of the subject and the nature of the test used to test memory. The level of processing theory is only one of many factors which must be considered when investigating memory. At the moment the two lines of research (working memory and levels of processing) have tended to follow their own paths, but there must be overlap, eg: the processing activities of Craik and Lockhart must involve the resources of the working memory.

Working memory can be defined as doing things, it is able to select inputs, access long term memory, select suitable strategies, solve problems and output responses.

At the moment, memory can be summarised as follows:

SENSORY MEMORY →	WORKING MEMORY ⇄	LONG TERM MEMORY
sensory processes feature analysis decoding	encoding central executive articulatory loop acoustic store visual-spatial scratch pad ↓ RESPONSE	episodic semantic

For the purposes of this piece of research work, the working memory space will be defined as the maximum number of items of information that a pupil can hold in their mind while working on a problem. Pascual-Leone

(92) defined this as M-space, he related this to age showing that it increased by about one unit for every two years of age and that it levelled off at about sixteen years of age. There is no agreement whether this capacity is a fixed amount from birth or if it expands with age. He stated that when a subject handles a problem if the demand of the task exceeds the M-space, then the problem cannot be solved. He also stated that other psychological factors such as Field Dependence could limit the amount of available space.

Johnstone has developed a theory of working memory that states that the space in the working memory must be available for both holding information, processing it and for accessing long-term memory. If there is little information, then there is plenty of room to work on it. On the other hand, if there is lots of information then the space for processing, like accessing long-term memory, will be limited. To sum up, a problem will only be solved in the demand (information + what has to be done) does not exceed the capacity.

F2 Measurement of Working Memory Space

To measure the amount of pupils thinking space tests were needed that used both holding and manipulation of data. There are several standardised psychological tests which meet these requirements. In this study two tests, the Digit Backwards Test (DBT) and the Figure Intersection Test (FIT) were used.

To measure the amount of working memory space, pupils must be given a test which involves holding and processing information. The test must involve a novel situation so that they cannot call upon previously learnt strategies.

In the DBT sets of numbers are read out at a fixed rate and the pupil is asked to write them down in reverse order. The test is an oral one given by the tester to the pupil. In order to standardise the test as much as possible, the instructions for the test and the test itself were recorded onto an audio cassette. The rate of delivery of the digits was one per second. The time given for the response was also controlled to one digit per second.

Tape Transcript

"I am going to read out a set of numbers. Wait until I have finished each set then write down the numbers on the answer sheet. Make sure you write from left to right. We will start with the practise items.

6 4 3 9
7 2 8 6
4 2 7 3 1
7 5 8 3 6

I expect you found these fairly easy.

I am going to give you another set of numbers <u>but</u> this time there is an added complication. When I have finished each set write down the numbers in reverse order.

Example: 7 1 9

you would write

9 1 7

No cheating now, make sure you write from left to right.

Listen carefully, turn the numbers over in your mind and <u>don't</u> forget to write from left to right.

2 4
5 8
6 2 9
4 1 5
3 2 7 9
4 9 6 8
1 5 2 8 6
6 1 8 4 3
5 3 9 4 1 8
7 2 4 8 5 6
8 1 2 9 3 6 5
4 7 3 9 1 2 8
9 4 3 7 6 2 5 8
7 2 8 1 9 6 5 3

Don't forget to make sure you have written your name on the answer sheet.

Thank you.

ANSWER SHEET

Name: ....

Practice Items

4					
5					

Test Items

2								
3								
4								
5								
6								
7								
8								

Marking the Digit Backwards Test

When scoring the test, the subjects level was taken as the highest number of digits she/he could correctly reverse, assuming there had not been two previous errors.

Examples:

1

Level	Digits Reversed	Right/Wrong
2	4 2	✓
	8 5	✓
3	9 2 6	✓
	5 4 1	X
4	9 7 2 3	✓
	8 6 9 4	✓
5	6 8 1 5 2	X

Child scores level 4

Working memory capacity is 5 (4 correct digits and reversing).

2

Level	Digits Reversed	Right/Wrong
2	4 2	✓
	8 5	✓
3	9 2 6	✓
	5 4 1	X
4	9 7 2 3	X
	8 6 9 4	✓

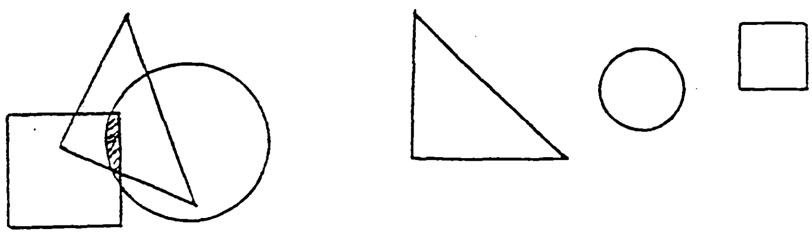
Child scores level 3

Working Memory Capacity is 4.

The DBT was used with the initial group of pupils, but a large number of problems were encountered when administering the test. In the initial groups the researcher was able to supervise the test which was sat by the pupils in groups rather than individually. Pupils often did not carry out the test as requested. The main strategy used was not to reverse the digits in the memory but to write them down right to left, thus removing the manipulation part of the exercise.

In the final testing, the Digit Backwards Test could not be used because it is a face-to-face oral test. The test of working memory had to be suitable for administration by the class teacher, since the researcher could not administer the test herself. Instead of the DBT a paper and pencil test had to be used, this was the Figure Intersection Test. This test fulfils the criteria for a test of working memory capacity. It is unfamiliar to the pupils and involves both holding and manipulating data. The FIT was designed and used by Pascual-Leone (93). The test asks a subject to find the common area of a number of simple overlapping shapes.

Example:



The FIT (pages 324-333) has many complex designs, ranging from three to eight overlapping shapes. The test given to pupils in this study had a specially written introductory page, including examples. This was felt to be necessary since the test was being administered to younger subjects than usual. The test was designed to contain six sets of figures with four items in each set, unfortunately due to a clerical error one set contained three items and the next five items. The test therefore consisted of the following:

number of shapes:	3	4	5	6	7	8
number of items:	4	4	4	3	5	4

This error was taken into account when the results were analysed. The scoring of the test is shown on pages 325-333. Each pupil received a score out of twenty-four.

Correlation between DBT and FIT

Both these tests have been used to measure working memory space. Hasson (94) found a correlation of 77-78% with his group of 272 students and El-Banna (77) using 754 students had 70% with identical scores and a further 11% within a score of one, giving 81.7% ± 1.

Since these tests correlate quite well, it was felt to be acceptable to use the Figure Intersection Test to measure the working memory capacity.

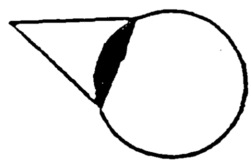
Glasgow University Science Education Research Group

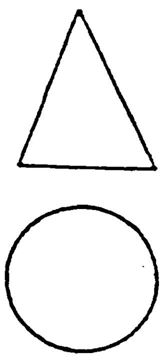
FIT Test

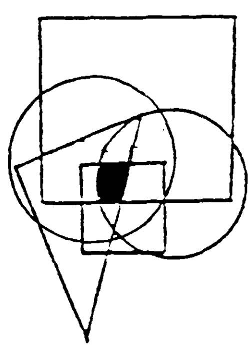
Test 6

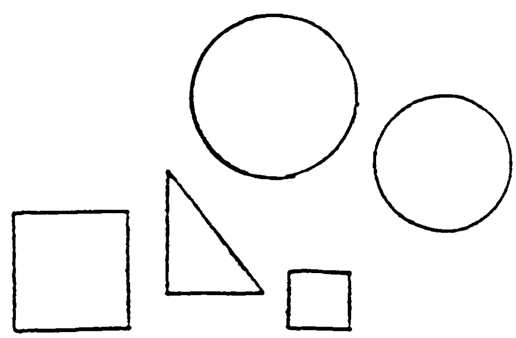
Name: ______________________________

Look at the shapes on the right hand side. Look at the figure on the left hand side. Shade in the part of the figure which is common to all shapes, ie: the area where they all overlap. Two examples have been done for you.

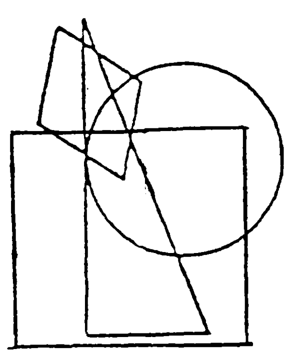


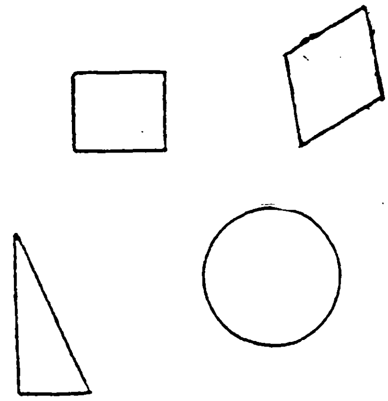




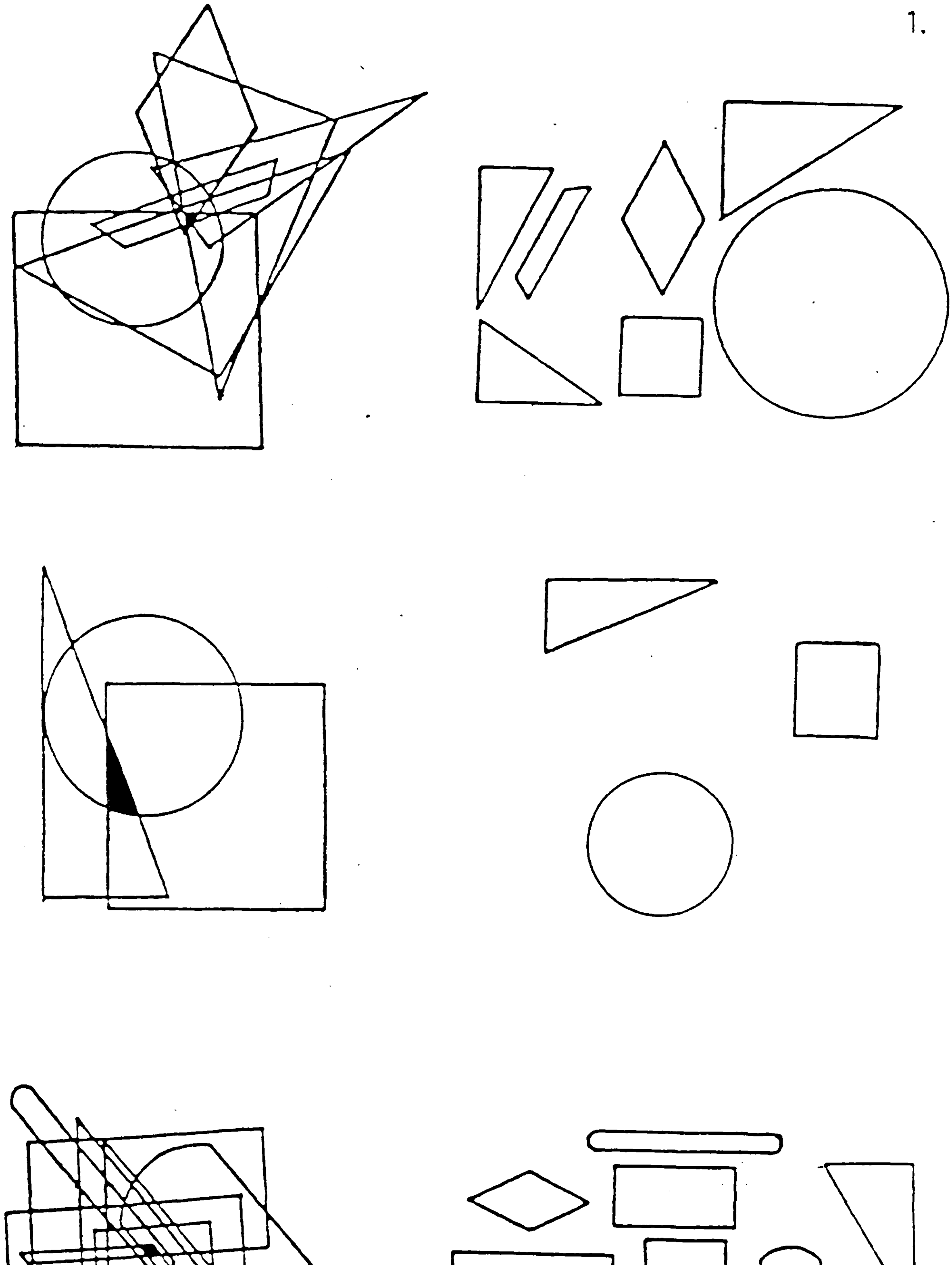


Try this example for yourself:

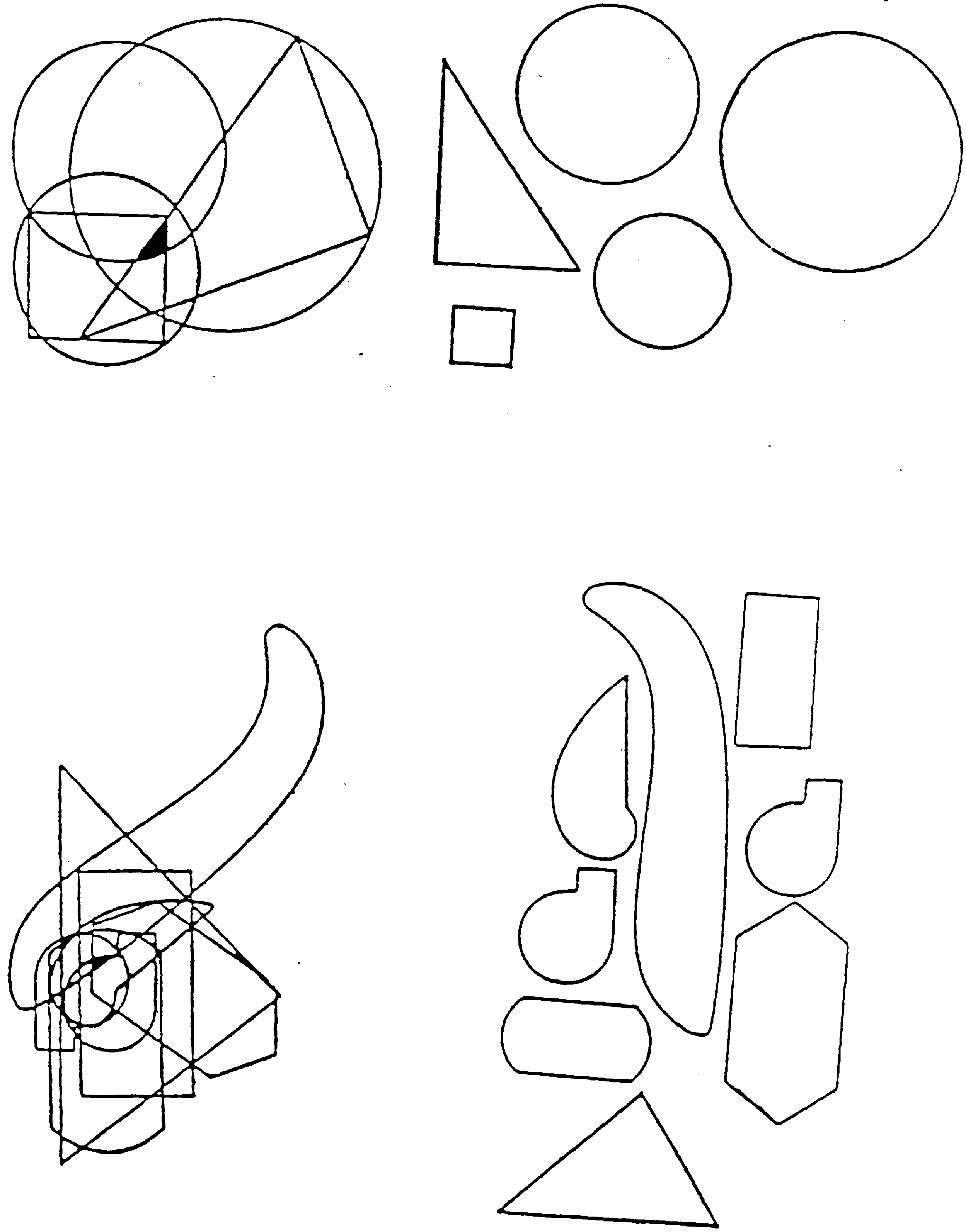




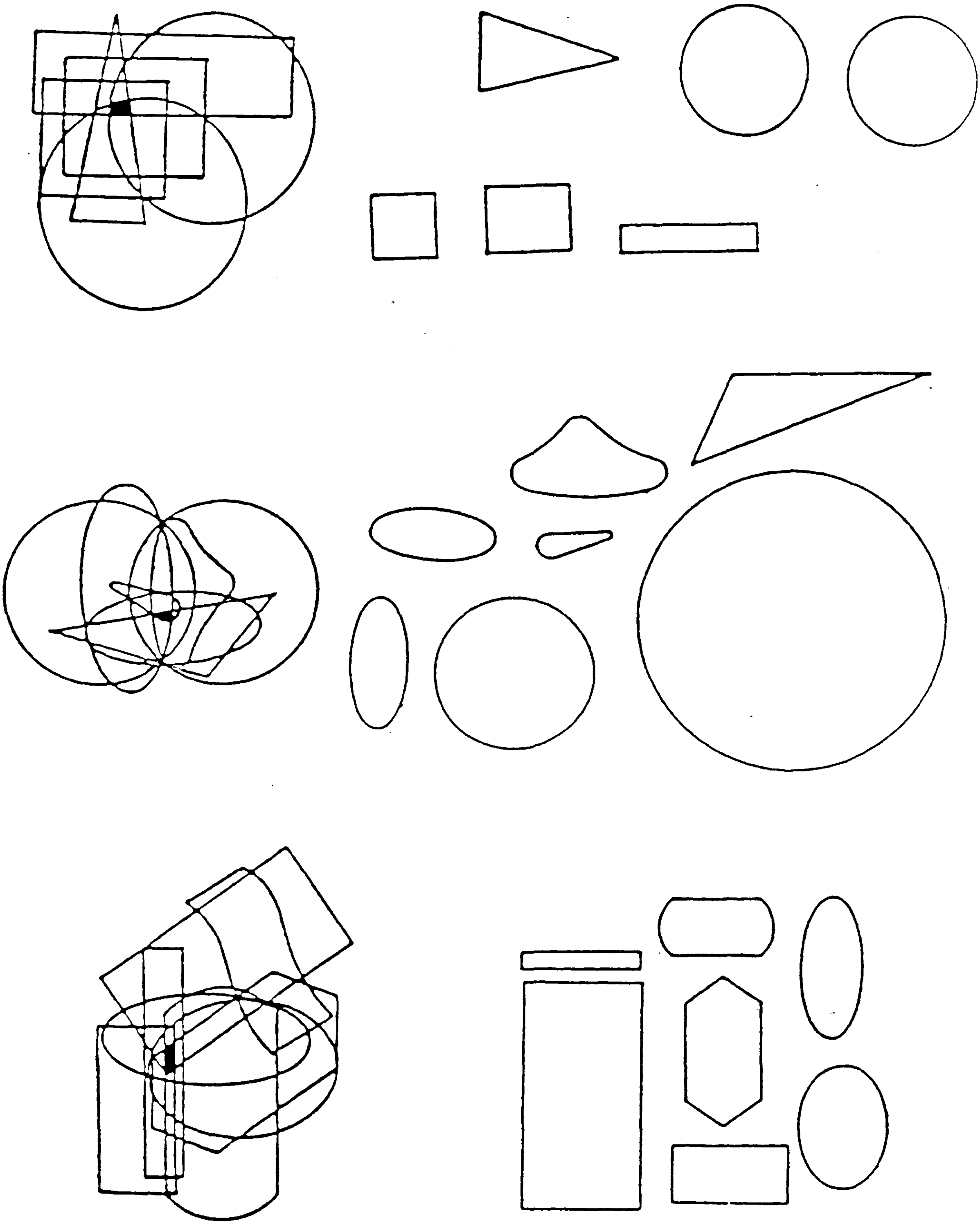
1.



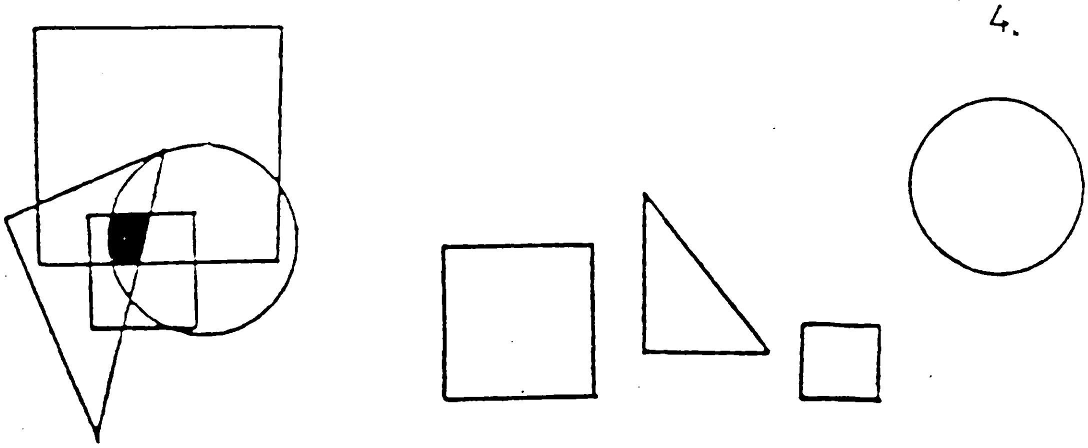
2.

