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AN INTERRELATED APPROACH TO

TEACHING MATHEMATICS IN FURTHER EDUCATION

by

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A doctoral thesis submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy of the Loughborough University of Technology, 1986

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by S Turner, 1986

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ABSTRACT

AN INTERRELATED APPROACH TO TEACHING MATHEMATICS IN FURTHER EDUCATION

by S Turner

CAMET

(Centre for Advancement of Mathematical Education in Technology) Loughborough University of Technology

Reports and consultative documents published at national level since about 1980 have indicated that British Industry must look to modern technology, and also educate and train its workers on a 'broad base' with an 'integrated' approach. Traditionally, and still very much the mode of operation, teaching has been confined within subject boundaries.

A research group was established by Professor Bajpai consisting of the author, Mr Rod Bond (Burleigh Community College, Loughborough) and a few others working overseas to investigate a teaching strategy based on an interrelated approach to teaching mathematics. Measurement was chosen as the first topic of investigation using this approach which then formed the basis for further research undertaken by the two research workers of the group whose work is reported in the form of two theses.

This thesis aims to show that mathematics is naturally related to science and technology in industrial practice and that when taught in an interrelated way it would be more interesting and have more relevance to real applications in technology-based employment at craft and technician levels. To help establish the case experiments carried out by the author are referred to; these include a few case studies, a questionnaire survey and results analysed from more than five hundred basic mathematics tests.

The various kinds of mathematics taught in further education are described and compared with mathematics in a practical context as seen from a case study within an engineering training school. Next a survey of mathematics at work shows that, like the training school, there is a task associated with the mathematics which is also related to science or technology or both. Another case study in the pharmaceutical industry lends further support to the way mathematics is used in industry. Much of the mathematics also seems to be basic and used in association with measurement and a particular task. It was decided by the research group that a tape/slide programme on measurement for students and educators should be developed by the author and tested in different situations.

Teaching modules on relevant mathematical topics based on the interrelated approach were constructed for students with strong support from industry in the form of materials and advice. Testing of these modules, in their original and revised forms after feedback, is described. These trials were also carried out in other establishments.

Modules based upon the interrelated approach developed by the author formed a basis for promoting the underlying philosophy behind this approach. These were presented to educators in in-service training and staff development programmes in the north western region of the UK with success.

Observations and conclusions drawn clearly indicate that this type of method makes mathematics more interesting and relevant for students of different abilities and backgrounds. Finally pointers are given in the thesis as to the wider use and promotion of this approach for teaching mathematics in further education. Key words

Interrelated teaching, case study approach, pharmaceutical production, tape/slide for educators, mathematical education, mathematics in industry, teaching measurement, teacher training, team teaching, technical colleges.

ACKNOWLEDGEMENTS

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To my research associate Rod Bond I extend my warmest thanks for the most efficient, pleasant and considerate way in which he has treated his colleague on so many occasions, and has always been ready to offer his assistance.

From the Wirral Metropolitan College I would like to thank Harold Darlington, John Hewitt and Clive Lacey for their keen interest and support. They also contributed much to the projects which ensured success: their interest remains as strong as ever.

Beyond Wirral, at Halton College, Mike Hewitt became a dedicated supporter of my research, producing many excellent suggestions and contributions. The keen support of Roland Pritchard of Halton resulted in much useful information: his discussions always made some valuable contribution. My deepest thanks go to Mike and Roland. The many students who tried the research material must not be forgotten and I am deeply grateful for their interest and many practical suggestions.

Finally, meaningful teaching materials would not have been obtained without the help of industry. This was given whenever asked for and nothing was too much trouble: there were many invitations to 'come and see for'yourself'. I would like to thank all who have supported the research (too many to mention), and made contributions from industry, for their most generous and ready response to many requests.

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CHAPTER 1

BACKGROUND AND OVERVIEW

1.1 Education, Training and Change

1.1.1 Further Education

Full-time education is a legal requirement for every child up to the age of sixteen years: beyond this any decision to continue to receive education rests with the individual concerned. 'Further Education' was a term defined by the 1944 Education Act as 'post-school education as a whole' and the definition still stands. However, some categories of Further Education have been defined: 'Higher' (leading to degree or degree-equivalent qualifications), 'University' (leading to a degree award) and 'Adult' (a broad provision for the adult population as a whole). Further Education itself now becomes a separate category and provides courses in conjunction with the training needs of industry for the education of Craft and Technician employees. The bulk of the work in a college of Further Education was traditionally provided in one day of release from employment in a working week: here a 'day' continues and embraces one evening. This mode of attendance is then 'part-time'. However there is no longer a simple definition of a college of Further Education by type or level of work. General Certificate of Education courses belong to the school sector but are also found in the colleges on a full-time or part-time basis; post-graduate degree students work within the author's college and are supervised from within; and training courses for teachers are conducted from within the author's college. The GCE course provision by Further Education establishments

requires some further consideration. It provides the pupil of 16+ who requires a GCE course with a more mature atmosphere than found in a school. GCE Advanced level courses lead to degree courses but passes in certain subjects at the Ordinary level are often pre-requisites of employment in industry and commerce or entry requirements for vocational courses. Although the schools and colleges have the GCE course as a common element they tend to show a difference: class numbers in a school are more stable than those in a college where the students are free to leave altogether or change courses and this can present problems when students are testing research material. Students who leave the courses tend to lack interest and motivation. One possible system for working with such 'restless' students could be to concentrate on the production of interesting teaching materials with useful exercises, closely related to industrial practices and to relate what is taught to the needs of industry through appropriate courses.

1.1.2 Changes in Education and Training

To put down simple definitions, 'training' is the process by which a worker acquires skills for the job while at work and 'education' is a course of theoretical instruction, usually provided at a college of Further Education, and designed to support the skill training. Precise definitions of these terms would not be to the benefit of any of the parties involved since flexibility in adjusting the balance between education and training would be lost. For example, a student had a problem to solve at work in connection with erosion of a concrete pipe used to carry chemicals: nobody at work could help him (the 'training' had failed) so he enlisted the help of those in the 'education' service. This is just a simple example of the lack of flexibility in training but it reflects the national concern behind the publication of a consultative document 'A New Training Initiative' [1] in 1981. The foreword opens with:

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Vocational education and training have been the subject of continuing public debate and attention; yet to a considerable extent we still lag behind our competitors in having an educated, trained and flexible labour force.

This document also points out three important objectives for the 1980's and beyond, which are:

- 1 developing skill training,
- 2 improving the vocational education and training of all_young people, and
- 3 opening up more opportunities for <u>adultsto train</u>

This is a very important document because it sees major defects in our approach to industry and commerce but it also recommends rather drastic methods to put it right. ALL young people and MORE adults are to be brought into the 'classroom' which they may not relish. What are they going to receive? a repetition of school lessons, of separate subjects presented in an uninteresting manner? There is then, a challenge for the innovators in this document, and it does ask for those who are interested and can make a contribution to respond. Without much thought, two essential ingredients for any education or training programme for industry must be MATHEMATICS and COMMUNICATION. The mathematics could be simply keeping a record of the movement of goods in and out of a factory; communication could be by the written or the spoken message. It would probably be very difficult to separate these two from the actual job.

Again, when making a product, technology is used and mathematics is usually involved, even if it is only controlling a temperature or a flow-rate, and science too, in the applied sense, is ever-present. But no job would be considered as being made up of precise amounts of mathematics, science, technology and communication. They become INTERRELATED as a whole by

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the job or task. So if we must bring more people into education for work they must be shown these subjects, in relevant mixes and situations, related together: this should lead students to be more interested in their education.

This may seem a very simple and natural view of education for industry but to put it into practice would require considerable changes: Further Education presents its courses as separate subjects, as do schools, and staff would certainly resist immediate change but in any case would have to be persuaded to change and be made aware of the benefits of Research is indicated here and Professor Bajpai had change. conceived the idea of investigating the effectiveness of an interrelated approach to teaching several subjects. Rod Bond (RB), a teacher at Burleigh College, Loughborough, and the author (ST) were at the time both registered research students under the directorship and supervision of Professor Bajpai (PB) who suggested that these three should become a research team and investigate the interrelated approach to teaching mathematics, science and technology. The subjects for Bond's research would be pupils between the ages of fourteen and sixteen years, with occasional exceptions, and for Turner's simply those receiving Further Education which implies from the age of sixteen upwards. Two theses would be produced and would be complementary in that similar ideas would be tried in different parts of the educational spectrum.

To come forward some four years from the message of 'A New Training Initiative', a new report of an independent study of the attitudes of British management to investment in vocational education and training has been produced. The following statement from it [2] is endorsed by the Director General of the National Economic Development Office and the Director of the Manpower Services Commission:

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For our part we find disturbing the accumulating evidence of the country's poor investment in training, the lack of knowledge about what training we do, the absence of concern to find out, and the implications for our economic performance of these failures.

The author is fully convinced after undertaking this research that Professor Bajpai has initiated and promoted an activity which would be beneficial to the nation's education and training system well into the future.

Note: with 'training' one must read 'education' since it is difficult to separate the two.

A final note on changes in the school curriculum from [2] is relevant here and is [2, 24]:

... many employers complained about the relevance of the school curriculum; in time, a full system of training qualifications could exercise an influence on the school curriculum in the same way as the more academic 'O' and 'A' levels do at present - thereby increasing the effectiveness of subsequent employer-based training.

1.2 The Author's Background

The author is a full-time member of the staff of the Science and Mathematics Department of the Wirral Metropolitan College, Merseyside, North West England. The College is an amalgamation of what were three separate colleges of Further Education situated on the Wirral Penisula. The region supports a declining shipbuilding industry (workforce down from a peak of 12 000 to about 1500); a number of chemical-based industries; a Shell oil refinery; a major manufacturer of soaps and allied products (Lever Brothers Limited); and a manufacturer

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of margarine and edible oil products (Van den Berghs & Jurgens Ltd, workforce 1200 whose brands are household names) together with many smaller industries. The incoming raw materials for the industries are handled by the local dock services which include tank storage and container handling facilities. The Science and Mathematics Department exists on two of the three sites of the separate colleges. Each site has a Mathematics Section leader for the department and the author holds this position at Birkenhead. He is also responsible for most of the computer courses/requirements. The author is also responsible for mathematics on the third and the smallest site (Wallasey) where the provision is just O-level mathematics. Duties include time-tabling, providing equipment, engaging and looking after part-time staff (at present six in number) and providing a service to the other departments. Computer studies, appreciation or computer education in schemes of work, brings the author into contact with other disciplines and practical applications through requests for assistance from members of staff from college departments. Useful contacts have been made in this way and used in furtherance of the research. Occasionally the author has helped a local school by teaching mathematics for them when they were short of staff. The author's Head of Department likes staff to pursue their own education and is actively engaged in promoting short courses for industry, some of which are at present being negotiated and would certainly benefit from the results of this research: here then is a very strong link between university research, Further Education and industry. The reduction in the number of workers in many of the local industries by the employment of modern technology and retraining rather than redundancy is often practised.

In-service courses for teachers have been organised and provided by the department according to demand: examples of such courses which have been provided by the author are 'New Developments in Mathematics' for teachers in local

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authority schools and 'The Computer and Numeracy Teaching in Further Education' which was structured to meet the needs of Further Education lecturers from the local Merseyside region (six area authorities). The departmental staff (between sixty and seventy members in total on all sites) support the educational needs of local schools in providing short courses for school laboratory technicians and jointly staffed courses for pupils which come under the Technical Vocational and Educational Initiative (TVEI). The author sees to the requirements of such courses in respect of mathematics and computer studies. His first degree (BSc) included mathematics, physics and electronics and was followed by a Diploma in Education. The electronics was used in a course he ran called 'Electronics for Chemists' and a further interest in mathematics education resulted in parttime research being carried out at Loughborough University of Technology. The degree of Master of Science was awarded after the thesis entitled 'An Investigation into Modern Mathematics studied at the Secondary Level' was submitted in The research was supervised by Mr L R Mustoe and 1977. directed by Professor Bajpai.

Thus the demands on staff extend beyond one subject and such flexibility is in keeping with the modern needs of industry where CHANGE is the important key to survival and development.

1.3 The Thesis

As was explained in section 1.1.2 the investigations carried out in this thesis are part of the work of a research team of three and Bond's work complements that of the author. For example, both Bond and the author tried to present teaching materials in an interesting way: Bond concentrated on good quality reprographics, the author on slides. Common to the work of both researchers was the trial of material produced with the cooperation of industry, for use within industry. Professor Bajpai supported both researchers by

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trying out the materials produced in different parts of the world and keeping educators informed of the benefits of the research being carried out. From within the author's thesis Bond's unpublished thesis [3] will be referred to from time to time and this will remind the reader of the 'research team' approach. Frequent meetings of the research team and communication between members served to keep all members informed of what the others were doing and this was particularly important in respect of the development and trials of new materials.

Chapter 2 looks at the provision of mathematics by Further Education. A survey of a sample of colleges by a group of Her Majesty's Inspectors was followed by a report which was circulated to colleges. One of the significant aspects of the report was the identification of the teaching of mathematics as a separate, isolated subject, much as in schools, without relating it to other subjects. Numeracy and mathematics at a basic level were also shown to be considerable components of the mathematics provision. Case studies help to bring some measure of reality to general considerations: thus one can construct a basic mathematics syllabus and then teach from it but a look at a particular case in which similar mathematics is used in industry would enable the teacher to modify the syllabus in the light of what industry Thus the next part of the chapter considers a case needs. study of the mathematics needed by the craft apprentices in an Industrial Training School. This does not stop at mathematics because the mathematics is seen to be related to technology through tasks. The formal mathematics courses are next surveyed and these are seen to be treated in isolation from the disciplines which they support.

Chapter 3 represents an attempt to survey some of the uses of mathematics in industry. Questionnaires were issued to students at the craft and technician levels and more than four hundred were returned. A computer-assisted analysis of

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the responses was attempted in order to gain (or perhaps not) some coherent facts, patterns or trends. The most important fact to emerge (based purely on the limited sample) was the prevalence, and so importance, of BASIC MATHEMATICS such as percentages and that the <u>mathematics was used in</u> <u>relationship to science and/or technology through a task</u>. Also, there was general awareness that experience of a computer as a user, or simply to know something about a computer, could enhance job prospects. The students were fully employed in permanent jobs and attended the college for one day per week (the 'day-release' system) and perhaps one evening as well.

Information on what mathematics is practised, and to some extent, how it is practised, has also been provided in Chapter 3. This was followed by something more precise and with greater depth to it so as to test the validity of the broad deductions in Chapter 4. A case study provides the means to support these deductions and is based on the author's 'call' to obtain a solution to Basic Mathematics problems within industry. The particular industry involved happened to be the Pharmaceutical Industry and the management were appreciative of the interest shown by the author in setting up an educational provision: photography and interviewing techniques were used by the author and considered to be of prime importance in a research exercise of this nature. Because of the cooperation of the management this case study became a very useful piece of research and Professor Bajpai was interested in its potential because it involved NOT ONLY MATHEMATICS BUT SCIENCE AND TECHNOLOGY. Later on this case study was to play an important role in formulating ideas for a team approach to research. The courses provided, although based on the mathematical needs of the workers, had to involve science and technology to be relevant to the needs of the production workers and this echoes what was generally indicated in Chapter 3. The idea that you cannot teach one subject without relating it to other subjects is now materialising.

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Chapter 5 explores the interrelationships disclosed in the previous chapter, in particular those between mathematics, science and technology. The idea was brought to the notice of the author by Professor Bajpai during a research discussion. It was at this meeting that the author produced the results of the case study of Chapter 4 and it proved to be of great interest to him because it made into a reality his suggested 'interrelated' approach to teaching mathematics.

During the team's discussion a particular topic had emerged quite naturally - that of 'measurement' as a prime component of almost any task and the reason for using mathematics in industry. The author's survey of Chapter 3 showed that measurement was part of most industrial tasks and science would not exist without it. Thus it was decided that the team would investigate the interrelationships between mathematics, science and technology through measurement.

The author produced a tape/slide programme on Measurement for educators but he has since shown it to students at all levels. Using the author's Pharmaceutical Industry project (Chapter 4) as a 'model' the team investigated the production of <u>modules of study</u> based on an <u>interrelated</u> <u>approach</u> involving mathematics, science and technology; guidelines for the construction of modules and strategies for their implementation were also formulated. All three components feature in each person's daily life to a varying degree be it at work, shopping or 'play'; this last activity being supported by a large industry.

The initial strategy employed by the team (working together) for the construction of a module was to start with a topic or theme and try to write down, in a brainstorming session,

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as many examples of interrelationships as possible. A suitable diagram is better understood by students and proves helpful to teachers who wish to explore the construction of their own modules; a block diagram based on the Oil Industry (Appendix 1.1) illustrates the technique. The experiences gained from pilot studies were fully discussed and out of these came suggested modifications to modules or strategies employed. Further trials of the modules were then made. For his own guidance the author set down three hypotheses (H1, H2 and H3) to be tested on the modules before it could be said that the module had proved to be successful.

Chapter 6 develops the pilot study of Chapter 5 based on the Building Industry. A modified module was produced with the help of a small college team. These early experiences were also used to construct a second module based on the Oil Industry and the trials of both these are reported on in this chapter. Both Rod Bond and the author have reported that industry and commerce were very helpful in their support for the construction of modules. Key materials have been provided by them and realistic modules could not have been produced without this support. Valuable experience from the complementary attitudes of Bond and Turner to the use of educational technology was also gained.

The involvement of other lecturers in the use or production of modules of study or just the interrelated approach to teaching is an important feature of Chapter 7: if the method of interrelated studies is so useful then it must be passed on. Staff development is a general term used to cover any strategy that will improve the service delivered by the teacher. Sometimes a course of lectures or a conference or a small group meeting for one purpose, over a number of weeks, is the form which staff development takes. One feature of staff development in this chapter is the attempt to produce trials of modules in other colleges and to inform others, who

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are not within easy reach of the author, about what the researcher thinks is something new and worthwhile in teaching. The author found that there were difficulties encountered due to the non-regular hours worked in Further Education and also that course schedules are constrained compared with pupils in a school who take the CSE examinations early in the year and so are available for trials before the end of the summer term. The author published a short paper directed to those in Further Education, which explained the research ideas and requested contacts from people who would like to try out modules. Membership of a Numeracy Committee which had representatives from six local education authorities also helped to provide contacts and the author confined himself to such committee activities which he thought could directly support the research.

Trials of the tape/slide programme on Measurement are described and these came from a number of sources. The opportunity to construct a module 'Measurement and the Motor Car' and try it out, on behalf of a Youth Training Scheme area coordinator, arose and the module has been accepted and should receive some publicity through the coordinator. A module was sent to the pharmaceutical company featured in Chapter 4, and has been accepted for use 'in possibly modified form when we decide on a new training programme' as the management has put it. Help with coursework for a local school with which the author's department runs a joint Technical Vocational and Educational Initiative (TVEI) scheme was provided in the form of a module. The college provides the mathematics component of the TVEI scheme and one of the author's mathematics team volunteered to write and try out a module on 'Water' with the class (only six of them because only one school wanted to join the scheme). There is often a problem in Further Education when running a course because students are not obliged to attend and so classes are often small and attendances vary considerably; further, if numbers dwindle the class is likely to suffer closure. The school, however, can guarantee a class size for at least a session.

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As it happens, both Bond and Turner produced 'car' and 'water' modules but for different reasons. Bond's approach was a broad one and Turner's was more subjective because both modules were related to course needs such as mathematics and vocation.

Finally, Chapter 8 summarises the findings of this thesis, draws some conclusions and suggests ideas for further research.

1.4 Educational Technology and Information Technology

This is a wide term and covers all materials from the simple to the sophisticated, that enable those who are being taught to receive and understand the teacher's ideas. 'Information Technology' [4] is defined in this little booklet with the aid of the Oxford English Dictionary but has a common interpretation as electronic apparatus using modern technology in the form of micro-electronics circuitry. The most prevalent examples are the electronic calculator and the microcomputer. These two have enormous potential for the world of teaching: the author recently visited a dockland primary school to see if it could use a SECOND computer and was very impressed by the sensible approach of the head teacher who looked very closely at the educational benefits resulting from the use of the computer. At the higher end of the scale a researcher must become aware of the enormous contribution of GOOD PRACTICE in the use of the computer which has been generated by projects such as the MIME Project [5], the programming software for which is very complex and would not be suitable for a researcher with limited resources to emulate because of the time involved. However, using the computer with simple self-constructed software is always worth trying out for the effect and the author has taken the integrated approach to using the computer - if it does a job with ease and speed then joins the equally important pencils,

paper, rulers, etc, and they all co-exist together for the benefit of the student. Software used in the research has been produced by the author and makes use of a limited number of statements such that it is transferable to any hardware system. An example of the output obtainable from a program 'TANKS' is illustrated in Appendix 1.2: this shows sample depth/volume calibration tables and curves for the cuboid, cylindrical (axis vertical or horizontal) and spherical tanks.

The slide projector and the overhead projector are also very useful because one picture can convey a lot of information and the scene can be changed at will. The sound tape recorder is also very useful for assessment by recording interviews with students. Sometimes a student will eventually produce a correct answer when allowed to talk about a problem and not be committed to the first thing written on paper. This thesis will report considerable use of the tape recorder. The author had one video film made during a 'concrete' session with a set of Building students but it wasn't very satisfactory chiefly because the sound was not being recorded To summarise, for this research, equipment has been clearly. used when justified even though extra time has been taken to set it up, but once the first experiences are gained the use becomes easier and usually shows benefits. The computer often provides a focal point for discussions between students thus leading to mutual help.

Author's Note

Copies of the modules, tape recordings and slides are available with this thesis at CAMET.

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CHAPTER 2

MATHEMATICS IN FURTHER EDUCATION

2.1 Introduction

Education after leaving school has been traditionally available for the main purpose of acquiring a qualification as a technician for someone employed in industry below the status of 'graduate' or 'professional' and the pattern of attendance was one day (plus an evening) for which the person secured paid leave of absence: this is known as the 'day-release' system and is still the mode of attendance. The course of study could lead to the award of a National Certificate [6] or a City & Guilds of London Institute [7] Technician Certificate, the latter body also awarding Craft Certificates after pursuing a similar pattern of work and study. Beyond this level further study could lead to the award of a Higher National Certificate for example in Mathematics [8] with associated subjects. Changes in the nature of the provider (for example a training unit within an industrial organisation) and the provision (such as the Youth Training Scheme one-year course) in the technician and craft areas have resulted from legislation and reports. Also, education available to any person after leaving school has broadened in that it is no longer dedicated to those in employment: all such education is available in one of about 500 colleges of Further Education. Some of these colleges used to offer degree or equivalent courses but this work has largely been removed or moved to, for example, the polytechnics. It is necessary to see how the further educational pattern has changed in order to obtain

some idea of the varied provision of 'mathematics' used here in the broadest sense.

2.2 Legislation in Education and Training

The 1870 (Forster) Education Act brought central government and local authorities together in the provision of public education (the churches had previously been the main providers of elementary education for children).

The 1902 Education Act required the County and County Borough Councils to provide local education and it also extended the period of compulsory schooling.

