AN INVESTIGATION OF S1/S2 CROSS CURRICULAR MATHEMATICS IN GENERAL SCIENCE

A CASE STUDY: BO'NESS ACADEMY

LORNA M CHAPMAN  MAY 1992
AN INVESTIGATION OF S1/S2 CROSS CURRICULAR
MATHEMATICS IN GENERAL SCIENCE

A CASE STUDY: BO'NESS ACADEMY

Professional project submitted in partial fulfilment of the requirements for the Post Graduate Certificate in Education (Secondary) in Mathematics, at Moray House Institute of Education, Heriot Watt University (incorporating the Scottish Centre for Physical Education, Movement and Leisure Studies)

LORNA MARGARET CHAPMAN

MAY 1992
This project was selected as a result of my interest in Mathematics and Science. During my first placement of the Post Graduate Certificate in Education (Secondary) at Bo'ness Academy, it became apparent after discussions with members of staff of the Mathematics and Science Departments that pupils of S1 and S2 were experiencing difficulties with certain aspects regarding knowledge and skills of mathematics which are necessary for pupil instruction in some techniques and analyses.

I felt that analysing these difficulties would be a valuable study not only for my personal benefit, but would also produce a piece of important work which could be of use to those members of staff concerned within Bo'ness Academy.

The main aim of this project is to try and identify problem areas in S1 and S2 Mathematics within General Science and to give some recommendations to help reduce and/or overcome these problems.
ACKNOWLEDGEMENTS

I would like to express my thanks and gratitude to the following people for their help and advice in the compilation of this project:

Members of staff of the Mathematics and Science Departments of Bo'ness Academy, with special mention to Miss Isabel Johnston, Mr Steve Dougan and Mr Ronnie Weir.

My Tutor Mr Morris Grassie and Staff of Moray House Institute at Holyrood and Cramond Campus'.

Finally to my Dad for the use of his computer.
TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Acknowledgements</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Table of Contents</td>
<td>111</td>
</tr>
<tr>
<td>Chapter 1</td>
<td>The School</td>
<td>1</td>
</tr>
<tr>
<td>Chapter 2</td>
<td>Research Method</td>
<td>5</td>
</tr>
<tr>
<td>Chapter 3</td>
<td>Review of Literature</td>
<td>7</td>
</tr>
<tr>
<td>Chapter 4</td>
<td>Analysis of the Mathematical Content in a Sample of Integrated Science End of Topic Tests</td>
<td>12</td>
</tr>
<tr>
<td>Chapter 5</td>
<td>Analysis of Questionnaires</td>
<td>16</td>
</tr>
<tr>
<td>Chapter 6</td>
<td>Conclusions and Recommendations</td>
<td>21</td>
</tr>
<tr>
<td>APPENDIX A</td>
<td>Integrated Science End of Topic Tests -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Section 1</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td>Section 5</td>
<td>III</td>
</tr>
<tr>
<td></td>
<td>Section 9</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Section 10</td>
<td>VII</td>
</tr>
<tr>
<td></td>
<td>Section 12</td>
<td>IX</td>
</tr>
<tr>
<td>APPENDIX B</td>
<td>Questionnaire</td>
<td>XI</td>
</tr>
<tr>
<td>APPENDIX C</td>
<td>Sample Summary Fact Sheet 1</td>
<td>XV</td>
</tr>
<tr>
<td></td>
<td>Sample Summary Fact Sheet 2</td>
<td>XVI</td>
</tr>
<tr>
<td>REFERENCES</td>
<td></td>
<td>XVII</td>
</tr>
<tr>
<td>BIBLIOGRAPHY</td>
<td></td>
<td>XVIII</td>
</tr>
</tbody>
</table>
Bo'ness Academy is a comprehensive school in Central Region serving the Burgh of Borrowstounness (Bo'ness), and has five feeder primary schools.

At present the school has a role of approximately 920 pupils and a staff of 65 and includes the following departments: Mathematics, Computing, Science, Technical, Home Economics, English, Art, Physical Education and Religious Education.

The average S1 intake is 180 pupils and these are allocated into the classes 1B, 1D, 1U, 1C, 1A, 1T, 1I, 10 or 1N depending on their number. Pupils are also split into smaller groups for practical subjects, namely Science, Technical, Home Economics and Art.

S1 and S2 classes are all of mixed ability but from S3 onwards some departments prefer to stream pupils according to their ability. The Mathematics Department, from an assessment of pupils' performance during S1 and S2, stream pupils at the commencement of third year. Conversely in the Science Departments, streaming is not carried out.

Learning Support and Extended Learning Support Services are available in the Progress Unit for pupils with learning difficulties and/or social problems.