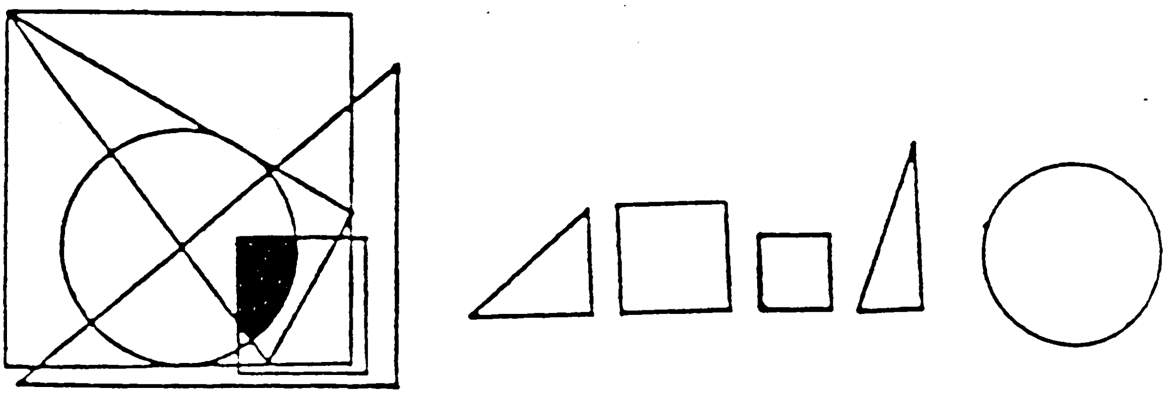


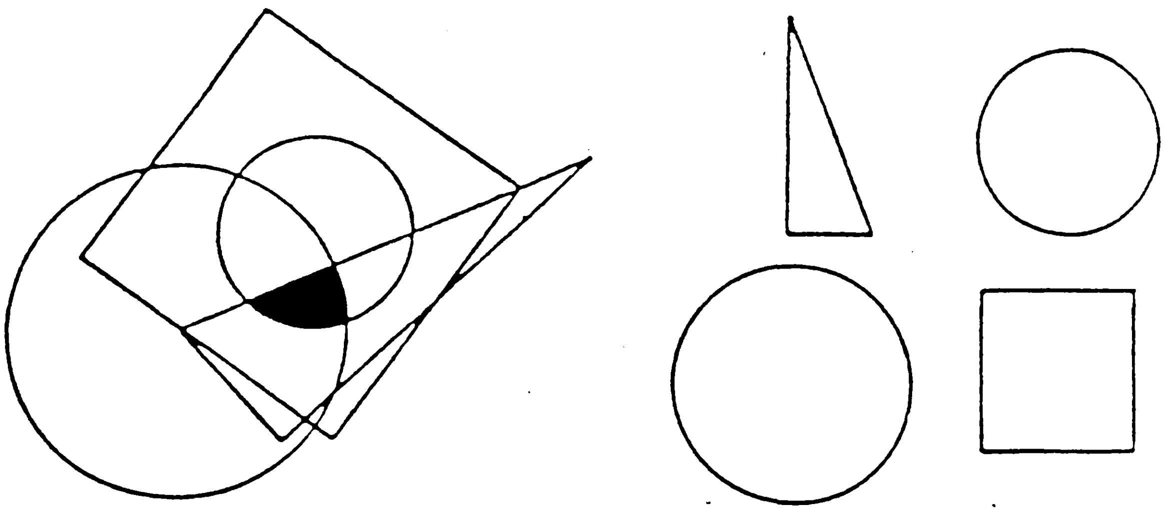
3.



4.







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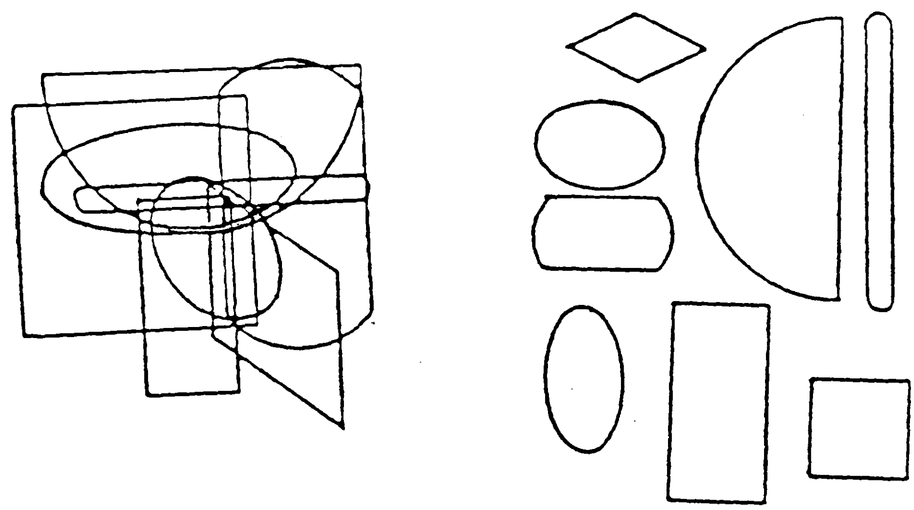
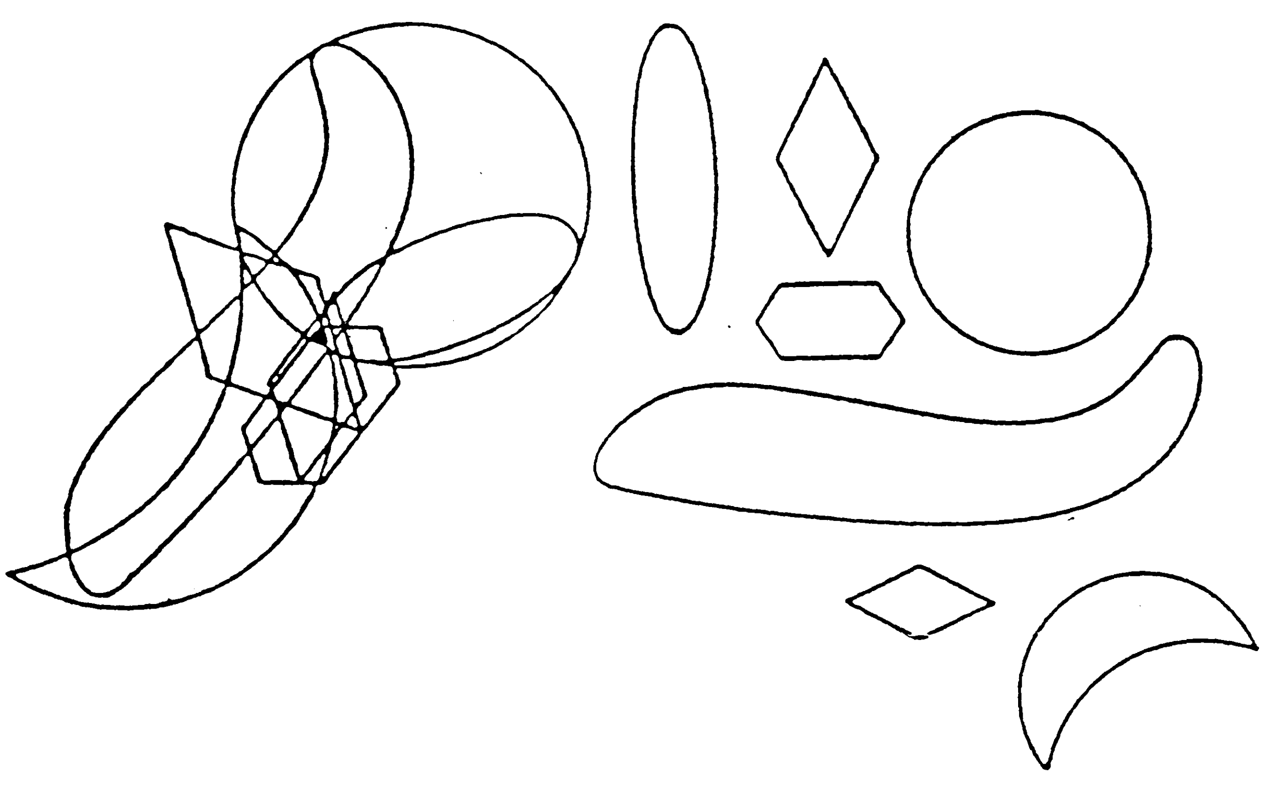
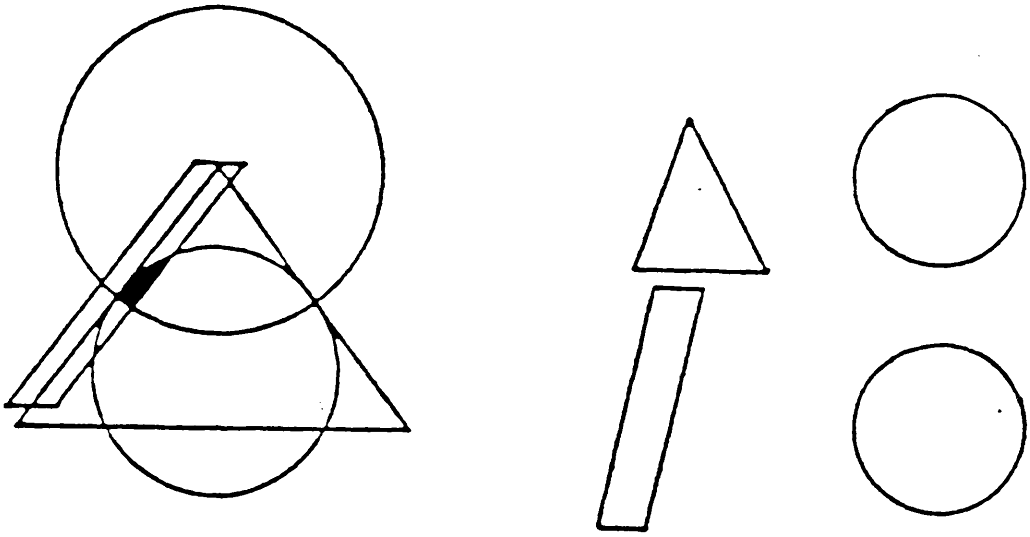
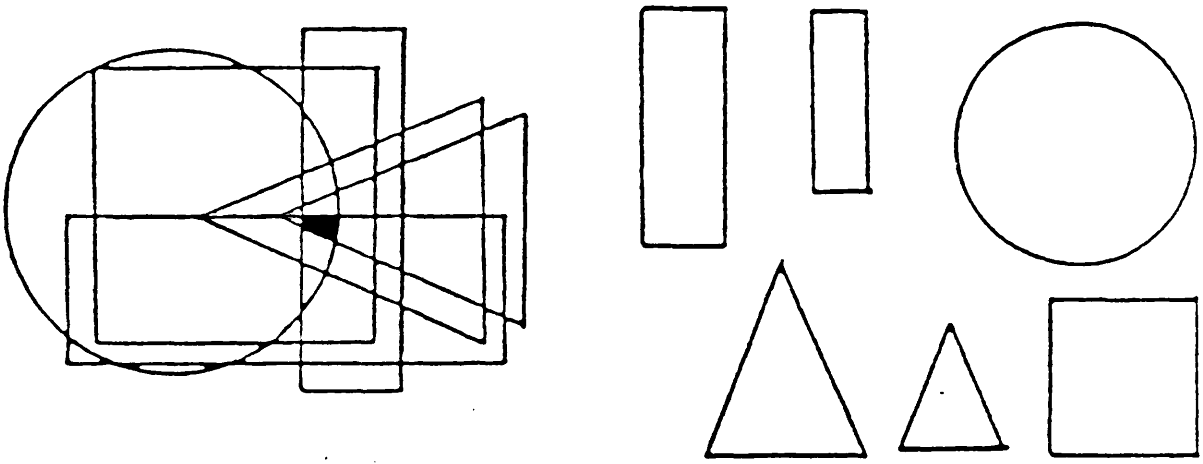
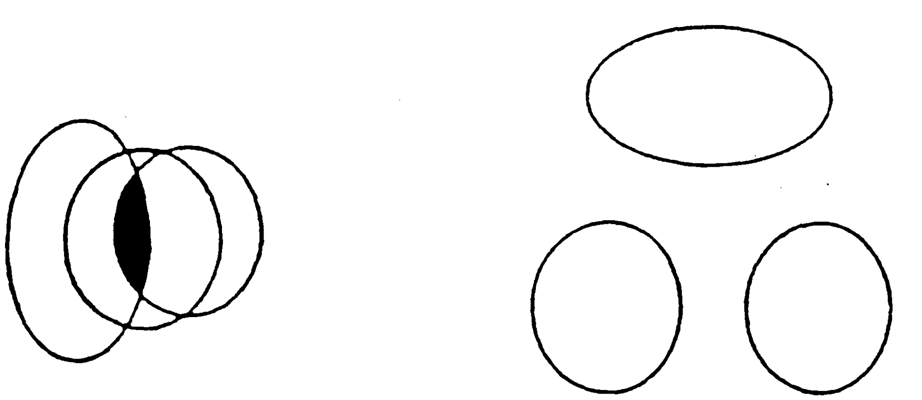




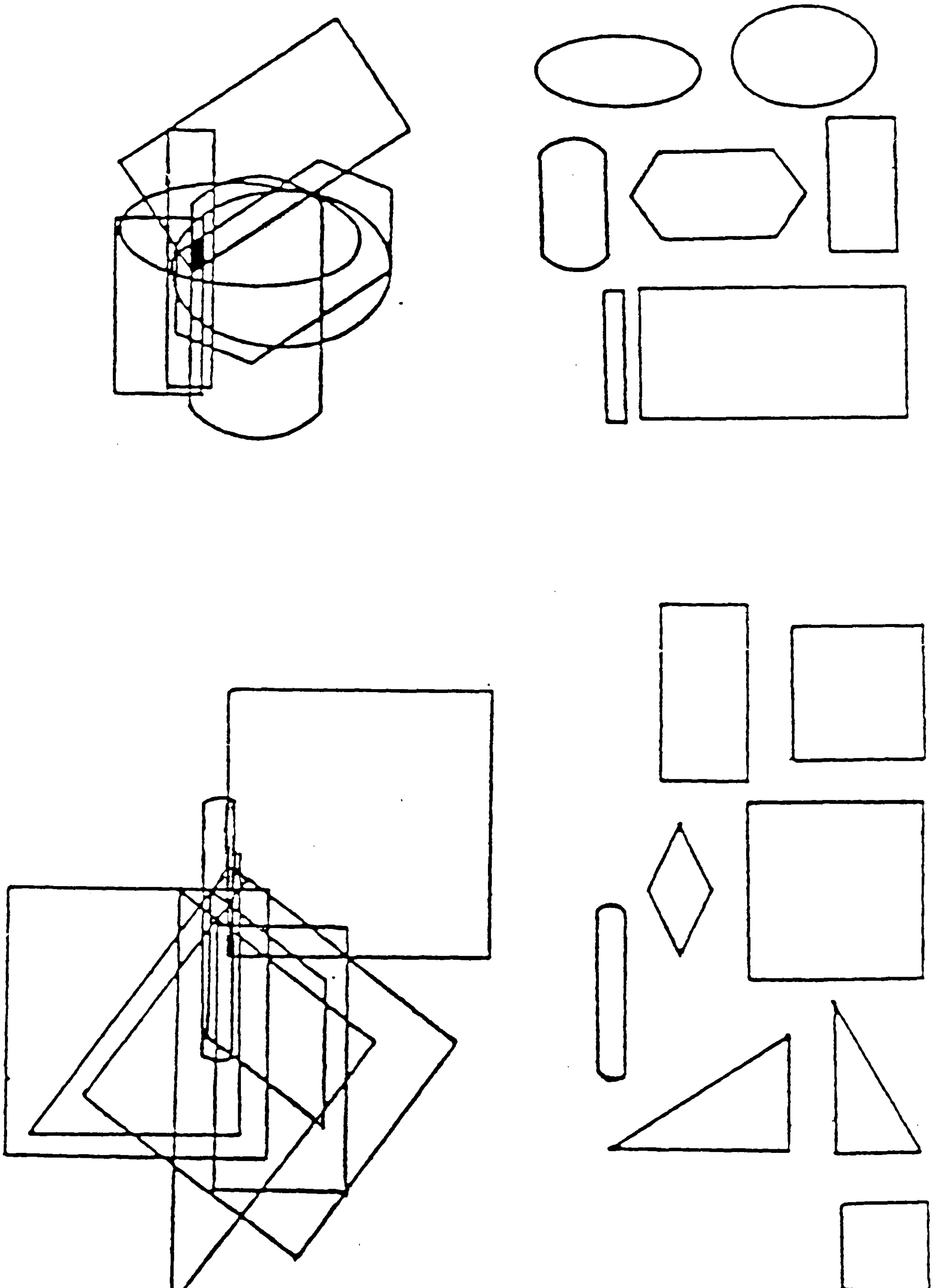
6.



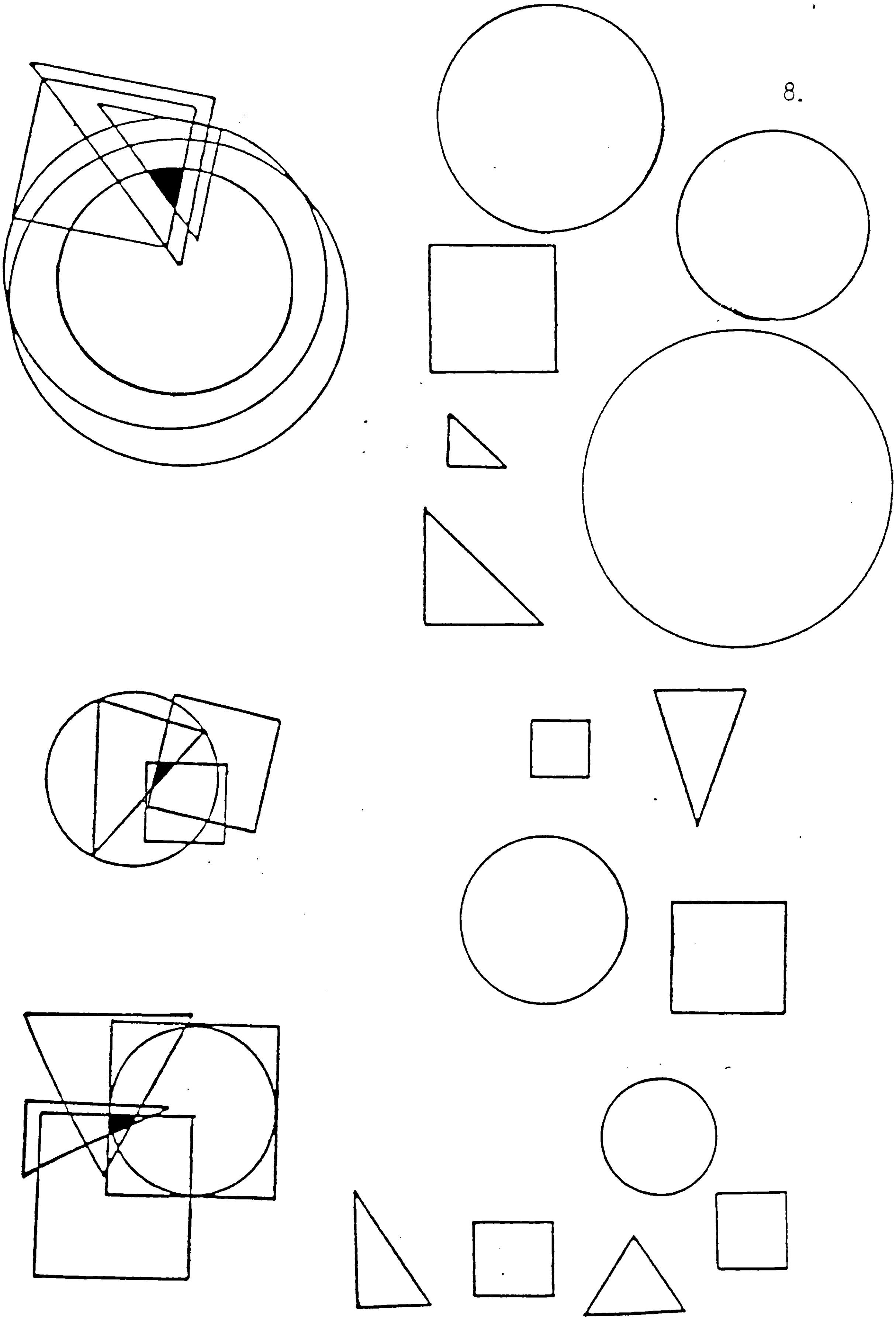




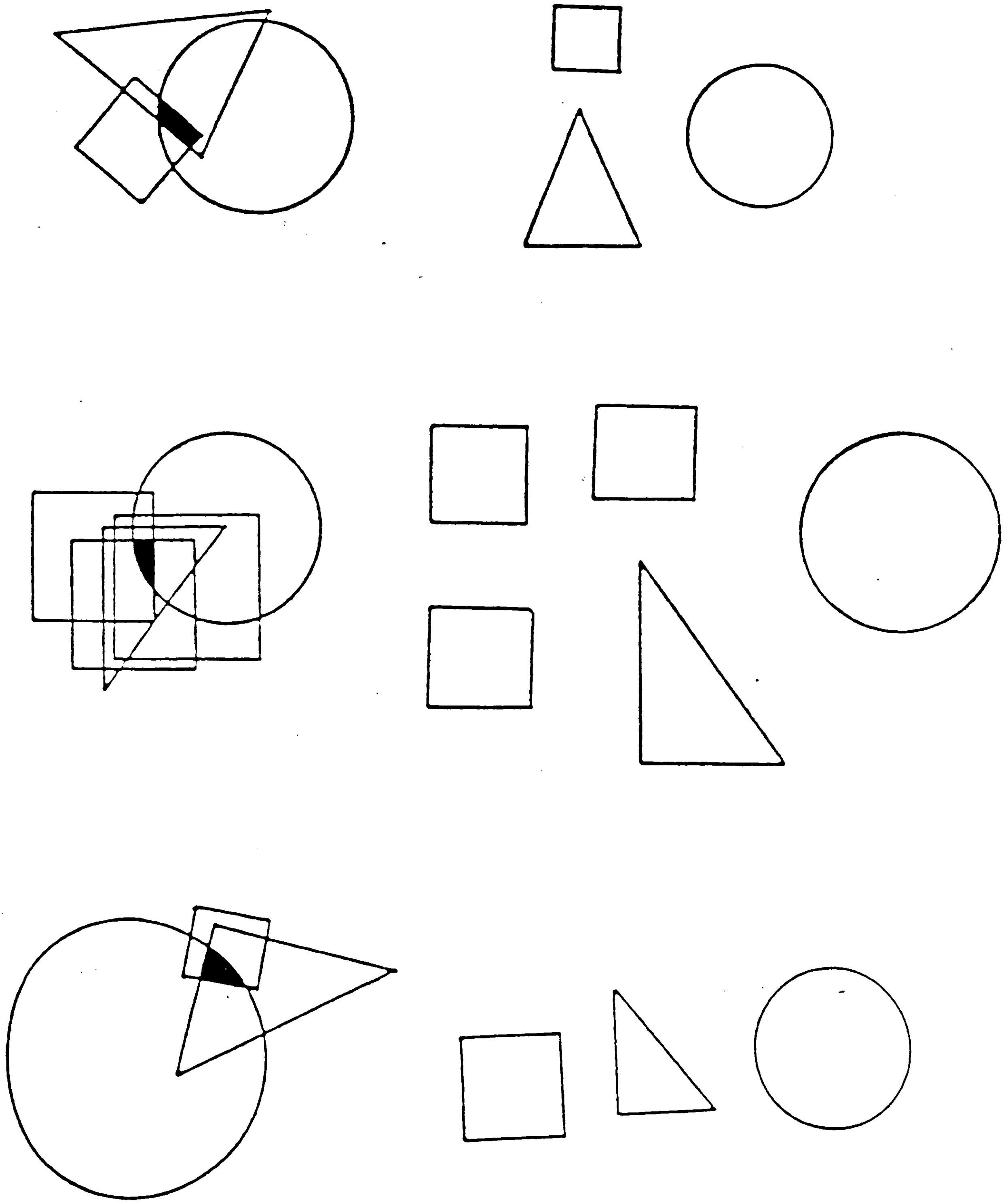
7.



8.



9.



APPENDIX V G

G1 Disembedding

G1.1 Measuring Disembedding Ability

G1.2 Disembedding Test

G1.3 Marking the Test

G 2 Hidden Figures Test (HFT) with Marking Scheme

G1 Disembedding

Disembedding is the ability to extract relevant information from irrelevant, ie: signal from noise. Individuals can be divided into groups according to this ability. Those who find it easy to disembed, ie: can extract relevant material, are known as Field Independent individuals. Those who find it difficult to disembed, ie: cannot extract relevant information, are known as Field Dependent individuals. Those who are neither Field Dependent or Field Independent, are known as Field Neutral individuals. A number of studies, Pascual-Leone (93, 95), Kempa (96) suggest that individuals who find it difficult to disembed, so called Field Dependent individuals, function at a lower level than expected. If working memory is a limited space then a pupil who is filling working memory with both signal and noise will have less space available for solving problems.