The 1918 (Fisher) Act raised the school leaving age to 14.

The 1944 (Butler) Act established the post of Minister of Education to promote education and be concerned with the educational institutions; this Act also required the local authorities to provide education at three levels - primary, secondary and further. The school leaving age was to be raised to 16 (achieved in 1972 via a first stage at 15 years of age in 1947).

The 1964 Industrial Training Act brought into being the Industrial Training Boards: for example the Construction Industry Training Board (CITB), the Paper Industry Training Board (PITB) and the Shipbuilding Industry Training Board (SITB).* There was a levy on industry as well as a government grant to support them and they were to encourage industry to adopt approved and improved training practices as well as to share the cost of these changes between their grant and the employers' compulsory training levy. There would be a measure of centralised control at national level.

The 1973 Employment Act reduced the compulsory training levy of the 1964 Act and a new organisational structure was set up

* One of several no longer in existence

within the context of manpower requirements. Government funds were provided to encourage approved first year 'offthe-job' (eg at a technical college) training and to support measures directed to the young unemployed.

The 1973 Education (Work Experience) Act* enables local authorities to provide work experience for pupils in their last year of compulsory attendance at school.

The 1978 Training for Skills: A Programme of Action Act formulated the rules which supported and made the 1973 Act work.

The 1982 Industrial Training Act to a large extent dismantled the Industrial Training Board structure and replaced it by voluntary training arrangements. Generally these ITBs were only retained where they were supported by their industries and their operating costs were transferred back to the industries concerned. At the time financial provisions made by the 1978 Act were largely removed and there is now massive support for the Youth Training Scheme which would replace all previous MSC training schemes and eventually also replace existing traditional apprenticeship schemes. A minimum requirement was general education in three areas:

- 1 Problem Solving
- 2 Communication

3 Computer Literacy and Information Technology.

The Careers Encyclopedia [10] gives some idea of what may be expected of trainees in that '<u>YTS (banking) entrants will be</u> <u>expected to have a standard of literacy and numeracy close</u> to the four O-level standard'.

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^{*} The 1973 Employment and Training Act resulted in the setting up of the Manpower Services Commission (MSC) [9] to run public employment and training services. It is separate from the government but accountable to the Secretary of State for Employment. It has a chairman and 9 members (each serving for 3 years): three are elected after consultations with the Trades Union Council; three are elected after consultations with the Confederation of British Industry; two are elected by Local Authorities; and the last one is an educational professional.

2.3 Reports on Education and Training

Reports of committees which have been set up with particular terms of reference which are relevant to further education may refer to schools but as these areas often have common interests (for example in the General Certificate of Education) they are not considered out of context. The year of reporting is given after the title of each of the following resumés of the Reports.

Spens Report (1938) - on secondary schools with particular reference to the education of pupils who leave school at 16. Recommendations included an expansion of the technical schools, the introduction of vocational guidance and the appointment of teachers with special responsibility for careers.

Crowther Report (1959) - on the education of boys and girls between the ages of 15 and 18 recommended raising the school leaving age to 16, introducing county colleges (outlined in the Butler Act). It was hoped that the measures would encourage pupils to stay in full-time education until 18.

Henniker-Heaton Report (1964) - made recommendations for the day-release mode of part-time education for young people in employment and under the age of 18.

Haslegrave Report (1969) - dealt with the existing courses and examinations for technicians. Recommendations included the setting up of two new bodies:

> The Technician Education Council; and The Business Education Council,

which have been shortened to TEC and BEC respectively.

The TEC would cater for all levels of technician occupation in industry and elsewhere. The Technician Certificate course would entitle the holder to proceed to a Higher Technician

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Certificate course. The BEC would be concerned with those whose occupations fall, or will fall, within the broad areas of Business and Public Administration: no general change was thought desirable in the certificate and diploma structure of courses in business studies.

The Haslegrave Committee also identified areas of vocational educational need which the two councils could meet jointly and one such area was Computer Studies. The two Councils established in May 1977 the BEC/TEC Computer Studies Committee which was given the responsibility of planning, administering and keeping under review the development of a nationally recognised integrated framework of courses leading to awards in Computer Studies, so as to meet the requirements of employers and professional bodies and the needs of students. A main feature of this development, which had no established base to build from in the educational system, was the issue of a comprehensive set of Course Guidelines [11].

Russell Report (1973) - was a review of non-vocational adult education in England and Wales. Recommendations included the establishment of development councils and regional advisory councils (similar to those for Further Education [12]). Also, all new Further Education and secondary school buildings were to be designed with the needs of adult education in mind.

Holland Report (1977) - looked into ways of helping the young unemployed and recommended that work preparation and work experience schemes be set up.

Waddell Report (1978) - was to enquire into the feasibility of a common 16+ examination which would cater for the previous General Certificate of Education (GCE) Ordinary Level entrants as well as Certificate of Secondary Education (CSE) entrants in one examination. The steering committee was set up in 1976 and recommended that a common system should be designed for the same range of ability as GCE O-level and CSE together. Consortia of approved examining

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bodies have been set up from the existing bodies and there are just five which cover the requirements of the country. One such body is the Northern Examining Association* for which the Joint Matriculation Board (Manchester, England) provides the GCE O-level experience. Twenty percent of the marks for an award will be contributed by a student's 'coursework' which must COMPLEMENT but not SUPPLEMENT the syllabus. The first examinations are scheduled to be held in 1988.

Mathematics in Further Education Report (1982) - was produced by a group of Her Majesty's Inspectors after inspecting a sample (about 10%) of Further Education colleges other than polytechnics. The report concerned itself with mathematics in its own right (eg for GCE qualifications) as well as in association with another discipline. Aspects dealt with included teaching, organisation as a subject within the college, liaison with schools and industry and resources. The report notes that exercises of this kind are usually associated with schools, which to the author implies that it has been somewhat overdue. The covering letter which accompanied the report asked interested parties to request a member of the inspectorate concerned to talk to a group of staff about the report. After many telephone calls the author managed to speak to one of the inspectors who said he was due to visit a local college and would contact the author at the time of The contact was never made but the events the visit. recorded in the next section more than compensated for the inspector's default.

2.3.1 Observations

The Acts <u>legislate</u>, that is they carry more weight than the Reports which merely recommend. It also takes something like ten years for some recommendations to come to fruition: an example is the <u>Waddell Report</u> from which we are just experiencing the <u>new GCSE examinations</u>. It is also significant that the 'unemployed' are singled out for educational

* Serving the region containing the author's college

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consideration as in the Holland Report which saw first the Youth Opportunities Programme and now the Youth Training Scheme. It is important that unemployed young people (an increasing population) who would turn to or be encouraged to turn to Further Education to improve their prospects of obtaining employment, should be given something <u>interesting</u> and <u>different from what they had experienced at school</u> in order to encourage them to maintain their studies.

2.4 A Significant Conference

A conference was arranged by the Mathematical Association [13] called 'Mathematics in Further Education' at the headquarters in Leicester. One of the main purposes was to discuss the Report [14] and to this end the one mathematics specialist Inspector out of the investigating team of five (Mr E Fanthorpe) attended the conference. The event was organised by the Further Education Sub-Committee of the Association's Teaching Committee, and was attended by delegates from all parts of the country. The following is a report of Mr Fanthorpe's main address to the conference:

Eric Fanthorpe, who recently retired, has been instrumental in initiating and producing the HMI Report, in spite of difficulties. He pointed out how limited the HMI resources were in the area of FE mathematics and how limited was the regard in which FE mathematics service had been held over the last 20 years. He described the difficulties he had in getting the report written at all, and paid tribute to the Mathematical Association for the attention that they had drawn to the report. He reminded us of the variations in qualifications of those teaching mathematics in further education and of the variation in time they spent in teaching mathematics as opposed to other subjects. He reminded us that it was unusual for mathematics to be organised on a

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college wide basis, and that Mathematics Departments were extremely rare. He spoke of the way in which the status of the subject was low as a result of this lack of central organisation and how this led to extra difficulties in gaining resources. He described a number of situations in colleges. It seemed that in most cases the progress that was made was as a result of the interest and efforts of particular individuals. The lack of central organisation also led to difficulties in monitoring standards and in liaison with both industry and schools. He touched on the connection between numeracy and mathematics and noted that there was in the population at large little respect for numeracy and perhaps this was due to the separation between these. He concluded by posing two questions:

1 Should mathematics embrace numeracy?

2 How do you get resources?

2.5 Numeracy

As has been seen 'numeracy' is used within the context of mathematics and is sometimes interpreted as a person's ability to understand and use numbers for a task. In Mathematics Counts, the published report of the Cockcroft Committee [15], the term is discussed at some length, but no precise definition is offered. One suggestion (para 35) is 'the ability to cope with the mathematical needs of adult life, as we have described them ... (para 31, 32, 33, 34). The concept was introduced in the Crowther Report (section 2.3) to parallel 'literacy'. In May 1980 the Institute of Mathematics and its Applications organised a national course [16] on 'The Role of Numeracy in Adult Basic Education', which the author attended. Just to what extent numeracy (a small part of all mathematics) concerns workers in the field of education can be seen from the bodies represented at the conference:

this extends from the universities to the armed forces (an arithmetical error could spell disaster). Carman reported to the course participants on the results of a test (not published) for first year business studies students who are required to undertake a course of study in basic numeracy and accounting. In his conclusion he states that:

Some of the students who had difficulty with arithmetic appeared to grasp the (more) complex ideas of numeracy such as logarithms...

which indicates that a numeracy definition can be flexible enough to suit the context of the rest of the mathematics which may be complex though 'number' relevant. The Adult Literacy and Basic Skills Unit - ALBSU [17], received a grant from the Department of Education and Science and the Welsh Education Department to develop within the general education service in England and Wales:

Provision designed to improve the standards of proficiency for adults, whose first or second language is English, in the areas of literacy and numeracy and those related basic communication and coping skills without which people are impeded from applying or being considered for employment.

In addition to its main role ALBSU is able to sponsor a limited number of Special Development Projects which must conform to certain guidelines [18, 1.4], for example:

Projects for sponsorship will need to demonstrate national or regional relevance and be innovatory or experimental...

One of the ALBSU Special Development Projects was devoted to numeracy and broadened from its regional confines to become almost national by virtue of the interest shown in the developments. It is worth noting in the context of research

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and development that the efforts of the participants were not dictated by some syllabus but by the needs of users as they arose out of contacts with people whose needs were largely determined in relationship to employment.

2.6 Basic Mathematics

2.6.1 Introduction

Numeracy problems experienced by users or potential users of mathematics very often occur within a section of mathematics classified as 'basic'. In many Further Education establishments (technical colleges, county colleges, etc) courses are developed by demand which are of a remedial or revision nature and are usually based well within the scope of the first eleven years of the compulsory period of school atten-Similar schemes are often promoted so as to encompass dance. a much wider population through support from various agencies and media. For example in 1976 the Walk-In-Numeracy project started in the London Borough of Hammersmith [19] and continued to develop to serve people of all ages and backgrounds. Eventually a successful application was made for an Urban Aid Grant to fund a 'Numeracy Research Project' in the Borough of Hammersmith. For a change of medium from the classroom with desks, blackboard and teacher consider the potential number of students who can be reached through the national television medium at home (for general as well as specific educational topics). For those with numeracy problems Yorkshire Television started a series of thirty programmes on Channel 4 in January 1983 [20]. Again, but this time as an example of a regional programme which became national, 'Lift-Off' was funded for a limited period by the Adult Literacy and Basic Skills Unit [17] the national body, but developed its own courses and materials freely within the confines of the allocated funds. The twelve Lift-Off newsletters [21] served to make the project materials more widely known to educators in many parts of the country, using the well established printed paper medium. Indications from the

demand for back copies and letters to the editor are that the newsletter and materials are being used to advantage. A course of study devised by college staff can turn out to be a failure because there is a marked tendency for potential students to ask about the course qualifications, particularly in respect of its standing in the world of education and employment. To obtain good credence a qualification must be issued by a body which is nationally known and has a proven record of acceptance and more importantly, is asked for by employers. Acceptable examining bodies are any of the General Certificate of Education Boards some of which operate their examination systems in countries outside Britain or have acted as models for similar systems set up in other countries. An example of one Board which has established an international reputation is the University of London General Certificate of Education Board. However, these Boards are usually associated with schools and not the specific world of adults and employment. As far as a definition is concerned since the Ordinary Level Certificate is considered a basic educational requirement for many purposes in the world of work the mathematics at this level and below is termed BASIC and thus what is a relative term takes on a more specific meaning. Of course, the term is open to any different definition as with most terms and thus it is up to the user to be that much more specific.

2.6.2 Examinations for Adults

The City and Guilds of London Institute (CGLI) is very acceptable as regards credentials [7], being well known for craft examination awards. In 1979 the CGLI piloted an examination based on a published syllabus: Numeracy Level I [22]. The author used this examination in the first instance in his college to provide for low achieving students what would probably be their only professional mathematics examination success, at a low level maybe, yet recognised by potential employers because of the familiarity of the awarding body. The examination attracted some 3000 candidates in the

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first year of being offered and by comparison about 40 000 candidates up to July for 1985 (the examination is offered several times a year). The Level I examination was soon followed by a pilot scheme for an examination at Level II which would be more demanding on the candidates. Appendix 2.1 gives some information on the Level I syllabus and examination and includes the sample set of typical questions which have been used by the author as a diagnostic test for basic mathe-As the questions have all been drawn from the matics. question bank they have been validated, a task difficult to match by the private researcher when considering the resources and large number of institutions (schools as well as colleges) available to the CGLI for support. The test was thus ready for service and so far has been given to more than 500 students which the author regards as a 'population' against which further groups or just individuals can be measured. Starting later than the CGLI scheme, but somewhat similar in syllabus is one from the Associated Examining Board, whose main operations are in the field of General Certificate of Education awards: however in Examinations in Arithmetic [23] AEB departs from formal practice in that the first part the of the examination is given orally, i.e. the examiner recites the questions at thirty second intervals, the candidates perform mental calculations and write down the answer in an appropriate space on the response sheet. These new examinations were used for the first time in December 1982 and are aimed at the 'adult' market but have perhaps one disadvantage in being associated with a body whose existence is primarily for serving schools. The author was impressed by the CGLI and the contacts he had with the administrative and academic staff at the Institute. Both the form of the examination and the assessment scheme appealed to the author as being easy to manage and so it was decided to look at the scheme in more The examination was very suitable for the adult detail. market although it, like many CGLI examination schemes, also operates within schools which help with the validation of new examinations. Section 2.6.3 will consider a test using CGLI Numeracy Level I type questions, which has been adopted by the author and tried with a wide range of students.

2.6.3 A CGLI Numeracy Type Test: Background and Information

This is the set of sample Level I Numeracy questions and will be used in this thesis as a measure of performance in Basic Mathematics so some space is now devoted to providing reasons for adopting this test when it is perhaps more usual to construct questions based on one's own judgement with as much external guidance as possible. The most attractive aspect of the test to the author was the fact that the questions were of the 'multiple choice' or 'objective' kind which means classifying each response by a key letter or number then counting responses of a particular kind: thus a computer could be made to carry out the tedious tallying tasks and by programming in a suitable fashion, produce The background was investigated during a various analyses. series of discussions with CGLI officials. The origin of the Numeracy examination was in Brunel University's investigations into the mathematical abilities of the CGLI's entrants for Engineering courses during the 1960 decade. The results showed that many of the Craft students needed a foundation level course in mathematics as the use of mathematics was implied though not taught as a separate subject this was an 'integrated' approach. Industry was brought into the discussion and eventually a Numeracy examination committee was set up out of which arose the Level I examination. The scope of the examination was widened to benefit adults in the world of work and everyday mathematics requirements. The question writers are usually ex-industrialists or those who work closely with industry. The questions must not be too difficult contextually in that people with different backgrounds have to understand them and also a question must not be too closely related to a particular vocation. The multiple choice technique as used by the CGLI for this examination is described in detail by Plumpton [24] in the preface to his book, the examples being for O-level candidates: both the strengths and weaknesses of this method are considered [24, 3]. The University of London General Certificate of Education Examination Board uses the same method for such

subjects as Biology, Chemistry, Economics, History, Mathematics and Physics and has published a guide [25] which also deals with statistical analyses of the results; the method is also used by the Board in other countries [25, 1]. Thus the method is widely used by established educational bodies but the author still required some professional views on the method and the following is a summary of his discussions with various representatives of bodies using the method:

Technician Education Council: Jenny Hill

The method is not used very much because the questions are difficult to write and pre-test and also it is not easy to ensure that the objectives are clear.

National Foundation for Educational Research: Lynn Joffey

Little use is made of this mode now (10%). The questions do not give information on strategies used and there is the problem of guessing the response. Given working, you can see the errors. Hard questions can be set as some of the options could set the candidate thinking along the right lines.

School Mathematics Project (SMP): Douglas Quadling

The first SMP O-level paper is of the multiple choice kind. Its purpose is to assess the lower level of basic knowledge content of the syllabus, rather than the analytical objectives which require some synthesis of ideas. The method seems to be very effective. Contact Dr William Wynne-Wilson who is strongly associated with assessment.

University of Birmingham: William Wynne-Wilson

The method is useful for testing the use of mathematics without requiring deep knowledge of techniques, e.g. when asked to select the correct solution for an equation the method of solution is not required. Again, a question can require a candidate to select a matrix which is inverse to the given one without having to remember how to find the inverse, by using the multiplication test.

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The conversations were not just confined to this one method of 9 assessing but broadened into other assessment areas such as the difficulties which arise when analysing many candidates' submissions, and responses requested in the form of a decision as to a statement being true or false which teachers apparently do not favour. However at the end of the day there seemed to be enough evidence of acceptance of the objective method for the author to make use of it and in his case it should be noted that:

the validated questions were available and the computer could be used to remove an enormous amount of tedious counting and classifying which would multiply as the population was increased.

The author built up two computer programs to service the analysis of the results from the response sheets: Program 1 to read the responses into a data file along with the student's name and basic mathematics qualifications and Program 2 to read the data out of the file and process it according to the user's menu selection. The two programs were eventually merged and are shown in Appendix 2.2. The analyses and information shown in Tables 1, 2, 3 and 4 (Appendix 2.3) will now be considered in more detail. The responses are entered into the computer as 1, 2, 3 and 4 which correspond to the letters A, B, C and D respectively. The numbers are used instead of letters because they are easier to type in with the numeric key pad of the keyboard, a very common feature of microcomputers. Numerically, if the candidate selects the correct response then the score is 1 and otherwise it is 0. Thus scoring and analysing score total amounts to manipulating integers and this task is ideal for the computer which the author has programmed in several ways. The professional bodies who have to mark large numbers of papers often use an optical reading device which senses a black mark by the candidate when selecting a response. The tables shown to illustrate the processing of the students' mark sheets for the CGLI sample set of thirty objective questions used by the author. These are now described.

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Table 1

The sets of students whose responses have been stored in the computer are briefly described; for example the fourteenth group belonged to the full-time Science Laboratory Assistants course. The sets of responses occupy data records 246 to 253 inclusive.

Table 2

This shows the score and the score as a percentage for each of nine students who belonged to a 'New Opportunities for Women' course. The author wrote a short module 'Introducing Science' for them which lasted for just two periods.

Table 3

This gives the number of correct responses to each question and also expresses this as a percentage, for a population of 504.

Table 4

Here the number of students who chose each alternative response is shown together with the number who did not select any response, for the population of 504.

There is a menu on the computer screen which enables the operator to select any or all of the records for processing as for example if one wanted to analyse the performances of craft students and then say technicians and compare them. This type of examination has its own vocabulary:

Stem:	This is the question
Options:	These are the responses
Key:	This is the correct response
Distractors:	These are the incorrect responses

How well a question has been answered in a trial by a group is judged from the ratio of the number who choose the key to the total number in the group and this statistic is called the 'facility index' or just the 'facility'. The facility is sometimes stated as a decimal [25, 26] and alternatively as a percentage [26, 41]. The author's Table 3 uses the percentage because the students find this easier to understand (they are encouraged to study the results) but the change to the other form takes a few seconds to make within the computer program. Each time an item is used the facility will have to be evaluated. Associated with the facility is the term 'difficulty' which will be high if the frequency is low. Slatterley [27] defines:

difficulty = 1 - facility index

but again it should be noted that the London GCE Board uses the terms facility and difficulty as alternative measures of the same thing. Plumpton [24] gives some useful guidance on the construction of questions and points out that the probability of correctly guessing the key is increased when the options are reduced, to say four from five [24, 4]. Opinions are divided as to the value to choose but most testers seem to go for more than four and yet there is no advantage in going beyond five: also according to Plumpton some reliability is lost when only four options are used. Clarke and Norton [28, vi] state that the effect of guessing can be reduced by increasing the number of options but care must be taken to see that the extra distractors are plausible; also, finding four reasonable distractors is often impossible. Perry [29] uses six options in his book of examples for O-level mathematics tests and the University of London GCE Board [25] provides five per question. At the university level a mathematical attainment test [30] for new undergraduates gives candidates five options for the multiple choice questions. Thus to summarise, the method of multiple choice options is. established but is not by any means universal; opinions are divided on its usefulness in particular circumstances, such as failing to test actual knowledge; and some of the established users are much respected in, and serve a large number of beneficiaries of, education. To the author the

method offers the following advantages:

- (a) the tests can be marked and the results computer-stored at the same time
- (b) once stored as data, the results can be manipulated statistically by using the computer programming facilities, which may require some help
- (c) because the tedious task of sorting responses is taken over by a machine, a population of results can be built up which as it grows can be used to detect areas of weaknesses, etc, and these could be used diagnostically
- (d) educators are freed from the tasks of marking and correlating and so will be more inclined to spend their time discussing the implications of the tests
- (e) the test takes about forty minutes to operate and a person's name, responses, etc, will take between one and two minutes to type into the computer
- (f) the test is a simple way of keeping a check on basic arithmetic standards.

2.7 <u>Mathematics Related to Courses</u>

Knowledge of mathematics of a basic nature is often implied within a course of study even though it is not examined as such or has a syllabus. Craft courses for the Engineering industries which are assessed by the CGLI and Business Studies courses are just two examples of such courses for which students need mathematical knowledge yet mathematics does not feature as a subject of the complete course. If the mathematical ability of a student on one of these courses (a low grade CSE award is usually acceptable) does not match up to the mathematical demands of the course then some remedial provision is arranged or the lecturer simply has to deal with the mathematics at the same time as the application. This

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is not a problem which belongs solely to the low achievers as can be seen by the following criticisms of graduates by N Anderson of Boots Management, Nottingham, voiced at a conference on mathematical abilities and deficiencies of graduates [31]:

- 1 Graduate students on the commercial side sometimes have problems because there are sometimes long periods between their initial learning of the mathematics and their applying it.
- 2 Even at the lowest level some business students do not know how to calculate, or how to use calculators effectively. Further, they do not consider using a check - they rarely KNOW HOW to do one.
- 3 Generally the concept of number for these students is poor...