One of the school's objectives is to

"... provide for each pupil an appropriate, fulfilling and broad based education tailored to his/her needs". (1)
The school aims to prepare the pupils as members of the community with a variety of subjects which are studied in S1 and S2 to give them experience in a number of areas; from S3 onwards pupils are advised which subject areas and skills are most suitable to his/her needs so that all can attain qualifications and experiences according to their ability. This is also relative to the pupil's selected career choice (if known).

Through their academic work, guidance and recreation programmes pupils are given an

"understanding of life outwith school". (2)

S1/S2 Mathematics

S1 and S2 pupils use the SMP (Schools Mathematics Project) booklets as their main resource but topics inadequately covered by SMP are then taught in more depth by the teacher. Small investigations are carried out during one period every two or three weeks.

The staff implement SMP, with some personal discretion, according to the method suggested by the authors. Pupils complete a booklet and also complete the review sheet for homework, which is to be marked by the teacher for the next time they attend Maths (unless such work involves equipment only available in the classroom - for example an angle measurer - in which case this review sheet is then completed during class time). Work completed from the Review Book apertaining to that level is assessed prior to sitting the appropriate end of level tests.
These tests which are written and compiled by staff consist of, as requested by the 5 - 14 National Guidelines and for the future training of Standard Grade examinations, questions involving knowledge, understanding, reasoning and application.

The SMP system allows pupils to progress at their own rate although they are, or should be, monitored as regards this rate of progress. This also permits continuity from the primary school for the majority of pupils.

S1/S2 General Science

It is now a requirement for all Science teachers irrespective of their specialist science subject (Biology, Chemistry or Physics), to teach a general science course to Standard Grade level.

Due to the practical requirements of the 'Sciences', S1 and S2 classes are reduced in size in order that experiments and skills can be acquired efficiently and, most importantly, safely.

Pupils are not streamed according to ability in S1/S2, in fact they are also not streamed to this effect in S3 or S4. The work is mainly all resource based learning using worksheets for each topic/section to be studied. The Science Departments issue an A5 sized 'Integrated Science Homework-Book' for S1 and another book for S2. Each section contains four or five exercises.
On completion of a section and relevant homework, pupils sit an end of topic test - these contain questions which require the appropriate skills in the areas of:

a) Information Handling
b) Problem Solving (Reasoning and Application)
c) Knowledge and Understanding

The pupils' practical skills as well as their academic ability are assessed.
The main research method used was by issue of a questionnaire to members of the Mathematics, Biology, Chemistry and Physics Departments. This questionnaire covered many areas concerning both mathematics and the mathematical content within general science. All questions were to be answered if possible, and some questions were to be answered by the Science or Mathematics Department only. The identity of those completing the questionnaires was kept anonymous.

The analysis of these questionnaires is discussed in the findings chapter 'Analysis of Questionnaires'. Appendix B contains a copy of the questionnaire.

<table>
<thead>
<tr>
<th>DEPARTMENT</th>
<th>NUMBER OF STAFF PER DEPARTMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>3</td>
</tr>
<tr>
<td>Chemistry</td>
<td>4</td>
</tr>
<tr>
<td>Physics</td>
<td>2*</td>
</tr>
<tr>
<td>Mathematics</td>
<td>7*</td>
</tr>
</tbody>
</table>

* includes one part-time Physics/Mathematics teacher - employed for three days per week; teaching for two periods in the Mathematics Department with the remaining teaching time in the Physics Department.
The Learning Support Service Department was not included in this survey although this might have been necessary if a more in depth analysis of mathematical difficulties had been required.

Of the seventeen questionnaires issued, fifteen were completed and returned (two members of staff were away from school at that time), and this ensured a wide range of opinions.
Documentation regarding this area of study is quite limited. This came as a surprise because I believe Mathematics in Science is important, especially as areas of study in Science require knowledge and skills which are more likely to be taught in the maths class initially. Obviously problems will arise if pupils have not acquired these skills when they are asked to bring a piece of work in the Science class to a successful conclusion.

Reading and language difficulties are often a barrier to pupils' mathematical progress. Consequently these difficulties will have an even greater effect on pupils' scientific progress, the degree of which will depend on each pupil's level of ability.

The understanding of mathematics can be enhanced by contextualised teaching and learning – one criteria for mathematics in the Department of Education and Science HMI Series states

"The mathematical needs of the whole curriculum provide excellent opportunities for placing mathematics in context." (3)

This is also emphasised in the S1/S2 Mathematics Bible, as some teachers call it, namely the National Guidelines for Mathematics 5 - 14. With the introduction of these guidelines staff in both primary and secondary schools expressed apprehension, but most agreed changes in the curriculum were required.
It was felt contextual teaching and learning is very important, allowing pupils to see there is both a purpose and focus for learning skills and gaining knowledge in the subjects of Mathematics and Science. For example, pupils should encounter mathematics in relevant contexts as recommended in the