1.1 Measuring Disembedding Ability

To measure the ability of pupils to disembed a Hidden Figures Test (HFT) was used. This test was devised by El-Banna (77) and is based on those of Witkin (97). The design of the test is based on their definition of the Field Dependent/Field Independent cognitive style. This states that an individual who finds difficulty in separating an item from its context or in overcoming the influence of a surrounding field is classified as Field Dependent. Other individuals who can separate items from their context are classified as Field Independent.

1.2 Disembedding Test

The test consisted of seven simple shapes (geometric and non-geometric) embedded in complex figures. There was one shape per complex figure. Each of the simple shapes featured in at least two questions, giving eighteen items in all.

QUESTION	1	2	3	4	5	6	7	8	9
SIMPLE SHAPE	C	D	F	E	B	A	E	F	C

QUESTION	10	11	12	13	14	15	16	17	18
SIMPLE SHAPE	A	F	A	A	D	E	C	D	B

In the test, pupils had to find and outline the correct shape making sure it was of the same size, same proportions and faced in the same direction as the original. Since the test had been previously given to older pupils and university students, the instruction page was rewritten for younger pupils and included two worked examples.

1.3 Marking the Test

An item failed if:

a) no shape was drawn
b) the shape was the wrong size, proportion, direction
c) another wrong shape was drawn

Although only one correct shape was meant to be included in the pattern, in two of the questions very similar shapes were marked correct. This was done because of the younger age of the testees and because of inaccuracies due to printing of the test.

The test was used twice, in the initial (pilot 2) studies (see p266) and in the final testing of 285 pupils. El-Banna (77) measured the reliability of the test in a number of different ways and concluded that the test was able to show the disembedding ability of the subjects tested.

Witkin (97) Group Embedded Figures Test, upon which this test is based, is also considered a valid measure of Field Dependence/Independence.

Each pupil received a score out of eighteen.

H.F.T. TEST

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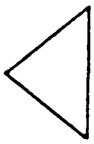
TEST 3

NAME: ______________________________

CAN YOU FIND A SIMPLE SHAPE WHEN IT IS HIDDEN IN A PATTERN?

Example 1:

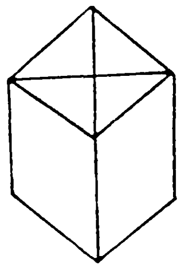
Here is a simple shape
labelled (x)
pattern



(x)

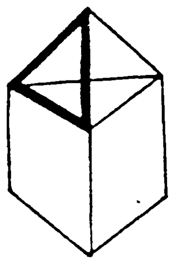
This simple shape (x)
is hidden in the

below:



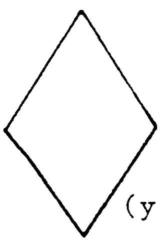
Look for the simple shape. It should be the same size and face the same direction. Trace the shape on the pattern above.

Your answer should look like this:



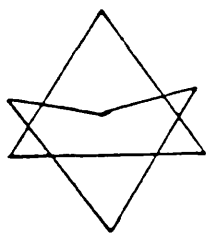
Example 2:

Find and trace shape (y)

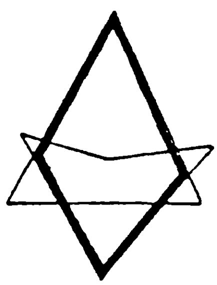


(y)

in the pattern:

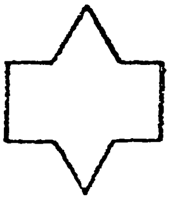


Your answer should look like this:



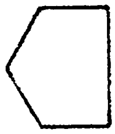
NOW DO THE ITEMS ON THE FOLLOWING SHEETS.

<u>SIMPLE FORMS</u>



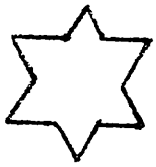
A

B

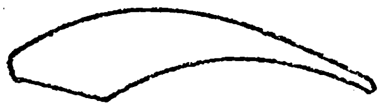


C

D

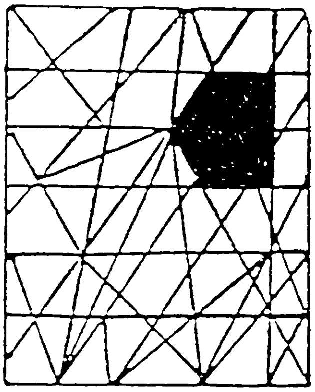


E

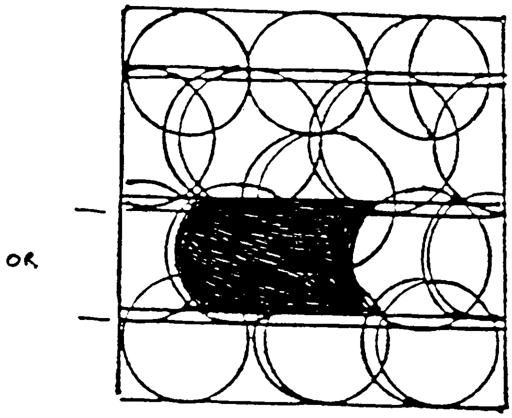


F

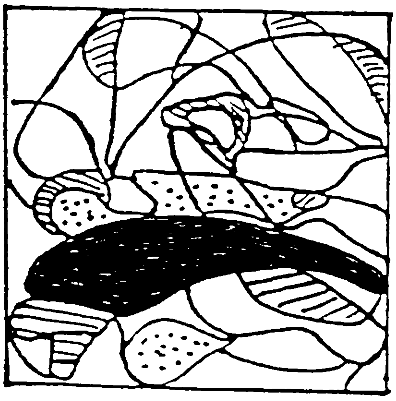
FIND SIMPLE FORM "C"



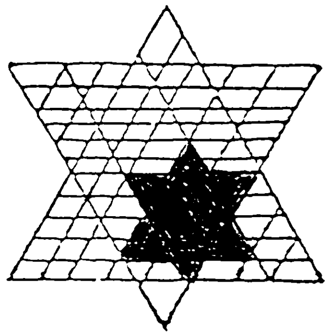
FIND SIMPLE FORM "D"



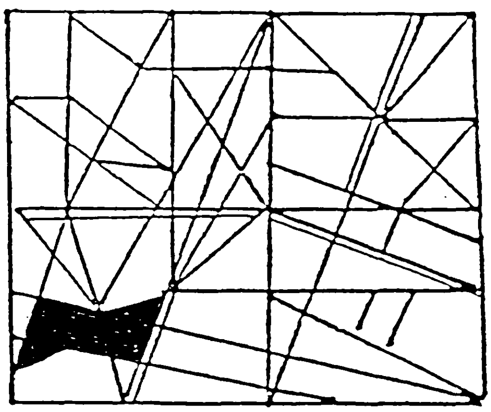
FIND SIMPLE FORM "F"



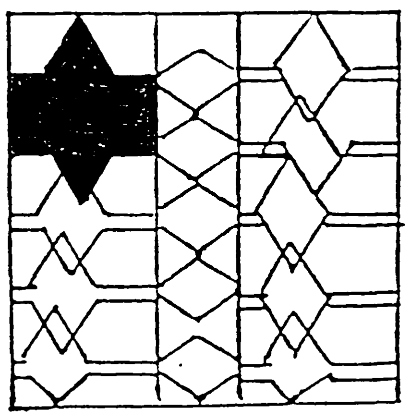
FIND SIMPLE FORM "E"



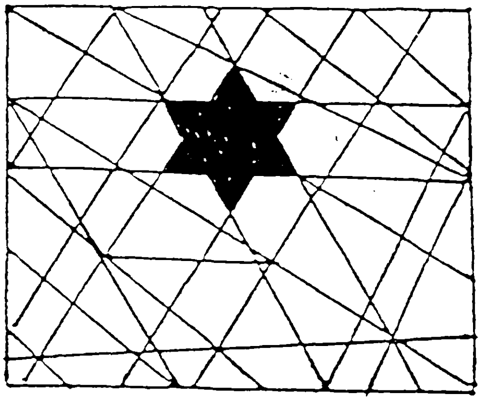
FIND SIMPLE FORM "B"



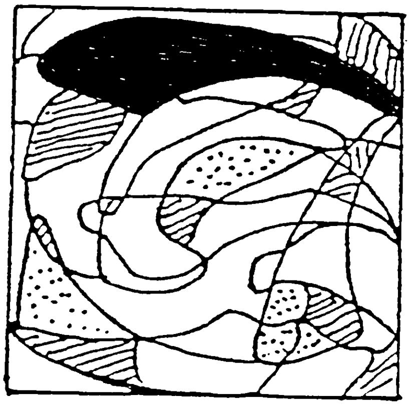
FIND SIMPLE FORM "A"



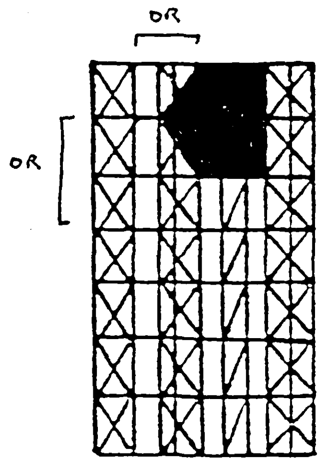
FIND SIMPLE FORM "E"



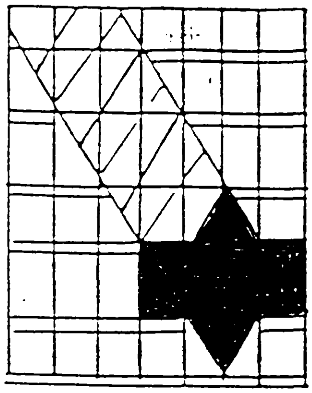
FIND SIMPLE FORM "F"



FIND SIMPLE FORM "C"

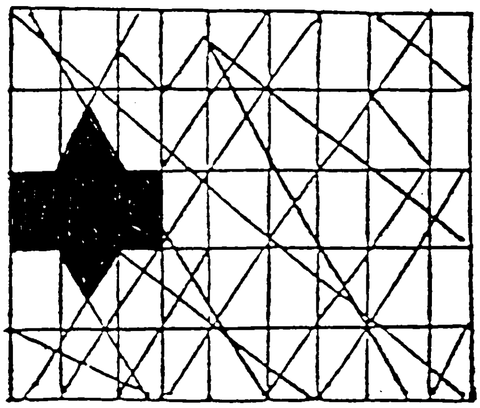


FIND SIMPLE FORM "A"

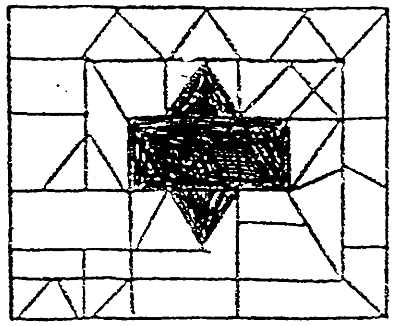


FIND SIMPLE FORM "F"

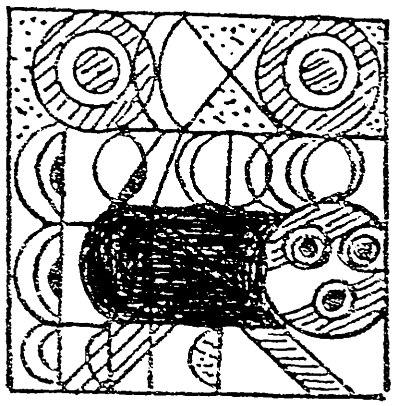
FIND SIMPLE FORM "A"



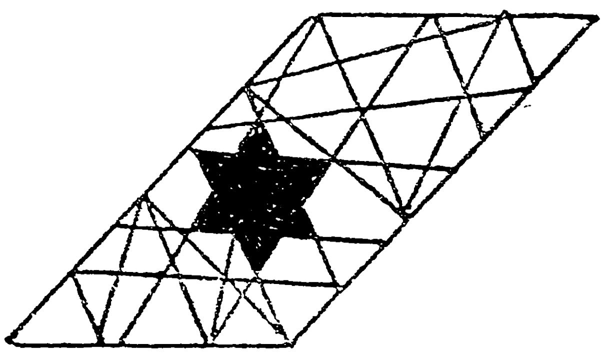
FIND SIMPLE FORM "A"



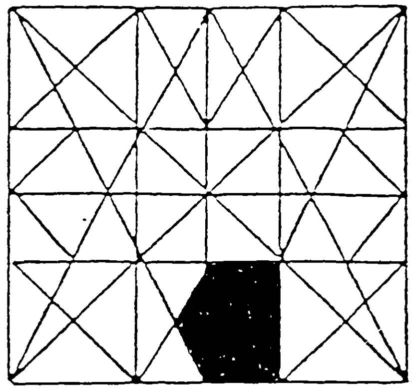
FIND SIMPLE FORM "D"



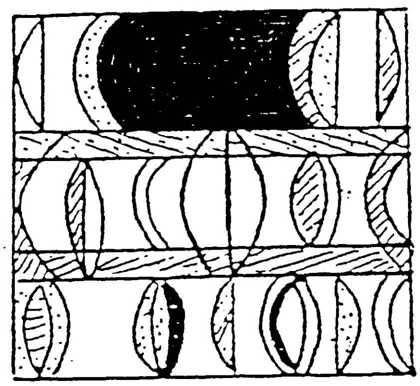
FIND SIMPLE FORM "E"



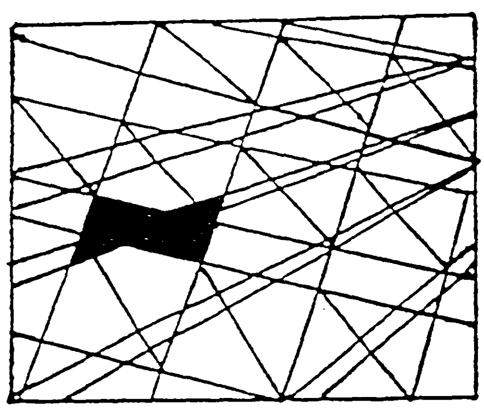
FIND SIMPLE FORM "C"



FIND SIMPLE FORM "D"



FIND SIMPLE FORM "B"

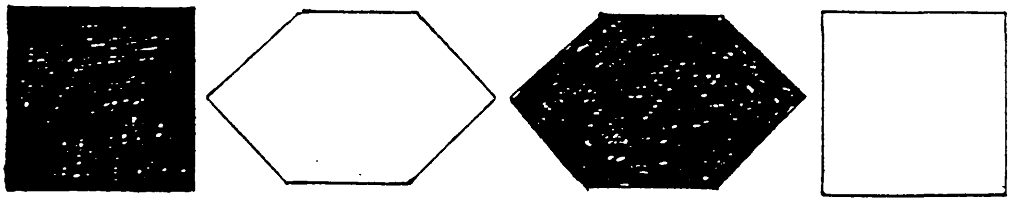


APPENDIX V H

Pilot 2: Test 2

Test Items and Marking Scheme

Test 2
Question 1



A B C D

Divide the objects into 2 groups. Draw your objects in the boxes below:

Group 1 **Group 2**

What thing did you use to separate the objects?

Group 1 has .... Group 2 has ....

.... in common .... in common

Divide the Objects in Group 1 into 2 Groups. Draw the objects.

Divide the Objects in Group 2 into 2 Groups. Draw the objects.

Group 3 **Group 4** **Group 5** **Group 6**

Write down the thing that you used to separate each group.

Group 3 has .... Group 5 has ....

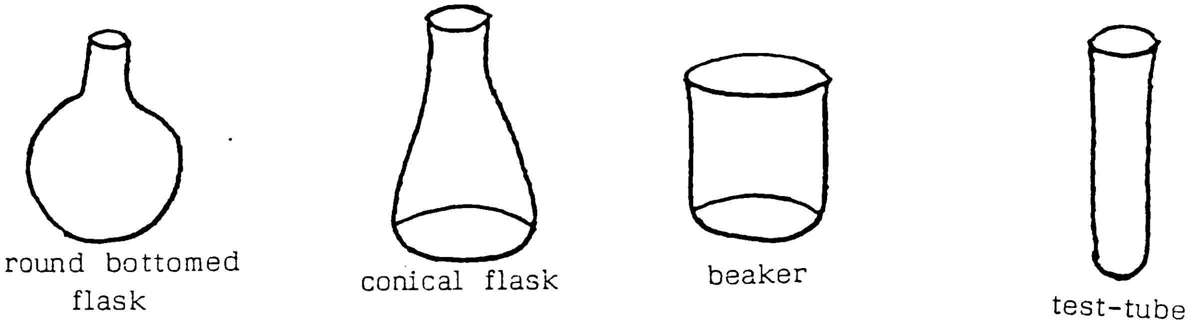
.... in common .... in common

Group 4 has .... Group 6 has ....

.... in common .... in common

Marking: Number of sides/name of figure/colour - light & dark Sort could be done in any order. Picture had to agree with feature chosen.

Question 2



Divide the objects into 2 groups. Draw your objects in the boxes below:

Group 1 **Group 2**

What thing did you use to separate the objects?

Group 1 has .... in common

Group 2 has .... in common

Divide the Objects in Group 1 into 2 Groups. Draw the objects.

Divide the Objects in Group 2 into 2 Groups. Draw the objects.

Group 3 **Group 4** **Group 5** **Group 6**

Write down the thing that you used to separate each group.

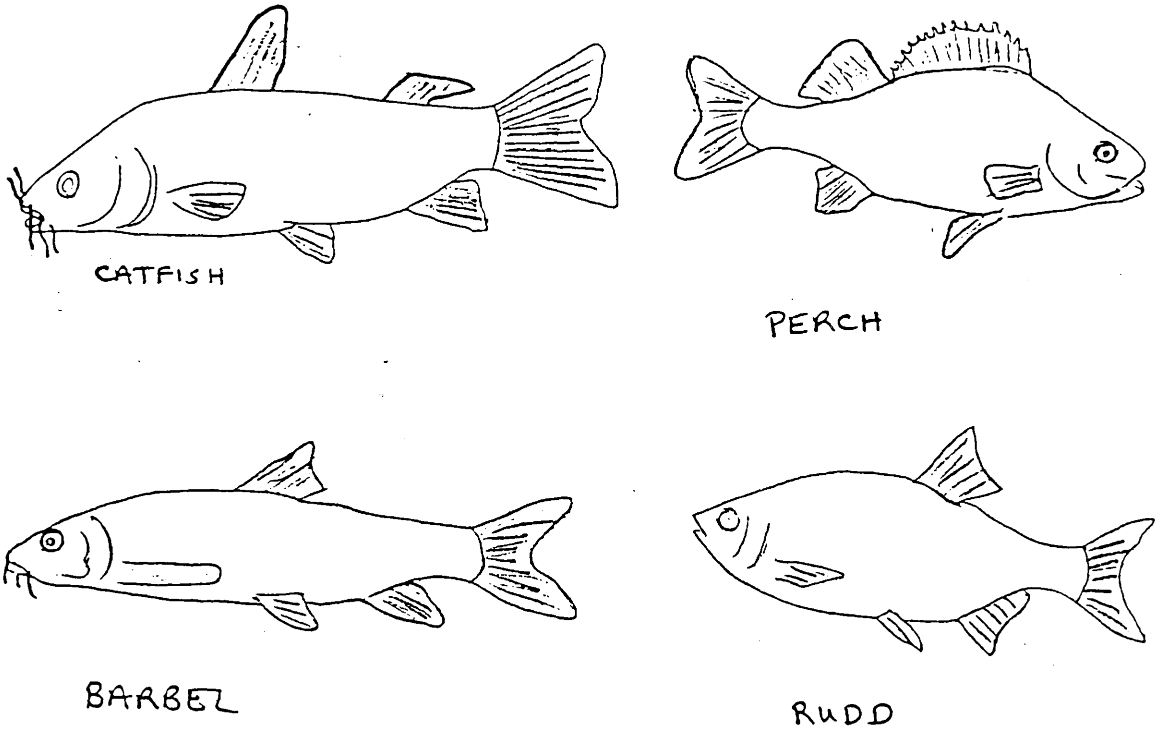
Group 3 has .... in common

Group 4 has .... in common

Group 5 has .... in common

Group 6 has .... in common

Marking: Curved base/bottom or flat base.
Straight sides/neck/narrower at the top.



Look at the appearance of each fish. What important things about each fish might help you to make a key? Write down the things you have found.

CATFISH

PERCH

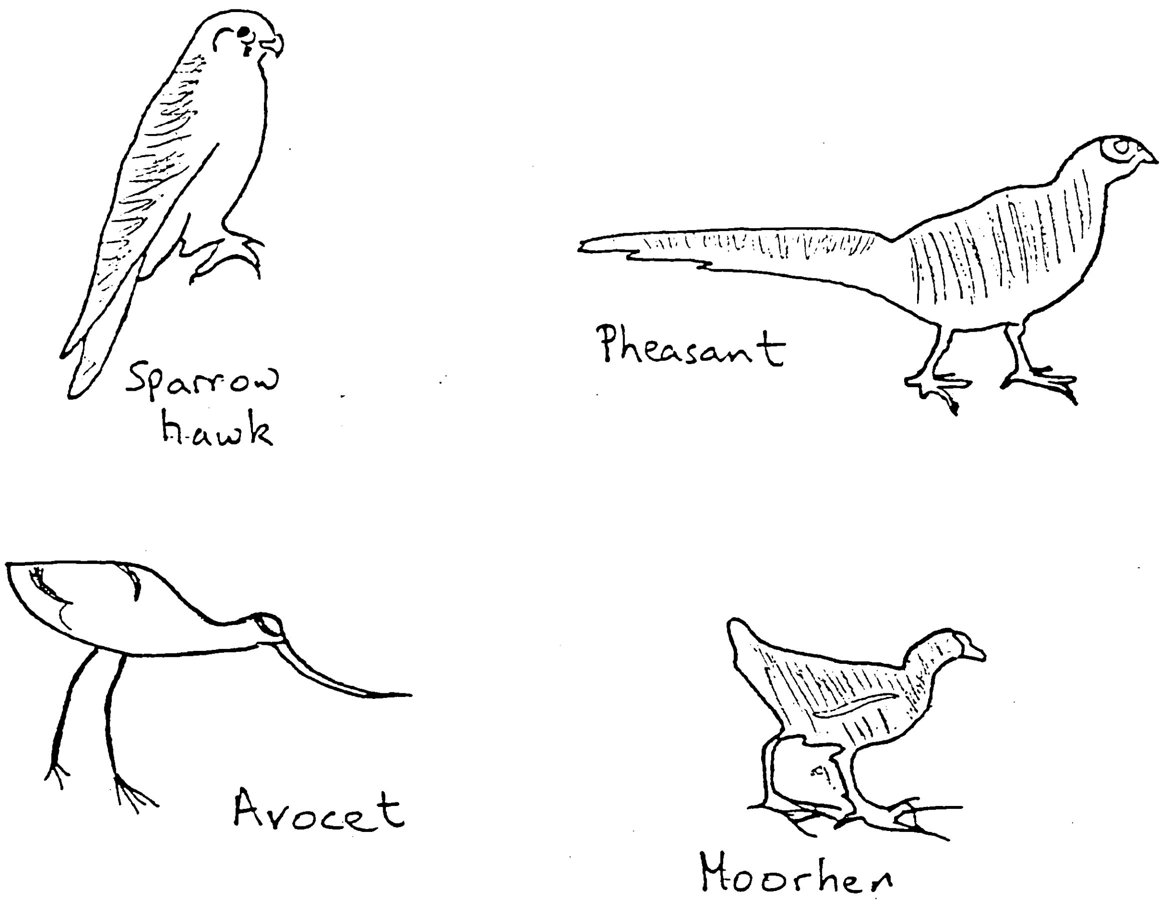
BARBEL

RUDD

Marking: number of fins/type of top fin, eg: lots of spikes presence or absence of barbels/whiskers.