Graduates or not, lack of competence in the applications of number skills to a variety of situations becomes a Further Education problem when children leave school. The root of the problem is suggested by Brown (neé Seed) [32] as too much emphasis being placed on the practice of routine skills at school. As she points out the evidence indicates that a solution to the problem of lack of understanding is not teaching 'by rote' although the author sees and hears much of this in Further Education establishments. A better strategy with children is suggested as:

... abandon all teaching of routine skills... concentrate instead on building up a network of mathematical relationships (schemas)... through different types of problems in different contexts ... with concrete materials and calculators.

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This approach is well suited to Further Education which indeed has the right mandate - to cater for adults with a wide range of abilities and problems. Some time ago the author sensed that out of the two to three hundred students who enrol for O-level Mathematics each September there were sufficient 'mature' ones to justify a separate class: the class usually includes some potential teachers who have graduated but cannot undertake a course of teacher training until they have an O-level Mathematics pass. They had failed to pass the subject at school and take the course solely to become qualified teachers: their disciplines are generally non-scientific. At a much lower level the CGLI 687 Foundation Course (Science Industries) [33] is intended for '... students who have an interest in the science-based industries...' and in explaining the structure of the course which is set out under six component headings the following statement is made:

The component headings ... indicate areas for assessment. It is anticipated that within the teaching programme these will be integrated.

The fourth component is Communication Studies and includes a section headed Numeracy. Thus there is the distinct possibility that the students will not be treated to a series of 'separate subjects' but an integrated learning package.

Thus here are just three examples of courses at different levels requiring the use of mathematics to be supported by courses or study modules or some such provision, for which the Further Education sector is an obvious provider. One solution to a student's problems with mathematics at the level discussed, where there is no formal tuition, would be to make good use of a self-paced, self-study book such as Apprentice Mathematics [34] or Applied Math [35].

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2.8 <u>A Case Study: Mathematics Related to Industrial</u> <u>Training</u>

2.8.1 Introduction

The Study falls within the Engineering Industry at the craft and technician levels which represent a continuum as far as progress and training are concerned as the craftsman often aspires to the attainment of Technician status by means of further study. The author paid a number of visits to the Cammell Laird Training School which was established by the shipbuilding company of the same name, in order to discuss with the staff what was required in the teaching of mathematics which was undertaken at the local college (Wirral Metropolitan). As the staff were keen to discuss learning problems. mathematics as it related to the training programmes became the purpose of the Case Study, which theme can be seen to have been discussed within the context of the general education of the apprentices. The mathematical abilities required of the students were expected to materialise out of their school qualifications, and be verified by initial tests. It was during one of the author's visits that mathematical attainment tests were being discussed and the author mentioned the computer program he had written to mark and analyse the results of the CGLI type of objective test described in section 2.5.2 but had not yet used. The offer to test and process the results for the group of about fifty apprentices was readily accepted and Group 1 (Appendix 2.3), Table 1, is this set of students, the first of what is now a population of nearly six hundred. If during the course a student's performance was considered to be low then the staff were disappointed as the selection process components were chosen with care and reasons would be sought as to why a student had compromised the selection process. Communication via the written and spoken word were of considerable importance and one of the author's visits coincided with that of the headmaster of a local school who had come to find out just what should be taught in English lessons in order to

better equip the potential apprentice for training and work. Mr Ball the Director of the School asked each of the visitors if they would like to hold a joint discussion with him as he thought that numeracy and communication could not be entirely separated. The author had met Mr Ball on a previous occasion when he was chairman of a discussion group (and representing industry) at a conference 'Mathematics and Industry' at Liverpool University. The two disciplines of 'English' and 'Mathematics' were not such an incongruous mixture as might have appeared to be at first sight because discussions showed that they were related: <u>using mathematics</u> <u>involves writing</u> and Mr Ball carefully pointed out this 'interrelationship' which occurs through, for example, a measurement task and recording its details. So here was a very natural way in which two key subjects became integrated.

2.8.2 Background to Cammell Laird Training School

Management: Mr E Ball, Director Mr H R Cannell, Training Officer Mr A Hodson, Training Supervisor

The School is situated on the banks of the River Mersey at Birkenhead, the district having been strong in the building, servicing and using of ships with particular expertise in the military sphere. It was established in 1970 as a subsidiary of the local shipbuilding company, Cammell Laird (Shipbuilders) Ltd, for the purpose of training apprentices mainly for the shipbuilding and allied trades (eg fitter, electrician, joiner, metal worker), with strong engineering relationships. In 1984 the name of the training centre was changed to British Shipbuilders (Training, Education and Safety) Ltd. The establishment (the 'school') serves some 12 firms basically, as far away as Holyhead (one of the seaports for Ireland), and one of the clients is British Rail. Thus the apprentices are by no means 'local', that is drawn from the Wirral district. There are 300 training places

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available but not all can be maintained by engineering craft training requirements so that some diversification has taken place in the form of management training. More recently the School has become a managing agent for the Youth Training Scheme (YTS). The income for the maintenance of the School is derived solely from the fees charged for training personnel.

2.8.3 Outline of the Training Scheme

This starts with a potential apprentice being employed by a company which is to provide training in one of the following modes:

- A practical training with the firm and academic training at a college of FE ('off-the-job')
- B the School provides everything on behalf of the firm
- C a College of FE provides all the training.

When a college is involved attendance at the college is usually for one full day (including perhaps some evening work) per week of training. The examinations taken are those of the CGLI which are fully external as compared with examinations which are set and marked by the staff with an external moderator available to inspect the results with powers to make firm recommendations. Mathematics is not an examinable component of a CGLI craft course so that if there are problems in this direction there has to be special provision outside the time allocated to academic study. The BTEC study programme, however, has specific units for mathematics.

2.8.4 The Training Modes

This is carried out at the age of 16 by the apprentice first making an application for a place. Minimum school qualifications are at Grade 3 of the Certificate of Secondary Education examination. Basic ability in reading, writing, spoken

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communication and arithmetic are essential: log books have to be kept and reports written. Before the expansion of higher education by the creation of the polytechnics and colleges/institutions of higher education, all offering more degree opportunities, many of the applicants were of the higher education calibre but without degree course prospects because places were limited and went to the best qualified. The applicants are banded as suitable for one of:

craft training technician training, or thick sandwich course training,

and the latter band is difficult to fill because parents push and schools pull potential A-level candidates into the sixth form.

2.8.5 Selection

There is an interview and the applicant is asked: 'Do you read?' to which the response usually reveals that the set books for school examinations are read. The selectors also look for interests in the 'microchip' field. Individual qualifications fall into broad groups:

passes at GCE Ordinary level CSE awards at grades 1 and 2 CSE awards at grades 3 and above.

For an intake of about 70 there would be about 10 in the lowest category. There is always a compromise arrived at by the selectors between academic qualifications and motivation.

The National Foundation of Educational Research (NFER) and Personnel Tests for Industry (PTI) are used. The NFER tests are quickly marked and are completed in about one hour. The selection of tests covers numerical, verbal and mechanical assessments and can be put together to form a profile for easy reference.

2.8.6 Training Course Needs

- 1 Knowing how to calculate in order to be able to use the calculator
- 2 Knowledge of tables (up to 12 times)
- 3 Certain basic mathematical knowledge:
 - (a) linear measurement in metric and imperial units, for example a sheet of plywood is specified as
 8 ft by 4 ft by 1.4 mm thick; dual units are no longer taught at school
 - (b) decimal/integer fraction conversions, both ways
 - (c) approximation
- 4 Before the expansion of higher education opportunities (and corresponding employment opportunities) many of the applicants were A-level material but still only sixteen years old. The CGLI does not allow craft apprenticeships to be started by anyone older than sixteen years: if not for this regulation it would be possible to accept as apprentices those who had completed an A-level course but due to poor results had not been successful in achieving a university place. Such a person although eighteen years of age would be a more developed student because of the A-level course
- 5 Students who have the motivation to be educated
- 6 Experience of Technical Drawing as a subject
- 7 Art, as a good foundation subject for joiners

8 Physics as a good preparatory subject for the electrician

9 The ability to produce a rough estimate for a calculation

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2.8.7 Management Comments: School Education

- 1 Deficiencies at the 11+ level in Mathematics and English seem to continue to the end of the school period
- 2 Social class differences are noticeable in students; we do not get the best out of our school-leavers regardless of class and financial support available from the home
- 3 <u>Some preparation for apprenticeships would be helpful in</u> <u>schools</u>. Bond [3] had described experiments carried out jointly with local industry in this direction, with great success
- 4 Why not study mathematics in General Studies, say in relation to the log book?
- 5 <u>Using calculators takes away the understanding of the</u> <u>mathematical processes</u>. Author: algebraic and language need to be understood
- 6 This is not uncommon, and comes from school: $5 \times 7 = 7+7+7+7+7$, with the separate addition being written down
- 7 An employer does not see GCE or CSE examination papers or knows much about the examinations: education meetings produce figures and graphs for the audiences but there is never the opportunity to discuss what the employer really wants from the examination
- 8 Parents, pupils and schools tend to look down on Engineering so there is the problem of getting a good recruit. Quite often we are left with the lower end of the school leaving population to select from. Teachers pull and parents push pupils into the sixth form rather than encourage them to enter an Engineering career along a 'practical' route.

2.8.8 General Observations by the School Staff

- 1 The general standard of education today is better than in past years
- 2 Education is broader than it used to be
- 3 Today's pupil is not as good at the 3 R's as the pupil of the past
- 4 There should be much more free movement for students between craft and technician courses
- 5 Engineering Science and General Science are not the same as Physics although some teachers seem to think so

The above opinions, facts and observations have all been from staff of the School, at all levels.

2.8.9 Author's Observations

- 1 Since this was written the School has become involved with the Youth Training Scheme as a managing agent and this does imply a broader base of training, with the staff able to take a greater part in the selection of course material etc. The author has contributed in a small way to this in that he was consulted by one of the staff when setting up an Information Technology unit; recommendations from this research project were made.
- 2 From visits to the School, discussions with the staff and students and observations of the practical training, it is quite obvious that <u>Mathematics, English, Science</u> and Technology were being used because of the demands of <u>some particular practical task</u> ('the job') from which one can conclude that the job serves to interrelate all these topics
- 3 During this investigation the author listened to some strong criticism of the GCE Boards by the management for

not relating the syllabus to the needs of industry. This point was taken up with the Joint Matriculation Board who verified that there were subject committees with places for representatives from both sides of industry but the attendance of some of these members was not very regular

4 From the fact that apprentices had weaknesses in basic mathematics and at the beginning of training mathematics at this level is very important, the author saw a connection between the initial testing carried out at the School and his test based on the CGLI Numeracy examination [section 2.6.3]: the two were related by level. The author approached the management who agreed to arrange for their fifty-three craftsmen to take the test and undertook the organisation of this. These students provided the start of the author's 'population' of test results. It is worth pointing out that a population has to come into being so this was a good start. The total now is closer to six hundred.

2.9 Mathematics Courses for Careers

2.9.1 Technician Course Mathematics

As has been explained, two bodies - the Technician Education Council and the Business Education Council (TEC and BEC respectively) - were brought into being to develop and operate a unified system of technician education in England and Wales (Scotland has its own similar bodies). The system would subsume all the Technician Certificates of the CGLI, leaving this body to offer courses for and make the appropriate awards for training at the craft level. In a document [36] issued by the TEC the role of industry is described thus: In order to meet the personal and vocational needs of technician students, the activities of technicians in industry and the knowledge and related skills they require must be identified. To do this successfully both TEC and the colleges have to work closely with industry: in effect the system depends on cooperation between the three interests.

The bodies award Certificates and Diplomas and Higher Certificates and Higher Diplomas, the latter two requiring further study. A qualification is obtained by successfully completing a programme of Study Units, each corresponding to a subject or area of study and a level of study. There are levels one, two and three for programme units leading to the Certificate and Diploma. A committee, representative of Further Education and Industry, initially decides the syllabus for a unit which is then written objectively in terms of general objectives and specific objectives. Extracts from Mathematics Units (Appendix 2.4) illustrate the style of unit. A complete set of Programme Units would give the а impression of a set of separate subject courses with little being done to encourage the exploration of the relationships The method of teaching is usually directed between them. towards the completion of the unit syllabus and providing that the student is good at 'mathematical mechanics' success should come eventually since there is no limit to the number of times that re-testing can be carried out. When one reflects on the system in terms of new teaching methods and course organisation the Inspectors' Report [14] makes the following observations on what they saw across forty eight colleges:

Only in a few cases was there any attempt to relate mathematics to any other subject of the curriculum or to the main discipline of the course. Indeed it seemed doubtful in many programmes whether the mathematics units were in any way determined by the technician employment of the young people. A further change in the organisation of technician education has not improved the above situation. As from 1 April 1984 BEC and TEC merged to become the Business and Technician Education Council, with a new single News Bulletin: each organisation had previously published its own quarterly 'Bulletin' giving organisational changes, news about students' successes and staff. Thus BEC/TEC or BTEC (hereafter BTEC) is launched.

2.9.2 General Certificate of Education Courses

These are usually associated with schools but as many people leave school without the required successes in certain subjects there is usually some part-time as well as full-time course provision across a range of subjects and at both the Ordinary and Advanced levels. With people having to re-train for new jobs and secure professional qualifications, O-level Mathematics and English are usually in heavy demand as a pass in one or both is often the pre-requisite for entry to professional courses. Thus Further Education makes a useful contribution to education and training by making this provision. There are signs that the General Certificate of Secondary Education (GCSE) replacement for the O-level and the CSE examinations, thus giving them a unifying effect, will provide the first examinations in 1988. A syllabus under the scheme is:

Mathematics (for Mature Students)

which means that the needs of Further Education have been recognised within what has always been primarily a school provision. This is one of several syllabuses which are qualified by '(for Mature Students)'.

2.9.3 Other Courses

The Royal Society of Arts Examining Board [37] provides examinations for Business Studies courses such as typewriting as well as theoretical subjects. Examinations are offered

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at three stages under the title of Arithmetic. These three examinations span a considerable range of achievement in spite of the 'elementary' nature which the title conveys: from below Ordinary level to above this level.

2.10 Some Conclusions and Questions

- 1 The needs of employment have dictated changing patterns in the education system
- 2 There is a sense of attempted 'integration' which is a move away from the rigid subject barriers in schools
- 3 It is considered a good thing for Industry to be involved in Further Education planning
- 4 There is a need for some provision for the recall of mathematics in adult life during employment
- 5 <u>Numeracy problems affect people at all parts of the</u> <u>educational spectrum and command considerable educational</u> resources
- 6 Just how useful is most of the mathematics studied for work-related qualifications?
- 7 What mathematics is practised in Industry day by day?

In the following chapter a sample of the mathematics used in employment will be considered in order to see how it related to what is actually provided by the Further Education section of the natural educational provision. Will the mathematics be used in isolation or will it be associated with other subjects as has been suggested in the case study of this chapter?

CHAPTER 3

MATHEMATICS IN EMPLOYMENT

3.1 Introduction

This chapter is directed to item 7 of section 2.10 which ideally asked for a statement on the mathematics used in employment (work). <u>The information is not that easy to</u> <u>discover because this would mean a firm disclosing what it</u> <u>uses the mathematics for</u>. Without some guidance from industry on what and possibly how to teach, the effectiveness of the educator will be much reduced. Thus some sort of close <u>cooperation between education and industry is necessary</u> so that each side will see the need to work with the other. This cooperation has been encouraged by the work of the Department of Industry's Industry/Education Unit [38] which exists to:

- (i) improve attitudes towards manufacturing industry among young people; and
- (ii) encourage more young people to develop an interest in manufacturing careers.

In a Review of Initiatives 1977-1980 [39] there are examples of liaison in the fields of communication, engineering, science and mathematics. One example for mathematics is the case of the Dacorum Mathematics in School and Industry Working Group [40] which for three years had been working with the aim of promoting a better understanding among young people of the importance of mathematics. Classroom material was produced to demonstrate the ways in which mathematics is used in industry and commerce. 'Mathematical Links Between Education and Industry' [41] resulted from a study initiated by the Schools and Industry Committee of the Mathematical Association [13], which produced a list of projects involving liaison between education and industry. There are altogether more than 100 projects quoted and they are such that for 'education' one could read 'schools'.

3.2 Views on Industry's Mathematical Requirements

Kershaw [42], writing in the Chartered Mechanical Engineer asserted that even if one never uses one's early mathematics in subsequent practice, the mental exercise in acquiring proficiency and applying the knowledge to various problems is invaluable as it teaches one to think and we should get better designs if deeper thought were given to many jobs. O'Beirne, an industrial mathematician, [43] noted that we are in an increasingly technological age and that '... the country must exploit its intellectual and educational potential to the maximum...'. The dominant objective of school mathematics education should be to make as much insight into mathematics as possible rub off onto who will depend on their schooling for all the formal mathematical instruction they will ever have ... and this mathematics must have drastic changes if we are to benefit sufficiently from a greater appreciation of quite simple and fundamental mathematical ideas, all the way from science and engineering through other professions like medicine, law, management and public administration. Reporting on his investigations into the extent to which electrical engineers made use of advanced mathematics, Scott [44] found that the use of mathematics beyond A-level was mainly confined to those working in research and development and design, manufacture, administration, installation/operation and sales accounted for very much less use. From within the Oil Industry, Coaker [45], writing about links with industry, noted that firms differ markedly in their mathematical requirements and

that schools need to know a lot more today about the needs of local industries: and surely that interesting topics can be found for every student. About pure mathematicians he makes the point that to them mathematics may exist in a box of its own but to the rest of us it should live alongside other subjects, not in isolation. Writing on the contribution of the London Borough of Hillingdon to cooperation between employers and educationists, Collins [46] puts forward the view that employers should be equipped with banks of 'modern mathematics' questions as part of their selection procedures because this is the way that the school syllabus has developed, and he quotes the case of a question which simply consists of the multiplication of two matrices. Collins did not question the value to industry of his pupils' ability in the field of matrix multiplication and only wanted to make sure that industry was aware of what was being taught in schools: so perhaps industry should then find some way to make use of acquired matrix algebra skills!

In contrast to this last approach to cooperation between schools and industry, Ezard [47] reported in the Guardian on an unusual and ambitious plan for schools and factories to get together and agree what basic mathematics skills need to be taught in Essex County Council schools. Under the scheme the two sides would decide a local 'common core' of mathematics skills and would devise tests for fifth-formers, and the results would then be given to prospective employers. A pilot test in basic numeracy [48] makes an interesting report because this test (devised and arranged by the Institute of Mathematics and its Applications with teachers), stemmed from a statement of the Council of the Institute:

Everyday life, the requirements of citizenship and the average job need certain basic skills in arithmetic, geometry and statistics and schools should equip the great majority of pupils with these skills.

On the one hand the Council has recognised that jobs need mathematics yet, on the other hand it seems quite satisfied

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with a test devised without the cooperation of those who Some statistics were presented and the need for employ. further comment and interpretation was noted. The test was Dawes and St J Jesson [49] investigated a possible printed. basis for specifying the mathematical requirements of the 16 year old entering employment. After a short review of some earlier investigations and opinions they took the data obtained by Knox [50] from 113 firms in South Yorkshire and extended her analysis by the application of statistical The researchers were looking for consistent techniques. specifications by different employers for the same job and also for an agreed profile by concensus, for a particular job. It was concluded that the employers could not be consistent in respect of specifying the mathematics required for a particular job and also that a consistent picture failed to emerge. A research project 'Mathematics in Employment 16-18' carried out at the University of Bath drew attention to the diversity of types of employment and the variety of the mathematical demands within each: so one can only define in general terms the types and level of mathematics by certain broad categories of employees [51].

A very practical and factual investigation of working mathematics is presented by the television broadcasting service of the British Broadcasting Corporation (BBC) series 'Mathematics' [52] of which 'Mathematics at Work' [53] shows a range of mathematical techniques and concepts being applied by young people at work, who also give their views on certain aspects of work and mathematics.

3.3 <u>A Survey: Mathematics at Work</u>

3.3.1 Introduction

During a college residential seminar [54] a topic for discussion was the provision of teaching aids. The value of prepared notes was raised as this is the most convenient and common form of teaching aid. The ensuing discussions showed that the seminar members who represented all college departments were somewhat divided on whether the students preferred to receive constructed notes or to write their own. It was obvious that the only way to determine the students' views was to ask them. The author offered to carry out a questionnaire survey which would also include the use of mathematics and computers at work. The analysis of the questionnaire would provide a valuable contribution to the author's research and the collection of data would be supported by official backing from the college through the Academic Board: this exercise would be more rewarding than the one carried out by the author on his own. The students come to the college from a wide and varied background of employment which spans light as well as heavy engineering and the use of practical skills as well as administrative The construction and distribution of the questionnaire skills. (Appendix 3.1) was left to the author as was the collection and analysis of the returned papers. It should be noted that the questionnaire shown in Appendix 3.1 is attached to an introductory letter for the class lecturer. The questionnaire for the student did not of course include this letter.

3.3.2 A Guide to the Questionnaire

All but two of the seven items to which the student was asked to respond are questions and three of the seven items refer to prepared notes. The items phrased in question form require the student to insert one character in a square. Descriptive responses are confined to two items as there is always the danger that if a lot of writing is required the responder will tire of the exercise or that the quality of the responses all round will suffer.

In a survey carried out on behalf of the Technician Education Council by Yorke [55] he issued a questionnaire to the staff of colleges which consisted of thirty-four items, some of

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which solicited lengthy responses. The author assisted with this and experienced some reluctance of staff to complete the questionnaire because of its length.

There now follows some short notes on the questionnaire items.

Item 1

Some subjects such as chemistry require few, if any, complex diagrams but in contrast motor vehicle technology makes use of complex diagrams and statistics of lengthy tables.

Item 2

This broadens the responses to 1(a) and would help to determine how copying facilities should be distributed throughout the college.

Item 3

Some staff think that lecture summaries should be made available to students who have been absent; others said that this will encourage absenteeism. Attendance cannot be made compulsory and a consistently low class attendance can result in the course being terminated.

Item 4

This will hopefully supply research data and was behind the author's offer to carry out this survey. The students were encouraged to write as fully as possible on this item and if necessary continue on the reverse side of the paper. The words in brackets are a reminder that mathematics is not just algebra or formulae but to practitioners, mainly something very basic.

Item 5

The computer, if it exists, could be located anywhere.

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Item 6

The association could have nothing to do with the student using a computer. For example, measurement data could be passed on to be analysed by a computer. Responses to this could include the control of repetitive mechanical processes, stock control or as an aid to the design of manufactured articles.

Item 7

It is expected that a student would be influenced by the presence of a computer at work, even though not a personal user. Learning about the computer at college could lead to a job in this direction instead of perhaps 'redundancy' when a traditional skill is no longer required by the firm.

3.3.3 Distribution and Completion of the Questionnaires

Selected College Population

By the nature of their courses some of the departments had few students who were working: for example the General Education Department had mainly full-time GCE O- and A-level students. Such departments were eliminated from the survey. Table 1 shows that just three subject areas were involved in the survey and these would capture the bulk of the technologybased jobs. The uneven distribution of the 541 returned questionnaires between the subject areas should be noted as this weakens the validity of any attempted statistical analyses which compare subject areas. The only way to achieve a better balance between numbers would be to include other colleges: the major difficulty here was seen as that of obtaining the cooperation of specific members of staff of other colleges.