5 - 14 Mathematics Guidelines

1) managing everyday situations;
2) designing and making;
3) studying aspects of the environment;
4) investigating in science;
5) investigating areas of mathematics;
6) play, games and puzzles;
7) text book series

Practical examples of these contexts may include

1) buying and selling; using timetables, clocks (eg setting videos); cooking and DIY activities involving measuring and/or weighing
2) making containers; displays; creative work
3) personal life; local history; school and country environment
4) categorising and identifying; looking for connections; rate of change; observation and analysis
5) number sequences; properties of shape and movement; measurement
6) board games; songs; calculator; computer games
7) texts with day to day situations. (4)

Mathematical problem solving will also not only be applied in the maths class,

"Pupils need to be encouraged to use and improve their problem solving skills, discuss confidently, work collaboratively and participate in decision making." (5)
Pupils should be familiar with the relationships they studied in primary school with regard to Environmental Studies and Mathematics.

"At all ages, investigations in the environment may involve the acquisition or use of skills relating to calculation, shape and measurement, mathematical equipment from area grids to calculators and data bases; processes such as estimation, mathematical reasoning and problem solving. Recording of studies in the environment may involve tables, graphs and scaled maps." (6)

Teaching in most secondary schools is mainly within subject departments, therefore there needs to be considerable staff consultation and planning to develop common policies relating to their subjects. An important consideration would

"... include co-operation between departments on such matters as subject-specific examples to be used in mathematics and vice-versa, together with some agreement on their timing." (7)

Most of the problems encountered in working across the curriculum are due to and enhanced by the extensive lack of awareness that exists in schools about what everyone else is doing, especially about the nature of different subjects. This is notably true of mathematics where remarkable misconceptions are abundant. 

Pupils may become confused if, for example, there are different methods of solving equations or constructing graphs. Inter departmental meetings should be held quite frequently.

"Co-operation must develop at teacher level and has major implications for teacher release and staffing" (8)

but this will only depend on each department and attitude of the school management.
Many teachers consider mathematics to be a service to other departments - but those who teach mathematics should be aware of the mathematical skills required in other subject areas, for example, science, social studies, home economics, and consequently make allowances for them.

The Cockcroft Report recommends mathematics teachers

"...should also try to arrange that the mathematics course and the courses in other subjects are developed in such a way that pupils will be familiar with the necessary mathematical topics by the time they are needed in other curricular areas." (9)

Although the order in which topics of mathematics is taught is important and leads to logical progression applying previous acquired knowledge, it would be easier to change the teaching order of complete units of mathematics than change those of the science departments. The main factor being due to use of required equipment which is sometimes limited. The Science Department should be prepared to adapt their order of syllabus if possible. Cockcroft suggests that

"Furthermore, there should be liaison between teachers so that those who make use of mathematics in the teaching of their subjects do not use an approach or a language which conflicts with that which is used in mathematics lessons." (10)

Additionally, Departments which may use mathematics should be aware of the techniques and teaching methods used in the maths class, for example use of equations and percentage calculations.
Cross curricular links with other Departments, especially science, is an important area to develop, and schools should try and foster these links with Senior Management, Head Teachers, Principal and Assistant Principal Teachers playing

"... a supportive, facilitating role through, for example, flexible timetabling and staffing. Where initiatives are imposed by management on their staff without those teachers being involved and committed such initiatives are unlikely to be sustained." (11)

Mathematics is an international method of communication and display of information, and teachers of all subjects, including mathematics, need to be aware of the part which mathematics can play in furthering such presentation.
The end of level tests should represent the areas of work covered and also give an indication of the mathematical skills and knowledge pupils should have acquired in order to complete the test successfully, together with the scientific knowledge required.

This analysis is my personal view - although there are contradictory opinions of the amount of mathematics contained in S1/S2 General Science.

Section 1  Information Handling  Appendix A; page I

My initial reaction from reading this test was: "is this a maths or science test?" The reason being that the questions included the need for an analysis of the number of children at a party from a bar chart; percentages of the different colour of eyes in a survey displayed in a pie chart; and finally pupils are asked to draw a bar graph using information from a given table of results. All of the questions in this test required the use of mathematical skills and knowledge. Pupils have to interpret bar graphs and pie charts - skills which pupils should have come across initially in the maths class.

Section 5  Problem Solving  Appendix A; page III

Although the content in this test refers to chemical reactions, temperature, time and volume, 1 of which are associated in science, the tasks again involve the use of mathematical skills - interpretation and construction of line graphs. Are pupils familiar with the complete construction of a line graph at this stage in their mathematics or are pupils only expected to plot points and draw the 'best fitting' line on the graph? Where should this first be taught: in the Science or Maths class?
More questions in this test involve scientific knowledge and skills application than the Section 1 test, and there is quite a high percentage of mathematics involved.