The information had to be suitable for use in a key. At least 2 features per fish were expected to pass.

Question 4



Look for the important things about the appearance of each bird. Choose things which might help to make a biological key. Write down these things below.

SPARROW HAWK

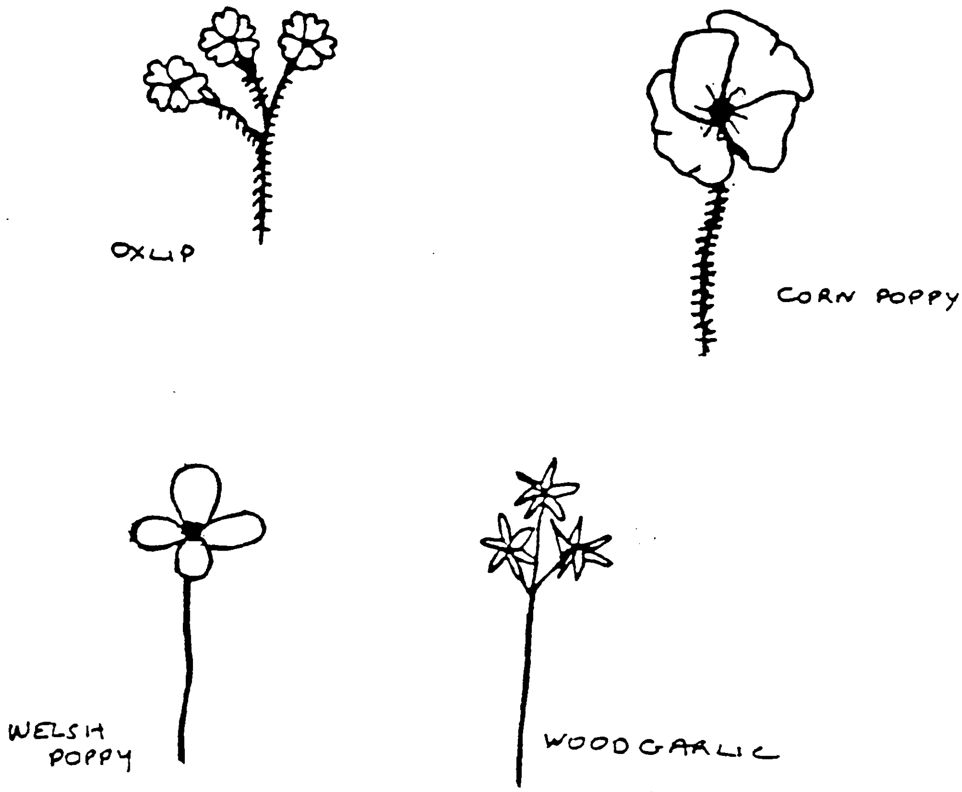
PHEASANT

AVOCET

MOORHEN

Marking: type of beak/type of tail or presence/absence of tail type of feet, type of legs

Question 5



Use these pictures of common flowers to do the following:

1 You are asked to describe the corn poppy to someone over the 'phone. Write down at least four things you might mention about it.

Marking: hairs, 4 petals, dark centre, 1 flower/stem, shape of petals.

2 Look at the other three flowers. Choose two of them which have something in common (the same) but different from the third one.

The two flowers chosen are .... and ....

What was the same about them? *no of flowers/stem or group of flowers* ....

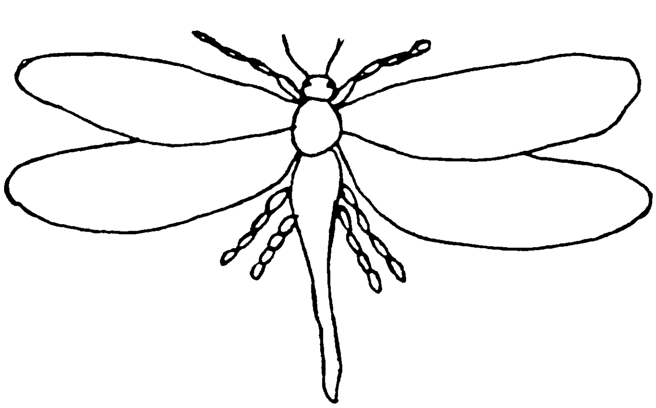
lack of hairs

These flowers are not exactly the same. Can you find something that is different about them?

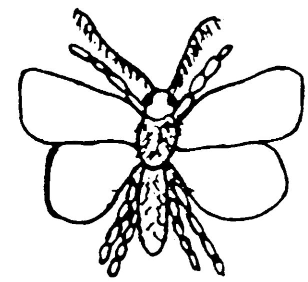
depending on answer to question above.

....

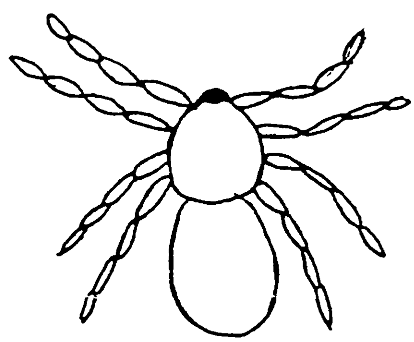
Question 6



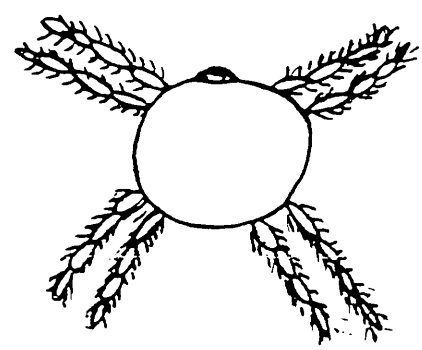
DRAGON FLY



MOTH



SPIDER



MITE

If you look at the pictures you will notice that the dragonfly and moth have feelers but the spider and mite do not. This has been written in the table for you. Now look for three other things which are different about these animals. Put these in the table.

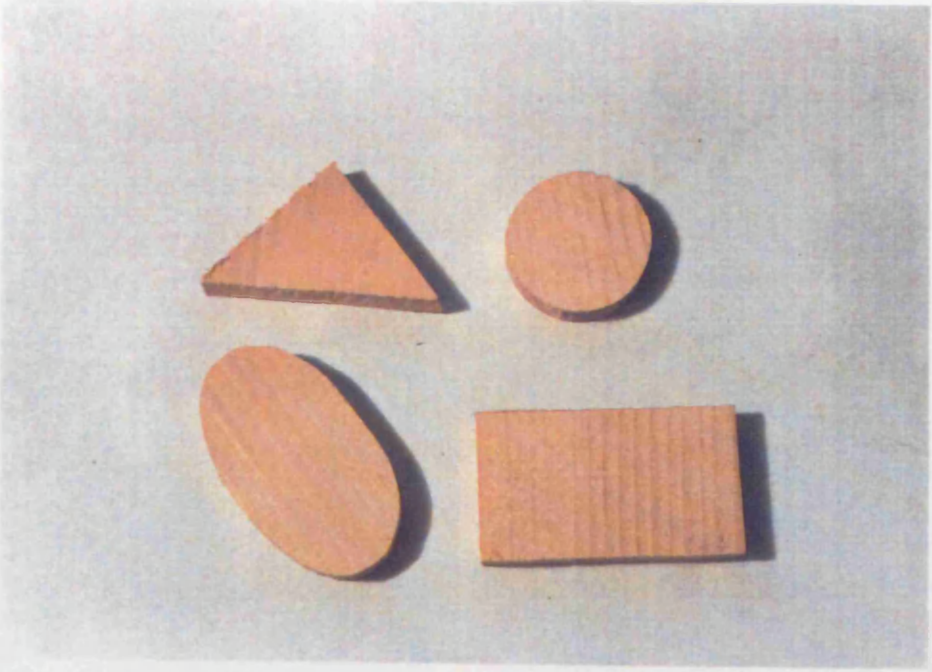
	Thing 1 Feelers	Thing 2 *Wings*	Thing 3 *No of Legs*	Thing 4 *Hairs*	*No of Body Parts*
SPIDER	No				
MOTH	Yes				
DRAGONFLY	Yes				
MITE	No				

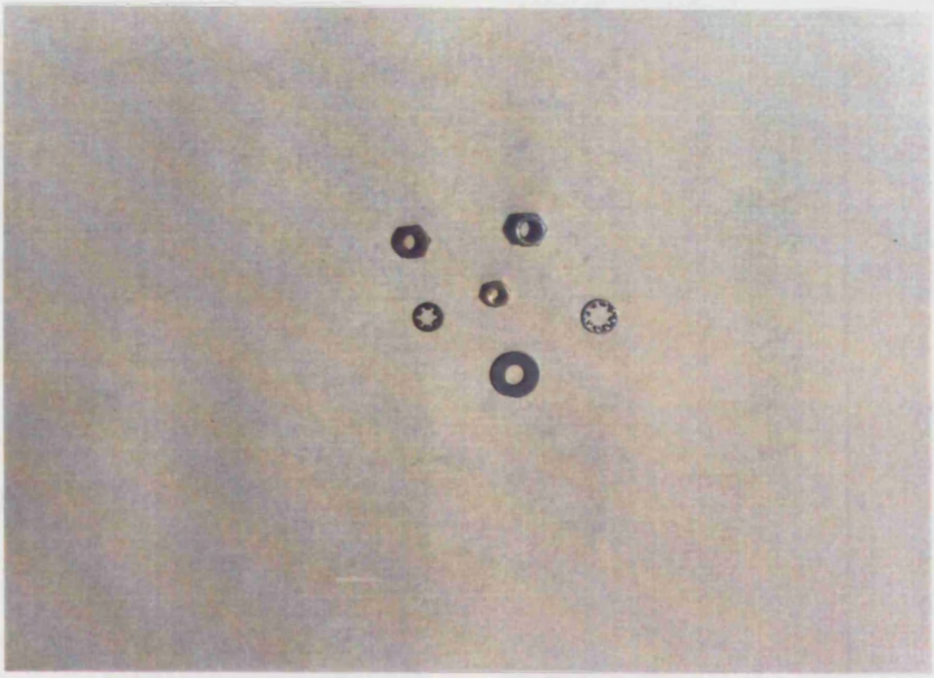
Using this table, could you make a key? *organism must have unique features.*

APPENDIX V J

Pictures of Interview Items

Items:	1	wooden shapes
	2	non-biological objects: nuts/screws
	3	non-biological objects: screw/nail/bolts
	4	flowers: chicory/nipplewort sowthistle/cornflower








APPENDIX V K

Pilot 2 Results

Test 2 (written items testing ability to choose attributes)

Test 3 (Digit Backwards Test to measure working memory capacity for marking see Appendix V F)

Test 4 (Hidden Figures Test to measure disembedding ability for marking test see Appendix V G)

Interviewees: *** High Ability
** Middle Ability
* Low Ability

Groups of Pupils Tested Pilot 2

Group	Year	School	Number of Pupils	Tests Completed
1 (pre-pilot)	S2	A	16	2
2	S1	A	15	2, 3, 4
3	S1	B	12	2
4	S1	B	3	2, 3, 4
5	S1	C	18	2, 3, 4
6	S3	A	18	2, 3, 4
7	S3	B	15	2
8	S3	B	3	2, 3, 4
9	S3	C	17	2, 3, 4

GROUP 1

Pupil No	Test 2 Score /6	DBT	HFT (/18)
1*	1	5	6
2*	2	5	6
3	3	5	6
4	1	8	8
5	4	8	9
6***	5	6	7
7	1	8	4
8***	4	6	4
9**	4	2	4
10	3	5	0
11	5	6	9
12	3	5	1
13	3	7	7
14	3	8	1
15	3	3	3
16**	2	5	1

GROUP 2

Pupil No	Test 2 Score /6	DBT	HFT (/18)
1	3	5	7
2***	2	5	7
3***	3	5	5
4**	1	3	12
5	1	4	8
6	1	3	6
7*	1	3	4
8	3	6	13
9*	3	7	11
10**	1	3	4
11	2	4	9
12	1	4	11
13	2	4	10
14	1	5	4
15	3	7	12

GROUPS 3 & 4

Pupil No	Test 2 Score /6	DBT	HFT (/18)
1	2		
2	0		
3	1		
4	1		
5	0		
6	0		
7	0		
8	0		
9	0		
10	1		
11	2		
12	1		
13**	0	4	0
14*	0	8	0
15***	1	3	4

GROUP 5

Pupil No	Test 2 Score /6	DBT	HFT (/18)
1	2	5	10
2***	3	4	15
3	2	5	5
4	0	8	4
5***	2	6	10
6	2	6	7
7	3	3	6
8	0	4	1
9*	1	8	0
10	1	4	13
11	-	7	3
12**	4	3	6
13*	1	6	0
14	2	5	12
15	3	4	9
16	1	-	4
17	1	6	0
18**	2	7	0

GROUP 6

Pupil No	Test 2 Score /6	DBT	HFT (/18)
1***	1	7	13
2	3	6	15
3	1	4	6
4***	4	4	8
5	3	7	8
6	3	6	5
7	3	5	8
8	2	7	9
9**	1	8	5
10	1	4	11
11*	2	4	10
12*	4	3	1
13	1	8	8
14	4	6	9
15	2	8	7
16**	1	3	8
17	2	5	7
18	1	6	4

GROUPS 7 & 8

Pupil No	Test 2 Score /6	DBT	HFT (/18)
1	1		
2	1		
3	4		
4	2		
5	0		
6	3		
7	2		
8	1		
9	5		
10	2		
11	2		
12	2		
13	3		
14	2		
15	1		
16*	3	8	0
17**	1	8	5
18***	2	6	3

GROUP 9

Pupil No	Test 2 Score /6	DBT	HFT (/18)
1	3	5	2
2	-	5	2
3	5	6	11
4***	4	4	5
5	3	4	5
6	-	7	5
7	5	6	8
8*	0	5	10
9	2	6	6
10**	3	5	14
11***	2	5	9
12	-	5	6
13	-	3	3
14**	3	5	0
15	2	7	6
16	3	4	8
17*	0	6	5

CHAPTER 6

INVESTIGATION OF THE SKILLS NEEDED TO MAKE A KEY AND THE PSYCHOLOGICAL FACTORS THAT MIGHT AFFECT THESE SKILLS

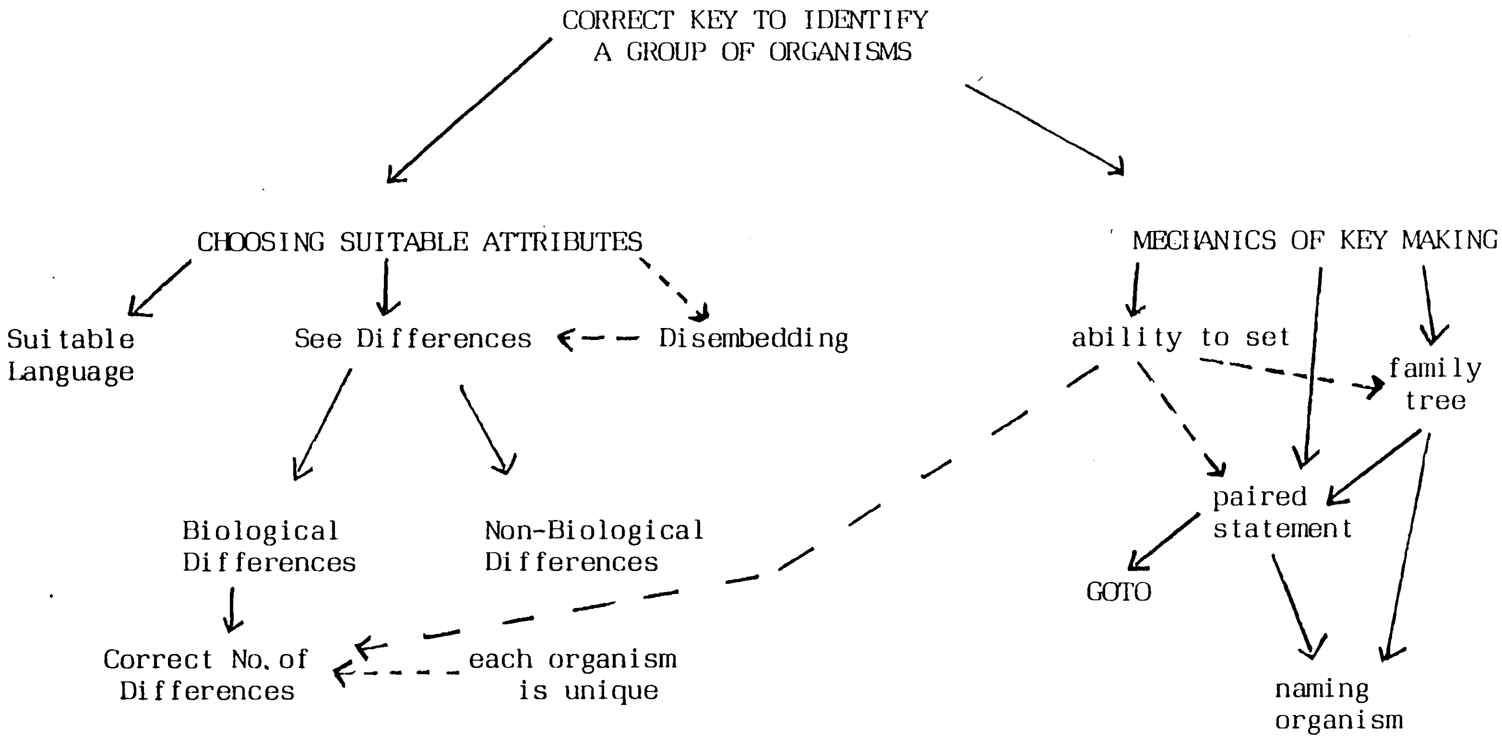
6.1 Learning Hierarchies

Gagne (98) suggests that the psychological organisation of intellectual skills can be shows as a learning hierarchy.

The learning of an intellectual skill, in this case the construction of a biological key, can be shown to consist of a number of prerequisite skills. These may be rules and/or concepts. These prerequisites may be learnt as part of the learning of the new skill or may be recalled from long term memory. Learning hierarchies imply that learning is cumulative. All the rules and concepts must be learnt in order to have a full understanding of the topic.

In theory, a learning hierarchy can be made by working backwards from the target objectives to analyse the component skills. When the learning hierarchy is completed, the sequence of skills can suggest a teaching/ learning order. In practice the construction of a learning hierarchy can be difficult. Skills are not necessarily confined to one part of the hierarchy. Skills are often interdependent. Constructing a learning hierarchy is therefore a useful exercise. However in the learning of a complex skill like key making there are a number of possible hierarchies. The making of a series of hierarchies like the program design earlier (Sect 5.4) helps the teacher to decide on pupil skills to be learnt or revised and on the best possible teaching strategy.

HIERARCHY OF SKILLS FOR MAKING A KEY



6.2 Skills Needed to Make a Biological Key

Firstly, the task can be divided into two distinct areas:

1. Choosing suitable biological attributes
2. Mechanics of making the key

Within the area of choosing attributes, the following skills are needed:

1. the ability to distinguish features
2. the ability to name these features
3. the ability to choose biologically significant features and to disregard unsuitable differences
4. to know when there are enough suitable features so that all organisms can be identified.

The end product of this is to have the correct number of suitably named attributes.

Within the area of making the key, the following skills are needed:

1. the ability to sort or set objects
2. the making of a family tree key
3. the making of a paired statement key.

6.3 Perception

What a pupil sees or perceives is obviously important. Accurate observation is an essential part of many biological skills, including key making. It is not an easy skill to learn.

What the pupil sees will be dependent on a large number of factors, experience, expectation, interest and previous knowledge. The pupil's schema or mental model will be based on these and other factors. The effect of context, other information, eg: a picture can be distorted to fit in with words or existing schema. Assumptions can be made about size (Ames, 99) so that things fit in with normal schema. Features can be ignored or rejected so as to fit in with the normal expected pattern.

Abercrombie (78) in her studies with medical students noted that they tended to see what they expected, whether it was there or not. They made assumptions and confused inferences with descriptions. Information received is dependent on assumptions and preconceptions.

While observing we check perceptions against expectations. Children often see what they expect to see and do not always know what to pay attention to and what to ignore (Driver, 80).

Perception of what we see or think we see can be divided into two categories:

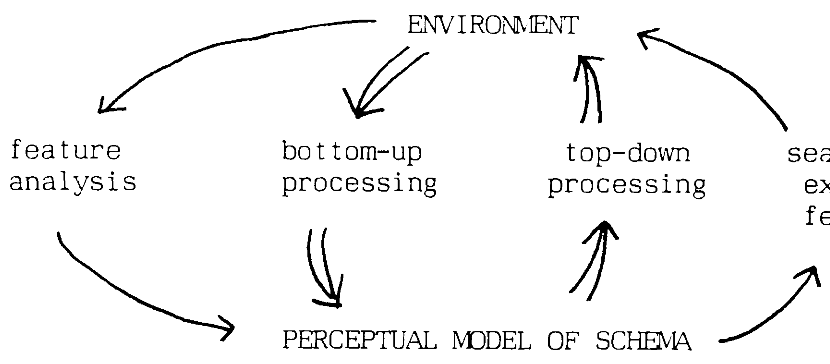
a) innate or in computer language bottom-up or data driven processing;

b) learnt or top-down or concept driven processing.

In the former, the input is received by the sense organs which pass on the information to the brain for higher analysis. In the latter, knowledge of past experiences is used to interpret sensory input in terms of expectations about the environment.

Figure 6.2

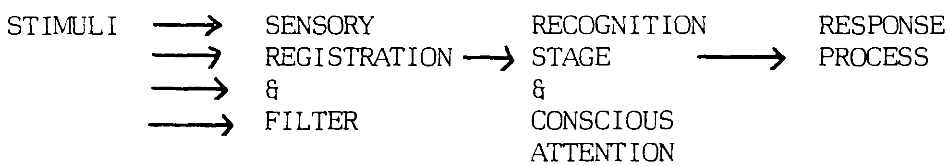
Neisser (100) proposed "an analysis by synthesis" model of perception.



According to Neisser, perceivers generate models of objects which they use to interpret features and to initiate a search for further features to confirm their expectations. This model is a cyclic one which has the ability to be constantly updated as new information is received which in turn affects schema, etc.

Perception and attention are intertwined. We can only attend to the things we perceive and perceive the things we are attending to. Two models of attention have been put forward Early and Late selection models.

Broadbent, 1958 (101) and Treishman, 1964 (102) advocate early selection models.



Broadbent suggested a selective filter so that only one channel can be processed at a time - a temporary sensory buffer. Trieshman's filter allows unattended material to pass on in an attenuated form.

Deutsh, 1963 (103) and Norman, 1968 (104) propose late selection models.