Subject Area	No. of courses	No. of Questionnaires returned
Mechanical Engineering	22	243
Electrical Engineering	14	175
Building	6	92
Science	2	31
Total	44	541

Table 1

Attitudes of Staff and Students

The author took the questionnaires into the appropriate classrooms and explained the nature of the project and what was required of the student. Most lecturers agreed to distribute the questionnaires and many took the time and trouble to see that the students completed the sections satisfactorily. A few members of staff refused to have anything to do with the questionnaire on the grounds that it would consume valuable lecture time but the author's response to this was that the results would enable the college to improve its service to the students. Most of the attendance patterns of the students were on the basis of one day per week or just one evening per week and if a student was absent on the particular day one had to wait for a week before a second contact could be made. The completed questionnaire was collected the following week and, of course, a number of students defaulted on this. Some students wrote very little and by comparison others quite a lot, continuing on the reverse side of the paper. Transcriptions from tape recorded interviews would have been the ideal way to obtain the maximum information from the students but this would have needed a considerable extension of time and the assistance of the lecturers.

Table 2

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<u>No</u>	Course	Questionnaires	Course Description
1	BP2D	15	Year 2 or 2-year Plumbing Craft Certificate course. NWRAC/ULCI exam
2	BCJAD	11	Carpentry and Joinery Advanced Craft Certificate – 1 year course
3	BCJ2D	12	Year 2 of 2-year Carpentry and Joinery Craft Certificate course
4	BTCS2	21	Level 2 TEC Certificate programmes in Civil Engineering Studies
5	BHTBS1	20	Level 4 TEC Higher Certificate programme in Building Studies
6	BHTBS2	13	Level 5 TEC Higher Certificate programme in Building Studies
7	EI2AD	14	Year 2 of 2-year C&G Electrical Installation Part 1 course
8	EI3D	5	1-year course for C&G Electrical Installation Work Part 2 exam
9	EI4D	16	2-year course for the Electrical Installation Work Course 'C' Cert with EI5D below
10	EI5D	4	see 9
11	ECS1	21 .	Year 1 of Craft Studies in Electrical and Electronic Engi- neering Part 1 - see 12
12	ECS3D	17	Year 3 of Craft Studies in Electrical and Electronic Engineering – Part 3, C&G Cert.
13	EICT1	11	1-year block release course for the C&G Part 1 Electrical Installation exam
14	EICT2	13	1-year block release course for the C&G Part 2 Electrical Installation Certificate

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15	ET1AD	8	Level 1 TEC Electrical Engineering Cert.
16	ET1BD	12	Duplicate of 15
17	ET2D	13	Level 2 TEC Electrical Engi- neering Cert.
18	ET3D	14	Level 3 TEC Electrical Engi- neering Cert.
19	EHT 1	10	Level 4 TEC Electrical and Electronic Engineering Higher Cert.
20	ETC4	17	Part 2 of C&G Telecommunications Technician's Cert. (later TEC)
21	MD41'2	14	Year 1 Marine Engineering Diploma course (F/T)
22	MD4'2J	18	Year 2 for 21
23	M31D	21	Endorsements for the Marine Engineering OND: to be replaced by a Higher TEC qualification
24	MCF1	14	Craft-Basic Engineering (Fabrication)
25	MVT3D	14	Year 1 of C&G 390 Motor Vehicle Technician Part 2 course
26	MVT4	8	Year 2 for 25- a 2-year course
27	MTMV2	9	Level 2 - TEC Motor Vehicle Technician's Cert.
28	MCM2'1	8	Year 1 - Craft Engineering
29	MCM2'2	14	Year 2 for 28
30	MCW3	5	1-year Welding Craft course beyond C&G 215
31	MCFS1	13	Year 1 - Craft Basic Ship- building Engineering
32	MCS2	8	Year 2 for 31
33	MTS2	8	Level 2 TEC Shipbuilding Cert.
34	MTS5	4	Level 5 TEC Shipbuilding Higher Cert.

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35	MTM1	16	Level 1 TEC Mechanical & Production Engineering Cert.
36	MTM2	15	Level 2 for 35
37	MTM3	23	Level 3 for 36
38	MTF1	2	Level 1 TEC Fabrication & Welding course
39	MTF2	9	Level 2 for 38
40	MTF3	11	Level 3 for 39
41	MTF4	5	Level 4 for 40
42	MTF5	4	Level 5 for 41
43	ST3A	22	Level 3 TEC Science Technician Cert.
44	STHC1	9	Level 4 TEC Science Technician

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Classification of the Returned Questionnaires

Table 2 shows how the questionnaires have been grouped by courses. The columns have the following meanings:

column 1	just a	reference number
column 2	the cou eg B fo	rse classification code or Building
column 3	the num	nber of questionnaires returne
column 4	a short	t description of the course

Table 3 shows how the questionnaires were grouped for processing. For example, the first group consists of all questionnaires and is identified by the letter A. The numbers in the first column are those in the first column of Table 2.

Group.of questionnaires processed	Reference letter	Remarks
1 to 44	A	A11
21 to 42	В	Mechanical
7 to 20	С	Electrical
1 to 6	D	Building
43 to 44	E	Science
1 to 3, 11, 12, 24, 28 to 31	F	All craft
4 to 6, 15 to 19, 27, 33 to 42	G	All technician

Table 3

3.3.4 Processing the Responses

Tables 4, 5 and 6 represent the results of processing the responses to items 4, 6 and 7 respectively of the questionnaire. This does not include the descriptive part of item 4 of course. The actual processing of the responses is a matter of sorting

Group	Job requires some maths		No maths 1	Total	
	Number	%	Number	%	
А	463	86	78	14	541
В	202	83	41	17	243
c ·	156	89	19	11	175
D	74	80	18	20	92
Е	31	100	0	0	31
F	109	79	29	21	138
G	182	84	35	16	217
1				1	

Table 4

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Table 5

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Group	Have a computer at work		No compute work	Total	
	Number	%	Number	% -	
A	259	48	282	52	541
В	118	49	125	51	243
с	88	50	87	50	175
D	26	28	66	72	92
Е	27	87	4	13	31
F	50	36	88	64	138
G	180	83	37	17	217

Group	College computer experience would be useful		College c experienc be useful	Total	
	Number	0/ /0	Number	%	
А	413	76	128	24	541
В	178	73	65	27	243
с		82	31	18	175
D	64	70	28	30	92
Е	27	87	4	13	31
F	98	71	40	29	138
G	180	83	37	17	217

Table 6

and counting and recording the gross counts for the various categories. This represents an enormous task for the human being when the data runs into hundreds and accuracy becomes threatened by fatigue and external disturbances such as a telephone ringing. The best way is to use a machine and such a one exists in the form of a computer. Once the sorting job is taken care of the user of the system is then free to decide what to process and how to process the data. The machine must be suitably instructed or 'programmed' and the author developed a program to print out the results of the processing of the data. The responses were coded as digits as these could be easily identified by the computer and so the processing was assured. Several checks were performed periodically as without these the value of the program would be in doubt. No attempt was made to encode the written responses to item 4 because there were insufficient responses in any of the categories to be able to make reasonable numbers. The author wrote a computer program to

process the encoded questionnaire responses and Appendix 3.2 is a sample of the printed output.

3.3.5 Interpretation of the Tables

Table 4

Most of the responders realised that they use some mathematics at work, as seen from Group A. Scientists (mainly chemists, but not all users of chemistry) cannot get along without mathematics. Apart from Group E the other groups are remarkably consistent in their use of mathematics.

Table 5

About half have a computer at work and those in Science and all the Technicians (group G) are outstanding from the other groups in respect of this. Two groups would be expected to make the maximum use of technology and craft workers to use computers minimally. Thus Building (which includes a small number of Civil Engineering and Architecture students) has the least use for the computer. As the use of modern technology expands due to reduced costs of equipment the use is expected to widen as happened with the pocket calculator.

Table 6

All groups are consistently high in their assessment of the advantages of college computer experience - the figure is 76% - even though only 46% have a computer at work. This could indicate that the students are aware of current trends in industry. When viewing the consistency of the overall responses of the groups it should be noted that there is a wide range of academic levels of achievements of the students between groups, which levels range from that of the craft to that of the higher certificate level.

Table 7

This table summarises information extracted from item number 4 on the questionnaire for each of the groups except the Marine Engineers who came to the college straight from school and so had not worked. The table is presented in three sections, each corresponding to one of the three departments (see Table 1). Each section is then further divided according to the courses in Table 2. This table then was the prime reason for the author offering to organise the questionnaire. Many of the items on the questionnaires for this table were common to the experiences of many students and have been recorded just once. The analysis of this information will concentrate mainly on common broad features such as the use of basic mathematics and will be dealt with in section 3.3.6. (See Table 7 at the end of this chapter, pp 66-74.)

3.3.6 Observations on the Responses to Item 4

This item was the cause of the author's interest in the questionnaire survey and why he offered to undertake it. The responses were varied and did not justify codifying so that they could be classified and analysed by using tables of categories. The impression was that a wide range of uses and job functions was captured in the survey and although this could be criticised because it makes coherent analysis difficult, the advantage of a broad overview of mathematics at work results. Many of the following points arise from impressions gained by reading through the responses many times and also after asking lecturers for some clarification of the terminologies used by the students.

- 1 There is frequent reference to 'calculations' which implies that the mathematics was to a great extent numerical and that a formula was often involved. The phrase 'evaluation of a formula' also occurred and again it can be assumed that calculating is taken as synonymous with formula evaluation for some people.
- 2 Measuring in its many forms seemed to be quite a common task and on reflection calculations are usually carried out before certain measures can be estimated, eg in the case of area. Reading an instrument or a drawing is also measuring.

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- -62-
- 3 When reference is made to measuring or measurement this is usually within the context of a task which could be to make something or supply materials to a given specification.

Examples are:

stress calculations implying structures sheet metal measurement for tanks costing a project, eg a building, and sizing a cutting tool for manufacturing.

4 The reference to 'lengths of welded joints' (second item under MT35, Table 7) is worthy of further consideration. The length of the joint is one of the contributing factors to the final cost of the welded joint. As an example, consider two hollow steel tubes which are to be welded at an angle: the British Steel Corporation supplies the diagram [56] which illustrates how the calculation of the joint length is made. The formula is given (the joint is usually non-planar) and also a table of lengths for which certain parameters are required. There are two important points to be noted in respect of the evaluation of the formula: first, the tube cross-section parameter is the diameter, not the radius as is taught in schools; second π has not been taken as 22/7 which is a value so deeply entrenched in schools that it is often believed to be the prime value. The reality of the diameter as a circle measure is driven home when mensuration formulae have to be related to cylinders, tubes, tanks, etc, in industry. Here then is a case for 'education' to learn from industry what is required at work. The formula gives the approximate length of the perimeter of the ellipse there being no formula from which to compute the exact value: this is a difference between real applications of mathematics and the exercises of school mathematics, certainly in those up to GCE O-level where each problem has an answer. The author uses this example with engineering students who have to compute

the length of the weld in order to estimate how much it would cost to make. They cannot accept the fact that there is no formula as there is for the circumference of a circle.

- 5 Algebra can be read into most of the calculations although it is in the main the manipulative algebra associated with school leaving examinations.
- 6 Imperial and metric units are required and their relationships for conversions and dual units can be seen on many commodity labels in shops and industrial supply warehouses. The oil industry still uses imperial measure for its pipes as this is an agreed international standard and any changes would have to involve many countries.
- 7 In the Mechanical Engineering section there is quite a wide range of mathematical techniques involved with circle mathematics being quite common. A change of job in this field would probably mean some change in the mathematics involved and lead to the need to recall school or post-school course work.
- 8 Although the logarithm is no longer required to assist in performing calculations because of the availability of the electronic pocket calculator, this survey reminds one that the logarithmic function is still current and important in, for example, science and electronic engineering.
- 9 Ratio and percentage are fairly common, particularly in the science field.
- 10 Statistical calculations seem to be confined to science yet it is unusual to find a mathematics syllabus without the topic: for example most GCE O-level syllabuses have Statistics as an integral or optional topic and BTEC Mathematics syllabuses also feature Statistics. This

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must prompt the question 'where does one find relevant examples when teaching the subject to engineers?'

11 In a most comprehensive investigation through a case study into numeracy and its relationship to the needs of industry, Dickson [57] not only looked at a group of craft apprentices at work but also investigated their school experiences. One of her calculations was that some of the mathematics teachers displayed ignorance of the practical applications of their subject within industry. Some feedback to schools of a survey similar to this one might help to make teachers better informed so that the service to pupils could make a more relevant contribution to life after school.

3.4 Some Conclusions of a General Nature

- 1 Mathematics is used to quantify something with a physical meaning.
- 2 Measurement and mathematics are closely related at work with the mathematics being invoked by the need for measurement.
- 3 Sometimes the measurement is 'direct'; that is it is carried out by reading an instrument and the only mathematics involved is that related to approximation (this is seen later in Chapter 4).
- 4 Basic Mathematics and Arithmetic are a fair description of much of the mathematics encountered across the fields surveyed.
- 5 Deductive and analytical mathematics such as is found in the BTEC level two and three units does not seem to be used.

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- 6 Sometimes the computer can deal with computational mathematics more efficiently than the human being and it is seen to be useful in the industrial environment: the students usually trust the computer. There is also much popular support for the computer by the media and the many college courses of the 'appreciation' type which are offered. The efforts in schools to provide 'computer education' is supported by the government which funds half the cost of the first computer must also mean that industry recruits school-leavers with some experience.
- 7 Technology is ever present in measurement whether it is mechanical technology as in the use of instruments or electronic technology as in the use of digital electronic balances.
- 8 A simple overall deduction would be that mathematics does not exist in isolation at work for its own sake but is related directly or indirectly to a final product thus <u>integrating mathematics and technology</u>. That <u>mathematics and measurement are related seems to be</u> <u>indicated by many of the responses in Table 7</u>. This strengthens the suggestion in this direction which came out of the case study of Chapter 2.

Table 7

Mathematics at Work

Building

BP2D

Calculating heat losses with formulae Working out wages bonus Ordering pipes and other materials

BCJAD

Estimating, calculating Simple measuring Checking calculations plus small design work Reading drawings and calculating from them Building calculations; costing Working out wages bonus

BCJ2D

Cutting wood to size Estimating job costs

BTCS2

Stress calculations.

Measurements and costing analysis.

Some calculations.

Determination of stresses, strains and negative buoyancy. Counting, calculation of areas and volumes.

Calculations for bricklaying and plastering and schedules. Basic arithmetic calculations.

BHTBS1

Trigonometry and the use of the theodolite.

Structural calculations for plumbing runs.

Measuring, counting, estimates, office work and accounts. Beam and structural calculations.

Heat loss, structural and drainage calculations.

Calculation of bending moments and loads for structures. Mainly arithmetic.

BHTBS2

Costing jobs.

Trigonometry and related calculations.

Structural calculations.

General and trigonometric calculations.

Calculation of areas, volumes and final accounts.

Electrical and Electronic Engineering

EI2AD

Calculation of voltage drop, fusing factors and ambient temperature fuse ratings.

Transformer primary and secondary calculations.

Electrical properties of wire, Ohm's Law and power calculations.

Circuit loads, power and cable size calculations. Application of Standard Regulations.

EI3D

Measuring sizes of cables.

Fuse rating calculations.

EI4D

Measurements, current ratings, calculation of current loa Reading of meters, verniers and micrometers.

Basic maths.

Measuring.

EI5D

Calculations.

ECS1

Reading micrometers.

Evaluation of formulae.

Electrical calculations.

ECS3D

Simple calculations.

Sheet metal calculations, e.g. area of a circle.

Sizes of wire and insulating material.

Transformer ratios and magnetisation curves.

Resistor, inductor and power calculations.

<u>ET 3D</u>

Costing of equipment.

Calibration.

Electrical calculations and measurements.

Imperial to metric conversions.

Earth loop impedance calculations.

<u>EHT1</u>

Time constants in electronic circuits.

Calculation of circuit component values.

Cable sizes, space needed.

Quote :"---name a job where maths never appears at all." Calculations for timing devices : hexadecimal calculations. Circuit maintenance and development.

ETC4

Frequency and radio calculations.

Formulae for specifications.

Component ratings.

Calculation of circuit parameters.

Time sheets for jobs.

Simple Ohm's Law calculations.

Mechanical Engineering

MD41'2, MD4'2J and M31D are full-time Marine Engineering apprentice cadets without job experience and are not therefore included in this analysis .

EICTL

Circuit values, cable sizes.

Volume, cable lengths and sizes.

Simple maths.

Calculating the amount of cable needed under Regulation Ohm's Law and resistivity calculations.

EICT2

Cable calculations.

Power and resistance.

Power factor, cable sizes and current ratings.

ETLAD

Circuit design calculations.

Pricing for projects.

Ohm's Law.

ETIBD

Power and current calculations.

Lathe and milling machine speeds - checking.

ET 2D

Analysis of laboratory results with statistics.

Cable sizes and ratings.

Current loads, conduit calculations.

Formulae.

Accounts, tariff comparisons, % error on meters. Measuring dimensions and voltages.

MCFL

General maths.

Sizes and circle diameters.

Circle and trigonometric calculations.

Pipe calculations.

MVT3D

Conversion of measures; angles for steering.

Pints to litres.

Wages, bonus and overtime.

Experiments with car engines.

MVT4

Engine codes.

Gear ratios.

MTMV2

Measurements, adjustments.

Tolerances, timing and injection points.

MCM211

Dimensions on engineering drawings.

Calculating cutting speeds and feeds.

Converting sizes and measuring.

MTM2 '2

Cutting speeds.

Calculation for removal of metal in conjunction with compression ratio alterations.

Reading the vernier and micrometer.

Work out angles and feeds for lathes.

Working out hole positions.

MCW3

Pipe fabrication and formulae.

Ratio, area, logarithms and trigonometry.

MCFSL

Plating calculations e.g. for cylinder work. Formulae.

MCS2

Circle area, Pythagoras.

Geometry.

Marking off plates ; developing lengths etc.

MTS2

Ship design.

Plan dimensions.

Boat displacements, calculations.

Arithmetic on measurements : scaling.

MTS5

Weights, plate sizes for ordering.

Lengths of welded joints.

Making of steel fabrications.

MTM1.

Calculating lengths in imperial dimensions. Calculations for lathes and micrometers. Cutting speeds, threads, tapers and angles. Sizes for marking out jobs. Gear ratios, feed speeds.

MTM2

Using sine bars as in MTM1. Calculations.

MTM3

Algebra, trigonometry and conversions. Sizes, tolerances, angles.

Costing.

Calculating weights, journey distances, periods of rest,

expenses and delivery times.

Reading verniers and micrometers.

Calculations on drawings.

Sizes of cutting tools, angles.

Boiler calculations for water treatment.

For re-grinding of a lathe tool.

Technical calculations - pressure drops, torque and stress. MTFL

Drill speeds.

Working out sizes of metal for jobs.

MTF2

Bending allowances, triangulation and using pi.

Bonus calculations.

Area, volume and trigonometry: how many parts can be cut from a bar?

Use of pi:allowances for thickness of metal. Calculation of dimensions.

MTF3

Bending allowances.

Area and true length.

Norms, percentages, totals: stress calculations. True lengths (developments).

Calculations from drawings e.g. cylinder volume.

Calculations of lengths and for bends in metal. Mathematics for construction.

Circumference of pipes.

MTF4

Labour and material costs.

Bend allowances.

Sizes of job, circumference etc.

MTF5

Calculating size and strength of a welded joint. Plate area, weld size, stresses on welded and fabricated

Science

<u>ST3A</u>

components.

Tabulating data: substituting results into formulae. Averages, standard deviations and simple statistics. Processing experimental results with the calculator. Titration calculations.

Rates of flow, concentrations of additives.

Molarity, kinetics, concentrations.

Graphs.

Partition coefficients.

Assay limits.

Molarity calculations: use computer.

Formulae.

STHCL

General calculations for percentage.

Sizing treatment plants and design adjustments. Basic calculations for limits, construction of charts. Using set formulae, quantitative analysis and statistics.

CHAPTER 4

A CASE STUDY: MATHEMATICAL PROBLEMS IN THE PHARMACEUTICAL INDUSTRY

4.1 Introduction

The prevalence and importance of basic mathematics in industry has been demonstrated and discussed in previous chapters. A case with problems at this level which has been encountered will now be described together with appropriate remedial action, determined in consultation with industry. There were certain constraints and in this and other respects differences between this provision and that of formal Further Education will be indicated. A most important aspect of the course of instruction provided is the close relationship to Attitudes of workers and management are also applications. considered. Much useful background information was obtained from interviews with the workers about themselves. After an in-depth investigation of the production line tasks and what is required of the workers in carrying out these tasks, it became clear that mathematics, science and technology came together as an 'integrated' whole through the requirements of the production tasks.

4.2 Background

Publicity for college courses is usually through agencies such as the press, libraries and by sending a copy of the college prospectus to each recorded employer of students registered for courses. One response to this was a letter (Appendix 4.1) from a local company manufacturing, and carrying out research in relation to, pharmaceutical products. The author was asked to respond to this letter and as a result a meeting was arranged with the Personnel Development Manager, the Production Manager and the Assistant Production Manager. The first and subsequent meetings produced:

- 1 information on difficulties experienced with mathematics
- 2 permission for each of the workers concerned to be interviewed
- 3 a lecture scheme, and
- 4 certain management constraints.

The author was concerned about the attitudes of the workers to instruction in mathematics which was prime to their jobs because they could interpret this as lack of confidence in their competence by the management and this would cause them to resist any efforts to help them. The response to this was that they (the workers) had been prepared for the course of lectures. Thus it would appear that all the author had to do was to carry out a course of instruction. But the fact that this was to be the first course of its kind in the company left the author feeling a little uneasy about the feelings of the workers towards being told how to carry out some of their tasks when that was what they had already been doing. A strategy would have to be evolved to deal with this situation.

4.3 The Production Line Mathematics

The management discussions revealed some of the difficulties the workers were experiencing and the following list summarises these:

- 1 reading a balance/scale* to a given accuracy and interpreting the reading
- 2 use of the four rules with integers and decimals

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3	understanding where to put the decimal point after a calculation, or relating the decimal point to units
4	converting between different metric units
5	the evaluation of A as P_{k}^{\prime} of B (eg P = 1/4)
6	changing a quantity by adding to it a percentage of it
7	using specific gravity to convert volume to mass or mass to volume.
*	The technical term for any weighing device is 'balance' although the term 'scale' is also used. Any term which has an unambiguous meaning within the context of its use

will be acceptable.