Section 9  
Information Handling  
Appendix A; page V

This is a test of the first topic section completed in second year. The mathematical content is obviously built upon prior knowledge and as result is more demanding - it includes more complex information displayed in a bar chart (in this test a bar chart is asked for but in the Section 1 test it is referred to as bar graph - should there be standardisation of vocabulary?)

A more detailed line graph is required to be plotted. Quite a complex pie chart is displayed and the percentage of heat loss through a roof has to be calculated. Are pupils able to recognise this diagram as a quarter of a circle or are they expected to calculate this fraction of a circle using an angle measurer and then convert the figure to a percentage. Is the Science Department aware when each of these methods are covered in the maths syllabus? ✓

Again a high percentage of mathematics is involved in this test.

Section 10  
Problem Solving  
Appendix A; page VII

The techniques required in this test are very similar to those contained in Section 9 - interpretation of a bar chart and the drawing of a line graph to display chemical information.
Pupils are required to construct a pie chart and the final question involves algebraic manipulation of a formula. Are pupils taught the same method of solving for the unknown variable as they are taught in maths?

The question is

The concentration of an acid can be worked out using the following formula.

\[ C \times V \text{ of acid} = C \times V \text{ of alkali} \quad \text{where } C \text{ is the concentration} \]

\[ V \text{ is the volume} \]

In a neutralisation experiment it was found that 25 cm³ of acid neutralised 100 cm³ of alkali whose concentration was 2 units.

Calculate the concentration of the acid.

Do you substitute the values of C and V first, then solve, or rearrange the formula first then substitute the values of C and V. This equation involves multiplication and division of variables to solve for the unknown, not just merely adding or removing so many V's or C's from the equation.

From my analysis of these test papers you perhaps will agree that there is a large amount of mathematical knowledge, skills and operations required in order to be able to complete these tests successfully.
The Mathematics studied in S1/S2 is through the SMP individualised learning - this may of course cause problems when some pupils have not yet completed the required work in order to sit these tests. I am not suggesting maths should not be taught in the Science class, but teachers should be aware of the approach and language which is used in the Maths class and therefore avoid the possibility of confusion.

I am also not discrediting the teacher(s) who may use 'old fashioned' teaching methods when teaching maths - only that they be aware of the different explanations and teaching methods in the recent developments in mathematics, especially with the introduction of the 5 - 14 National Guidelines.
Questionnaires were issued to all members of staff in the Mathematics, Biology, Chemistry and Physics Departments. Fifteen out of the seventeen questionnaires were completed and returned.

A wide variety of questions were asked, ranging from: the age of the teacher; subject department; length of time they had been teaching, and their opinions and suggestions regarding difficulties pupils have with mathematics and mathematics in science.

In all of the departments 76 - 100 % of S1/S2 pupils' work is resource based/individualised learning. As regards how effective this type of learning was, staff of the Mathematics and Physics Departments thought it was effective (one member of the Maths Department selecting very effective) but the majority of those in the Chemistry and Biology Departments preferred to describe it as quite effective. One member of the Biology Department said that individualised learning was not effective at all.

Difficulties with maths in science can be caused due to a number of reasons; the main problem is that pupils are working at different/levels and as result

"... some of the pupils may not cover relevant topics until a lot later than some of the others" (Maths Department)

One comment sums up my findings when I analysed some of the integrated science end of topic tests in Chapter 4 -

"Assumptions have been made in Science worksheet construction and assessment materials" (Biology Department)
Two members of staff feel that no problems have arisen in maths in science as a result of SMP resource based learning.

40% of those questioned felt there was too much emphasis on individualised learning in S1/S2.

All but one member of the Mathematics Department agreed that streaming according to ability was necessary in S1/S2 to some extent because it was believed that

"Credit level maths needs more time to complete the syllabus - streamed groups in S2 would enable this course to begin before S3" (Maths Department)

"For credit pupils some setting could be useful in S2 to allow formal algebra to taught" (Maths Department)

All except one member of the Science Departments said streaming was not necessary in S1/S2 as

"Pupils can progress at their own rate through RBL. If streamed - you are determining their ability and so not giving pupils a chance to change and improve as they mature" (Chemistry Department)

Table 1
Areas of Difficulty in Maths and Maths in Science

<table>
<thead>
<tr>
<th>Mathematics Department</th>
<th>Science Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ratio</td>
<td>• Percentages</td>
</tr>
<tr>
<td>• Percentages</td>
<td>• Manipulation of Formulae/Equations</td>
</tr>
<tr>
<td>• Angles</td>
<td>• Line Graphs</td>
</tr>
<tr>
<td>• Negative numbers</td>
<td>• Averages</td>
</tr>
<tr>
<td>Area and Volume</td>
<td>• Histograms</td>
</tr>
<tr>
<td>Estimation</td>
<td>• Data Handling</td>
</tr>
<tr>
<td>Scale Drawing</td>
<td>• Forces</td>
</tr>
</tbody>
</table>

• Stated in more than one questionnaire.
With the areas of mathematics causing concern (shown in Table 1), explanation and language used must be consistent with the way the pupils are taught. Failure to do this will result in the pupils becoming confused.