STIMULI → SENSORY REGISTRATION → RECOGNITION STAGE → CONSCIOUS ATTENTION → RESPONSE PROCESS

At present there is difficulty in deciding which takes place, since both occur at the unconscious level. It seems likely that we do have a perceptual filter which can be overridden. Sometimes we are conscious of unattended information, but at other times it is monitored at an unconscious level. We can do tasks in parallel, while at other times all our attention is allocated by the central processor to one particular job.

I would suggest that in the normal classroom situation, the late selection model operates but the focusing of a pupil's attention onto a particular task shifts the filter forward. The shifting of the filter does not exclude other information which can pass through in an attentuated form. The filter can move back very easily, perhaps more easily than we might want.

We must not forget that the contents of the long term memory and the capacity of the working memory will also influence perception. Knowledge and therefore learning and memory are also important in determining what we perceive and attend to.

6.4 Further Analysis of Skills

1 **Choosing Suitable Attributes**

To choose suitable attributes, a pupil must be able to name features; they must have the correct language. They need to be able to recognise features from a number of different inputs. Under ideal conditions, pupils should be able to recognise features from the living organism and make a key accordingly. In practice, the majority of keys will be made from a variety of pictures and drawings. The making of keys is a problem-solving activity in the Standard Biology and may be tested in the written exam in which case pupils might be asked to make a key from drawings. The ability to disembed influences pupil's ability to recognise features which can be used to make the key. The ability to sort or set features will be necessary if the pupil is to decide whether they have enough features to make the key work.

2 **Mechanics of Key Making**

Having chosen enough suitable attributes, pupils must be able to group the organisms according to these features; usually this involves putting organisms into two groups then four, etc. Pupils have to be able to sort according to both similarities and differences always holding in mind the uniqueness of each organism. This ability to set affects both types of key. In family tree or branched keys a pathway has to be worked out and the names of the organisms put in the correct place. In the paired statement key the path to be followed through the key is not shown by a line but by numbers and a GOTO instruction.

6.5 The Final Testing

In the light of the previous work, it can be said that the construction of a biological key requires a large number of skills. These may have to be taught during the work or may be accessed from memory. It is only when all these prerequisite skills have been learnt that the problem can be solved. Teaching also provides the pupil with a plan or strategy to allow them to use these skills in the correct order.

Familiarity with the subject material and the possession of a strategy will reduce the load on the working memory but can the relevant perception be taught? Practice and familiarity may help, but if an innate capacity such as Field Dependence is a significant factor how is this to be overcome?

As a result of the pilot studies, the final test material was formulated. It set out to test the following hypotheses:

1 that there is a relationship between the skills needed to make a biological key and a pupil's working memory capacity;

2 that there is a relationship between the skills needed to make a key and whether a pupil is Field Independent or Dependent.

The test material consisted of a number of items which set out to investigate the skills needed for successful construction of a key (Appendix VI A: Tests 5a and b).

In addition to this, all pupils also completed a test to measure their working memory capacity (Appendix V F: Test 6 FIT). They also completed a Hidden Figures Test to determine their disembedding ability, ie: whether they were Field Independent, Field Neutral, Field Dependent (Appendix V G: Test 3).

6.6 Pupil Groups

In view of the variable nature of the teaching in first year, it was decided that only third year pupils would be tested. Two hundred and eighty-five third year Biology pupils in five schools were used. All the schools were situated in the West of Scotland and ranged from city to small town schools. One was in the independent sector and one was Roman Catholic. This sampling is a reflection of the total Scottish secondary school distribution.

The proportion of boys and girls who took part is representative of the total presentations for Scottish Certificate of Education Ordinary Grade Biology, allowing for the fact that one of the schools was girls only.

Table 6.1

Numbers of Pupils who Took Part in the Investigation

School 1	54		
School 2	36		
School 3	39		
School 4	51		
School 5	105		
Total	**(285)**	**Boys (82)**	**Girls (189)**

6.7 Analysis of Test 5 Items

(see Appendix VI A for complete test)

The previous testing showed that some pupils were unclear as to what a key was and the names of the different types they had used, although they had been taught this topic before completing the test material. In view of this, an introductory page was made up to illustrate the two types of key which were used to identify four common leaves.

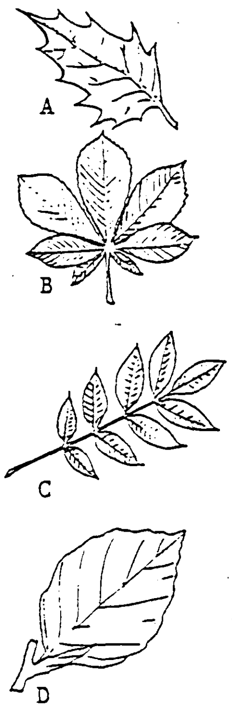
Figure 6.2

Test 5: Introductory Page

HELLO!

Thank you for helping to find out why pupils find making biological keys difficult. If you have forgotten what a key is, here is one that names 4 leaves. Using either the branching tree or paired statement key we can name the leaves:

A is HOLLY; B is HORSECHESTNUT; C is ASH; D is BEECH.



leaves

- single leaf
  - prickles — HOLLY
  - no prickles — BEECH
- leaflets
  - fan shape — HORSE CHESTNUT
  - not fan shape — ASH

1.	single leaf:	go to 2
	leaflets:	go to 3
2.	prickles:	Holly
	no prickles:	Beech
3.	fan shape:	Horse chestnut
	not fan shape:	Ash

Try to answer each of the following questions as well as you can.

If you cannot answer a question, go on to the next one.

DO NOT TURN BACK.

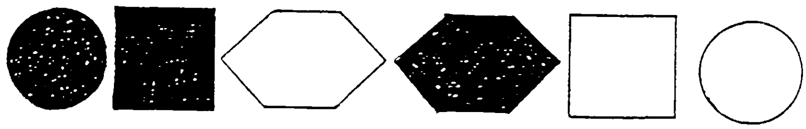
There is no pass or fail. Thank you for your help.

Items A & B tested pupil's ability to set using non-biological objects. Also to recognise the differences between non-living things and to be able to put these into suitable language.

Figure 6.3

Test 5: Items A & B

A



1 Divide all the objects into 2 groups. Draw your objects in the boxes below.

Group 1 has ....

.... in common

Group 2 has ....

.... in common

2 Now find another way of dividing all the objects into 2 different groups. Draw the objects in the boxes below.

Group 3 has ....

.... in common

Group 4 has ....

.... in common

3 See if you can find a third way to divide all the objects into 2 different groups. Draw the objects below.

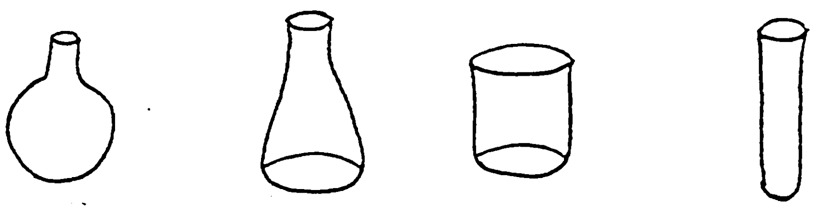
Group 5 has ....

.... in common

Group 6 has ....

.... in common

B

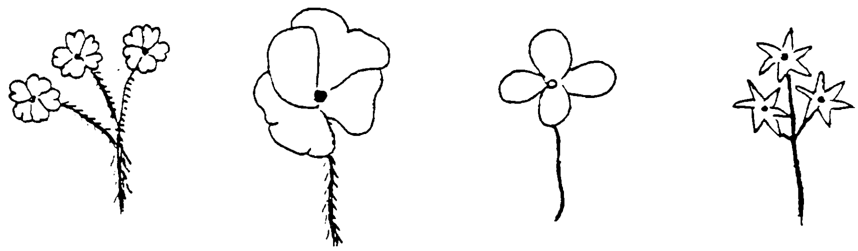


Items C1 & C2 tested pupil's ability to describe living things using a word bank. These items tried to eliminate the problem of the pupil failing to record suitable attributes because they did not possess the correct biological vocabulary.

Figure 6.4

Test 5: Items C1 & C2

C1

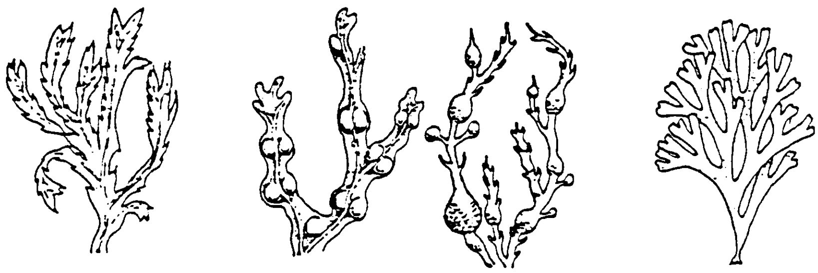


A B C D

Using words from the following list, choose at least 2 things to describe each flower. Use only things you can see in the pictures.

LIST: long stem; big leaves; hairy; 4 petals; yellow; single flowers; 3 petals; thing stem; 6 petals; short stem; group of flowers; 5 petals; not hairy.

C2



A B C D

Using words from the following list, choose at least 2 things to describe each seaweed. Use only things you can see in the pictures.

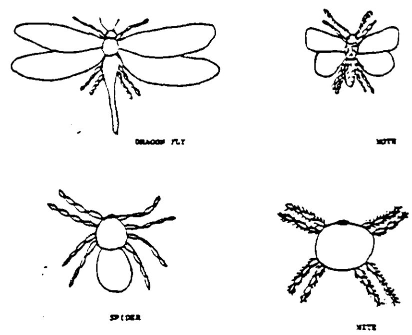
LIST: bladders; jaggy edge; brown colour; large bladders; live in the sea; 3 pieces; paired bladders; no bladders; 12 bladders; like a hand; small; single bladders; different sized bladders.

Items D1 & D2 tested the pupil's ability to describe a living organism from a drawing and then to choose which features were biologically significant.

Figure 6.5

<u>Test 5: Items D1 & D2</u>

D1



Da: Look at the pictures of each animal. Describe each animal by writing down all the things you can see.

Dragonfly:

Moth:

Spider:

Mite:

Db: From your lists write down only those things which could be used to make a biological key.

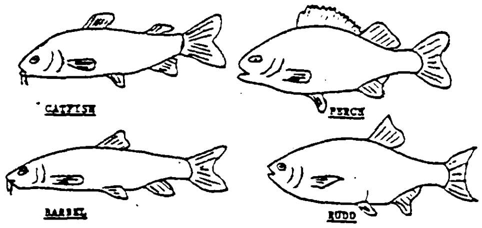
Dragonfly:

Moth:

Spider:

Mite:

D2



Item E tested the pupil's ability to decide if enough information had been given, ie: that for a key to work an organism must have unique features.

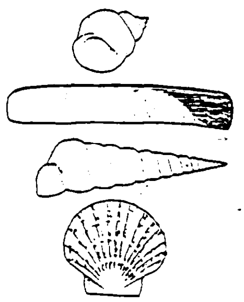
Figure 6.6

Test 5: Item E (part)

E

In each of the next 4 questions, you must decide if you have been given enough information to make a biological key. Answer each question 'YES' or 'NO'.

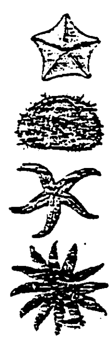
a)



Name	Coiled	Fan-Shaped
WINKLE	YES	NO
RAZORSHELL	NO	NO
TOWERSHELL	YES	NO
SCALLOP	NO	YES

Answer: ....

b)



Name	No of Arms	Distinct Body
CUSHIONSTAR	5	NO
URCHIN	0	YES
STARFISH	5	NO
SUNSTAR	12	YES

Answer: ....

Items F1 & F2 tested the pupil's ability to change a table of suitable information into a family tree type key.

Figure 6.7

Test 5: Items F1 & F2

F1

From the information in the table - make a family tree (branched) key.

Name	Number of Petals	Colour	Type of Stem
Mustard	Four	Yellow	Hairy
Oxlip	Five	Yellow	Hairy
Barrenwort	Four	Yellow	Smooth
Saxifrage	Five	Pink	Smooth

F2

From the information in the table - make a family tree (branched) key.

Name	Length of Coat	Type of Ears	Length of Legs
Greyhound	Short Coat	Hang Down	Long
Bulldog	Short Coat	Hang Down	Short
Alsation	Long Coat	Stand Up	Long
Retriever	Long Coat	Hang Down	Long

Items G1 and G2 tested the pupil's ability to turn a table of information into a paired statement key.

Figure 6.8

Test 5: Items G1 & G2

G1

From the information in the table, make a paired statement key.

Name	Number of Legs	With/No Wings	With/No Hairs
Spider	Eight	No Wings	No Hairs
Fly	Six	Wings	Hairs
Greenfly	Six	Wings	No Hairs
Crab	ten	No Wings	No Hairs

G2

From the information in the table, make a paired statement key.

Name	With/No Legs	Body Covering	With/No Fins
Horse	With Legs	Hair	No Fins
Frog	With Legs	Skin	No Fins
Adder	No Legs	Scales	No Fins
Goldfish	No Legs	Scales	Fins

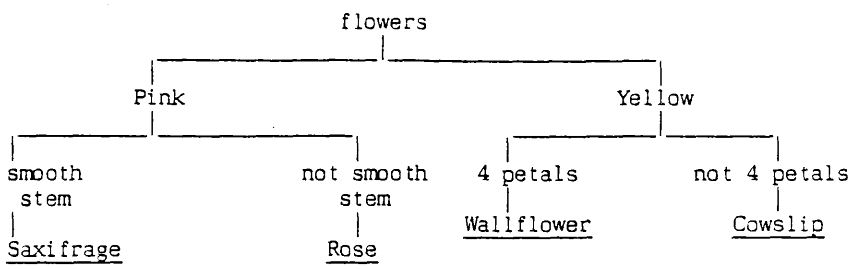
Items H1 & H2 tested the pupil's ability to turn a family tree key into a paired statement key.

Figure 6.9

Test 5: Items H1 & H2

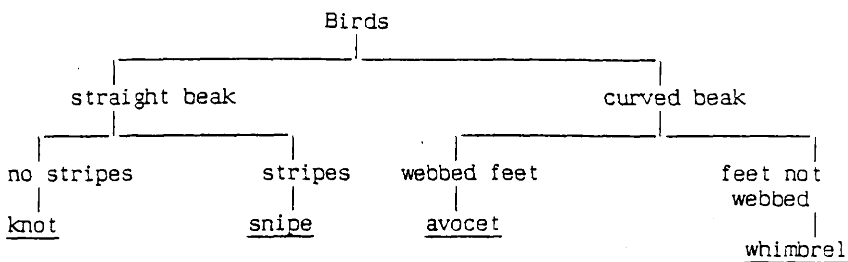
H1

From the information shown in the tree key, make a paired statement key.



H2

From the information shown in the tree key, make a paired statement key.



6.8 <u>Marking Test 5</u>

Two tests were made up as follows:

Test a	items A, B, C1, D1, E, F1, G1, H1
Test b	items A, B, C2, D2, E, F2, G2, H2

The tests were scored according to a marking scheme (Appendix VI A). The marking scheme was designed in advance of the testing. A small sample of papers were examined and minor adjustments made before the final marking was done. The major marking difficulties were encountered in marking item D. Many pupils did not include the tail fin in the count and this was marked wrong unless the pupil stated 5 fins + tail. A few pupils were far out in their count, making the researcher wonder if they were trying to take into account the fact that some fins are paired (this was not shown on the drawing). All other items were straightforward to mark.

6.9 <u>Test Equivalence</u>

Due to the variable nature of biological material, the equivalence of items was sometimes difficult to achieve (Table 6.2). This was shown in the pilot studies.

Table 6.2

<u>Test 5: % Scores Tests a & b</u>

Item	**Test a**	**Test b**
A	35.7	33.8
B	32.2	33.8
C	15.4	13.4
Da	65.0	35.9
Db	29.4	11.3
E	49.0	50.0
F	65.0	50.7
G	54.5	54.2
H	69.2	75.4

Tests a and b were distributed by the class teacher on a random basis (142 pupils did test b and 143 pupils did test a). Data was compared using a X^2 test. Items which appear in both tests (A, B, E) show no significant differences, so that we can say the groups of pupils were similar.

Items D & F showed the biggest differences. There was a significant difference at the .1% level between items D1 & D2 and at the 2% level between items F1 & F2 (these X^2 tests were carried out on raw data not % scores). To obtain better equivalence, more pretesting using large populations of pupils is necessary. This is one of the major problems of this type of work because a standard test cannot be used and the researcher must design and validate the test.

Apart from items D & F, the alternatives offered in the two tests seem to have been equivalent (Table 6.2). The item about arthropods (D1) was done better than the fish item (D2), this illustrates the great problem in finding pictures of organisms that have the same level of difficulty. Further discussion with pupils showed that they were more familiar with the arthropod example. Another possible way to account for the differences between items D1 & D2 was the way the answers were marked. Why there were differences between items F1 & F2, the pupils could not enlighten me. On further detailed analysis of items F1 & F2 (Fig 6.7), item F2 did have more words in the table, on the other hand the dogs should have been a more familiar set of organisms.

6.10 Measurement of Working Memory Capacity and Disembedding Ability

A constraint placed upon the work was that the tests had to be administered by the class teacher. For this reason, the measurement of working memory was carried out using the Figure Intersection Test, a pencil and paper method, not the Digit Backwards Test. The Digit

Backwards Test was used in the pilot 2 studies, but it is strictly an oral test. Another problem with using the Figure Intersection Test is that it is a similar test to the Hidden Figures Test (measuring disembedding ability). In fact, Pascual-Leone excluded all Field Dependent (those who have difficulty disembedding) students from his sample because of this similarity. With all these caveats in mind, it was still thought that these were the best way to carry out the investigations given the circumstances.

6.11 Interpretation of Results

(details of raw results, see Appendix VI B)

Table 6.3

Test 5: Percentage Scores of all Pupils, all Items

Item	Score
A	34.7
B	33.0
C	14.4
Da	50.5
Db	20.4
E	49.5
F	57.9
G	54.4
H	72.3

Items A & B show that only one third of the pupils tested could set or choose correct features to set with either geometric shapes or lab. apparatus. In item A, 75% of pupils could get at least 2 out of 3 differences (Table 6.4). In item B, a similar percentage got at least 1 difference. In item B, 25% of pupils could not find any difference, many of them could draw the correct shapes in the boxes but were unable to describe the feature they had chosen.

Table 6.4

Test 5: Details of Scores Items A-D shown as % of Total (285 Pupils)

Item	Max. Score Possible	Actual Score 4	3	2	1	0
A	3	-	34.7	41.1	20.0	4.2
B	2	-	-	33.0	41.4	25.6
C	4	14.4	28.4	21.8	17.9	17.5
Da	4	50.5	15.1	11.2	4.6	18.6
Db	4	20.4	8.4	9.5	8.1	53.7
Item D1, 143 Pupils; Item D2, 142 Pupils						
Da1	4	65.0	16.8	11.2	1.4	5.6
Db1	4	29.4	13.3	15.4	9.1	32.9
Da2	4	35.9	13.4	11.3	7.8	31.7
Db2	4	11.3	3.5	3.5	7.0	74.6

Item C was meant to test the ability to see differences when some of the problems of language were removed. Only 14% of pupils could accurately describe the flowers or seaweeds. Many of the errors were due to using "live in the sea and brown colour". Many pupils failed to understand the question, choosing items that were not listed. The question may have been at fault for not emphasising the facts that descriptors could be used more than once or that not all the descriptors need to be used.

Items D1 & D2 gave very different results. The results for item Db obviously depend on those from Da. Except for one or two, pupils could not choose suitable biological attributes if they could not describe the organism in general terms. The pictures of the arthropods gave better results than the fish. 65% of pupils could accurately describe these while only 36% described all four fish correctly. The percentage of pupils who could describe 3 or 2 of the organisms were similar. 5% of pupils could not describe any arthropod while 32% of pupils could not describe one fish from the drawings given. The problem appears to be with the general unfamiliarity of pupils with the drawings of fish. Obviously practice helps pupils in choosing attributes from a particular group of organisms. After the results had been analysed, the researcher found out that all pupils at some time, either S1 or S3, had examined arthropods but not fish. This information has implications for question setters.

In item E only half the pupils understood that for a key to be successful, the information given must be a unique combination (Table 6.3).

Over half the pupils could convert tables of information into keys (items F, G), interestingly there was not much difference between the types of keys. Over 50% of pupils could convert a table of information into either a paired statement or a family tree type of key.

The mechanics of doing a paired statement key, (item H) which was thought, at the beginning of this piece of work, to be one of the more difficult operations was completed successfully by over 70% of pupils.

It would appear that the problems with keys can be found in all of the skills needed. Pupils could not set, choose attributes or convert this information to the correct form of key.

6.12 Comparison of Girls and Boys

Table 6.5

Test 5: Percentage Scores Boys & Girls

Item	Boys	Girls
A	43.9	31.2
B	29.3	36.0
C	15.9	12.7
Da	51.2	51.9
Db	19.5	21.7
E	43.9	53.4
F	54.9	58.7
G	45.1	57.7
H	62.2	76.2

There is no clear trend in the questions about setting. Boys did better in the geometric shapes, while girls did better in the laboratory equipment item.

Boys also did better in item C but the girls did better in all the key items (F, G, H) and in the item about the uniqueness of information (item E).

An X^2 test was carried out on the data, but there were no significant differences between the responses of boys and girls except in item H. This was significant at the 5% level.

6.13 Comparison of Schools

Table 6.6

Test 5: Percentage Scores Shown by School

Item	School				
	1	2	3	4	5
A	44.4	27.8	25.6	33.3	36.2
B	46.3	27.8	43.6	35.3	22.9
C	29.6	2.8	23.1	5.9	11.4
Da	63.0	33.3	53.8	54.9	46.7
Db	33.3	8.3	23.1	17.7	18.1
E	68.5	22.2	66.7	52.9	41.0
F	75.9	19.4	66.7	33.3	70.5
G	74.1	19.4	66.7	21.6	67.6
H	90.7	52.8	82.1	39.2	81.9

The method of teaching, the type of pupil and the time taken on this particular topic will all affect the results obtained by pupils. These factors can be very specific to a school. When comparing the schools, one school did best getting the highest score in all the questions. Another school obtained the lowest scores in all the questions except two where they obtained the next lowest score. The other three schools showed no specific trends.

Table 6.7

Test 5: Percentage Scores, School 1 Compared with the Average Score from the Other Four Schools

Item	School 1	Average Schools 2-5
A	44.4	30.7
B	46.3	32.4
C	29.6	10.8
Da	63.0	47.1
Db	33.3	16.7
E	68.5	45.7
F	75.9	47.5
G	74.1	43.8
H	90.7	64.0

An X^2 test was carried out between the two sets of data. School 1 did significantly better in items F, G, H at the .1% level, in items C, E, Db at the 1% level and item Da at the 5% level. School 1 followed the modified course (Appendix V C) using these worksheets as an introduction to making keys. This was followed by practice in making both types of keys from a wide variety of material. The other schools followed their normal courses which included both using and making keys. School 1 also showed the same trend in item D more pupils found D2 (fish) harder than D1 (arthropods). In spite of extra work, pupils from School 1 still had difficulties choosing suitable attributes.

6.14 Comparison of the Skills Needed to Make a Key, Working Memory Capacity and the Ability to Disembed

The skills needed to make a key, working memory capacity and the ability to disembed were compared (Table 6.8).