At this point it is relevant to consider how these mathematical tasks relate to the formal Further Education courses provided by various bodies. Here 'mathematics' includes not just formal operations on numbers but interpreting numbers in relation to physical attributes such as volume, weight and percentage loss in weight. Such calculations as are involved are within the levels of attainment as required by industry and commerce. The City and Guilds of London Institute [7], an organisation with national and international standing, provides foundation courses for commerce and industry starting at a foundation level; an example of the basic level of mathematics required can be seen from the Numeracy component of the Institute's Foundation Certificate (Science Industries) course [58]. A body which provides a testing service to industry is the National Foundation for Educational Research, and its Assessment of Clerical Aptitude test [59] interrelates literacy and numeracy by testing 'perception of text ... and simple arithmetic skills'. There have been many studies devoted to the problems at work with basic mathematics. Rees [60] observed that the school-leaver experienced problems in selection tests during the early stages of training and in further education. Fitzgerald [61] has attempted to define the mathematical requirements for young entrants to

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industry in the early stages, while the Institute of Mathematics and its Applications actually brought together trainers from five industrial situations in order to specify (with examples) what their particular industries required of the school-leaver. An in-depth research project by Matthews [62] attempted to state the relationship between school learning experiences and first-year craft training in the engineering industry. Most of these studies are concerned with the problems of those yet to leave school, or are about to leave, or have just left. But what about the problems of the matured (not aged) school-leaver when confronted with mathematics in the job when the recollections of past mathematical studies have become dimmed? Such cases will be seen when the backgrounds of the workers are analysed further in If the worker fresh from school has problems, this chapter. then those of the matured worker must be more acute. An example of what school studies may have excluded or failed to consider adequately is the electronic calculator and how to use it sensibly as well as correctly. At the conference 'Mathematics in Industry' [63] the main speakers were from the Pilkington Glass Company and I G Davies, Head of Research and Development Services, emphasised strongly three needs:

to teach the use of imperial and metric units in school
to equip school-leavers with some computer knowledge, and
to teach the use of the electronic pocket calculator.

All these are applicable to the production mathematics of this case study except for imperial units. Yet the schoolleaver without formal knowledge of imperial units would find this lack a hardship in the oil (pipe fittings) and glass (rolls out in miles per hour) industries. Imperial and metric units are also found together: J K R Agriculture [64] advertises bulk storage tanks with capacity in gallons, outside dimensions in feet and inches and the plate thickness in millimetres. Another field in which formal school education differs from what is required in industry is that of electronic devices which can be grouped under the general

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heading of Information Technology [65] and of which the commonest examples are the pocket calculator and the microcomputer. History shows that the computer was a commercially viable piece of equipment thirty years ago in the form of LEO [66]: in schools there is still controversy over the use of the calculator, and evaluation and assessment of the use of a computer from the primary school level up has yet to be seen in any measure. Thus education beyond school, ie for work, could contradict the ideas of good practice in schools, but if that is the requirement it falls to Further Education to provide it in conjunction with industry. When it is known what has to be provided a better provision can be made. Thus it seems that it is more appropriate to consider the needs of each industrial unit rather than search for a general mathematical education which will satisfy all: then perhaps some generalisations can be made. But what else is required to go with the mathematics - for it cannot be just pure mathematics at this level? To answer this a closer look at the production tasks of this case study and those who carry them out is required.

4.4 The Interviews

4.4.1 Introduction

The production workers who were to form the class students would be facing their lecturer with each side knowing very little about the other and this could lead to learning inhibitions. In educational establishments some student information is transmitted via an enrolment form or a pre-course interview. This was discussed with the management, and the author explained that besides obtaining educational background information an interview might help to alleviate inhibitions regarding going back to the classroom, perhaps after a considerable lapse of time for some. Also, as this project was viewed by the author as an excellent opportunity for a research exercise, it was important to accumulate as much basic information as possible with a view to using it later on. Such information would have to be obtained at opportune times: for example it would be unwise to ask a member of a class in front of the others:

At what age did you leave school?

The management agreed to the author's suggestions and at one stage the author was told with a smile 'you are very keen...' which indicated approval for a procedure which it was felt was totally unexpected but soon found to be necessary and acceptable.

4.4.2 Recording at the Interviews

A record of the discussions must be kept and if possible this should include notes on attitudes, etc. A sound taperecorder would be ideal for this and once accepted would free both sides from constraints. However, without discussing it with the management, the author rejected this in case the recorder would inhibit free discussion and at worst abort a discussion at the very start. Also, an objection by one person could lead to similar attitudes from others through personal influences. It was therefore decided to make written notes during the interviews and as soon as possible afterwards enlarge these from memory as necessary.

4.4.3 What is wanted from the Interviews?

The first requirement is a willingness of the interviewee to talk freely and discuss difficulties without inhibitions. Useful information can be set down under the following headings:

- 1 school and post-school education
- 2 difficulties experienced in the job
- 3 personal remedies for difficulties
- 4 personal mathematical techniques used, and
- 5 attitudes to receiving tuition.

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In the synopsis of the interviews the following key is used to classify the information:

- Q for qualifications
- E for job experiences
- D for difficulties with mathematics
- G for general comments and observations
- S for attitudes to joining a study group
- C for author's comments and observations

The interviews were arranged by work function as follows: Coating - where tablets and capsules are coated Compression - where tablets are formed Granulation - where the ingredients for tablets are prepared Pharmacy - where bulk ingredients are dispensed.

The workers were of mixed sexes and it came back to the author that the ladies would be interviewed but only together as one group. This was accepted as the alternative was no interviews for them. There were to be three groups of men (they outnumbered the women) which will be coded as G1, G2 and G3. The seven women will not be identified separately but the men will be coded, for example, as G1B, which means the second person in the first group. Within each group there were workers with experience of different manufacturing sections and several had worked in more than one section.

4.4.4 The Interview Arrangements

Sufficient time was provided for the interviews which had to be carried out within the constraints of production schedules. The workers had been primed to the effect that 'someone from the college would be coming to set up classes' but beyond this they did not know what to expect except that there would be an interview, which was voluntary, as indeed was joining a class. It was decided to use first names: the author would introduce himself as Stan and it was hoped that this would encourage a relaxed and friendly atmosphere, conducive to a free flow of information. The interview room used depended on what would be available and ranged from the medical centre reception room to a board room. Each worker would come straight from work and be allowed to change out of working clothes. There now follow synopses of what was said at the interviews. The notes were written either during the interviews or between interviews or from memory after the conclusion of an interviewing session. The total interviewing time was about seven hours.

<u>G1A</u>

- (Q) City & Guilds Full Tech. Business Studies Certificate;had started an Institute of Works Management course
- (E) Cadbury's chocolate factory; wholesale meat warehousing redundant
- (D) None
- (G) Others have difficulties: if you are fresh from school or young then you have no problems. Mainly the older ones who have problems. There has been apprehension about the interviews/course for a number of days and some think it means a change of job. We work in twos and usually they consult me if they have any difficulties. Others have difficulty in reading a scale, a drum weight to one place of decimals, or in converting from say 510.03 kg to whole units in the form of 510.03 kg = 510 kg + 30 g

G1B

(Q)) Studied some mathematics at school.	No	formal	qualifications
(E)) With Lever Bros., manufacturers of so	oap	produc	ts
(D)) No problems			

- (G) Had a 'watchdog' job at Levers and so plenty of time to read. He worked in a group and they would set each other problems out of a mathematics book. Today children are not learning basics but their range of education is greater (eg microwaves, electronics, computers) with only a superficial knowledge of many topics. His own children now grown up and married but he has observed their education. Hobby is boats/sea fishing and he has taken a course in trawling. He spoke at length about boats. Mathematics is implied in navigation aids, through radar and electronics equipment which replaces mathe-The choice of a hobby can influence one's mathematics. matical experiences and knowledge: sailing is a good one for this.
- (S) No. But he did join a group
- (C) Note how mathematics is related to other things or do they relate to mathematics?

<u>G1C</u>

- (Q) Nothing formal
- (D) None, as just simple arithmetic is involved
- (G) Others have difficulty with working out $\frac{1}{4}$ % or $\frac{1}{8}$ % of say 1000 kg. There is plenty of time to do the calculations and they all seem to get there in the end.
- (S) Yes
- (C) The 1000 kg quoted in his example could have been any weight

- (Q) O-level English and CSE in Elementary Mathematics
- (D) None
- (G) Only elementary arithmetic is involved and your work is always checked by another worker or the supervisor
- (S) No

G1E

- (Q) Army training certificate
- (E) Some years in the army
- (D) Percentage did not do it at school but I picked it up in the last three years. One can ask the supervisor or the others, work in pairs and re-work the calculation until you both agree. There are so many different ways of working out percentage, which one should be used? Example: $\frac{1}{4}$ % of 500 would be 1.3 but someone using a different method would show it as 0.13.
- (S) Yes

G1F

- (Q) No school qualifications; 11+ failure. No CSE at the time. Had done decimals and the four rules
- (E) Present: works out the weight of a drum which has to contain 20000 tablets
- (D) Would like to move round (flexible working) and this would require knowledge of percentage which he had never done
- (G) Wants to learn as much as possible about all jobs on the line - anything and everything

(C) He gave a clear explanation of his job function

Group 2

G2A

- (Q) CSE grade 4 in mathematics: ULCI motor vehicle certificate after 3 years in college
- (D) Percentage. Imperial to metric conversions personal interest
- (G) Good explanation of his job. Wants to learn about litres and millilitres etc. Some people perform calculations by rote but do not always understand why
- (S) Yes. Very willing to join a group. Thank you
- (C) Nephew of G2B

G2B

- (Q) None. At school all units were imperial
- (E) Worked in the food industry all his life
- (D) Metrication. Conversions between units. Decimal arithmetic alright. Would need metric units for the Pharmacy
- (G) Older people have difficulties a mistake to have gone metric
- (S) Yes. Pleased to join a group. 'I could help by suggesting different approaches to others if you could not get through to them'
- (C) The Pharmacy seems to be a challenge or a desired goal

G2C

- (Q) None. The mathematics he uses was not done at school
- (D) No problems at my age do I need to learn? But if I move to the Pharmacy, volume calculations will be needed
- (S) Not willing to study at first but on suggesting that he could help others by discussing different ways of doing things and stating that the study atmosphere would be informal he agreed to join. 'Thanks very much'
- (C) Study probably has associations with school for children, not adults

G2D

- (Q) Left school at 13 years of age and had never done any of the required mathematics before
- (E) Helps his son to run a public house on a part-time basis.Works in Compression but has worked in Coating. He has opted for flexible working to work in any section
- (D) Decimals, metric units and percentage
- (G) His children had done well he helped and encouraged them and hopes that they will encourage their children
- (S) He hinted that perhaps he was too old to learn but agreed that he would join a group to help and encourage others
- (C) Good attitude to learning one like him in each group would encourage others to learn

Group 3

G3A

- (Q) None from school
- (E) Twelve years with this firm

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- (D) Percentage. Expressing the weight of a small quantity of an additive in mg when it is read from the scale as say 0.005 g
- (G) Others have the same difficulties
- (S) Very willing to learn. If we learn about percentage then we will be alright for other jobs
- (C) He had experienced initial difficulties but had learned what to do mechanically but would like to understand 'why'

G3B

- (Q) None not very good at school
- (E) Is fully flexible on the production line, ie has tried and is willing to try the lot and is accepted as such
- (D) No idea of volumes but it is needed. Also need some information on percentage and a general course for the job
- (G) He had recommended such a course (with others) some time ago
- (S) Yes. Very willing to learn
- (C) Once more the idea of a general course emerges to suit all jobs

<u>G3C</u>

- (Q) None. Had not done much at school and anyway had forgotten a lot
- (D) Feed in numbers to the calculator and read the answers on the display. This is done by knowing the correct routines but not why they work. Difficulty also with percentage

- (G) Wants to know more about mathematics in general
- (S) Yes. Would like to learn about anything it all helps
- (C) 'Understanding' keeps coming through

G3D

- (Q) Grade D, O-level mathematics
- (E) Has spent 18 months in the Pharmacy
- (D) So far no problems with the work. Have learned how to convert litres to kilograms using specific gravity
- (G) When this course idea was discussed the older ones did not seem to like the 'back to school' idea having left school many years ago.
- (S) No personal problems but the older ones have problems at first yet seem to manage
- (C) In spite of what Tim says about the older ones not liking the idea of 'school' again, some of them must have changed their ideas during the interview judging by the willingness to study.

G3E

- (Q) None
- (E) Had worked for Lever Bros. (soap etc) in the animal food section about 15 years ago
- (D) Arithmetic with the four rules (but can cope the long way), percentage, and specific gravity
- (G) If flexible working is undertaken then a broader base of arithmetic will be required
- (S) Yes
- (C) Seemed a little apprehensive at first perhaps not knowing what to expect

<u>G3F</u>	
(Q)	O-level Geography and English
(D)	None
(G)	Uses the calculator for specific gravity calculations
(S)	Yes
(C)	Not as forthcoming as some of the others but then he had accepted the course without dissent
<u>G3G</u>	
(Q)	CSE Mathematics - no grade given
(D)	None
(S)	Willing to join a group to help others
<u>G3H</u>	
(Q)	Some success in a National Certificate second year course in engineering
(E)	Inspector on a tool production line
(D)	Percentage - a long time since this was studied. Carry out specific gravity calculations but don't understand why they work
(G)	Use the calculator but get a rough estimate first – important with the calculator

(S) Yes. Will it enable me to work flexibly?

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<u>G31</u>

(Q) Grade 7 in O-level mathematics: 1 to 6 are passes and other grades are 6, 7 and U. This system of grading is no longer used

- (E) Working in the Pharmacy
- (D) No problems
- (G) Would like a course for O-level mathematics
- (S) Would like to join a group
- (C) Seems keen to make good the O-level failure

Group 4: The Ladies

The author had received advance information that the female workers (the 'ladies') did not wish to be interviewed: on pursuing this it was found that they did not want to be interviewed individually but agreed to a 'group' interview which would be more like a discussion. It was then to be expected that this would reduce by a considerable amount what the individuals would disclose about themselves but, as a researcher, the author was willing to extract all possible information and then decide how useful it would be. Any move which would antagonise one or more of the workers could mean resistance to learning building up and put the project in jeopardy. Thus the only recordings from the ladies are as follows:

- (D) Changing units and percentages gave rise to difficulties
- (S) Attitudes to study were very negative at first but after a time it appeared that most really wanted to learn and remain as a group - but not mixed in with the men!
- (C) Once again percentage and units are found to be difficult.

As a final note on all interviews it is worth recording that the author was occasionally asked about the effect that poor class performance might have on job security, but there was no intended connection between them as far as the management was concerned, although suspicions were there.

4.5 Production Line Photographs

During the course of the lectures there was constant reference to particular equipment. It was not possible to leave the room in a group in order to see the actual piece of apparatus so the next best alternative was decided on, namely pictorial reproductions. The author obtained permission to go round the production line again with a guide and a photographer.

The following reproductions were made:

- 1 colour slides
- 2 postcard size black/white prints for passing round (sets)
- 3 large versions of (2), more detailed and suitable for copying
- 4 black/white overhead projector transparencies

which showed the same objects but reproduced using different ways. Descriptions of these are given in Appendix 4.2 and will be referred to later. The photographs became available towards the end of the sets of lectures and so were not fully used but have proved very useful for modules: see Chapter 7. The slides and transparencies were intended to cover a variety of user conditions such as not having a slide projector. Copies could also be made with a photocopier from the black/ white photographs.

4.6 Applications of Mathematics to Production

These have been obtained from discussions with production management staff, the workers and from the personal tour of the production line. Photograph references will be used to aid clarification. The omission of names of products and constituents has not been deliberate in some of the examples and it is felt that no further explanation of this is required. The examples, together with the working, are shown in Appendix 4.3 and are not intended to illustrate the ways in which a particular problem is solved. It is important to note that these are the result of real problems requiring a solution - there is little restriction on method or means of solution and from the interviews it can be seen that each person has some particular way of arriving at a solution. A feature of many mathematics courses and books is 'problem solving' but if real problems cannot be found, one can ask if it is worth bothering with the techniques.

4.7 The Courses

4.7.1 Organisation

After negotiations with the management three groups were formed and each was allocated one and a half hours each week for The time was to be made available within the three weeks. working periods of the workers so that there would be no loss in earnings. The venue was to be on the company's premises but the same room could not be guaranteed to be available each week. The author supplied calculators so that each person would have the same model, which makes teaching how to use it much easier. Many had personal calculators and it was felt that the model chosen was not always the most The teaching periods were used sometimes for suitable. discussions and sometimes for formal lecturing as the needs dictated. The ability range within any group (no more than six in number, by intent) was considerable but that did not prove to be the problem that was expected; perhaps this was because all had experienced problems at one time and therefore there was more tolerance shown to those who required more attention. More than just mathematics was involved and the background to a calculation had to be explored and discussed but then this was teaching dedicated to a topic - and this implied 'round the table' discussions, as well as formal tuition.

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4.7.2 Prepared Notes

The last occasion on which a worker had been issued with a sheet of paper connected with mathematics for the job was probably when attempting the entry test (Appendix 4.4) which consisted of pure arithmetic. It was explained that the material was for reference and in no way implied a test or enforced study; an A4 cardboard folder was also given to each person and a label so that course papers would be treated with some respect. Notes on numbers (Appendix 4.5) deal with:

Interpretation of Numbers Fractions The Place Zero Named Units of Measure, and Percentage.

The fourth sheet gives some equivalents between units, metric of course. Alternative uses of percentage are shown, together with some worked examples and alternative methods of performing the calculations.

4.7.3 Worksheets

A sample of worksheets constructed by the author is shown in Appendix 4.6. Some of these give practice of the four rules of arithmetic, and require an entry in one column to be made, the entries in the other having been made by the lecturer beforehand and then copies made for the class.

The last two sheets provide examples on working with the concept of percentage, and certain conversions which are required when dealing with units which would be met at some point on the production line. This could raise difficulties when a worker was moved to a different section of the production line where the units of measurement were very much larger or very much smaller than those last experienced.

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4.8 Observations From the Courses

These will be given first for the students and then for the author. Separate groups will not be differentiated between since they were intended to be mixed in ability as well as with respect to production line jobs.

4.8.1 The Students

There should be a uniform way of writing a volume, ie 600 ml or 0.600 l but 0.6 is wrong.

The unit cc should go out altogether.

Tablets should be given in g or mg.

The supervisor's ability is sometimes doubted.

If the supervisor has not been properly taught how can he instruct us?

The worksheet for the conversion of units is very good.

Converting between units was done by moving the decimal point at school; not very impressed with it.

We like relating the position of the digits to units because by looking at a number it relates to kg or g or mg of a substance.

We have not as yet had a general look round the whole plant and this would make our arithmetic more interesting.

We need a lot of instruction on the calculator.

We would like a longer course.

The calculator is believed if it comes up twice with the same answer.

G2B refused to do tests but one of the ladies asked him how he could become proficient without practice.

4.8.2 The Author

Some particular reactions were noticed which were related to the nature of the project. There was some apprehension about submitting written work for appraisal in case a poor performance would be used to measure working ability and used to deny promotion. One person refused to carry out any written work at all because of this. The correct use of the calculator was not always understood and the blind acceptance of the correctness of anything that appeared on the display was consistent with other users at all levels, of both calculators and computers. On one occasion the calculator produced the same (incorrect) answer twice in succession and this was considered sufficient justification for it to be accepted as the correct answer. Agreement with another person's results was also accepted as a sign of correctness, and one was encouraged to work with another for the purpose of checking. When the author visited the Testing Room he asked the operator who was working out values of friability if she understood the method and she replied that she knew what to do with the instrument readings but not why the process gave the required result.

Attitudes towards supervisors were sometimes ones of criticism, eg they would enter a log with .373 g instead of 0.373 g and the author asked for a sample log to be brought up to verify this. The danger in omitting the leading zero in front of the decimal point is that if the decimal point is feint then the interpretation could be 373 units. Thus a new field is brought in, ie written communication which is related to mathematics by the need for good practice. The problems which were discussed were referred to apparatus, ie something physical, which means that abstract arithmetic to these people was not acceptable as it is in schools and particularly as it must be for school examinations. Sometimes the impression was of the course 'pushing itself along', powered by the problems of the students, and the discussions were felt to be an important component of the learning.

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4.9 Conclusions

- 1 The course was non-conventional because of the absence of a fixed syllabus and an assessment examination, although some of the worksheet results were seen by the management. <u>The workers showed a great deal of interest and liked to</u> discuss problems - one way to learn.
- 2 Most of the production line tasks (as indeed even those in the research laboratories) made use of some form of MEASUREMENT.
- 3 The ways in which mathematical facts were communicated must be understood.
- 4 Numbers were related to real things such as tablets and apparatus.
- 5 Science and biology were ever-present, eg in antibiotics.
- 6 Mathematics did not stand alone but was closely related to science and technology by measurement tasks: to have taught it in isolation would have been irrelevant and probably boring.

It is worth noting at this point the relevance of the paper by Geoffrey Matthews and Margaret Seed [67] to 6 above, because they question the separation of mathematics and science in schools (equally true for education in other institutions). The work-place after all comes after school and the case study of this chapter highlights very clearly how mathematics and science do occur together in a way not usually experienced at school. The authors broaden their argument for 'integration' by stating:

We have concentrated in this article on mathematics/ science co-operation but it is equally important to explore the considerable overlaps between mathematics and other disciplines particularly, perhaps, economics, geography, art and design, and home economics. To this could be added a case for considering the overlap between science and technology as well as mathematics and technology, supported by the results of this case study. The reference in this paper to another technological facility, the computer, which at the time of publication was only obtainable as a very large and expensive item, by:

'.... a much subtler and more exciting task which the computer can perform is not only the analysis of the results of experiments, but also, in effect the carrying out of experiments themselves....'

serves as a reminder that the workers were also exposed to the computer when working in the Production Testing Unit where apparatus weighed individual tablets of a sample drawn from the production line, this being repeated at intervals. The statistics derived from the raw data were displayed by a computer printer; Appendix 4.2, number 44 shows this. School experience of such a use for a computer, with the data being obtained by manual weighing of individual tablets (even lumps of sugar could be used to illustrate the method), would have been useful experience of mathematics integrated with technology (computer and weighing) from a real industrial environment. Perhaps then, this would have provided a meaningful use of the computer in preparation for employment.

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CHAPTER 5

THE INTERRELATED APPROACH IN TEACHING

5.1 Introduction

In Chapter 3 the analysis of mathematics at work across a number of disciplines showed how much of the mathematics was basic and related to measurement and technology associated with a particular task or area of work. In Chapter 4 the case study of mathematics in industry gave weight to the idea that mathematics, science and technology as well as communication are a not unusual mixture, one, so to speak, not being able to exist without one or more of the others. This idea of relationships was seen to be necessary in order for the teaching to be meaningful. Further support for this as an approach to teaching will be considered in the next section after which teaching strategies and materials will emerge to set down a firm base for a new approach to teaching. Examples of teaching modules based on the fundamental concept of measurement will be illustrated for particular topics using the proposed interrelated approach. The importance of measurement will be highlighted by a tape/slide programme which was developed by the team which worked on the modules.

5.2 Relationships in Education

At the Conference on Mathematics for Engineers, Professor Davies [68] spoke about the changes taking place in the practice of engineering and about the role of the design engineer. He said:

'The design engineer must always have an appreciation of the physical situation, sometimes the chemical situation as well ... but the ultimate reliability and economy of his design are determined by ... mathematical techniques....