40% of the staff receive no verbal feedback regarding mathematical problems which occur in Science, 46% occasionally receive feedback and the remainder are undecided.

The Science Departments identified areas of mathematics in science where there are either knowledge and skill difficulties, or that these areas have not yet been taught, in order that this situation can be rectified in science teaching during S1/S2:

i  ) "Solving for unknown in an equation eg. $X \times 20 = 4 \times 15$"

ii ) "Calculating averages in early S1"

iii) "Sometimes pupils claim that they have not worked with percentage calculations"

iv ) "For S1 and S2 data handling skills"

v  ) "Percentages; graph drawing, equations"

vi ) "Manipulation of formula and equations"

Obviously the timetabling would need to be reconsidered if these topics in Maths are to be taught before the same skills are required in Science.

The Maths and Science Departments have, at present, only met once, and 33% say they meet only if difficulties arise. ✓
73% of staff questioned believed that rearranging the order in which the syllabus is taught in both the Maths and Science Departments would be beneficial in assisting the resolution of difficulties of Maths required in Science.

The Science Departments syllabus

"... is already arranged to suit available apparatus" (Chemistry Department)

and in Science there are resource problems

"A rota of teaching materials operates" (Biology Department)

67% of Mathematics Department said they would be willing, if possible, to rearrange the timetabling of the syllabus to accommodate the mathematics required in Science according to the Science timetable. One member of the staff was not willing to rearrange the timetable, and another felt this was not a problem for which action would be required in the near future.

Everyone agreed that it would be useful if the Maths Department produced summary sheets giving details of how the Maths Department promoted working within certain topics.

Some suggestions and comments made by staff which they thought might help overcome difficulties with cross curricular maths in General Science were:

"It would be useful if the science teacher used the same mathematical techniques and methods as the Maths Department" (Maths Department)

"It would be very advantageous for the Departments to liaise on a regular basis to enable consolidation and changes to take place" (Maths Department)
"More liaison would be welcome, if only at P.T. level" (Biology Department)

"It is essential to ensure methodology in teaching problem solving skills the same in both subjects" (Biology Department)

"Agreement about the order of topics" (Physics Department).

One interesting observation from these questionnaires - contradictory comments from two members of the same department:

"The mathematical content of the science course is minimal. The pupils can be taught the simple maths as and when it occurs"

"There are many mathematical skills in S1/S2 science eg. reading/changing scales, drawing graphs, calculating averages. I feel more liaison between Science and Maths Departments could lead to a more uniform reaching of these skills and would assist all pupils, but particularly the less able."

The analysis of this questionnaire is purely factual and hopefully will be helpful and beneficial to those who read it.
CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

This study has provided evidence from relevant literature, together with an analysis of Integrated Science 'End of Topic Tests' and questionnaires, that there are difficulties in some areas of Mathematics and General Science.

Syllabuses are produced by the Scottish Education Department but the implementation of their content is surely at the discretion of the teachers - as long as attainment levels according to each pupil's ability are reached. Obviously, drastic rearrangement would cause more problems, but surely by introducing some topics of maths at a more appropriate time it is possible that pupils would have a better chance of understanding the required mathematics in science.

It will not be possible to solve these problems immediately but hopefully in the not too distant future action could be taken to reduce them and thus assist resolution of the difficulties of mathematics in science.

From the analyses, the main areas of difficulty occurred in the use of percentages, manipulation of formulae and equations and graph work (construction and interpretation of data related to graphs).

Communication and liaison between the Departments is lacking, especially when science staff are unsure of the mathematical knowledge and timetabling of maths topics, and therefore assume prior mathematical skills and knowledge have been acquired in maths lessons when they are compiling Science worksheets.
As a result of this study I would make the following recommendations:

1. Cross curricular co-operation must be developed at teacher level and be based on a strong, shared working commitment with inter departmental meetings held as frequently as possible. ✔

2. Senior management must play a supportive role, providing flexible timetabling and staffing if possible. ✔

3. Teachers in the Mathematics and Science Departments must become aware of each others Departmental requirements as regards mathematical content and the time of year these skills are required. ✔

4. The Mathematics Department to produce, in consultation with all concerned, summary or fact sheets giving details of how the Maths Department promotes the working within certain mathematical topics. For example: equations, using formulae, graphs and so on. ✔

5. Investigate the possibilities of rearranging the timetabling of certain topics in maths so that pupils will use correctly the mathematical skills required in General Science. ✔

These recommendations are only given as a guide and a more in depth survey may facilitate further development.
Possibilities for Further Study

1) To analyse in detail the timetabling of syllabuses in the Mathematics and Science Departments.

ii) Carry out a similar investigation in another school(s) and compare the findings.
1. The bar chart shows the ages of a group of children who went to a party.