Table 6.8

Point Biserial Correlations
Pupil Scores, HFT, FIT

	v. HFT	**v. FIT**
A setting (shapes)	0.224 t = 3.864****	0.219 t = 3.781****
B setting (lab. equip)	0.205 t = 3.517****	0.176 t = 3.011****
C language/ describing pictures	0.167 t = 2.843****	0.131 t = 2.219**
Da pictures/attributes	0.181 t = 3.095****	0.106 t = 1.793*
Db pictures/biological attributes	0.118 t = 1.993**	0.115 t = 1.952*
E correct no of pieces of info.	0.286 t = 5.013****	0.368 t = 6.660****
F table → f. tree	0.252 t = 4.372****	0.224 t = 3.858****
G table → p. st	0.191 t = 3.274****	0.235 t = 4.075****
H f. tree → p. st	0.125 t = 2.115**	0.170 t = 2.895****

Significance **** = .01 1%
*** = .02 2%
** = .05 5%
* = .10 10%

Scores obtained by pupils in each of the items in Test 5 a & b were compared with first their HFT and then their FIT scores using the Point Biserial Correlation Coefficient. This correlation coefficient is used in computing the relationship between a continuous variable (HFT or FIT score) against a dichotomous variable (items in test 5 were right or wrong). The test works out the correlation coefficient and its significance which can be checked using standard tables.

The correlations show how important the ability to disembed is in relation to all aspects of key construction. All the skills except for those of deciding which of a group of differences are important biologically and the ability to manipulate the information in a family tree key need the ability to disembed. These are significant at the 1% level. Field Independent pupils will find these tasks much easier to do because they are able to extract information from its surroundings.

Working memory capacity as measured by the FIT also shows a significant correlation at the 1% level for setting skills and those of deciding if there is enough information and the mechanics of key making.

Since both tests (FIT & HFT) rely on the pupils ability to see shapes in a pattern, the ability to disembed could well influence the results in the Figure Intersection Test. Pupils who are Field Dependent may score less when their working memory is measured using such a test as FIT. The correlation between the two tests is high 0.39.

The Figure Intersection Test was used because a paper and pencil test was needed to measure working memory capacity. The Digit Backwards Test which had been used previously is strictly an oral test and should be administered face to face. In spite of the influence of Field Dependency on the Figure Intersection Test scores the two tests (FIT & DBT) do correlate in a high percentage of cases (Appendix V F).

6.15 Problem Solving

When a pupil sets out to solve a problem such as the construction of a biological key, she/he is provided with information about a group of living things, in the form of the organisms themselves, or more commonly pictures or drawings or a table of information. The pupil has to extract suitable correct information, ie: decode and subsequently encode this information in working memory. Long term memory has to be searched for similar patterns and suitable methods for dealing with the information have to be selected. It is at this point that the pupil may access alternative frameworks (Section 5.29). This searching and selection process is not necessarily a one-off process, but may be repeated several times until a response is given. If there is too much information to be processed and the pupil cannot organise it in a suitable form (chunking) then working memory capacity will be exceeded and a suitable response will not be given - the problem will not be solved.

6.16 Novice Problem Solvers

Anyone faced with a new type of problem is a novice. Brown and Deloache (105) state that novices fail to perform efficiently because they lack skills, are deficient in self conscious participation and intelligent self regulation of their actions. They find it difficult to determine the necessary goals and the steps to get there. This is not related to age, but to inexperience. A pupil's inability to solve the problem is due to his/her failure to monitor and check ongoing activities and to analyse the task.

The ability to scan material and be able to extract the important features is necessary. Adults when given a difficult task will show some of the same deficiencies seen in children, eg: failure to scan exhaustively or failure to focus on the most informative areas. Fraser and Sleet (106) in their studies of problem solvers say that unsuccessful problem solvers cannot perceive a plan because they lack confidence and become confused. This uncertainty may put an additional load on the working memory. In their study, unsuccessful pupils could solve sub-problems but were unable to solve the whole problem. They were unable to formulate a clear plan with suitable steps for solving it.

The planning and solving of the sub-problems needs working memory. The problem will not be solved if the demand exceeds the capacity of the working memory. These pupils cope with the sub-problems on their own because there is less information to process and there is enough working memory capacity.

In the field of software design, Jeffries et al (107) defines novices as individuals who lack subtleties of schema and who do not evaluate alternatives, apply relevant information or acquired knowledge and understand relevant concepts.

Kempa and Nicholls (108) define poor problem solvers as those who do not have complex cognitive structures with strong links so that difficulties in collating or chunking information are also difficulties in extracting relevant from irrelevant information.

6.17 What Makes a Good Problem Solver?

According to Brown & Deloache (105) a novice becomes a learner by becoming acquainted with the rules and going through an active period of self regulation. When expert, the sub processing and co-ordination are automatic. There is an expanding knowledge of how to think and an ability to monitor and co-ordinate activities. Fraser & Sleet's (106) Chemistry students had a clear strategy subdivided into stepwise procedures for solving it. The expert software designers (Jeffries, 107) had a good schema and could access previous and acquired knowledge. Kempa and Nicholls (108) good problem solvers had more complex cognitive structures with strong associations which led to better chunking and reduction of the load on the working memory.

In addition, there are some general metacognition operations that will help in any problem solving situation (Brown & Deloache, 105). These are:

1 prediction;
2 checking results (did it work?)
3 monitoring (how am I doing?)
4 reality testing (does it make sense?)
5 co-ordination and control.

These skills should be content free and transferable to all areas of problem solving. However, it would appear that the acquisition of the majority of good problem solving skills require practice in a given content area. This is a function of experience not age, although we obviously acquire more experience with age.

6.18 Summary

The hypotheses proposed at the beginning of this piece of work stated that there was a relationship between the skills needed to construct a biological key, the working memory capacity and the ability to disembed. All the skills tested with one exception showed a high level of correlation with the ability to decide which of a number of general descriptors have biological significance. These skills, which are affected by a pupil's ability to extract relevant information from its background, include the choosing of a correct number of suitable attributes, setting and the mechanics of key making.

The skills of setting, choosing the correct amount of information and mechanics of key making are also affected by a pupil's working memory capacity.

Why do pupils fail at the task of making a key? The task presented to the pupil is, as has been shown by this piece of work, very complex. To solve the problem correctly, the pupil must have a plan or strategy. Within this plan she must be able to solve the various sub-problems. She must also know what information to pay attention to and what to ignore. She will fail to complete the task if she cannot solve the sub-problems or exceeds her working memory capacity. Finally, it is important to remember the influence of past experience on all the thinking and learning processes and the existence of "alternative frameworks" (Driver, 80).

Pupils will fail for a number of reasons, one of which is the overloading of the working memory capacity. This can be caused by unfamiliarity of the material presented to the pupil (comparison of D1 and D2 arthropods more familiar) or lack of confidence as to the strategy to adopt. If the task cannot be chunked enough or there are too many things to do, then the capacity will be exceeded. Field Dependence also contributes to the overloading of the working memory.

Pupils can fail at individual sub-problems or not possess certain skills. If these skills or strategies have already been learnt pupils may not be able to access the information from long-term memory. They may not be able to pick out the relevant information, this is related to the ability to disembed.

Field Dependency also affects the pupil's ability to complete the task successfully. Pascual-Leone suggested that Field Dependence/Independence acts as a moderator to the use of full mental space so that Field Dependent individuals function below their expected capacity. Field Dependent individuals take both signal and noise into the working memory. Since space is limited, there is therefore less space for other operations (El-Banna, 77). This factor will obviously affect low capacity individuals more than high capacity ones, putting even more pressure on an already overcrowded working memory. Also inexperienced individuals do not scan material as well and focus on unimportant features (Fish problem, p379 and Section 6.9) [Fraser & Sleet, 106].

APPENDIX VI A

Test 5 a & b with Marking Schemes

APPENDIX VI B

Raw Results

Test 5

FIT

HFT

Glasgow University
Science Education
Research Group

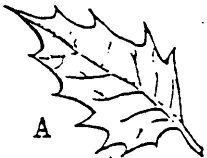
TEST 5a

NAME: ____________________

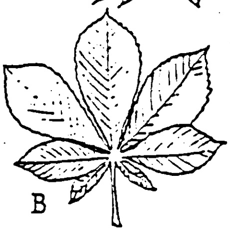
HELLO!

Thank you for helping to find out why pupils find making biological keys difficult. If you have forgotten what a key is, here is one that names 4 leaves. Using either the branching tree or paired statement key we can name the leaves:

A is HOLLY; B is HORSECHESTNUT; C is ASH; D is BEECH.

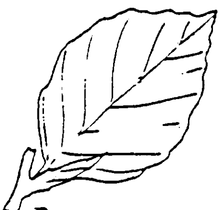


A



B

C



D

- leaves
  - single leaf
    - prickles — <u>HOLLY</u>
    - no prickles — <u>BEECH</u>
  - leaflets
    - fan shape — <u>HORSE CHESTNUT</u>
    - not fan shape — <u>ASH</u>

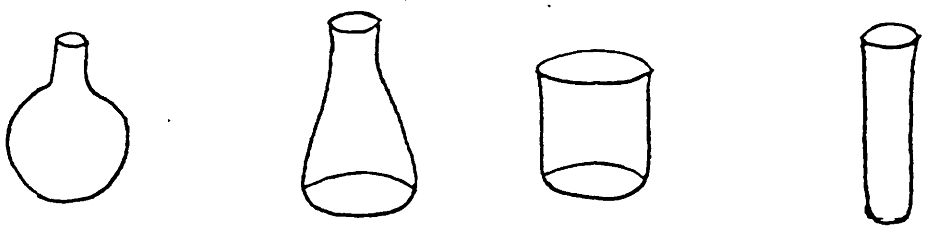
1.	single leaf:	go to 2
	leaflets:	go to 3
2.	prickles:	Holly
	no prickles:	Beech
3.	fan shape:	Horse chestnut
	not fan shape:	Ash

Try to answer each of the following questions as well as you can.

If you cannot answer a question, go on to the next one.

DO NOT TURN BACK.

There is no pass or fail. Thank you for your help.



1 Divide all the objects into 2 groups. Draw your objects in the boxes below.

Group 1 has *wider at bottom/ sides go in/out* in common

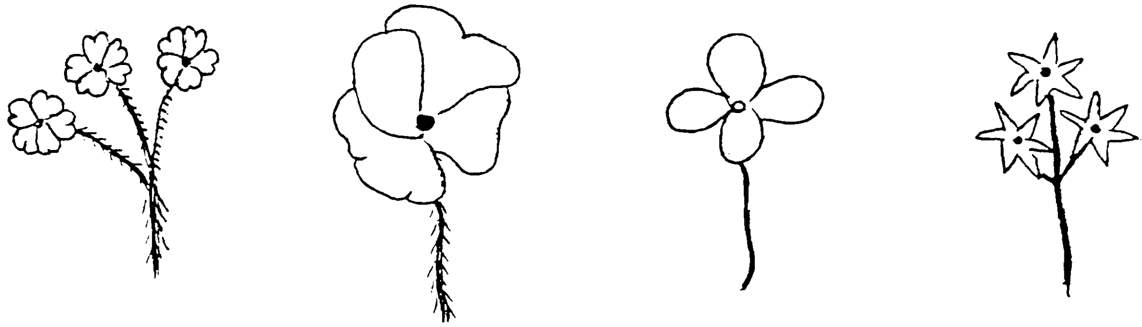
Group 2 has *straight sides/ same size all way up* in common

2 Now find another way of dividing all the objects into 2 different groups. Draw the objects in the boxes below.

Group 3 has *round bottom* in common

Group 4 has *flat bottom* in common

Score: 2 correct.



A B C D

Using words from the following list, choose at least 2 things to describe each flower. Use only things you can see in the pictures.

LIST: long stem; big leaves; hairy; 4 petals; yellow; single flowers; 3 petals; thing stem; 6 petals; short stem; group of flowers; 5 petals; not hairy.

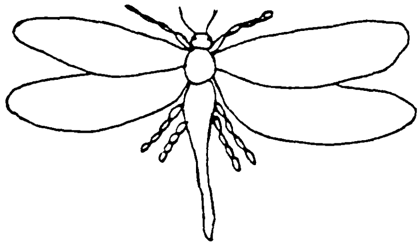
Any 2 per flower.

A: *hairy, group of flowers, 5 petals.*

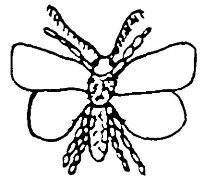
B: *4 petals, hairy, single flower.*

C: *4 petals, not hairy, single flower.*

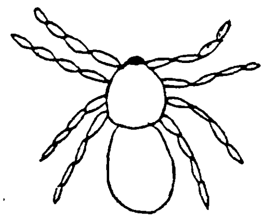
D: *group of flowers, not hairy, 6 petals.*



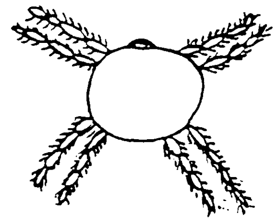
DRAGON FLY



MOTH



SPIDER



MITE

Da: Look at the pictures of each animal. Describe each animal by writing down all the things you can see.

Dragonfly:

at least three features per animal.

Moth: *eg: shape, proportions of body parts, no of legs, hairs, antenna, wings.*

Spider: *correct if all 4 parts correct.*

Mite:

Db: From your lists write down only those things which could be used to make a biological key.

Dragonfly:

at least 2 features per animal.

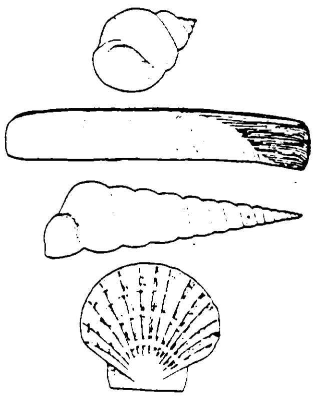
Moth: *eg: no of legs, antenna, wings hairs, no of body parts.*

Spider: *correct if all 4 parts correct.*

Mite:

In each of the next 4 questions, you must decide if you have been given enough information to make a biological key. Answer each question 'YES' or 'NO'.

a)



Name	Coiled	Fan-Shaped
WINKLE	YES	NO
RAZORSHELL	NO	NO
TOWERSHELL	YES	NO
SCALLOP	NO	YES

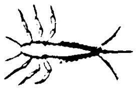
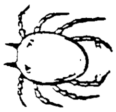
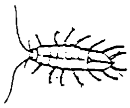
Answer: ...*NO*...............

b)

Name	No of Arms	Distinct Body
CUSHIONSTAR	5	NO
URCHIN	0	YES
STARFISH	5	NO
SUNSTAR	12	YES

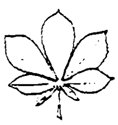
Answer: ...*NO*...............

c)

	Name	No of Legs	Antenna	Tail Forks
	MAYFLY	6	YES	YES
	WATERMITE	8	NO	NO
	STONEFLY	6	YES	YES
	WATERLOUSE	12	NO	NO

Answer: NO ....

d)

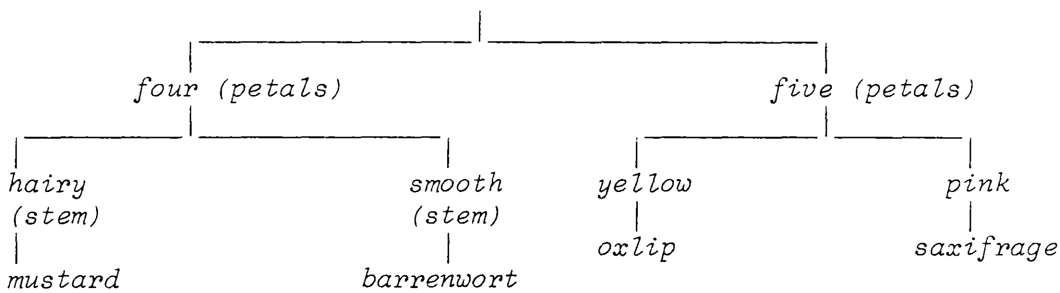
	Name	Hairs	Lobes	Serrated Edges
	CHESTNUT	NO	YES	YES
	OAK	NO	YES	NO
	BEECH	NO	NO	NO
	ELM	YES	NO	YES

Answer: YES ....

From the information in the table - make a family tree (branched) key.

Name	Number of Petals	Colour	Type of Stem
Mustard	Four	Yellow	Hairy
Oxlip	Five	Yellow	Hairy
Barrenwort	Four	Yellow	Smooth
Saxifrage	Five	Pink	Smooth

any correct key
example:



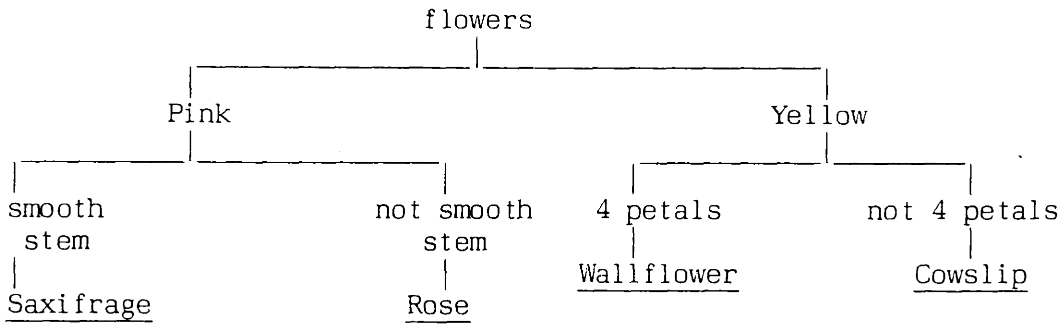
From the information in the table, make a paired statement key.

Name	Number of Legs	With/No Wings	With/No Hairs
Spider	Eight	No Wings	No Hairs
Fly	Six	Wings	Hairs
Greenfly	Six	Wings	No Hairs
Crab	ten	No Wings	No Hairs

any correct key
example:

1	*Wings*	*GOTO 2*
	No Wings	*GOTO 3*
2	*Hairs*	*Fly*
	No Hairs	*Greenfly*
3	*Eight Legs*	*Spider*
	Ten Legs	*Crab*

From the information shown in the tree key, make a paired statement key.



1	*Pink*	*GOTO 2*
	Yellow	*GOTO 3*
2	*Smooth Stem*	*Saxifrage*
	Not Smooth Stem	*Rose*
3	*4 Petals*	*Wallflower*
	Not 4 Petals	*Cowslip*

Glasgow University Science Education Research Group

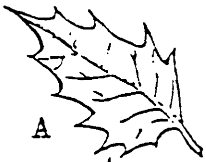
TEST 5b

NAME: ______________________

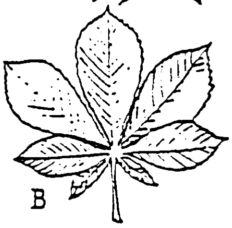
HELLO!

Thank you for helping to find out why pupils find making biological keys difficult. If you have forgotten what a key is, here is one that names 4 leaves. Using either the branching tree or paired statement key we can name the leaves:

A is HOLLY; B is HORSECHESTNUT; C is ASH; D is BEECH.



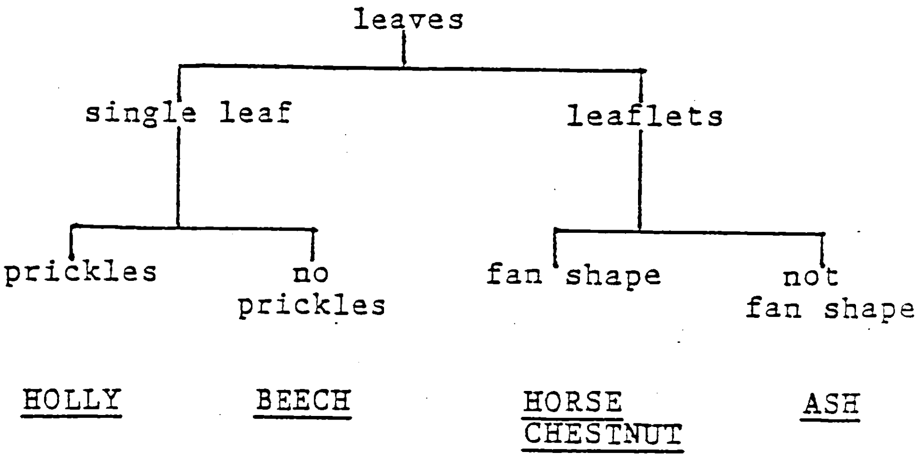
A



B

C

D



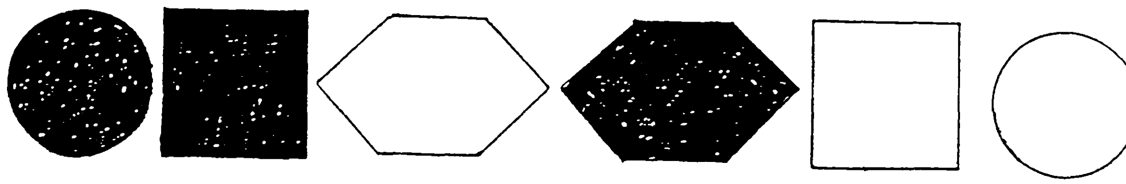
1.	single leaf:	go to 2
	leaflets:	go to 3
2.	prickles:	Holly
	no prickles:	Beech
3.	fan shape:	Horse chestnut
	not fan shape:	Ash

Try to answer each of the following questions as well as you can.

If you cannot answer a question, go on to the next one.

DO NOT TURN BACK.

There is no pass or fail. Thank you for your help.



1 Divide all the objects into 2 groups. Draw your objects in the boxes below.

Group 1 has ..*white*........
...*colour*......... in common

Group 2 has ...*black*...........
...*colour*............ in common

2 Now find <u>another</u> way of dividing <u>all</u> the objects into 2 different groups. Draw the objects in the boxes below.

Group 3 has *round/* ....
curved sides .... in common

Group 4 has *straight* ....
sides .... in common

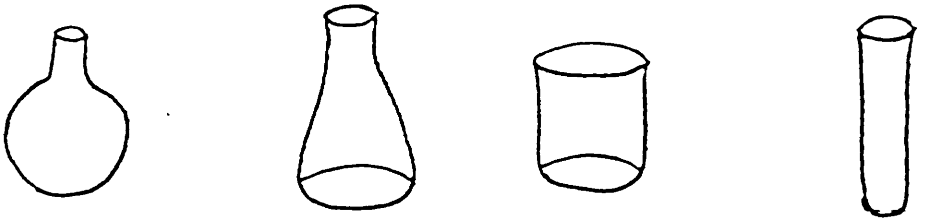
3 See if you can find a third way to divide <u>all</u> the objects into 2 different groups. Draw the objects below.

Group 5 has *4 sides/* ....
right angles .... in common

Group 6 has *not 4 sides/* ....
no right angles .... in common

Score: all three correct.