Thus we have physics, chemistry, engineering and mathematics together. In a paper introducing an experiment in the teaching of elementary ideas of vectors, Hughes and Bajpai [69] suggest showing a film of a falling parachutist to children in order to enlighten the teaching of elementary vectors. This would bring in discussion and show the need to investigate the phenomenon as well as generating interest. It is too easy to forget or put to one side the idea that there is more to teaching than theory and facts: here we have been shown mechanics, mathematics, interest and communication. Still with the visual aspect of education, in the Lecturer's Notes for the BBC TV Engineering Craft Studies series [70] section 19 reads:

19 Combining the principles

Background

One of the problems of teaching a fixed syllabus is the temptation to treat each topic SEPARATELY and without reference to the other syllabus content. The INTER-RELATION of some of the first year topics can be shown by following the stages in the manufacture of a comparatively simple component from a drawing to the finished article.

The notes go on to state that one of the aims is to consider how the syllabus topics relate to the manufacturing process. Shercliff [71], when writing about whether or not mathematics can form the heart of an engineering curriculum, states that mathematics can and should be the unifying factor. Where the aim is to produce versatile, creative people there are several compelling reasons for mixing the mathematics and other subjects together. In the published submission of the Council of the Institute of Mathematics and its Applications to the Committee of Inquiry into the Teaching of Mathematics in Schools [72], it is made very clear that in schools the nature and relevance of mathematics are not understood and that the application of mathematics is vital to the maintenance of a technological society. Sawyer [73], when writing on avenues for the advancement of mathematical education suggests:

... our chalk-and-talk method of teaching may have some analogy with the stone axe, and that some entirely different approach, with mathematics embedded in some purposeful, real situation, involving making and doing, might lead to an altogether higher level of achievement.

Sawyer has written a number of books aimed at a general readership which have been published in Pelican paperback editions [74]. In a short (three page) article Matthews [75] managed to cover briefly but positively ten topics on Mathematics Education from pre-school years up to the start of employment, writing from the strong position of many years of experience of the field. He comments on the isolation of mathematics as a subject thus:

Probably the most urgent need in mathematics education is to look at ways of integrating the subject with the rest of the curriculum, the whole lot having a firm eye on the curriculum.

At the basic mathematics level in Linking Skills to Applications [76], combining the learning of skills with their application is investigated using applications which are relevant to the student. A suggested relevant application of the decimal notation is the coloured digit on the car mileometer dial which represents tenths of a mile. The Department of Education and Science publication, Using Your Maths [77], which is aimed at the professional graduate level of use, also makes the case for relating mathematics to an application, thus:

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There are very few opportunities for people concerned solely with pure mathematics. Maths is supremely a subject which combines with others for the great majority of those who use it in their working lives. For example, statisticians need a subject area to which to apply their particular skills...

Bondi [78] has been critical of the education system which offers young people 'a false science prospectus' in placing too much emphasis on the results of scientific research and not enough on the acquisition of problem-solving and communication skills. Science should be made more attractive to much larger numbers of people. These views do not fit in with the usual 'subject' approach to science. Chadwick [79] has reported a new dimension added to her science teaching, namely technology. As a science teacher at the primary school level she gave children the initial objective of 'making something' which after discussions was by agreement to be a concrete chess table. As she saw the technological approach, it was a strategy for problem solving, having an inbuilt formula which enables teachers to structure the curriculum and yet allow for plenty of open ended thinking. Using concrete involves science in the broadest interpretation and the Cement and Concrete Association gave plenty of assistance in many ways. Thus concrete relates many classroom subjects in an interesting and acceptable way without formal classroom teaching.

Writing in Education in Chemistry, Knutton [80] singles out some of the changes in the national educational system in the last twenty years and one of these is 'integrated science' on which he comments:

... the pre-eminence formerly attributed to the separate sciences has come under attack. In most secondary schools pupils follow a combined/general/ integrated science course in the first two years.

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In later years specialisation continues to occur ... which has been questioned by HMI ... and teaching across subject boundaries is a cause for concern among many science teachers.

Further support for the idea of accommodating relationships between subjects in teaching arose in the one hundred and fifty-first meeting of the British Association for the Advancement of Science [81]. This featured for the first time a Mathematics Section. Professor Kendall's Presidential Address was 'Mathematics and the Humanities' which is another relationship for mathematics, perhaps unexpected by many. Removing the possibility of a pure mathematician being too pure seems to have been the idea behind the letter from the RSA which was printed in Lift-Off, Number 9, which shows that the Department of Education and Science [82] had endorsed the idea of secretarial teachers teaching mathematics and so relating it to their subject. Incidentally, it also looks as though the Royal Society of Arts was looking for some support from the new, though not inexperienced organisation, Lift-Off. The book Accounting Through Numeracy [83] supports this last theme and in context reinforces the learning of elementary mathematical principles by frequent applications to practical situations.

In the newer technologies which developed from microelectronics innovations, robotics is one of the technologies which has implications for changes in education and training. The opinion that there is a ground need for the multidisciplinary education of robot specialists is strongly held. Professor Keith Rathmill, in Management Today [84], maintains that the traditional boundaries between the degree disciplines are breaking down in the face of the demands of robot users and robot suppliers, the existence of these boundaries being one of the major problems retarding the supplies of adequate numbers of appropriate technicians and technologists. Robotics is a prime example of the need for an interrelated approach in respect of its industrial and educational contexts. Robotica [85], the international journal of information,

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education and research in robotics and artificial intelligence, edited by Professor J Rose [86], sets out the disciplines which are interrelated through robotics: the author discussed this with Professor Rose and as a result produced the diagram (Appendix 5.1) which illustrates the interrelationships. A personally conducted tour by Professor Rose round the Danichi-Sykes Robotics factory [87] enabled the author to see training, research, development and industrial applications of robotics, and to view an educational video film.

Still with an industrial (work) theme there is an important reminder in a Careers Bulletin article, devoted to the principles of the YTS, that the Youth Training Scheme [88] for schoolleavers is an integrated programme and should not be offered as separate isolated subject areas for teaching. This theme is considered in some detail and will affect the postschool education and training of thousands of pupils who will find a new format for the presentation of a group of subjects. Richardson [89] in making a case for 'teaching chemistry to the non-chemist' advocates the use of motivating topics which relate chemistry to something else such as pollution, household tasks and products, medicare and industry. She also notes that staff in many vocational areas have tended to identify themselves professionally with a particular subject and that vocational preparation courses require a far more flexible and integrated approach. Ensuring Integration [90] is an article by Mick Farley who expounds on integration thus:

It is essential that work experience and off-thejob training complement each other, so the MSC is anxious that the tutors have experience of the work placements and can identify the learning needs of trainees in them, so that these can be met in a properly developed and integrated programme.

In the same issue of Youth Training News a scheme operated by Accrington and Rossendale College [91], a college with

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considerable experience, is claimed to offer much more than conventional motor vehicle skills training through the new integrated approach. It is possible to provide a high level of general vocational training in storage, retailing, practical usage of computers and keyboard skills, with customer relations, communication skills, literacy and numeracy being essential ingredients. Here then have been some powerful arguments against the traditional educational pattern of teaching several subjects in isolation, with the argument carried over to the world of work through training, which now has a new leadership from the Youth Training Scheme. In full operation from September 1983, the scheme aims to provide 16 year old school-leavers with one year of training as a foundation for work. It provides planned work experience, training and Further Education which could be provided by a college. [90] gives more details of the scheme. In the next section the work of a research group formed to develop the ideas of an interrelated approach to teaching is described. From the cases just considered it is time that such an approach was formulated and tested practically, and this section will describe some early experiences.

5.3 An Important Discussion

After the author had completed the analysis of the questionnaire on students' opinions (Chapter 3) and the case study on the pharmaceutical industry (Chapter 4), he met Professor Bajpai for one of their periodical discussions on the progress of the research and part of the dialogue was as follows (PB - Professor Bajpai, ST - the author):

PB - Do you teach anything else other than mathematics?

ST - Yes. Computer Science to builders, engineers and scientists which involves their particular disciplines.

PB - Good! Do you teach measurement?

ST - Most of the applications of mathematics have measurement as the end product. The questionnaire item requesting information about mathematics at work turned up a lot of measurement, which was also the main reason for reading the scale of a weighing machine or performing a calculation in the pharmaceutical industry case study.

ST then produced the rough notes for the case study (Chapter 4) which he was going to show to PB and would have done so if not for this dialogue being initiated. The notes were handed to PB who perused them quickly.

PB - Yes! This is good. This is what I mean by mathematics and measurement being related.

Thus the first dialogue on the relationships between subjects in teaching, and indeed as they arise at work, was started and was the forerunner of many. There followed a discussion on measurement which could be viewed almost naturally as the common ingredient in engineering and all branches of science and technology.

PB - I am going to bring in another research student, R Bond (RB), who has interests at the school level, and we will form a research team investigating the interrelated aspect of teaching mathematics, science and technology. There will be discussions but also productive activity by yourselves. Leave your material with me.

ST - But it is in a very rough form

PB - That doesn't matter!

Further meetings, individual ones sometimes occupying up to twelve hours in one day with only short breaks, initially concentrated on the formulation of the basic and fundamental ideas embodied in, as well as the strategies for, the implementation of INTERRELATED STUDIES. These were the outcome of

the deliberations of the research team. The team operated with Professor Bajpai as leader but of course ideas, suggestions and criticisms from all members enjoyed equal parity. Professor Bajpai was always available when RB or ST wanted a third opinion, not because they could not work together, but because the experience of the professor as an author and director of research often provided a short cut to the solution of the problem. What follows in 5.4 concurs with the findings of the team. Support for the measurement thesis, that is measurement as a starting point for the interrelating of various subjects, will be described in two areas, both having the spoken word in common as a means of communication. First, by a case study of mathematics and measurement as experienced by catering students working in industry, and second by means of a tape/slide programme of slides based on measurement. The latter has the appeal of something visual This programme was originally intended for and changing. educators but its use need not be restricted. The production of teaching modules, trials and assessment of their effects will then be given in accounts of early experiences from which modifications and further trials take place. While the trials and modifications are being considered it would be expedient and less wasteful of reproduction facilities if a computer system were used to deal with the text, for storing and printing. Changes of a minor nature could be made 'on the spot': see Education Technology, Chapter 1.

5.4 <u>Teaching in an Interrelated Way</u>

5.4.1 The Problem

In many teaching establishments the curriculum is based on a timetable of separate subjects serviced by specialist teachers who work in isolation from teachers in other subject areas. Also, subjects are offered as an academic discipline with little or no reference to their practical value. In these situations the teaching of science and technology based subjects is largely confined to the classroom and the importance of

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doing, making and organising is often neglected. The analysis of Section 5.2 clearly points the way towards change in the separate subjects approach.

In order to break down the rigid lines of demarcation between subject disciplines the interrelationship between subjects must be recognised and exploited so that science and technology education is treated in a comprehensive way. The need to interrelate science, mathematics, technical and vocational curricula is supported by an examination of technological developments in the world of work. For example, the scientific research laboratory in chemical-based industries uses modern technology as a basis for measurement and the interrelationship between mathematics, physics, biology and chemistry is fundamental and undeniably strong, especially in respect of one simple mathematical concept, namely ratio and proportion.

It seems natural, therefore, to relate science, mathematics, technical and vocational subjects so that rigid boundaries are crossed in a smooth and effective way. Such interrelation will provide an education with interest and purpose, and assist the process of incorporating new technologies into teaching programmes. In order to reap the maximum benefit from an interrelated approach to the teaching of science and technology subjects, two essential requirements must be met the cooperation of teachers and the provision of comprehensive teaching modules.

An interrelated approach to the teaching of science and technology subjects is likely to stimulate a greater motivation to study. The isolated nature of curricula subjects - with little reference to experience related to the world of work is totally irrelevant to the needs of students. Dissatisfaction with traditional academic curricula may be one of the underlying causes of behavioural problems that arise in the final years of formal schooling.

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It must be recognised that any change from traditional curricula to a more interrelated approach is likely to be opposed by some teachers who may have serious misgivings about such curriculum reforms. However, if teachers are fully involved in every stage of change, they are likely to modify their attitudes and agree that the successful development and implementation of interrelated curricula must depend on a new teaching approach - with a greater emphasis on guidance for The preparation of curriculum materials, guidelines teachers. on implementation, management and assessment are also activities that require the participation of teachers and their whole-hearted support. Other areas of cooperation between teachers and education authorities are concerned with pre-service and in-service training, their implementation of interrelated curricula, and the provision of resources including buildings and equipment.

The interrelation of science, mathematics, technical and vocational curricula is likely to follow two separate, but related development paths:

- (a) The interrelation of existing curricula following identification of related topics.
- (b) The design of teaching modules covering topics commonly used in all science and technology subjects.

Resource constraints and a need to proceed in a step-by-step manner may favour the adoption of (a). However, in the longterm the development of interrelated curricula will lead to the production of special modules as described in (b). One topic, of essential use in all science and technology subjects, is <u>measurement</u>. Even at pre-school level measurement is important in respect of counting, classification and recognition. In later stages of education, measurement is the all-pervading topic in every aspect of science and technology education. The important first task is to develop a teaching module on measurement, together with guidelines on ways to present it as an interrelated topic with a view to helping communication in science, mathematics and technology.

5.4.2 Measurement in Science and Technology

In all science and technology subjects the measurement of physical properties is an essential objective, or a necessary component of an objective.

Physics and *Chemistry* are taught as a set of principles and practical phenomena, the latter being quantified by fundamental measures (count, time, length and mass) or as derivatives, for example:

- specific heat from volume (length), mass and temperature
- modulus of elasticity from mass and length
- melting point directly from temperature
- coefficient of thermal expansion (length, area or volume) all in terms of length and time
- electric charge from mass and time in a chemical cell
- molecular weight from atomic weight and a count of atoms
- density from mass and volume (length)

Biology takes account of the fundamental cell structure of animal and human forms, the macro-components of which have identifiable properties and specific structures which relate to particular species. The following examples illustrate some ways in which measurement occurs within biology:

- counting is used to establish and verify laws of genetics
- time is used to measure (with counting) pulse rates and heart beats
- cells are identified by colour and shape as determined by the configuration of lengths and angles
- cell multiplication is determined by counting and measured against temperature
- count of macro-components, eg number of ribs, vertebrae, etc

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Technical Education supports the fundamental industrial processes, namely design and manufacture. Measurement takes place at all stages varying from the use of elementary instruments to automatic, continuous monitoring devices. Examples of measurement are as follows:

- counting and classification
- shape, angle and size are measured with geometrical instruments
- smoothness is measured by the abrasiveness of filing and sanding devices
- automated machine tools can be programmed to produce a finished product having predetermined measures
- temperature is measured continuously and automatically regulated in order to maintain a constant temperature in the heat treatment process
- hardness of metals is measured on a variety of scales

Mathematical Education is such that mathematics is essentially taught in a 'pure' form and where possible reduced to rules and formulae. Some examples of how these concepts are used to produce measure are:

- in transposition of a formula the subject is the measured quantity expressed in terms of the other, more fundamental ones
- empirical statistical measures are compared with those expected from an assumed mathematical model
- simple numbers are used to convert practical measures to more meaningful values, eg 304 m is 300 m to the nearest 10 m
- gradient, etc, derived by means of graphical measures

Vocational Education is concerned with the training of clerical, operative, retail and wholesale distributive trades. Formal education is usually available, eg in the office skills. Examples of measurement are:

- shorthand/typewriting speed; teaching tabulations to typists
- money calculations as taught to clerks, cashiers, hotel receptionists, etc
- reading electricity supply meters
- making clothes and other items in small businesses/cottage industries
- weighing of raw materials by process workers
- measuring of customers in shoe and clothes shops to obtain appropriate sizes
- measurement involved in buying home improvement materials, eg timber, screws and various fittings

5.4.3 An Interrelated Approach to Measurement

In order to present the topic of measurement in an interrelated way it is necessary to establish a number of objectives and identify supporting strategies.

To assemble a team of specialists from a teaching establishment who are sufficiently interested and motivated to cooperate in the use of interrelated curricula.

Strategy: Identification of a coordinator who has specialist knowledge and teaching experience in one or more of the related areas. There must be a full acceptance of the new subject INTERRELATED STUDIES within the establishment. This would not mean that specialist subjects would no longer exist in the timetable any more than one would expect, for example, mathematics, science, English and other topics would not exist for students studying A-level general studies in the United Kingdom.

To motivate the students to learn.

Strategy: Use of colourful, attractive and well-prepared materials which relate to the real-life experiences of students. The cooperation of local commercial and industrial organisations must be sought - it is the experience of the author that a considerable amount of support is usually available.

The prepared material should take into account teaching strategies, programme planning, laboratory management and assessment. Teachers need help in these strategies right at the start so that they can develop new curricula.

To ensure that teachers are sufficiently prepared to cope with an interrelated approach, by means of an available teacher/pupil module and separate pupil modules.

Strategy: Preparation of separate teacher and student modules. The teacher module, while containing the student's material will be much more comprehensive in respect of background information, and the use and variation of this material will be at the discretion of the teacher. Solutions, hints, etc, for student exercises will also be provided. The format of the teacher module will clearly show the separation of teacher and pupil material. The teacher/user must understand that the content of the module will require regular updating by the teacher.

To draw on the experiences and particular interests of students.

Strategy: Teachers and students will need to bring together skills, experiences, knowledge, understanding, imagination and judgement in order to solve a problem. The teaching of these will be a difficult task but it is hoped that students will learn through experience and practice under supervision by the teacher.

Students' experiences, though sometimes not first-hand, are always relevant, eg, space travel through television broadcasts. It is important to give guidance on the collation and recording of experiences and interest material. An example is that of newspapers, being particularly useful as they regularly report on developments in commerce, industry and technology. To ensure that the treatment of important phenomena is at a level of explanation suited to the students.

Strategy: Demonstrations will help to show the results of theoretically derived relationships. Actual experiments carried out by the students should be encouraged for them to understand the explanation of the phenomena under investigation. Where results are to be expressed graphically, a linear graph should be used and, where appropriate, a log-scaled graph (detailed explanation of logarithms may be left until a later stage).

To consolidate learning processes by suitable student exercises.

Strategy: The exercises should be requested as the response to key questions and in simplest form this could imply a descriptive essay. At the other end of the scale, problems requiring numerically calculated answers should be applicable to real-life situations, whenever possible. Practical and investigative assignments would need to be carefully structured and checked for continuity, with particular attention paid to the time for completion by the average student. Where there are weaknesses in pedagogic, arithmetical and algebraic processes, suitable practice exercises (with self-checking facilities if possible) must be available. Using these strategies teachers should guide students towards independence in their learning as a preparation for the world of work.

To produce modules which are sufficiently flexible for a variety of teaching methods to be employed.

Strategy: There must be regular discussions between members of the teaching team to promote a greater use of audio-visual aids. If such aids are in short supply, eg microcomputers, it is acceptable to have a single piece of apparatus for use with a class. As an extreme example of the non-availability of apparatus for student use, the teaching of atomic energy generation has to depend entirely on slides, films, models and diagrams.

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5.4.4 Preparation of Modules

The following guidelines on the preparation of interrelated modules are based on experience gained in the development of the modules on measurement. It must be emphasised that there is <u>no</u> unique 'modus operandi' in this process and teachers will use the most appropriate method, depending on the resources available and the conditions prevailing in their own countries.

Preliminary discussion should be held amongst teachers regarding the need for an interrelated approach in teaching within a certain topic area. This should identify a topic which lends itself to an interrelated treatment in the form of a module(s). Once a decision to produce a module(s) is made the following steps to develop it may be taken. It is essential that clear objectives, based on sound educational principles, are adhered to in the development of such a module.

Guidelines:

- Assemble the 'teaching team'
- Outline the plan of action using a flow/schematic diagram, decide the title (which may be revised), and set the time schedules for module construction
- Define the target student group (age, range, pre-requisite knowledge, type of educational establishment)
- Formulate the general and specific objectives
- Produce motivational material to show teachers and students the relevance and interrelationships of the topic

Note: this could be achieved through illustrations, purposefull in style and related to practical settings. Suitable material could be obtained by:

Contacting commercial/industrial establishments to gather advertising, audio/visual materials

Seeking the cooperation of parents of students to obtain support material/equipment

Encouraging teachers and students to explore the local environment for pictures, specimens (biological, physical, chemical, geological and ecological) and locally available material in order to make low-cost equipment to support the practical content of the module.

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- Allocate the following to the members of the team as individual or group assignments:

preparing motivational materials in the form of texts, charts and tables pictures (in colour or black and white) overhead transparencies slides/audio tapes films/video tapes teacher modules in text form (with diagrams, illustrations) student modules in text form (with diagrams, illustrations)

- Assemble selected draft material, ensuring that the key points in the modules are suitably highlighted
- Discuss the final draft within the team and consult external bodies/persons. Modify as necessary
- Formulate procedures for testing and evaluation in a 'Pilot Study'. Agree procedures with students/teachers/parents/ education authorities and any other parties whose involvement is essential for the success of this approach

Note: It would be highly desirable to supply at least one original set with the multiple copies, so that participating teachers and students could see the module in its original form

- Test the final version as often as necessary before making it available for general use
- Explore the possibilities of getting the module 'published' so that a larger body of students and teachers could use it.

5.4.5 Implementation

Provision of suitable accommodation should be given consideration in the initial discussions by the team. It is possible that a room suitably equipped to teach interrelated modules may not be available for some time. However, it must be stressed that much can be achieved with few resources given the right enthusiasm and careful planning. Suitable in-service training would help to make members more familiar with disciplines other than their own. The availability of resources is bound to vary and it is quite conceivable that extra funds may not be immediately available to purchase equipment. The teacher should study the feasibility of using available resources in the most efficient way - this would certainly require cooperation and assistance from teachers outside the team.

Assessment should be discussed to formulate an appropriate scheme, although this may not be possible at the commencement of the programme. After some experience of teaching the module as a team, methods of assessment should be suggested, tried and modified in the light of feedback.

Educational technology should be adopted whenever possible by teachers everywhere so that their students find some excitement and interest in the presentation of the modules.

Many would argue that resources are not always available and the purchase of sophisticated equipment is out of the question. However, the most costly does not necessarily imply the most educationally effective when it comes to equipment and much can be done with simple self-constructed equipment. More will be said of educational technology later on.

5.5 · Development of Measurement

5.5.1 Measurement in a Broad Context

Many of the cases of measurement which occur in everyday life pass by without being thought of as measurement. For example, when sighting the bus before one has reached the bus stop one has to measure the time required to run to the stop in time to catch the bus. No measuring instrument is involved in this task. If a bricklayer wants to know the area of a semi-circular yard so that he may work out the number of paving stones required to pave it, this cannot be measured directly but has to be related to mathematics via the appropriate formula: the author defines this as 'indirect measurement'. On consideration direct measurements are only possible for length, mass and time. Writing on this narrow aspect of measurement in schools [92] Livingston, one of the researchers for the Bath Project [93] which was commissioned to report to the Cockcroft Committee of Inquiry, described the work of the project in producing and evaluating examples of mathematical skills as they are used in employment. Reporting on interviews with employees across the range of employment, she found their most commonly expressed need to be:

... not for 'the basics' (and that means different things to different people) but for an ability to make sensible decisions about 'basic' manipulations. They require a 'practical facility with measurement' and 'accuracy', and an 'ability to solve problems'...