   Number of children
   
   Age
   7  8  9  10  11  12

a. How many children were age 8?

b. What was the most common age of child at the party?

c. How many children were at the party?

d. How many children were aged 10 and over? (4)

2. The results from a survey are shown in the pie chart.

   Blue eyes
   Green eyes
   Brown eyes

a. What eye colour was least common?

b. What percentage (%) had blue eyes?

c. What colour made up about 30% of the total? (3)
3. The results table shows information collected in a survey.

It refers to the colour of dogs.

<table>
<thead>
<tr>
<th>Colour of dog</th>
<th>Number of dogs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey</td>
<td>6</td>
</tr>
<tr>
<td>Black</td>
<td>4</td>
</tr>
<tr>
<td>Brown</td>
<td>8</td>
</tr>
<tr>
<td>White</td>
<td>5</td>
</tr>
<tr>
<td>Other colours</td>
<td>3</td>
</tr>
</tbody>
</table>

You have to draw a bar graph of these results.

a. Copy the start of the bar graph which is shown. (1)
b. Make up suitable scales for the bar graph. (2)
c. Draw the bar graph. (5)

Total 15
1. Two solids, A and B, were dissolved in the same volume of water at different temperatures. The weights dissolving at the different temperatures are shown on the graph.

![Graph showing weight vs. temperature for solids A and B]

- a. What weight of solid B dissolves at 50°C?
- b. Which solid is more soluble at 30°C?
- c. At what temperature are the solids equally soluble?

2. A liquid is heated until it boils. The temperature is taken every minute. The results are shown in the table.

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>20</td>
<td>33</td>
<td>45</td>
<td>57</td>
<td>68</td>
<td>78</td>
<td>78</td>
<td>78</td>
<td>78</td>
</tr>
</tbody>
</table>

- a. Use the graph paper to draw a line graph of these results.
- b. What is the boiling point of the liquid?
- c. How long did it take the liquid to boil?
3. The volume of a drop of water is 0.5 cm$^3$.
If a tap drips into a beaker 6 times in 1 minute, what volume of water will collect in 1 hour?

4. The pupils in a science class wanted to find out if meths evaporated quicker than water.
Describe an experiment you would use to find the answer to the problem.

Your report should have:

a. A diagram of the experiment.
c. A list of the steps you would take to make it a fair test.

5. A group of pupils set up the experiment shown in the drawing.
They were trying to grow a big crystal.

A week later, when they looked at the crystal again, they found that it had dissolved.
Suggest two reasons why the crystal dissolved instead of growing bigger.
1) The bar chart below shows how well different materials conduct heat.

Rate of conducting heat (units)

<table>
<thead>
<tr>
<th>Material</th>
<th>Bar Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brass</td>
<td>1</td>
</tr>
<tr>
<td>Platinum</td>
<td>5</td>
</tr>
<tr>
<td>Copper</td>
<td>4</td>
</tr>
<tr>
<td>Aluminium</td>
<td>3</td>
</tr>
<tr>
<td>Titanium</td>
<td>2</td>
</tr>
</tbody>
</table>

a) Which material is the best conductor of heat? (1)
b) Which is the poorest conductor of heat? (1)
c) Which material has a rate of conducting of 4 units? (1)

2) A pupil carried out an experiment to find out which make of vacuum flask, A, B or C was the best at keeping the heat in.

Each flask was filled with the same amount of water at the same temperature. The temperature of the water was recorded every hour. The results are shown below.

<table>
<thead>
<tr>
<th>Time (hours)</th>
<th>Flask A</th>
<th>Flask B</th>
<th>Flask C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>95</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>1</td>
<td>92</td>
<td>88</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>88</td>
<td>84</td>
<td>86</td>
</tr>
<tr>
<td>3</td>
<td>86</td>
<td>80</td>
<td>83</td>
</tr>
<tr>
<td>4</td>
<td>84</td>
<td>77.5</td>
<td>81</td>
</tr>
<tr>
<td>5</td>
<td>82</td>
<td>75</td>
<td>79</td>
</tr>
<tr>
<td>6</td>
<td>81.5</td>
<td>73</td>
<td>77</td>
</tr>
<tr>
<td>7</td>
<td>80.6</td>
<td>72</td>
<td>76.2</td>
</tr>
<tr>
<td>8</td>
<td>80.4</td>
<td>71</td>
<td>76.0</td>
</tr>
<tr>
<td>9</td>
<td>80.2</td>
<td>70.5</td>
<td>75.5</td>
</tr>
<tr>
<td>10</td>
<td>80</td>
<td>70</td>
<td>75</td>
</tr>
</tbody>
</table>

Contd/...
a) Plot a graph of temperature against time for flask C.

b) On average, what is the hourly drop in temperature of the water in flask C?

c) How long does it take for the water in each flask to fall below 80°C?