B



1 Divide all the objects into 2 groups. Draw your objects in the boxes below.

Group 1 has *wider at bottom/ sides go in/out* in common

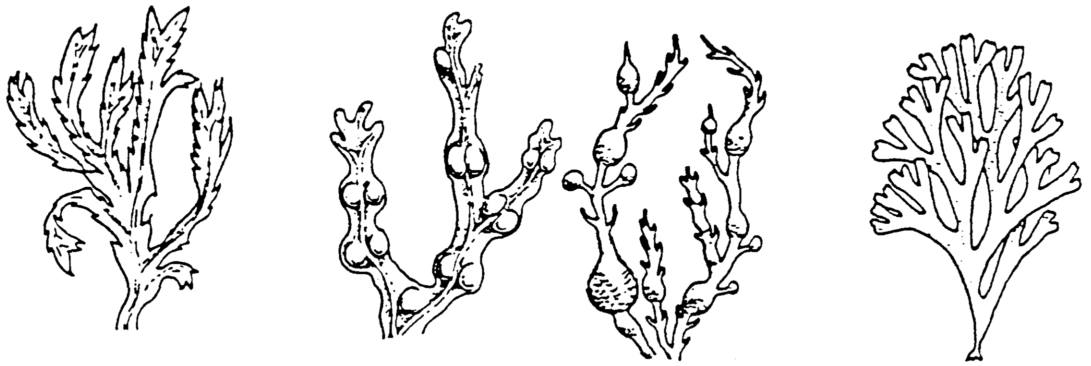
Group 2 has *straight sides/ same size all way up* in common

2 Now find another way of dividing all the objects into 2 different groups. Draw the objects in the boxes below.

Group 3 has *round bottom* in common

Group 4 has *flat bottom* in common

Score: 2 correct.



A B C D

Using words from the following list, choose at least 2 things to describe each seaweed. Use only things you can see in the pictures.

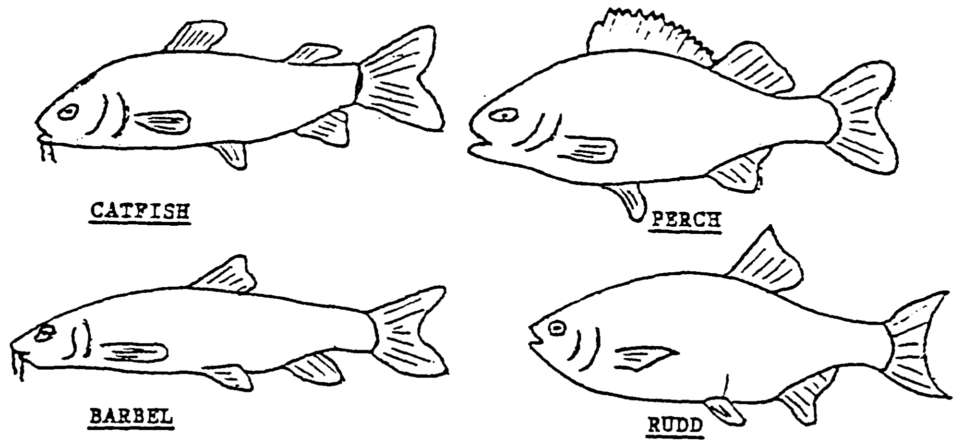
LIST: bladders; jaggy edge; brown colour; large bladders; live in the sea; 3 pieces; paired bladders; no bladders; 12 bladders; like a hand; small; single bladders; different sized bladders.

A: *jaggy, no bladders, like a hand.*

B: *paired bladders, 3 pieces, bladders.*

C: *single bladder, different sized bladders, 12 bladders.*

D: *no bladders, jaggy edge, like a hand.*



Look at the appearance of each fish. Describe each fish by writing down all the things you can see.

CATFISH:

3 features per animal.

PERCH: *eg: shape, no of fins, barbels/whiskers, shape of fins.*

BARBEL: *all 4 parts to be correct.*

RUDD:

From your list above, write down only those things which could be used to make a biological key.

CATFISH:

2 features per animal.

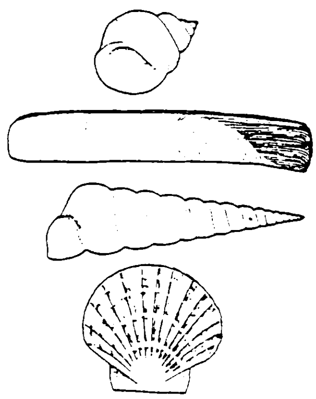
PERCH: *eg: barbels, no of fins, type and no of top fins.*

BARBEL: *all 4 parts to be correct.*

RUDD:

In each of the next 4 questions, you must decide if you have been given enough information to make a biological key. Answer each question 'YES' or 'NO'.

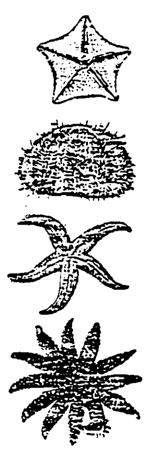
a)



Name	Coiled	Fan-Shaped
WINKLE	YES	NO
RAZORSHELL	NO	NO
TOWERSHELL	YES	NO
SCALLOP	NO	YES

Answer: *NO* ....

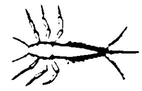
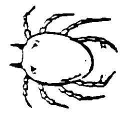
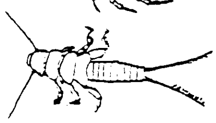
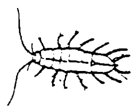
b)



Name	No of Arms	Distinct Body
CUSHIONSTAR	5	NO
URCHIN	0	YES
STARFISH	5	NO
SUNSTAR	12	YES

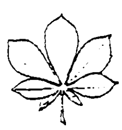
Answer: *NO* ....

c)

	Name	No of Legs	Antenna	Tail Forks
	MAYFLY	6	YES	YES
	WATERMITE	8	NO	NO
	STONEFLY	6	YES	YES
	WATERLOUSE	12	NO	NO

Answer: ....*NO*.............

d)

	Name	Hairs	Lobes	Serrated Edges
	CHESTNUT	NO	YES	YES
	OAK	NO	YES	NO
	BEECH	NO	NO	NO
	ELM	YES	NO	YES

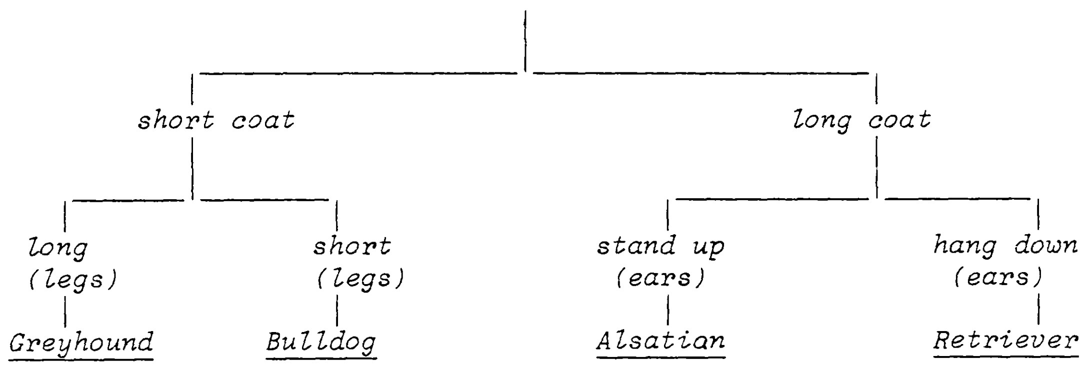
Answer: .....*YES*.............

F2

From the information in the table - make a family tree (branched) key.

Name	Length of Coat	Type of Ears	Length of Legs
Greyhound	Short Coat	Hang Down	Long
Bulldog	Short Coat	Hang Down	Short
Alsatian	Long Coat	Stand Up	Long
Retriever	Long Coat	Hang Down	Long

any correct key
example:



From the information in the table, make a paired statement key.

Name	With/No Legs	Body Covering	With/No Fins
Horse	With Legs	Hair	No Fins
Frog	With Legs	Skin	No Fins
Adder	No Legs	Scales	No Fins
Goldfish	No Legs	Scales	Fins

any correct key
example:

1	*With Legs*	*GOTO 2*
	No Legs	*GOTO 3*
2	*Hair*	*Horse*
	Skin	*Frog*
3	*Fins*	*Goldfish*
	No Fins	*Adder*

From the information shown in the tree key, make a paired statement key.

- Birds
  - straight beak
    - no stripes
      - knot
    - stripes
      - snipe
  - curved beak
    - webbed feet
      - avocet
    - feet not webbed
      - whimbrel

1	*Straight Beak*	*GOTO 2*
	Curved Beak	*GOTO 3*
2	*No Stripes*	*Knot*
	Stripes	*Snipe*
3	*Webbed Feet*	*Avocet*
	Feet not Webbed	*Whimbrel*

APPENDIX VI B

Raw Results - Keys

- FIT

- HFT

		A	B	C	Da	Db	E	F	G	H	Test a/b	HFT	FIT
							Item						
Girl 1	1	1	1	4	0	0	4	Y	N	Y	b	9	19
	2	2	2	0	1	0	2	N	N	N	a	9	11
	3	3	1	4	4	4	4	Y	Y	Y	a	13	16
	4	2	1	2	4	0	2	Y	Y	N	b	1	4
	5	3	2	4	4	0	4	Y	Y	Y	b	13	11
	6	2	2	3	0	0	2	Y	Y	Y	b	9	5
	7	1	2	4	4	4	3	Y	N	Y	a	14	15
	8	2	1	3	4	0	3	N	Y	Y	b	10	6
	9	3	2	2	3	1	4	Y	Y	Y	a	12	18
	10	2	1	4	4	0	4	N	N	Y	b	12	12
	11	3	2	1	4	0	3	Y	Y	Y	a	11	3
	12	2	1	2	3	0	0	Y	Y	Y	b	8	1
	13	2	1	0	4	4	4	Y	Y	Y	a	9	3
	14	2	1	0	4	0	3	N	Y	Y	a	6	1
	15	3	1	2	4	4	4	Y	Y	Y	b	14	0
	16	3	2	0	3	4	4	Y	Y	Y	a	8	17
	17	1	1	3	4	4	4	Y	Y	Y	b	9	2
	18	1	0	4	4	4	4	Y	Y	Y	a	1	4
	19	2	2	2	2	0	0	N	N	N	b	5	1
	20	2	2	3	1	0	4	Y	Y	Y	b	10	15
	21	2	2	4	4	3	4	Y	Y	Y	a	10	18
	22	3	2	1	4	4	4	Y	Y	Y	a	4	9
	23	3	1	2	4	4	4	Y	Y	Y	b	10	22
	24	2	0	2	1	0	4	Y	Y	Y	b	14	18
	25	1	1	4	4	2	4	Y	Y	Y	a	9	12
	26	3	1	2	3	0	4	Y	Y	Y	b	7	9
	27	3	2	3	4	4	4	Y	Y	Y	a	12	24
	28	2	1	4	3	0	4	N	Y	Y	a	9	14
	29	3	1	4	4	0	4	N	Y	Y	a	2	4
	30	3	1	3	4	2	2	Y	N	Y	a	6	12
	31	2	1	1	3	4	4	Y	Y	Y	a	10	17
	32	3	2	3	4	1	4	Y	Y	Y	a	11	16
	33	3	2	1	4	4	4	Y	Y	Y	a	10	17
	34	2	1	3	4	0	3	Y	N	Y	a	8	9
	35	1	2	3	4	0	3	Y	N	N	b	7	12
	36	2	2	2	4	0	4	N	N	Y	b	4	18
	37	1	1	3	2	0	4	N	Y	Y	b	7	15
	38	3	2	3	1	0	3	Y	Y	Y	b	4	14
	39	2	2	3	0	0	1	N	Y	Y	b	7	8
Boy 1	40	0	0	0	3	0	4	Y	Y	Y	a	4	13
	41	3	1	2	4	4	1	Y	Y	Y	a	7	11
	42	3	2	4	4	0	4	N	Y	Y	b	11	19
	43	3	0	4	0	0	4	Y	Y	Y	b	9	11
	44	2	1	2	0	0	3	N	N	N	b	1	8
	45	3	1	0	4	0	4	Y	Y	Y	a	8	8
	46	3	2	3	3	3	4	Y	Y	Y	a	8	1
	47	3	1	3	2	4	4	Y	N	Y	a	15	22
	48	3	2	3	4	0	4	N	N	Y	b	8	6
	49	3	2	4	4	4	4	Y	Y	Y	a	5	15
	50	2	2	3	4	0	3	Y	N	Y	b	7	18
	51	2	1	4	4	4	4	Y	Y	Y	b	7	6
	52	2	2	0	4	0	4	Y	Y	Y	b	9	13
	53	3	2	4	4	4	4	Y	N	Y	a	10	18

							Item						
		A	B	C	Da	Db	E	F	G	H	Test a/b	HFT	FIT
Boy 1	54	2	1	4	4	4	4	Y	Y	Y	a	4	9
Girl 2	55	2	0	2	4	2	3	N	Y	Y	a	7	7
	56	2	1	1	4	2	2	N	N	Y	a	5	7
	57	2	2	2	4	4	3	Y	Y	Y	a	5	15
	58	3	1	2	4	0	3	N	N	N	a	8	16
	59	2	2	0	4	0	3	N	N	N	a	2	7
	60	1	0	2	2	2	3	N	Y	Y	a	5	2
	61	2	1	2	3	0	0	N	N	N	a	10	8
	62	2	1	0	4	0	1	N	N	N	a	1	7
	63	2	0	1	4	3	3	N	N	Y	a	4	4
	64	2	1	3	2	2	4	N	N	Y	a	0	1
	65	1	0	0	4	0	1	N	N	N	a	2	0
	66	2	2	1	2	0	3	Y	Y	Y	a	4	9
	67	3	2	0	1	0	4	N	N	Y	b	7	5
	68	2	1	0	0	0	1	N	N	Y	b	5	0
	69	3	0	1	0	0	1	N	N	Y	b	2	3
	70	2	1	1	0	0	3	N	N	Y	b	3	1
	71	1	1	3	3	0	4	N	Y	Y	b	1	9
	72	1	0	0	2	0	1	N	N	N	b	7	4
	73	2	1	1	4	4	2	N	N	Y	b	8	13
	74	2	2	1	0	2	4	N	N	Y	b	4	17
	75	0	2	3	0	0	3	N	N	N	b	6	1
	76	2	2	3	1	0	4	N	Y	Y	b	9	7
	77	3	0	3	0	0	1	N	N	Y	b	5	4
	78	0	0	1	0	0	4	N	N	Y	b	6	5
Boy 2	79	1	2	0	4	1	0	N	N	N	a	6	1
	80	2	2	0	4	0	4	Y	N	N	a	11	12
	81	3	1	4	2	4	3	Y	N	N	a	9	13
	82	3	2	2	4	0	2	N	N	N	a	8	14
	83	2	1	0	3	3	0	N	N	N	a	6	13
	84	2	1	1	0	0	1	Y	N	N	b	8	19
	85	3	1	0	2	0	0	N	N	Y	b	4	12
	86	2	1	3	0	0	2	Y	N	N	b	8	13
	87	3	1	2	0	0	0	N	N	N	b	5	17
	88	3	1	1	0	0	4	N	Y	Y	b	12	15
	89	1	1	0	1	0	2	N	N	N	b	5	4
	90	3	1	2	0	2	1	Y	N	N	b	10	1
Girl 3	91	3	2	1	4	2	4	Y	Y	Y	a	6	14
	92	2	2	4	2	0	4	N	Y	Y	b	6	13
	93	3	2	2	4	4	4	Y	Y	Y	b	8	19
	94	2	1	4	3	0	3	Y	N	N	b	13	17
	95	1	2	2	4	3	4	Y	Y	Y	a	13	18
	96	2	2	3	3	1	1	Y	Y	N	a	8	15
	97	2	2	3	2	0	4	Y	Y	Y	b	13	22
	98	1	1	3	0	0	2	N	N	Y	b	6	11
	99	3	1	3	0	0	4	Y	Y	Y	b	9	16
	100	2	0	0	4	4	4	Y	N	N	a	10	15
	101	3	2	2	3	0	1	N	N	N	a	7	17
	102	2	1	3	4	3	3	Y	Y	Y	a	10	20
	103	2	2	0	4	0	4	Y	Y	Y	a	7	18
	104	1	1	1	2	2	4	Y	N	Y	b	8	8
	105	2	1	4	0	0	4	N	Y	Y	b	11	14
	106	2	1	1	4	3	3	Y	Y	Y	a	11	6

							Item						
		A	**B**	**C**	**Da**	**Db**	E	F	G	H	**Test a/b**	**HFT**	**FIT**
Girl **3**	107	1	0	3	4	4	4	N	N	Y	a	8	5
	108	1	0	0	4	1	2	N	N	Y	a	10	2
	109	1	1	0	3	0	4	N	N	Y	b	2	15
	110	2	0	1	2	0	1	Y	Y	Y	a	5	18
	111	3	2	4	4	4	4	Y	Y	Y	b	13	17
	112	2	2	0	3	0	4	N	N	Y	b	10	17
	113	2	1	0	3	0	2	Y	Y	Y	a	5	5
	114	3	1	4	4	3	4	Y	Y	Y	a	12	21
	115	1	1	0	4	2	1	N	N	Y	a	9	16
	116	2	0	1	4	1	4	N	N	N	a	9	14
	117	2	2	4	4	4	4	Y	Y	Y	a	13	23
	118	2	2	1	4	1	4	N	Y	N	a	11	10
	119	3	1	3	3	0	4	N	Y	Y	b	10	20
	120	2	1	2	4	4	4	Y	Y	N	b	8	17
	121	2	2	1	1	0	4	Y	Y	Y	b	11	14
	122	3	2	1	1	0	3	Y	Y	Y	b	9	15
	123	2	2	3	2	4	0	Y	N	Y	a	11	14
	124	2	2	4	4	4	4	Y	Y	Y	a	14	23
	125	3	1	3	4	1	4	Y	Y	Y	b	9	12
	126	3	0	4	4	4	2	Y	Y	Y	a	7	19
	127	1	1	3	4	1	4	Y	Y	Y	b	8	18
	128	2	1	4	4	0	4	Y	Y	Y	b	3	21
	129	1	2	1	3	0	4	N	N	Y	b	11	19
Girl **4**	130	2	2	3	0	0	4	N	N	Y	b	7	11
	131	3	1	2	0	0	1	N	N	N	b	7	12
	132	1	2	0	0	0	0	N	N	N	b	0	2
	133	3	2	3	0	0	4	N	N	Y	b	7	14
	134	2	2	2	4	0	3	Y	N	N	b	10	3
	135	2	0	0	2	4	1	N	N	N	b	2	1
	136	2	2	1	4	0	4	N	N	Y	b	12	19
	137	3	1	3	4	0	4	Y	Y	Y	b	11	16
	138	2	1	2	3	0	4	N	N	Y	b	10	12
	139	3	1	3	2	1	4	N	N	N	b	9	18
	140	3	1	3	4	0	4	Y	Y	Y	b	13	21
	141	3	1	3	2	2	2	Y	N	N	b	9	8
	142	1	2	3	4	1	2	N	N	N	b	1	16
	143	2	1	4	3	0	4	N	N	N	b	7	19
	144	2	1	2	2	0	2	N	N	N	b	6	7
	145	2	0	4	4	0	0	N	N	N	b	9	14
	146	3	2	3	4	0	4	Y	Y	Y	b	12	16
	147	2	0	3	3	0	4	N	N	N	b	4	13
	148	2	1	2	4	0	4	N	N	N	a	7	19
	149	2	1	2	4	4	1	N	N	N	a	10	18
	150	1	1	0	4	4	2	N	N	N	a	3	15
	151	3	1	2	4	4	4	Y	N	Y	a	6	17
	152	2	2	1	4	4	4	Y	N	N	a	11	5
	153	2	0	2	2	2	4	Y	Y	Y	a	10	20
	154	2	2	0	3	1	4	N	N	Y	a	9	13
	155	3	2	0	3	4	4	Y	Y	Y	a	9	20
	156	2	2	2	4	4	4	Y	Y	Y	a	7	16
	157	3	0	2	4	2	3	Y	Y	Y	a	13	16
	158	2	2	1	4	2	4	Y	N	N	a	9	17
	159	2	0	1	0	0	1	N	N	N	a	3	10

							Item						
		A	B	C	Da	Db	E	F	G	H	Test a/b	HFT	FIT
	160	1	0	3	2	0	0	N	N	N	a	4	7
	161	3	2	3	4	0	4	Y	Y	Y	a	13	16
	162	3	0	2	4	0	4	Y	Y	Y	a	12	14
	163	3	2	3	3	2	4	Y	N	Y	a	8	18
	164	2	1	2	4	2	4	N	Y	Y	a	9	17
Boy **5**	165	1	0	1	4	0	1	N	N	N	a	10	7
	166	1	1	1	4	0	1	N	N	N	a	6	12
	167	1	0	2	3	0	1	N	N	N	a	10	9
	168	2	0	2	2	0	2	Y	N	N	a	7	2
	169	2	0	2	4	1	3	N	N	N	a	6	16
	170	2	2	4	4	4	3	N	N	Y	a	16	10
	171	2	2	1	4	3	4	N	N	N	a	13	12
	172	1	1	2	4	2	0	N	N	N	a	10	20
	173	3	1	3	0	4	4	N	N	Y	b	5	19
	174	1	1	1	0	1	3	N	N	N	b	6	5
	175	3	0	2	4	0	2	N	N	N	b	7	15
	176	2	2	3	2	0	1	N	N	N	b	11	12
	177	3	1	3	4	0	4	N	N	N	b	7	18
	178	0	0	1	4	3	4	N	N	N	b	4	5
Girl/Boy	179	0	0	1	2	1	0	N	N	N	a	4	8
Girl/Boy	180	3	2	2	4	3	4	Y	Y	Y	a	11	19
Girl **6**	181	2	0	2	3	3	4	Y	Y	Y	a	6	14
	182	1	2	3	3	0	4	Y	Y	Y	b	1	9
	183	0	0	0	4	4	1	Y	Y	Y	b	5	10
	184	1	1	1	4	0	1	Y	N	N	a	6	0
	185	2	2	3	3	0	2	N	Y	Y	b	4	12
	186	3	1	0	3	3	1	Y	Y	Y	a	6	4
	187	2	1	1	4	3	2	N	N	Y	a	0	1
	188	2	2	3	4	4	3	Y	Y	N	a	3	15
	189	1	0	0	0	0	0	N	N	N	b	11	3
	190	3	1	3	4	3	4	Y	Y	Y	b	3	11
	191	3	1	3	4	0	4	Y	Y	Y	b	6	17
	192	3	2	3	4	0	4	Y	Y	Y	a	8	17
	193	2	1	3	0	0	1	N	Y	Y	b	7	1
	194	3	0	2	4	4	0	Y	N	Y	a	8	0
	195	1	0	0	1	0	0	N	N	N	b	1	0
	196	2	1	1	0	0	2	N	N	Y	b	4	14
	197	1	1	3	2	2	2	N	Y	Y	b	6	14
	198	3	1	4	4	4	4	Y	Y	Y	a	8	9
	199	3	0	4	4	4	4	Y	Y	Y	b	11	16
	200	3	2	2	4	0	4	Y	Y	Y	b	9	21
	201	2	1	3	4	0	3	Y	Y	Y	b	14	21
	202	3	0	0	0	0	0	N	N	N	a	6	7
	203	2	2	0	1	0	4	Y	Y	Y	b	10	22
	204	3	0	2	3	3	4	Y	Y	Y	a	7	14
	205	3	2	2	4	2	4	Y	Y	Y	a	9	15
	206	3	1	0	4	4	4	Y	Y	Y	a	9	8
	207	1	0	3	0	0	2	Y	N	Y	b	5	7
	208	3	1	3	4	4	4	Y	N	N	a	5	12
	209	1	0	0	0	0	0	N	N	N	b	8	8
	210	1	0	2	2	0	1	Y	Y	Y	b	8	7
	211	1	2	2	4	0	1	Y	N	Y	a	7	0
	212	2	2	3	3	1	2	Y	Y	Y	b	4	5