To illustrate the above statement it is reasonable to state that in schools practical measurement involves finding the length, weight, capacity of various containers, recording these measurement data on a piece of paper and perhaps manipulating the figures of the data. For an employer, practical measurement means for example that a telephone order from a shop to a wholesale bakery for 800 loaves for the next day must be questioned if shop orders have always been about 100 loaves per day; also that if the container used for measuring out coloured tile grouting cement weighs 0.9 kg then the weight of the container with cement cannot be 0.6 kg. Similarly accuracy in school means obtaining the one and only one answer to a question as for example the following GCE Ordinary level examination question A9 [94]:

Find the radius of a sphere whose volume is 64 times that of a sphere of radius 60 mm.

In this question the radius cannot be measured practically, is given precisely and 64 is chosen because the cube root is 4 exactly: but what practical basis is there for such a question?

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Again from the same paper A6 reads:

A man estimates the width of a river as 70 m. Given that the actual width of the river was 63 m, calculate his percentage error, giving your answer correct to three significant figures.

It is likely that most people would consider 'about 10%' to be a reasonable response especially as one would not expect the widths to be what they have been stated to be precisely 70 and 63 metres respectively. In industry an appraisal of the measurements to produce a reasonable estimate is what would be looked for. Moreover, what is learned in school becomes firmly entrenched and is brought up into Further Education where little time is available to change some of the school ideas.

5.5.2 Case Study: Measurement and Catering

5.5.2.1 Background

To be more specific on measurement as it is experienced, a case study from a field which must be known to everyone is now considered: catering. Let us look at some reports of industrial experiences of a number of students in a Department of Hotel, Catering and Food Science of Wirral Metropolitan College. The particular CGLI course the students were following requires them to take up work experience for a period of five weeks in the second of the two-year full-They are placed for training by the college time course. staff and the places of work vary from perhaps a small cafe to the kitchen of a large hospital or hotel. Arithmetical calculations and the use of mathematics are found throughout the course whether it is for ordering supplies for the college training restaurant or running the wine bar in the restaurant. Therefore, although the CGLI examinations are not specifically about mathematics the weaknesses of some of the students in the applications areas makes it necessary to devote a period of one hour per week to what is termed 'calculations'. The course is internal with no set syllabus in the sense that a lecturer can adjust the instruction to

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suit the clients and can relate to the practical side if they are sufficiently motivated. Problems which arise are, for example, estimating the production cost of a meal and fixing a selling price, working out bulk quantities, and organising cooking schedules which involves timing. All these activities are heavily dependent on measurement. Such measurement may be carried out by instinct, eg in the use of salt. In order to obtain some sort of overview of any mathematics and measurement involved in the various catering establishments the author asked a class of students to deliver short verbal accounts of their experiences after returning from the period of industrial experience.

The author first posed the question to the class:

Did you do any mathematics?

The reply was:

Of course not! We were catering.

The following notes were from the verbal accounts of five individuals, delivered in front of the class, of their work experiences. Some of their responses were prompted by questions asked by the rest of the class, which the author encouraged. No more than five could be induced to stand in front of their fellow students and if there had been an attempt to tape record the speeches then they would probably never have taken place. The notes were written by the author during the lecture and are not intended to be a full account of all that was said but more a record of the main points brought out by students or by questioner. The different styles should be noted; in particular the orderly way some of the information was given (the order has not been changed, nor the content). Each account starts with the name of the firm or establishment where the work took place and all except number 2 are household names. Indirectly number 2 is connected with industry, particularly shipping,

because the office block houses a lot of shipping and allied trades offices serving the seaport of Liverpool.

The aim of this research exercise is to identify mathematics in catering tasks and to show that the purpose of the mathematics is to achieve measurement.

5.5.2.2 The Reports

1 John Moores Centre (Football Pools)

Numbers served: Approximately 800 people in eight sittings of one hundred.

Staff: There were four cooks and nine assistant cooks.

Menu: Chicken soup, braised steak. Toast dish. Fish dish. Sweet.

Service: Waiter and cafeteria.

The week: Start the day at 7.45 am 6 days per week; 38 hours per week.

Pay: Unpaid, free meals.

2 Basement Canteen, India Buildings (offices) The day: 8.30 am to 4 pm. Break at 10.30. Dinner at 1.30. Staff: Ten in the kitchen.

Service: 200 to 300 meals are served at one sitting. The canteen has half waiter and half self-service.

Menu: Chicken, beef, chips. Fish and chips on a Friday.

Wages: Staff wages are £42 per week.

3 Mobil Lubricants Plant

8 am to 3.30 pm The day: Eight staff make sandwiches until 9 am for the break period which is from 9.30 to 10.30: sandwiches or cooked breakfast available. Sandwiches are sealed in a polythene bag with heat. 90 sandwich packs per day. Fillings for sandwiches: margarine with salad or egg or cheese. After breakfast tidy up and get own breakfast at 11 am. Start dinners at 11.30 and serve until 1.00. Tidy up. 1.30 to 2.15 get own dinner: tidy up. There is a workers' canteen and a staff room. Canteen workers earn less than £40 per week and have asked for a 12% rise.

4 Shell Oil Research Centre (Thornton)

- The day: Leave home at 7.15 am to arrive for 8 am: finish at 4.20 pm Prepare bread and butter in the morning. Serve 170 meals per day. There are three chefs. Visitors and workers catered for.
- Menu: Salads. Fish and chips. Drinks: coffee, tea, orange juice.

My pay: £5 per week.

5 Champion Spark Plug Factory

Staff: Outside caterers are employed on a contract basis. The 900 employees are served about 450 meals per day. The total annual cost to the firm is £400,000 which makes a loss since the meals are subsidised. Cheap good food is provided for the workers. Two shifts: 6am to 2 pm; 2 pm to 10 pm and there will soon be a third from 10 pm to 6 am. Early breakfasts: 7.30 am to 8.30 am Late breakfasts: 10.15 am

Menu: Salads, sandwiches and pies.

Wages: £2.90 per hour for kitchen staff.

5.5.2.3 Observations

It should be noted that the students do not expect to be paid because they make use of the firm for experience. There has been quite a lot of measurement here: time, sandwich and meal counts as well as costing and even percentage managed to make an appearance. It is also obvious that there must have been quite a bit of mathematics behind the scenes to calculate bulk quantities. All these points were discussed and most of the students could see that the measurement involved required some mathematics. Communication was also very important, between members of the staff and between the staff and customers. There did not seem to be a lot of written communication, however. Generally the students had enjoyed their work except for two of them who had not because they were used at the Holiday Inn hotel as cleaners instead of being allowed to carry out cooking and related duties. It is important to note that:

this case study is a good example of the necessary use of basic mathematics by people who do not take kindly to mathematics lectures as such. <u>They</u> <u>accept the mathematics because it is related to a</u> job which they like doing.

The analysis of what the students were involved with could have been taken a stage further into 'technology' when one considers the modern catering equipment used in large kitchens. Very much in evidence, if the students had been questioned in greater depth, would have been 'science' which is involved in selecting what to eat as well as the preparation of the food.

5.5.3 Measurement Through Slides

5.5.3.1 Examples of Measurement

The research team took to the task of investigating 'measurement' with enthusiasm and interest. Professor Bajpai suggested that a short programme of slides would be an effective way to convey the team's ideas. A number of meetings and discussions were devoted to this task.

....

The slides were to be chosen so as to present as broad a view as possible of 'measurement' across the spectrum of mathematics, science and technology. Of equal importance was the maintenance of continuity between the scenes represented by the pictures and lastly a major aim was to cover the basic measures of time, length and mass as evenly as possible. Sources for the slides which were made (occasionally ready-made ones were obtained), were 'industry'in the widest sense in the form of advertising literature, information publications and catalogues. The cooperation of industry was excellent and the desire to help the slide project was most commendable. In some cases offers to produce slides were received from firms. There were no problems over copyright and indeed the slides (intended for distribution as far as possible) were seen as providing some publicity for products and in this way participation in the project was welcomed. An excellent focal point for industry and education is the annual Education, Training and Development Exhibition and Conference [95]. The extent to which this represents industry could be judged from the range of exhibitors. The exhibition represents industry in many countries, as can be observed by listening to the many languages spoken by exhibitors and visitors to the stands. Another source of pictures and information was from attendance at an Open Day held by the National Physical Laboratory which was held in 1984 and for which invitations were sent out [96].

Any reference to the importance of measurement would seem somewhat incomplete without referring to the National Physical Laboratory. To quote from the brochure for the Open Days:

Manufacturing industry relies heavily on measurement for optimising the efficiency of its production processes, for maintaining healthy and safe working conditions and for ensuring the environmental acceptability of its activities... national and international consistency of such measurements, and hence their accuracy and reliability, depend on the National Physical Laboratory.

The nature, extent and international standing of the work carried out at the Laboratory is in itself an excellent testimonial to the importance of measurement.

On each of the Open Days visitors were able to see laboratories and workshops functioning normally and talk to scientists and technicians. An example is the section which investigates thermal properties of insulating materials used for buildings.

The author was able to obtain useful information to incorporate in a module of study for the Building industry. The British Oxygen Company was also present in the industrial exhibition section, and information on liquid gas densities and many other properties was obtained for use with a module based on 'Tanks' which will be referred to later when considering the early trials of modules. A bank of slides was gradually built up using all the available sources and contributions from the research team. The slide programme was eventually decided upon and was designed to run for about twenty minutes at the most. The next task was to put together a commentary with due regard to continuity between the scenes represented by the slides. <u>As an attempt to highlight the importance of</u> measurement without simply saying it or writing it on a slide

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the author constructed the following mnemonic in which each letter is a cue for a sentence and there is consistency between the sentences.

Man/woman from the beginning of evolution Experiences many phenomena, Asks many questions and, Seeks through an enquiring mind Universal and all-embracing Reasons and laws. As a result Evolves and tests Mathematical and quantified Explanations in terms of Numbers from simple to complex in order to develop Technology for the use of man/woman

This set of sentences became the second slide of the set the first being simply a logo using the word measurement' repeatedly. Brief descriptions of the banks of slides used to select the programme (110 in all) is shown in Appendix 5.2 with the actual programme set in Appendix 5.3. Appendix 5.4 gives the slide commentaries. It is important to realise that the selection could be varied and so could the bank for use with different groups, ie educators, educational administrators, teachers and students, and as will be seen this did happen to a minor extent.

5.5.3.2 Adding Sound to the Slide Programme

Following the selection of the slides the next task was to write a commentary. Again this was a team task and by this time the team approach was seen to be working because three views proved to be more efficient than one at spotting improvements or obvious changes and also the team members

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brought experiences from three different educational fields. As an example Professor Bajpai was insistent from the beginning that the commentary, although written, would have to be recorded on a sound tape cassette because then the cassette would be available for anyone to use in any part of the country or indeed the world (the cassettes travel like letters).

The live commentary required some rehearsal and the ability to deliver a continuous commentary in phase with the slides which would have to be done manually by the commentator. It was therefore decided to synchronise the sound with the slides using a synchronising unit which puts inaudible pulses on the tape which cause the next slide to drop. The time between pulses (slides) has to be phased in with the commentary as well as the interest content of the slide. At the same time if the slides drop too quickly and the commentary is delivered too quickly the audience will not be able to follow through the message of the programme. The following apparatus was used:

Projector - Kodak Carousel S-AV2000 Pulse generator - Philips Slide Synchroniser N6401 Recorder/player - Philips Sound Cassette Recorder N2229AV

Only minor changes were made after initial trials and these were:

- 1 The sentences of slide 2 could not be read because of the density of the writing. It was split up into three slides and the sentences were put into the commentary.
- 2 Both Concorde slides, 32 and 33 were French versions so the second was changed to a British one.
- 3 The last slide, a diagram for interrelated studies, in black/white could not be seen and its message did not register so it was removed and the 'orange' slide took

the final place. This slide was considered to be most effective in conveying the message of 'interrelated' approach of teaching within the framework of a 'whole' system represented by the orange; the segments of the orange representing the individual academic subjects.

4 A penultimate slide was added to show a group of musicians to illustrate a harmonious relationship within a group of any kind.

The commentaries were adjusted and the programme synchronised again. Extracts from the slides together with their commentaries are illustrated by the photographs in Appendix 5.5.

5.5.3.3 Using the Tape/Slide Programme

As has been mentioned the programme was intended for educators but it is probably correct to state that most of the scenes in the slides, and indeed the words and phrases in the commentaries, have been experienced by, say, television viewers in some context or the other. Difficulties are likely to arise in the appreciation of the message being conveyed and the concentration on measurement and its significance. However the author has used the slides with:

1 a Youth Training Scheme class of bricklayers

2 the module Introducing Science, for adults

3 teachers during their in-service training course.

More will be said of the use of the tape/slide programme when the particular circumstances arise.

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5.6 The Module in Further Education

5.6.1 A Decision: Where to Use a Module

In Further Education establishments most courses are dedicated to some objective such as a technical gualification or some remedial work in, for example, mathematics and English. Anything that appears to be outside the coursework necessary for success would be questioned by the students. Thus the first decision is to find a place for a module inside the limits of the time allocated to an existing course by using some of this time as an alternative way of enabling the students to achieve the course objective. As an example of time allocation most GCE Ordinary courses occupy one college year from September to June with a total class contact time of approximately 200 hours. Within this time the complete course has to be covered because one has to cater not only for the examination, and in some cases re-examination, of candidates but also for certain adults who have never studied the subject before. The corresponding time allocation in a school is three to four times the further education period, spread over eleven years. So someone has to make a decision to act and therefore justify the new method with its attendant departure from tradition. Justification for this action is supported by section 5.2. Putting the students on a diet of facts and notes copied from a blackboard is reminiscent of school so that a change in this format would be more likely to stimulate some interest in the subject which had been found boring in the past (ie at school). The study of this subject can : fail unless considerable thought and preparation are put into it to make it interesting and relevant for the learner. One subject which came to the author's mind is Computer Studies (sometimes called Computer Science). For the TEC programmes study unitt titles are 'Use of Computers' and

⁺ A TEC programme of study, say for a Higher Technician Certificate, is made up of a number of units which usually reads like (and is often treated as) a set of separate subjects.
'Computer Assignments' and have a practical bias: thus class exercises can be devised around useful applications. Research into the teaching aspects of a number of units including 'Use of Computers' at level 2 [97] was aimed at finding out, amongst other things, how the units were The Technician Education Council informed being interpreted. all establishments operating Technician programmes of study that it might call for information on how the subject was taught, material used etc, to use in its research programme. The author was anxious to learn of the result of this investigation so that he could compare the approach of others to a unit heavily weighted with factual objectives with that of an interrelated approach. After some searching of files across departments the response from the Technician Education Council was that the research project was discontinued because there had been only three responses to the request for information. Since the Council supports its investigations and projects will full-time staff at all levels, there did not seem much point in the author mounting a similar survey. However, the author spoke to Council staff concerned with the subject and there was no objection to the use of an interrelated approach. The author also made sure that he met the subject moderators and explained his course of action, showed samples of modules and work and they seemed quite pleased to see a practical approach which would be useful in relation to other subjects. As the moderator has the function of assessing the work of both student and lecturer it can be assumed that there was some approval for the author's methods. At the university level contact with a computer can be for a different reason, namely to provide remedial mathematics tuition [98], while at the primary and secondary school levels, where partial government funding has been available nationally, each school has at But providing the equipment or least one microcomputer. even a syllabus does not give the teacher the essential guidance on how to obtain the best use out of the equipment which has so many new concepts in its operation. Cox [99]

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raises a number of questions applicable to any level of teaching when considering 'computer assisted learning':

Does it enhance my current teaching methods? How am I going to use it in the classroom? Does it fit within the course I am teaching? Will it be worth dropping some other activity to include the computer program? and

Can I use it as a simple demonstration, or in a flexible way for several lessons?

<u>Some of these questions might well be answered by an inter-</u> <u>related approach</u>. In the immediate post-school domain, Youth Training Schemes stipulate some contact with a computer [100], within the context of useful applications in training.

To summarise, the computer could be used to instigate innovation in education which would be acceptable providing it could be shown to be educationally beneficial. In later sections accounts of how the author has used the 'computer' teaching units to introduce other subjects via an interrelated approach will be given: the teaching unit objectives also being satisfied within the allocated teaching periods. <u>Thus the problem of wishing to innovate but not having the</u> extra time within the time-table is dealt with satisfactorily.

5.6.2 Suggested Components of a Module

5.6.2.1 Hypotheses

It is important to be able to state in a simple way what benefits one can expect from using the 'module' approach instead of conventional teaching. A module will aim to test <u>some</u> or <u>all</u> of the following hypotheses:

- <u>H1</u> Teaching in an interrelated way makes <u>mathematics</u> <u>more acceptable</u>.
- <u>H2</u> Teaching in an interrelated way makes <u>classroom</u> learning interesting.
- H3 Teaching in an interrelated way supports the needs of modern industry for a broad base of education and training and the use of new technologies.

H1 and H2 can be tested by analysing and appraising discussions with, and observations of, the students at work with the modules. H3 will require testing by analysing and appraising responses to practical or theoretical exercises and assessing discussions.

The module will be accompanied by Notes for Lecturers which will help the lecturer using the module who is not particularly specialised in the subject of the module. Flexibility is intended which means that the contents can be varied to accommodate varying levels of ability. For example first year craft bricklayers, when testing concrete blocks, could simply be told to take ten samples of concrete and find the arithmetical mean of the results of a test such as crushing But Building Diploma students can be introduced strength. to more sophisticated statistics such as the coefficient of variation (which is mentioned in the British Standard Regulations on concrete blocks [101], because they need this in testing. Another example from the same field is the use of approximately sixty bricks for one square metre of wall for, say, first year craft bricklayers, but the more exact value $1/(0.225 \times 0.075)$ for Diploma students. Both sets of students have to be users of this information so there is no point in writing two versions of this section, one for each type of student. However, if a craft bricklayer shows interest in

just how the accurate value is worked out some attempt must be made to feed the interest such as by having a sheet of notes on the point.

5.6.2.2 Module Sections

The following sections are intended as a guide to the construction of a module and may be varied to suit particular circumstances.

General Objectives Specific Objectives Knowledge Tasks Exercises Information Pack

Objectives can be varied to suit classes, time available and to accommodate syllabus requirements. The tasks are practical things the students should do in order to become informed. For example a task could be to view some slides or an overhead projection of a diagram; or it could be something carried out outside the classroom such as asking members of the public for their opinions. Exercises which have anything to do-with mathematics immediately conjure up visions of calculations or algebra problems. Repeated practising of certain techniques may be required of some but this is not an objective of a It would be much better if the use of the techniques module. for some purpose such as investigating the relationship between the reading error of a weighing machine and the magnitude of the reading were to generate the practice. Again the term 'exercise' is used to show the student that something now has to be carried out by means of a personal effort, but the exercises should be seen as problems for which there may not be one simple solution. The student will also have to make

some decisions as to methods (with the help of the lecturer, if necessary) such as using a computer to carry out repetitive arithmetic. In some of the modules tasks have been suggested which are practical such as calibrating a model of a tank in, say, the physics laboratory, which will require some teamwork between lecturers. Obtaining realistic exercises is not always easy but the effort should be made and this is where the use of industrial information becomes important. The information pack can be made available to each student or just a few copies supplied, especially if it is not going to be used too frequently, or if resources are limited. This will mean either changing some exercises or instructing the student to concentrate on certain topics. For example, the general objective:

Uses basic notation and rules of algebra

from a TEC Level 1 Mathematics unit has the specific objectives:

Represents quantities by symbols and numbers which could be changed to:

represents quantities by symbols and numbers in

organic chemistry.

This would then focus mathematics on the relationship that it has with chemistry, if this is also a subject to be studied.

Tasks could involve visiting a library, or viewing slides, or studying a diagram using an overhead projector. A task could also be undertaken outdoors as when sampling opinions from the general public. Making a list of measurements in certain situations, for example gardening is another example of a task. The instructions for the task should be as clearly stated as possible in the text but some discussion and answering of questions will probably be necessary. The exercises could be theoretical, experimental or a mixture of both. An example of a mixture of theory and experiment is when applying statistics to data gathered from a survey or a series of laboratory experiments. It is worth mentioning that the theory of the use of a statistic is not usually the prime concern of the user.

'Educational Technology' is the term applied to teaching equipment and it is no use making a module very heavily dependent on sophisticated equipment although it is sometimes easier to obtain the use of a computer system than it is of, say, a slide projector. However, a good search of an educational establishment can often lead to equipment not previously suspected of being in existence. Much can be accomplished with little and this applies to making models to demonstrate technology. A regular feature of the publication Scientific American is the article The Amateur Scientist [102] which often contains instructions for making models. Very explicit in its supporting instructions for demonstration experiments is Building Craft Science [103] where the science is transferable to other disciplines.

Good reference sources which are usually current and available free of charge are leaflets and booklets used to publicise manufactured products and services. There are also many government publications issued through, for example, the Department of Industry. One advantage of using these sources is the excellence of the reproduction of drawings and photographs which save much time in describing situations. Oil companies and nationalised industries (eg coal, electricity, gas and water) usually provide some free educational services which include posters and charts as well as films. Travel brochures can sometimes supply useful information on other countries as well as illustrating the use of vectors, rates of currency exchange and modes of transport.

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5.6.2.3 Notes for Lecturers

These should follow through the module sections, adding further notes as necessary, bearing in mind that a module dealing with bricklaying may not mean much to a lecturer from a Department of General and Communications Studies. Thus the provision of adequate reference material or sources, without overwhelming the lecturer, is important. It may be hard for the mathematician to appreciate how difficult even simple mathematics is to the non-practising lecturer, who is just as entitled to forget things as the specialist. An assessment scheme could be appreciated but some lecturers like to construct their own. Solutions to problems, however elementary, would be helpful as a check on students' solutions. The use of special equipment may be required such as the overhead or slide projector and the question arises as to how reasonable it is to expect a lecturer in another college to provide this, bearing in mind the time and trouble this would involve. Yet many establishments have the equipment and even as far as the computer is concerned there is usually one available somewhere.