The pie chart below shows how much heat is lost through different parts of an uninsulated house.

a) Through which part of the house is most heat lost?

b) What percentage of heat is lost through the roof?
1. The bar chart shows the results that a group of pupils got when they added a metal to dilute acid.

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of gas</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

- a. What was the total volume of gas given off?  
- b. During which minute was most gas given off?  
- c. How long did the reaction last?  
- d. What was the average rate at which the gas was given off during the experiment?  

2. A group of pupils neutralised an alkali with an acid.

They added the acid 5 cm$^3$ at a time and noted the pH of the solution each time they added acid. The table shows their results.

<table>
<thead>
<tr>
<th>Volume of acid (cm$^3$)</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH of the solution</td>
<td>14</td>
<td>14</td>
<td>11</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

ON THE PIECE OF GRAPH PAPER.

- a. Draw a LINE GRAPH of the results from the pupils’ experiment.  
- b. What volume of acid neutralised the alkali?
3. The table shows the results of testing the pH of many different substances.

<table>
<thead>
<tr>
<th>Type of substance</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidic</td>
<td>15</td>
</tr>
<tr>
<td>Alkaline</td>
<td>33</td>
</tr>
<tr>
<td>Neutral</td>
<td>50</td>
</tr>
<tr>
<td>Amphoteric</td>
<td>2</td>
</tr>
</tbody>
</table>

a. **Copy** the pie chart and add to it the information from the table.

![Pie Chart](image)

b. If 200 substances were tested, what number were acidic?

4. The concentration of an acid can be worked out using the following formula.

\[
C \times V \text{ of acid} = C \times V \text{ of alkali}
\]

\(C\) is concentration

\(V\) is volume

In a neutralisation experiment it was found that 25 cm\(^3\) of acid neutralised 100 cm\(^3\) of alkali whose concentration was 2 units.

Calculate the concentration of the acid.
1. Three ores were tested to see how much copper they had in them. The results are shown in the table.

<table>
<thead>
<tr>
<th>Ore</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>% copper</td>
<td>75</td>
<td>20</td>
<td>5</td>
</tr>
</tbody>
</table>

Show this information as a pie chart.

2. The table shows information about the fractions obtained from the distillation of crude oil.

<table>
<thead>
<tr>
<th>Name of fraction</th>
<th>Number of carbon atoms per molecule</th>
<th>Boiling range (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>petrol</td>
<td>5 to 8</td>
<td>50 to 150</td>
</tr>
<tr>
<td>diesel</td>
<td>12 to 15</td>
<td>200 to 250</td>
</tr>
<tr>
<td>bitumen</td>
<td>over 25</td>
<td>over 300</td>
</tr>
</tbody>
</table>

a. What happens to the boiling range of the fractions as the number of carbon atoms in each molecule gets higher?

b. Which fraction has molecules which would boil at 225°C?
1. The table contains data about the % alcohol in home brew and the temperature at which it was made.

<table>
<thead>
<tr>
<th>% alcohol</th>
<th>0</th>
<th>2</th>
<th>3</th>
<th>5</th>
<th>7</th>
<th>4</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>10</td>
<td>14</td>
<td>25</td>
<td>30</td>
<td>35</td>
<td>45</td>
<td>52</td>
<td>60</td>
</tr>
</tbody>
</table>

a. Suggest another way to show this data.
b. Show the data using this other way which you chose in a.

4. Copper can be made from malachite by heating it with carbon. The same method can be used to get iron from haematite. Aluminium can be made by electrolysis of melted bauxite.

a. Suggest a name for this passage.
b. What is the name of the ore used to make copper?
c. Which process is used to make aluminium from its ore?
d. Show the information from the passage in the form of a table.

Total 15
MORAY HOUSE INSTITUTE
HERIOT WATT UNIVERSITY

POST GRADUATE CERTIFICATE IN EDUCATION (MATHEMATICS)

PROFESSIONAL PROJECT QUESTIONNAIRE

"CROSS CURRICULAR MATHEMATICS IN GENERAL SCIENCE - S1/S2"

To Members of staff in the Mathematics and Science Departments of Bo'ness Academy

In order to investigate the above as part of my professional project I would be grateful if you could complete the attached questionnaire and return to Mr Steve Dougan (Mathematics Department) by 12.00 noon on Friday 3 April 1992.

Thank you.