		Item											
		A	B	C	Da	Db	E	F	G	H	Test a/b	HFT	FIT
	213	3	1	3	2	4	4	Y	Y	Y	a	6	19
	214	2	0	2	3	0	0	Y	Y	Y	a	5	11
	215	3	2	3	4	1	4	Y	Y	Y	b	8	19
	216	1	1	1	0	0	2	N	Y	Y	b	0	14
	217	1	2	2	4	3	2	Y	Y	Y	a	7	10
	218	1	0	0	4	4	1	Y	N	N	a	3	6
	219	2	1	2	0	0	3	N	N	Y	b	5	4
	220	2	0	3	3	2	4	Y	Y	Y	a	10	9
	221	1	0	0	4	3	4	Y	Y	Y	a	3	4
	222	2	1	4	4	4	4	Y	Y	Y	a	7	15
	223	2	0	3	3	0	4	Y	Y	Y	b	7	13
	224	0	0	1	3	0	1	N	N	Y	b	5	9
	225	3	0	2	4	0	2	Y	Y	Y	b	1	13
	226	0	0	2	3	1	2	Y	Y	N	a	8	13
	227	2	0	1	4	0	1	Y	Y	Y	a	11	14
	228	3	2	3	4	0	4	Y	Y	Y	b	5	15
	229	1	1	0	3	2	3	Y	Y	Y	a	5	10
	230	0	0	1	2	0	4	N	Y	Y	b	4	13
	231	1	0	1	4	0	4	Y	N	Y	b	9	11
	232	1	1	3	4	4	2	Y	Y	Y	b	2	6
Boy **6**	233	3	1	2	4	1	4	Y	Y	Y	a	14	15
	234	1	0	1	4	0	2	N	N	Y	a	4	16
	235	1	1	3	3	4	4	Y	Y	Y	b	7	18
	236	1	0	1	0	0	4	N	N	Y	b	5	14
	237	2	0	1	4	0	2	Y	N	Y	a	7	11
	238	3	0	2	0	0	1	Y	Y	Y	b	11	17
	239	2	1	3	3	1	3	Y	Y	Y	a	0	18
	240	2	1	3	4	0	4	Y	Y	Y	b	8	20
	241	3	2	3	4	3	4	Y	Y	Y	b	8	24
	242	3	0	3	3	0	4	Y	Y	Y	a	10	15
	243	3	2	1	0	0	3	Y	Y	Y	b	9	1
	244	2	1	4	1	3	4	Y	Y	Y	a	7	10
	245	0	0	2	0	0	3	Y	Y	Y	b	5	9
	246	2	0	1	4	4	4	Y	Y	Y	a	7	8
	247	3	2	0	4	2	4	Y	Y	Y	a	5	18
	248	1	0	3	4	3	4	Y	Y	Y	a	8	16
	249	3	2	4	4	1	3	Y	Y	Y	b	8	15
	250	2	1	3	4	1	4	Y	Y	Y	b	8	21
	251	3	2	2	2	0	0	N	N	N	a	5	18
	252	3	1	4	4	2	3	Y	N	N	a	4	1
	253	3	1	3	2	0	1	N	Y	Y	b	8	14
	254	3	2	3	4	4	4	Y	Y	Y	b	10	19
	255	0	0	1	0	1	1	N	N	Y	b	5	9
	256	2	2	3	1	0	4	Y	Y	Y	b	12	12
	257	2	1	3	4	2	4	Y	Y	Y	a	10	21
	258	1	1	3	4	4	4	Y	Y	Y	b	5	11
	259	2	0	4	4	0	4	Y	N	Y	a	6	9
	260	3	1	3	2	4	4	Y	Y	Y	a	7	13
	261	2	0	0	0	0	2	Y	N	Y	a	0	12
	262	2	2	0	4	3	2	Y	Y	Y	b	11	1
	263	2	2	0	0	0	2	N	N	Y	b	9	18
	264	3	2	2	4	4	4	N	Y	Y	a	8	8
	265	1	0	0	0	0	0	N	N	N	b	8	15

	A	B	C	Da	Db	E	F	G	H	Test a/b	HFT	FIT
						Item						
266	3	2	4	3	0	3	Y	Y	Y	b	10	18
267	3	1	3	2	4	1	N	N	N	a	9	13
268	3	0	1	4	0	0	N	N	N	a	10	16
269	2	1	0	0	0	0	N	N	N	a	5	17
270	1	0	0	0	0	1	N	N	N	b	3	0
271	3	1	1	4	3	3	Y	Y	Y	a	6	4
272	3	1	1	4	2	3	N	Y	Y	a	5	16
273	2	1	3	3	0	3	N	N	N	b	7	7
Girl/Boy274	2	1	4	2	4	4	N	Y	Y	a	9	14
275	2	1	2	0	0	3	Y	Y	Y	b	9	12
276	3	1	4	4	3	4	Y	Y	Y	b	15	22
277	3	1	0	4	0	3	N	N	N	b	11	1
278	2	2	4	0	0	1	Y	Y	Y	b	2	7
279	2	0	3	0	0	4	N	N	N	a	0	0
280	1	1	0	4	2	2	N	N	Y	a	3	2
281	1	0	2	0	0	0	Y	Y	Y	b	6	9
282	0	0	1	0	0	2	Y	N	Y	a	2	17
283	2	1	2	0	0	1	Y	Y	Y	b	11	19
284	3	0	2	0	0	2	Y	Y	Y	b	11	18
285	1	1	4	0	0	0	Y	Y	Y	b	2	2

Note:

i) school 1, 2, 3, 4, 5 indicated after sex of pupil, eg: Girl **3** represents girl from school 3.

ii) Girl/Boy indicates that sex of pupil not known.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

Table 7.1 shows an overall plan of the research work carried out during the five year period from 1985 to 1989.

Table 7.1

Time	Project
85-86	Initial Literature Review
86	Attitude Survey (pilot study) year 1
87	Computer Program Design
87	Attitude Survey (pilot study) year 2
87	Attitude Survey (main study) year 1
87-88	"Key Problem" (pilot 1)
88	Attitude Survey (main study) year 2
88	"What Pupils See" (pilot 2)
88-89	Biological Keys (main study)

The work started out with two lines of inquiry, the investigation of pupils' attitudes to computing and the use of computers to help pupils in an area of Biological problem solving.

The attitude survey was refined and continued while the computer program design developed into a more detailed analysis of the problem solving task (key making).

7.2 Pupil Attitudes to Computers in School

The attitude survey was carried out with two groups (pilot and main studies). Each group was surveyed at the beginning of a particular year and one year later. This allowed different year groups to be compared and the same group to be compared over a period of time. Within each year group boys and girls were also considered as separate groups. Table 7.2 shows the organisation of the groups and the time scale involved.

Table 7.2

Group A	S1 (1986)	became	S2 (1987)
(pilot study)	S3 (1986)	became	S4 (1987)
Group B	S1 (1987)	became	S2 (1988)
(main study)	S3 (1987)	became	S4 (1988)

The attitude survey set out to:

1. Investigate the attitudes of first (S1) and third (S3) year secondary pupils to microcomputers including the areas of expectation of use, mode of use and links with other subjects.
2. Compare the attitudes of S1 and S3 pupils.
3. Investigate the change of attitudes as first year moved into second (S2) year and third year became fourth (S4) year.
4. Compare the attitudes of S2 and S4 pupils.
5. Investigate pupils' use of computers at home.
6. Investigate any differences in attitude between boys and girls.

Although the main body of the survey of secondary pupils was an investigation into their attitudes towards computers in schools. Work in school does not stand in isolation from the influence of both the primary school and the home. Obviously possession and use of a home computer will influence the attitudes of pupils within school.

Computers in the classroom started as electronic versions of existing resources such as text books. Early computer programs were just text on a screen without even any nice coloured pictures. Over the last ten years, both hardware and software have improved, but there is still a long way to go before computers are used to their full capacity within the classroom. They are still tools looking for a job to do.

Although extravagant claims are made for the efficacy of learning and pupil motivation by microcomputers, only a small amount of research evidence exists in support of these claims. Studies have been carried out that show a wide range of results. Those which show improvement of learning or increased motivation may be due not to the abilities of the computer, but to a novelty or newness effect. The improvement may not be due to the computer at all, but due to the increased energy and enthusiasm of the teacher. This is clearly an area which would repay further investigation.

In the mid 1980's schools acquired a large number of microcomputers. In view of this investment by the educational authorities and continued teacher in-service training, it is important to find out what the pupils feel. If computers are to be used successfully in schools, then the attitudes of the pupils using them are very important.

The attitude survey that was carried out (Ch. 3 & 4) showed that pupils enter secondary school with lots of positive attitudes towards computers and their use in school. As pupils move through secondary school their initial, very positive attitudes decline. Third year pupils find computers less exciting and have less expectation of using them than their first year contemporaries.

Boys and girls do not show the same attitudes to all questions. Change in attitudes are sometimes due to boys, sometimes due to girls and sometimes due to both boys and girls. Third year girls show a greater decline in interest than third year boys. This decline continues into the fourth year. Boys and girls do have different views of their own and the opposite sexes' capabilities with an expectation of computers. First year girls and boys show less diversity in attitude than other years, but in all years each sex sees itself in a better light than the opposite one.

In spite of the decline, the majority of attitudes stay in the positive sector of the attitude scale.

One of the attributes of the computer is its ability to individualise learning. There is no overwhelming evidence from the attitude survey that pupils see the computer as providing this type of use.

Pupils in all years like to play games on the computer.

Obviously this decline in positive attitudes is important, but not surprising. Other studies (Hadden, 61 and Kelly, 67) also show that attitudes to other secondary subjects such as Science decline as pupils progress through early secondary school. The other important point to note is that girls and boys' attitude to computers are not the same and show different patterns of change. This has implications for those who design courses and for those who teach them.

Unfortunately, these results must be influenced by the low level of use within the school (Section 4.11). In the third year only 18% of the pupils surveyed had used computers at least once a month. Boys appeared to use the computer more, but this could merely be a reflection of those doing computer studies.

It is to be hoped that since this survey was completed in 1988 the computer use in schools has improved. One important point that emerges is that in spite of the hardware present in schools, assumptions cannot be made about use. In view of the limited use of computers taking place while this survey was being conducted, the need to continue to examine pupils' attitudes to computers remains.

It is also important to make sure that any future survey of pupil attitudes is done in conjunction with information about levels of use within the school.

The use of computers at home will also influence the attitudes of pupils towards their school computer experience. Home machines (Ch. 4) are predominantly games machines. Other software is used to a limited extent, but the main home computer activity is to play games. More boys than girls have home computers (this is confirmed by other studies, Fife-Schaw, 50). This may reflect pupil interests or the interests and expectations of their parents. The playing of games may not be all bad, 80% of the pupils in Fife-Schaw's study went on to other computer uses and 50% went on to some form of programming. Moore (66) also showed that even pupils doing computer studies had their anxiety levels reduced if they possessed a home computer.

One the disadvantages of games playing (from the educational software point of view) is the highly sophisticated nature of the software available. These programs have excellent graphics and fast response times in contrast to the less sophisticated educational products. This discrepancy between the two types of software reflects, perhaps the relative amount of profit to be made in each sector of the market.

7.3 The Future of Computers in Schools

The use of computers in school will always be limited by the available hardware and its associated software. More sophisticated hardware and better software is necessary if pupils are not to think of school computer experience as "out of the ark". Hopefully the use of the machines already in schools will increase as teachers gain more confidence and expertise. The Standard Grade exams, with their emphasis on new methodologies, may encourage teachers to experiment with the new technology. In a resource-based learning situation, the computer is an extra resource which will help the teacher do what he or she is good at - teaching. Having said all this, the most important boost to computer use in the classroom is the provision of good quality, relevant software.

What sort of task should the computer be used for?

It would seem that the best possible use for the computer is to do something it is good at. Something it can do better than any other available method. These are some suggestions: the list is not exhaustive but gives some ideas for making the best use of the machine.

1 Many experiments in Biology are complex and time consuming. While computer simulations are no substitute for doing the real experiment, they can be used in a number of different ways to help pupils' understanding. Simulations of real experiments can be used (i) to collect large numbers of results; (ii) to investigate the effect of changing different variables in a complex experiment, (iii) as a method of familiarisation with a complicated method. It is important that pupils realise that they are dealing with a simulation and not a real experiment. For this reason, wherever possible the simulation should be combined with a real experiment. There are some occasions when the experiment is too difficult, dangerous or time consuming to carry out. In these cases a simulation on its own would be acceptable.

2 The computer is a fast and efficient handler of data. An important classroom use is to process large amounts of results and to draw graphs and charts quickly and neatly.

3 The computer can also be used as a database, storing large quantities of information. With a suitable browse facility, this information can be readily accessible to both pupil and teacher.

4 The right computer also makes an excellent word processor.

5 Other ways to use the computer are in the control of laboratory equipment or in the collection of data from an experiment.

The future holds out many possibilities like intelligent programs and 3-D graphics. Let us hope these end up in schools one day.

7.4 Computer Program Design

The original aim of the work was to identify an area of difficulty in the School Biology syllabus, write a computer program on this topic and see if, under controlled conditions, learning was improved.

Biology contains a large number of topics which cause pupils difficulties. Other workers have investigated the fields of Osmosis and Photosynthesis. For this study the topic of Biological Keys was chosen. Keys come in two forms, family tree and paired statement types. They are used to identify and classify living organisms. The principle underlining a key is that each organism possesses a unique set of attributes or features. The construction of Biological Keys is one of the problem solving skills in the new Standard Grade Biology Examination. The use of keys is one of the techniques in the practical skills assessment.

Using keys causes pupils few problems, especially in the very structured way they are often used in School

Biology. If pupils are given very complex keys with which to identify organisms, they may need help especially in the identification of specific features or attributes. However, the major problem pupils have is with the construction of both family tree and paired statement keys. This topic was thought to be suitable for writing a computer program. Keys are dichotomous, they involve yes/no decisions and this should lend itself to computer programming. A number of computer programs had already been written for pupils to use to identify a particular organism (109).

To allow the program to be written, it was essential that the possible content was thoroughly analysed. This involved a detailed analysis of the process of making a key. Initially, the process was divided into two major tasks: the choosing of suitable features by which the organism could be identified and the method of presenting that information.

The aim of the computer program was to break each task down into a series of small steps and to give the pupils a strategy for completing each part. The computer program would also allow pupils to progress at their own pace and receive appropriate remediation. Pupils were given suitable attributes and asked to make a simple key to identify these organisms. The program was then used, if somewhat clumsily, to transform the family tree key into a paired statement key.

The other part of the problem, the choosing of suitable attributes proved more difficult to program. Immediately problems arose when living organisms were introduced. These problems were shelved temporarily by using geometric shapes. A few simple frames were constructed but realisation soon dawned that the task of constructing a key was a great deal more complex than had been previously thought. No wonder pupils had difficulties. Coupled with the problems of the limitation of the available hardware were limited programming skills on the part of the researcher. A change of direction was needed, this involved a further analysis of key making skills.

7.5 Analysis of Key Making Skills

Table 7.3 shows an overall summary of the development of the work following the abandonment of the computer design project.

Table 7.3

Analysis of Key Making Skills

Time	**Project**
87-88	Pilot 1 "Key Problem"
88	Pilot 2 "What Pupils See" measurement of: ability to disembed working memory capacity
	Interviews
88-89	Main Study (i) analysis of key making skills (ii) measurement of: ability to disembed working memory capacity

The pilot studies yielded a large amount of very useful information. Initially it had been hoped to study both first year science pupils and third year biology pupils. Using and making keys are part of the syllabi in both years in the three schools that took part in the first pilot study. After the test material had been completed, it was found that in two of the three schools paired statement keys were taught to first year pupils only by the Biology teachers. Chemistry and Physics teachers who taught first year Science only taught the making of family tree type keys. Why this happened was not stated. Maybe they felt that paired statement keys were too hard or maybe they felt they (the non-biologists) lacked the expertise. It was therefore decided to use only third year Biology pupils in the study.

In the third school some of the first year classes followed a modified course. This course set out a possible teaching strategy and included some extra pupil worksheets. The course emphasised the importance of structuring the work. The task was divided into a number of small steps and the pupils were given a clear strategy for completing the task.

In the third year all the pupils in the same school as above completed a similar modified course. The scores of this group were compared with those of the other two schools. 88% of pupils who had done the modified course could make a paired statement key from pictures, while only 67% of the pupils from the other schools could do so. The modified course, while providing a strategy and practice with sub-problems obviously helps, but there are still failures (Section 5.17).

The second pilot study investigated in more detail the choice of suitable attributes. This included the effect of the type of objects presented and the number of features (variables) present. This part of the work showed the importance of how the material is presented. Bad diagrams make the process even more difficult for the pupil. Size was one of the most important features chosen by pupils. Pupils often looked for very small differences like in "Spot the Difference" type competitions, or used features not present in the diagrams like "lives in the sea" (Sections 5.29, 5.23, 5.24).

Interviews were also carried out with pupils in an attempt to further understand their thinking. These showed similar results to the written material; pupils using size as an important descriptor (Sections 5.26, 5.27, 5.28, 5.29).

7.6 Final Testing of Key Making Skills and the Factors that Affect Them

As a result of the pilot studies, it was found that the task of making a biological key can be divided into two distinct areas:

I Choosing suitable biological attributes.

II Mechanics of making the key.

Within the area of choosing attributes the following skills are needed:

1. the ability to distinguish features;
2. the ability to name these features;
3. the ability to choose biologically significant features and to disregard unsuitable differences;
4. to know when there are enough suitable features so that all organisms can be identified.

The end product of this is to have the correct number of suitably named attributes.

Within the area of making the key, the following skills are needed:

1. the ability to sort or set objects;
2. the making of a family tree key;
3. the making of a paired statement key.

These skills were investigated in the final testing, together with the psychological factors of working memory capacity and disembedding ability (Chapter 6).

Biological material is very variable and trying to ensure that alternative questions containing biological material were equivalent, produced some unexpected results. Pupils obtained much better scores with pictures of arthropods than with fish. The pictures of the fish did not seem any more difficult than those of the arthropods. On further investigation it would appear that the pupils who took part were in fact more familiar with the arthropod example. Although many Biology departments have fish tanks, it may be that pupils are more familiar with fish in the form they see them in the supermarket after they have been prepared for sale. In which case, they may be even more unfamiliar with the idea of "whole fish". This indicates the important part that previous experience plays in the successful completion of keys.

The results of the testing show that pupils have problems choosing attributes and deciding which of those attributes are biologically significant. The non-biological objects also gave pupils problems when choosing features. Many pupils did not understand the principle of key construction, ie: that each organism must have a unique group of features.

If pupils are given a table of information, making a family tree or paired statement show little difference in the scores achieved. In general, attribute selection is more difficult than the mechanics of key making.

The school has a significant effect on the results. This was not unexpected. Different schools have different courses, put emphasis on different aspects of the syllabus and use different materials. All these aspects seem to be important in successful key making (Section 6.13).

Boys and girls show no differences in responses to the test material.

The ability to disembed shows significant correlation with all the skills needed to make a key. Working memory correlates with the skills of setting, deciding if there is enough information and the mechanics of the key making (Section 6.14).

7.7 Why do Pupils Fail at Key Making?

What happens when a pupil is presented with a set of pictures or a group of living organisms? First of all they have to be able to choose suitable attributes, reject unsuitable ones and choose enough of them. They have to be able to hold this information and process it.

This seems the type of situation where the space available in working memory may be overloaded. According to Anderson (110) long term memory containing both factual knowledge and procedures can only be accessed through working memory. Working memory is of fixed capacity so that, if it is already full of information, the problem solving skills in long term memory cannot be accessed. Any further processing of the information into a suitable key will not take place.

Add to this the problem of being field dependent, unable to separate relevant from irrelevant material, then there seems very good reasons why pupils fail at making keys.

7.8 How Can we Help?

The most important part of this piece of work is to use the information collected to improve the teaching of this part of the Biology syllabus. Before addressing this particular problem, there is perhaps a more fundamental one to be answered. Should we be teaching pupils how to make biological keys at all? In an era of tight schedules would we not be better employed teaching pupils how to USE keys and not to make them.

The answer is, if we decide to teach them, that we need to be aware of the multitude of skills required. We need to teach the mechanics of key making but more importantly, the skills of correct attribute selection.

The first consideration is the presentation of the biological material. Pupils have to be prepared for both the real life situation of using keys in the field and being able to answer examination questions. This means that they must be able to recognise suitable attributes in living organisms, pictures and drawings. From this work it would seem important to give pupils as wide range of examples as possible.

Can we teach all the individual skills? The setting and the mechanics of key making can be taught relatively easily. The choosing of attributes would seem to be more difficult. Pupil's "alternative frameworks" are very important here. We sort and classify material from an early age. The use of size is an important criterion in classifying everyday objects. As school teachers of Biology we want to run counter to this. In an attempt to make keys easier for pupils, we try to make them forget about size and use discontinuous variables. No wonder pupils choose size as a discriminator when they are unfamiliar with the material or at a loss as to what to do.

Field dependency is an innate characteristic which significantly affects all the skills required for making a key. As teachers we need to be aware of this and try try and help those pupils who have difficulties because of this cognitive style.

As teachers of Biology we also have the problem that the making of a key from living organisms is different from that of using a set of pictures or drawings. Do we teach pupils to do the real thing, ie: make a key from living things or do we teach them to pass the exam questions.

Those setting exam questions on this problem solving task need to think very carefully about what they are trying to test. If the question is presented as a table of information they will mainly be testing a pupil's ability to set information and understand the mechanics of the key pathway. Are these the sort of problem solving skills we wish to test in our Standard Grade Biologists. If, on the other hand, the information is presented in the form of diagrams or drawings, the skills of attribute selection together with the mechanics of key making are being tested. This is perhaps a more biological set of skills. The type of diagram and the type of organisms used are all going to influence a pupil's ability to answer the question correctly.

Does making the different type of keys act as a discriminator between credit and general pupils as the syllabus (1) suggests? If pupil are given the information in the form of a table there appears to be little difference between making a family tree type key or a paired statement key. Under these conditions there would be few differences between credit and general pupils. If keys are to be discriminators, then the discrimination must come in the attribute selection or in the combination of the attribute selection and the mechanics of the key.

7.9 The Future

This work has investigated the effect of working memory and disembedding ability on the key making skills, another psychological factor that of convergent and divergent thinking could also usefully be investigated.

The method of skill analysis used in this piece of research could be applied to other areas of the Biology syllabus which case pupil difficulties such as genetics or sources of variation.

Now that the detailed analysis of the key problem has been carried out it is possible to return to one of the original objectives, that of constructing a computer program to assist with the teaching of keys. In the three years since the original design exercise took place, both the type of hardware and the programming tools available have improved. The introduction of the Apple Mackintosh computer and authoring systems such as Strath-Tutor and Hypercard might allow the development of a computer teaching package which could be evaluated and compared with existing teaching methods.

The suggestions above show that this field of computing and problem solving offers wide possibilities for future research.

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