LORNA M CHAPMAN
(Mathematics Placement Student, Bo'ness Academy, November - December 1991)
1 Which department are you a member of?
Mathematics [ ] Biology [ ] Chemistry [ ] Physics [ ]

2 Are you aged
20-30 [ ] 31-40 [ ] 41-50 [ ] over 50 [ ]

3 How long have you been a qualified teacher?
0-10 years [ ] 11-20 years [ ] 21-30 years [ ] 31-40 years [ ]

4 What percentage of S1/S2 pupils work in your department is individualised/worksheet based?
0-25% [ ] 26-50% [ ] 51-75% [ ] 76-100% [ ]

5 How effective is individualised learning in S1/S2?
not at all [ ] quite effective [ ] effective [ ] very effective [ ]

6 In what way, if any, will individualised learning cause problems with maths in science?

__________________________________________________________

__________________________________________________________

7 Is there too much emphasis on individualised learning in S1/S2?
Yes [ ] No [ ]

8 How are pupils assessed?

__________________________________________________________

9a Are pupils streamed according to ability in S1/S2? Yes [ ] No [ ]

b If yes, when and how are pupils streamed?

__________________________________________________________

10a Do you think streaming according to ability is necessary in S1/S2
Yes [ ] No [ ] To some extent [ ]

b Please give reason

__________________________________________________________

__________________________________________________________
11 Science Department only: Which topics in S1/S2 maths in science do the majority of pupils have difficulty?

12 Maths Department only: Which topics in S1/S2 maths do the majority of pupils have difficulty?

13 Do you receive any verbal feedback from pupils regarding mathematical problems which occur in Science?

Yes [ ] No [ ] Occasionally [ ]

14 Science Department only: Certain mathematical skills are required before some science topics can be taught. Can you identify specific examples in science where the mathematical knowledge/skills have not yet been taught to enable the pupils to carry out these specific tasks?

15 How often do the Maths and Science Departments meet?

Not at all [ ] Once a term [ ] Twice a term [ ]

Only if difficulties arise [ ]

16 Will rearranging the order in which the syllabus is taught in both the Maths and Science departments help solve difficulties of maths required in Science?

No [ ] To some extent [ ] Yes [ ]

17 Science Department only: would you be willing, if possible, to rearrange the timetabling of the syllabus to accommodate the maths timetabling of their syllabus?

Yes [ ] No [ ]

18 Maths Department only: would you be willing, if possible, to rearrange the timetabling of the syllabus to accommodate the science timetabling of their syllabus?

Yes [ ] No [ ]
19 Do you think it would be useful if the Maths department produced summary sheets giving details how the Maths department promote working within certain topics, for example, equations, percentages, using formulas.

Yes [ ] No [ ]

20 Have you any other comments or suggestions to help overcome difficulties with cross curricular maths in general science?

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Thank you for your co-operation.
Detailed below is a summary of how the Maths Department teach and work with

**SUBTRACTION**

We promote

- subtraction using decomposition as a written algorithm
- check by addition
- encourage alternative mental methods

We DO NOT promote

- "borrow and pay back"
- "use the method of 'equal additions'"
- "put anything on the doorstep"

Examples:

\[
\begin{array}{c}
61 \\
271 \\
- 38 \\
233 \\
\end{array}
\begin{array}{c}
391 \\
1000 \\
- 74 \\
326 \\
\end{array}
\]

This topic should be covered by most pupils by Commencement of S1
Detailed below is a summary of how the Maths Department teach and work with EQUATIONS

We promote

* balancing
* perform the same operation to both sides of the equation
* "undo" operations ... + with - ; x with ÷
* encourage statements like:
  - add something to both sides
  - subtract something from both sides
  - multiply both sides by something
  - divide both sides by something

We DO NOT promote

* "change the side change the sign"
* use decimal approximations when an accurate fraction could be used

Examples:

\[
2x - 7 = 13 \quad 3t + 19 = 6t - 8
\]

- add 7 to both sides
  - \[2x = 20\]
  - divide both sides by 2
    - \[x = 10\]
- subtract 3t from both sides
  - \[19 = 3t - 8\]
- add 8 to both sides
  - \[27 = 3t\]
- divide both sides by 3
  - \[9 = t\]
  - so \[t = 9\]

This topic should be covered by most pupils by Commencement of S2
Ro'ness Academy Staff Handbook. Section 2

2 Ibid.

Mathematics from 5 to 16 Curriculum Matters 3
An HMI Series. Chapter 3

4 Scottish Office Education Department. 1991. 
Curriculum Assessment in 
Scotland National Guidelines Mathematics 5 - 14. Chapter 3

5 Ibid.

6 Scottish Education Education Department. 1991. 
Curriculum and 
Assessment in Scotland A Policy for the 90's Working Paper No 13
Environmental Studies 5 - 14. Chapter 2

7 Bolton, E. J. op. cit.

Better Mathematics.
A Curriculum Development Study on The Low Attainers in Mathematics
Project. Chapter 7

9 Cockcroft, Dr W. H.; Chairman. 1985. 
Mathematika counts.
Report of the Committee of Inquiry into the Teaching of Mathematics in 
Schools. Chapter 9

10 Ibid.

11 Afzal, Ahmed. op. cit.