Without some effort by a lecturer the benefits of innovation will not materialise. These notes end with some guidance information on assessment, bearing in mind the broad way in which the hypotheses have been set up: for example whether or not the students enjoyed working with a module, even if it contained mathematics which they do not generally like, is covered by H1 and could be assessed by observing how they worked, if they were eager to start or even sang while they worked! On a serious note, <u>once they are seen to enjoy the</u> work then the module becomes an 'open door' to learning. Finally, if scores have to be awarded the following descriptions of the scales available in the order of precision are set down:

<u>Classifactory</u>	- for example: likes theory, likes practical
Ranking	- for example: very interested, interested
Interval	- for example: a temperature scale (no zero)
Ratio	- for example weight (interval scale with zero)

If the exercises are such that they can be scored numerically then the ratio scale can be used and with it a collection of parametric statistics. However the question without a unique answer which requires some thought and investigation in different directions, such as 'how would you provide heat for this house?', would serve the student better if marked according to effort and ideas by a ranking scale. It is interesting to note that the GCE Examining Boards which serve many members of the general public (in several countries) only provide results of their examinations on a ranking scale to the candidates. Two candidates can be awarded a Grade A pass and they will consider themselves of equal merit because the ratio scalings are not disclosed. Written assessments are the commonest means of examining performances but these sometimes go with a verbal component as with the GCE examinations for foreign languages. This method can strike nearer to a true evaluation of what a candidate has gained from a course because, although the idea in a candidate's mind is the correct one, whether or not it is conveyed to the examiner depends partly on the candidate's facility with the written word. When examining orally the examiner can ask for clarification of a point, but on paper what the candidate writes is final. Understanding can be tested more objectively when verbal interrogation is possible. If the student does not object and would not suffer from inhibitions then recording the discussions would ensure the capture of all that was said so that a careful analysis can be made later. In this respect, the tone of a reply can indicate the strength of an opinion or preference. Finally, special attributes such as the good use of a library may

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want to be assessed or just even commented on, as would be if <u>a diagram appeared in the student's submission</u> when it is known that few such examples are hard to come by.

5.7 Module Pilot Study: Measurement and Construction

5.7.1 Introduction

The trial to be described took place at Wirral Metropolitan College, Birkenhead, England, after the author (reference ST) had been approached by a member of staff (reference HD) of the Department of Building to assist with that part of a Youth Training Scheme college-based ('off-the-job') educational programme which dealt with Information Technology. The syllabus reference to the subject was very brief in that it indicated that there should be some form of 'computer awareness realised in a practical way' and left the details to be filled in by the teaching staff. ST responded with the suggestion that the computer should be used in relation to building problems, seeing in this approach the potential for developing a module as a research exercise. HD agreed to this and asked for the lecture programme to start the following week which did not give much time for the preparation of individual written modules. This was overcome by obtaining the use of a room with about ten computer systems and storing the written text of the lecture (kept to a minimum) on a disc and loading it into the memory ready for use. An important advantage of this method for research is the ease with which text can be altered in a very simple manner in the light of trial experiences whereas prepared copies of a text would have to be completely replaced at the expense of time and resources. Providing the students would not object the method would be used to develop a series of notes, worksheets, etc, into a module. After the Information Technology period the students would have a short break and then be taken by HD again for 'Building Technology' and their experiences in this could be used during the period with HD and ST to develop a module based on 'building' tasks.

The author's ideas would be to involve mathematics as it relates to measurement in 'building'. The hypotheses stated in section 5.6.2 (hereafter the hypotheses) would be tested by monitoring the students' opinions, behaviour and classwork. The computer would be used in a practical way that would be of benefit to the industry. The ideas of the interrelated approach were discussed with HD and he liked them: this then was the birth of a team approach (HD leading, ST the other member of the team of two) from which a module of study would emerge. The students would be working in a multidisciplinary environment with HD providing technical and vocational components and ST mathematics, science and practical computer technology. However each member of the team agreed that there would be no operating principle which involved rigid demarcation lines for allocating particular subjects to a member of the team. Thus as far as science was concerned HD could bring in the scientific names for cement components (eg lime) and then ST could intervene with the chemical name and composition, in a smooth and conjunctive There would be five weekly periods of ninety minutes way. each available to develop a module. The events of the first or pre-trial period are now described.

5.7.2 Planning The Pre-Trial Period

This period would enable the students to get used to the computer and the involvement of more than one subject, and the team to get some experience of how to deal with the integrated approach and assess the value of using the computer. This was very much a learning period and would probably show up much that could not be planned: team discussions after each period would help future developments. The following was the planned sequence of events:

 A brief introduction to the use of the computer keyboard would be given by ST for the purpose of reading information from the computer and obtaining answers or solutions to problems from the computer for checking.

- 2. HD then explained how the practical technology of building walls requires the use of mathematics to enable material quantities to be estimated and costed. He also explained the concept of the standard brick, one of many available brick standard forms.
- 3 HD and ST jointly described ways in which the number of bricks required to build a wall could be estimated. One method is to find how many courses (rows) make up the height of the wall and multiply this by the number of bricks which will make one length of the wall: a11 this will have to take into account is the thickness of the mortar (bed) which is 10 mm unless otherwise given. Another method is to estimate the number of bricks per square metre of wall and multiply this figure by the wall area; a figure of 60 is often assumed to ease the arithmetic (more exactly 59.259...). It is important to convince the student that the two methods are MATHEMATICALLY EQUIVALENT, using algebra if acceptable; at this point the mathematics ceases to be 'basic'.
- 4 Also in this period (a lot has been planned for this) the basic multiple choice test described in Chapter 2 would be carried out with the intention of measuring the students' abilities; this was in response to a request from HD.

As far as using the computer to receive instructions and text all the student had to do was type the command RUN when the following section appeared:

WALL CALCULATIONS

"Here are six problems of the same type. If you cannot do the first one then ask for help and you may be more successful with the others. The problem makes use of addition, multiplication and division and if you would like some practical examples in these techniques please ask. When you press the ENTER key as requested you receive more instructions and also are given the option of looking at either the answers to the problem you are working on or the entire working in easy steps."

Problem

A wall of given dimensions is to be built from standard bricks. The brick has dimensions:

face - 215 mm wide and 65 mm high depth - 102.5 mm

and the mortar bed is a standard 10 mm thick. Estimate the number of bricks required to build the wall.' The wall is then plastered ready for painting. If one litre of the paint to be used covers forty square metres of wall approximately and two coats are to be applied, estimate the amount of paint required. Sketch diagrams and use the paper supplied for rough working if this helps.

Dimensions of Walls

Number of Wall	Length (m)	<u>Height (m</u>)
1	22.5	8.5
2	45	17
3	2.25	8.5
4	200	30
5	250	50
6	20	10

Press << ENTER >> to continue.

<u>Note</u>: After pressing the ENTER key (RETURN on some computers) the options of the full working or just the answers would be offered, the user simply selecting a single key entry as indicated on the screen.

5.7.3 Review of the Pre-Trial Period

The team of two had a short discussion on what had taken place and it was decided that such a discussion would take place immediately after a module period so that changes of policy etc could be decided while the events were still remembered and this would possibly obviate further special meetings. The following points summarise the discussion:

- 1. The only special educational aids were the computers and these seemed to hold and maintain the interest of the students in what were simple mathematical exercises with a PRACTICAL BACKGROUND.
- 2. In order to estimate the number of bricks the technology of bricklaying in respect of taking into account the mortar thickness had to be brought into the problem mathematically and this involved sketches etc.
- 3. Some of the students asked for copies of the problems on paper, but this first exercise was not to be part of a module as it was just to test the INTERRELATED approach to teaching mathematics and building technology. The use of some computer technology was also under investigation.
- 4. There were twenty-three students (rather a lot for the room) and HD said that this number would be reduced from next week as some were joining a Technician's course; he also said that this week's test should be carried on next week as it was worth doing, seeing that the students were interested and were being extended MATHEMATICALLY without protest.
- 5. HD decided that there should be five more similar weekly periods devoted to technology, mathematics, and science, for example when it was necessary to use 'density', and ST agreed. The same team approach would be used. The

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idea would be to incorporate some of the mathematics which HD would have to teach and also some of his technology. The teaching method would then be that of 'interrelated studies' which HD liked and found acceptable as long as the students enjoyed their learning periods.

- 6. HD stated that he would like the first of the next five periods to be used to carry on with 'Walls' but in a modified form which would include a short statement of the objectives of the series of work units, which would eventually form a module.
- 7. 'Measurement and the Construction Industry' was to be the title. Sections would be referred to as A, B, C, D and E.
- 8. The mathematics in the module would include the four rules of arithmetic, fractions, percentage, ratio, conversion of formulae such as that relating mass to volume and density, area and circle mensuration.

5.7.4 <u>Module Trial: Measurement and the Construction</u> Industry

The twenty-three students who had taken part in the pre-trial were now reduced to about twelve for the module trial due to partitioning into groups and allocating to other modes of training. Aims of the module were included as follows as the first piece of text to be read from the computer screen:

Aims

- 1. To introduce the use of mathematics for practical measurement tasks.
- 2. To show that 1. involves mathematics, science and technology in an interrleated way.

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3. To make a sensible estimate of the quantity of paint which must be purchased to cover the wall as required.

The other sections are:

Section B

- Objective: To relate mathematics and science to the use of mortar
- Knowledge: Definitions of mortar The properties of mortar and how they are measured Types of mortar commercially available
- Tasks: Look at the nine mortar laboratory tests from the slides or pictures and study the Information Pack (Appendix 5.6)

Exercises:

- 1. For each mortar test write down a brief explanation of any science or technology involved
- 2. Describe at least two mortars, giving the ratios of their constituents and possible uses
- Describe any chemical change which takes place during the setting stage of mortar and explain any possible disadvantages these may have
- 4. A bulk consignment of 200 m³ of TILCON ready-mixed mortar is ordered. Find the quantities of basic constituents which would be required and estimate the weight that the set and dried mortar would add to the structure. Try to set out a routine for any final volume of mortar (you choose the type) and perhaps investigate how the computer could help with the calculations involved: talk to your lecturer about this but don't spend too much time on it

5. What is the function of the lime in mortar?

Note on the Information Pack

This consists of information for class reference and is a collection from a variety of sources. The term applies to any of the author's modules, the contents of the associated Pack being suited to the use as well as the subject of the There may be extracts from published literature, module. notes from conversations with specialists from industry or photographs and diagrams supplied specifically at the author's request or extracted from literature. Sometimes the author has received offers to make the slides or photographs for him and these have been gratefully accepted; many industrial organisations employ publicity specialists and produce work of a very high standard. Examples of material not included in this thesis, but illustrating the breadth of the support given to the author, are available for inspection. Bond also found excellent industrial support and indeed both Bond and Turner agree that their modules would have been relatively uninteresting and uninformative had it not been for such sources. Another educational advantage which derives from the industrial contact is that industry itself becomes more aware of recent innovations in schools and colleges.

Section C

- Objective: To appreciate how the climate interrelates chemistry, physics, mathematics and technology through the brick
- Knowledge: Bricks contain various chemicals which were present in the clays from which they were made and which can react with atmospheric chemicals such as acids. Rain and atmospheric water will be drawn into the brick (technical term?) and

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thus increase the weight. So here we have physics and mathematics (percentage) to describe how bricks react with water

Tasks: Read about brick properties in the Information 1. Pack

Soak a brick in water for four hours.
Describe the changes which have taken place

Exercises:

- A wall is to be constructed from Redland Surrey bronze bricks which have an average weight of 2.8 kg and absorb 9% of their weight of moisture. If 200 bricks are used what will be the extra weight on the foundations due to the water? The calculation may be carried out in two ways
- The Ashdown Pevensey brick has a dry weight of 2.2 kg and absorbs 20% of its weight of water. Calculate the increase in weight of 10, 100 and 240 bricks
- 3. The Chailey 2.1 kg brick absorbs up to 14% of its dry weight of moisture. In a laboratory experiment a dry brick is weighed after soaking in water as 2.26 kg. What is the percentage absorption figure for the laboratory conditions?

Section D

Objective: To understand and use the relationships between volume, mass and density

Knowledge: density = mass/volume mass = volume × density volume = mass/density Tasks: Study specifications of construction materials and write down as many instances of the use of the terms 'density', 'mass' or 'weight' and 'volume' as you can find. Note the units used

Exercises:

- The Tilcon company provides a ready-mixed mortar service to a building site. In one case a mortar of ratios 1:1:6 (cement:lime:sand) is delivered in their standard 0.3 m² containers. The average wet density is 1800 kg/m⁻³ and set and dried the figure is 1650. Calculate the wet and dry weights of 10, 20 and 30 container deliveries
- 2. Set and dried mortar has an average density of 2000 kg/m⁻³. Find to the nearest 1%, the volume of mortar which 'belongs to' one standard brick which is part of a wall, compared with the volume of one brick. What will the percentage figure be for weight if brick can be assumed to have the same density (this is reasonable) as the set and dried mortar?
- 3. Find the density of water. TACBLOC aerated concrete blocks have a dry density of 630 kg/m^{-3} and absorb on average 3% by volume of water. Find the weight of water absorbed, state the effect on the volume of the brick and then work out a value for the new (wet) density of the block

Note

The TAC Construction Company manufactures lightweight concrete blocks which achieve their low density by using gas to form spaces as one of the manufacturing processes. The company also publishes [104] a technical booklet containing much useful material which relates to mathematics and is a very useful source of practical teaching material. It also has had valuable and willing support from the company. The same can be said for Tilcon Mortar Company [105] which has supplied the author with what is virtually a textbook on the subject of mortar, concrete and bricks and contains information which is difficult to obtain elsewhere. The author encourages students and teachers to write for free literature etc, because this keeps them in touch with the latest developments and the Construction Industry's products.

Section E

Objective: To bring together properties of circles and bricks

Knowledge: How circles are involved in the construction of simple brick archways and this brings in GEOMETRY and the value for the constant π which does not have a definite value

Exercises:

No set exercises were planned for this other than plotting on graph paper sets of coordinate points which, when joined up, would give the outline of a circular arch section, starting with the base length of the arch and the height of the top of the arch above this line. The more able student could also calculate the radius of the arch from a given formula (it is derived using the intersecting chord theorem) but the intention was not to get involved with traditional geometry The full computer text is not reproduced here as such. because it was not ready but what there was could be used. Again, because the students had to construct brick arches the mathematics was relevant to them although in a TECHNOLOGY INTERRELATED way only. This approach, in which the complex mathematics was hidden from the student (or arguably, the student was protected from it) by the computer, is considered to be an important research objective because it can justify becoming involved with the computer technology.

5.7.5 Report of the Trial

The atmosphere of the trial was encouraged to be one of discussion between student and member of staff and between student and student. If an instruction was not understood or some help was needed then the appropriate action was Marks were not awarded for 'correct answers' as in taken. conventional examination classes, the emphasis being on testing the three hypotheses. A similar room to that used for the pre-trial provided the accommodation. It was equipped with a number of computers and a dry-wipe white board. The computers were not the same as those used for the pre-trial but the author's view of such variations is in terms of more experience of computer technology: this fact also did not seem to cause the students any concern. The modules were now also available on paper as well as from the computer (controlled by the user) and the students seemed to prefer this latter mode of presentation. Writing paper for solutions to problems was available as well as plenty of paper for rough sketches and working. There was nothing the students used which could not be provided in any classroom in any other part of the country so the module was transferable as far as educational technology was concerned. The computer facilities happened to be available as they might be elsewhere, and were by no means essential. If the small element of computer use suggested in the module is noted and acted on then this would be a bonus for students for whom 'computer awareness' and use was not mandatory. There now follow reports on the sections as they were tried, with the use of the Information Pack material in Appendix 5.6.

Section A

This was not so much a repeat of the pre-trial period but a continuation. As repetition of similar problems was involved not a lot of interest was expected to be generated but, however, the students seemed to find the use of sketches and simple geometry quite absorbing. Obtaining help from the computer as well as relieving the lecturer of routine tasks seemed to be found interesting by all but one student. It must be noted that the generation of INTEREST IN LEARNING was to be one of the hypotheses to be tested and was a prime reason for proposing the module style of learning. Most found the relationship between the area of the wall contributed by one brick plus just 5 mm (half) the mortar all round and 'belonging to' the brick, difficult to understand: the impression of the author was that the importance of understanding this concept far outweighed that of getting the correct answer to the calculation. Here pencil and paper came into their own, as the relationship could be constructed with simple geometrical lines. The method introduced by HD (technology) was to find the number of courses (height of wall divided by height of brick) and then the number of bricks in each course (length of wall divided by length of brick) and then multiply these together. This is equivalent to finding the contribution of the face of one brick and its mortar to the wall area and dividing it into the wall area. This can be proved very easily by algebra, but would have been out of place here. It was eventually realised that this was going to be a problem for most students and that the essence of the difficulty was relating mathematics or mathematical ideas to technology. In this case, the technology was building a wall and this could not be accomplished without an adequate number of bricks yet at the same time one would not want too many. The formal method of teaching this would be to use algebra to derive or just present a formula and then use it without verification. The understanding of the relationships between mathematics, bricklaying and walls would then be lost. Some students' comments and questions were:

Will you start me off, I have forgotten how? How do you change millimetres to metres? When working out the number of rows what about the top one which has no mortar on it?

1.9 litres of paint would have to be 2 litres

Section B

This was introduced by ST with a short discussion, hoping for some dialogue. Why we use mortar started an interesting discussion which brought in technology and science for the chemical composition of cement. Sand, of course, was wellknown and this was linked with silicon and so round to modern electronics technology through the silicon chip. Measurement of mortar constituents was always by volume but technically how would this be done on a building site? This was asked in the module but needs more discussion than just a set of notes. More measurement came from the drying time of wet mortar, the hardness of set mortar and the ratio of constituents, as this is how mortars are classified - so relating to mathematics. HD suggested that it would have been helpful if a worked example to show how quantities of constituents for a volume of specified mortar were displayed on the overhead projector. Assistance was frequently requested when one component of a mortar ratio (such as 1:1:2.5) was not a whole number. The first ratio component is always '1' for mortar ratios. The practice of increasing the fraction of sand in the mortar was raised by one of the students and this of course makes it cheaper to produce with the technical effect of reducing the strength of the mortar. Lime, a plasticiser which helps to make the mortar workable, is expensive and so the more sand the better for the builder. The following discussion question was set to the class on this point:

One mortar has cement, lime, sand ratios of 1:1:6 and another ratios of 1:2:9. What is the fraction of sand in each mortar?

The fraction of sand in each mortar is 3/4 and this question was used to introduce the idea of a fraction as a comparison measure: this then led on to percentage, a very important fraction. The point of this exercise is that the difficult mathematics of fractions and their many forms was accepted in the context of and with the support of technology. It did not appear to the students that they were learning mathematics. Any other emphasis could have been chosen through the module, eg for teaching of computer skills. The team discussed this and agreed that the module was producing learning opportunities in areas such as mathematics which would not have survived in formal circumstances.

Section C

Difficulties were experienced with the use of the percent idea. This is not unusual and is found even at higher levels It is in common use in the construction of attainment. industry as indeed it is in many others. It was the experience of the team that the students did not want to be given a direct formula for substitution but preferred to try to understand the particular application from first principles in a way strongly integrated with the practical aspects; perhaps this then is one effect (not a bad one) of It was noted that mass and weight are using a module. considered as equivalent terms but when the force of the wall on the foundations has to be given, the mass must be multiplied by the gravitational acceleration to give a value in newtons. The technology lecturer came in strongly on the relationship between the strength of the foundations and absorbed water and also snow on the roof in the winter. These points could be given in notes for the lecturer, but not in any notes for students who would not then be able to reason

out (with a little prompting) the effects of climatic changes. Some observations by the team were:

- Placing the decimal point when multiplying by 10 or 100, say, could prove confusing
- 2. Constant refreshing of useful techniques through problems is probably needed during a working life and a short interesting module would suffice
- 3. Solutions written out on paper were not wanted
- 4. The less able students will try a problem and check their working by using the computer more willingly than if the lecturer does the checking for them
- 5. The verbal question 'a 100 kg brick wall absorbs 10% of water by weight, then releases 10%; what is the final weight?' produced answers: 100 kg and 110 kg

Section D

This section is by no means a repetition of the school density concept because industry has its own definitions and terminology to add. Thus the terms 'material dry density' and 'equilibrium density' would be enough to put any O-level physics candidate off physics, but these terms are found in connection with aerated concrete blocks and only have meaning when interrelated with physics, block material and mathematics. The emphasis can be placed on any of the sciences or technology to suit the class. The manufacturer's information book [104] gives plenty of scope to go very heavily into algebra and the computer can be brought in if experience is required in this direction. It appeared that the method of working with the computer was liked by most of the students (assessment of answers to problems was available in this way) who worked in small groups, argued, discussed and defended their individual solutions. The reluctance to invoke the computer until they were reasonably certain of success was also noticed

as a feature common to all sections of the module. A student who was shown to be correct by the computer, when others in the group were wrong, would sometimes make this fact known loudly. This demonstrated competition generated by motivation to succeed and the team were pleased to see that this was taking place in an <u>ATMOSPHERE OF PHYSICS AND</u> <u>MATHEMATICS</u>. The use of writing materials was still vital but the computer added to this the fact that the student did not have to wait for the lecturer; motivation to try exercises was very evident in respect of the computer checking facility. Even those who resented solving problems commented:

this is not the same as school

which can be interpreted as school methods having proved to have been somewhat <u>uninteresting or had failed to motivate</u> <u>them</u>.

Section E

This section brought in the very common circular shape found in brick structures which naturally involved the constant π . The problem of making a circular frame for the bricks of an arch to rest on so that the set shape of the arch will be truly circular can involve complex mathematics in the form of geometry. There seemed to be little to be gained from the evaluation formulae yet it is important to give some indication how the shapes are obtained, working within the ability range of the particular class (and it need not be a class of builders). The geometrical methods are well-known so it was decided to let the students see the very strong relationships between mathematics and a nicely shaped arch for the two algebraic methods outlined in the module. The mathematics behind the methods could cause A-level students to think hard but it was covered up by the computer which merely gave out the results for the plot. One student asked how the radius could be found if you did not know where the centre was. The formula for this (O-level mathematics would

derive this) was put on the board and worked through step by The student then tried a few examples and this seemed step. to make the undisclosed mathematics more acceptable. The plotted points for the outlines of the arches were joined to give as smooth an arc as possible. The mathematics was completely new to HD but he found it acceptable because the application results were available. Several very good arcs were plotted and this was enough for the students to be able to accept the work of the computer. The following page shows an example of an arch constructed by a group of students. The caption notes that two methods for producing plotting points were provided initially, the second one involving an angle and a distance, but this method was discarded because the students did not like using protractors.

A short appraisal of the module as a whole was attempted in a brief discussion with students after the completion of the last section and <u>they agreed without dissent that they had</u> <u>enjoyed the time spent on it</u>. The written classwork was collected in and no reference was made to this in front of the class. The main observations on the written work are that there <u>are considerable sketches</u> and that some had made neat presentations but others had not bothered; no request was therefore made for any form of presentation.

<u>Note</u>: readiness to sketch is worth encouraging for all technology-based studies.

5.7.6 Team Appraisal of the Complete Module

The usual short meeting of the team took place immediately after the students had departed and the module as a whole was discussed. <u>The main point of criticism was the lack of</u> <u>a theme</u> which could generate the sections in a naturally interrelated way, although the students had not complained on this point. This was probably because they had been interested in what they were doing and so would not have time

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An example of a brick arch constructed. by the YTS bricklayers. Note the frame made from wood which is used to form the bricks to a circular arc. The students plotted points for an outline template for the arc using the computer to perform the complex mathematical calculations, for which two methods were available. to appraise the sections. The team went to the Building Department staffroom and asked round for ideas. There was an almost immediate suggestion:

show some slides of the bungalow project

from CL* who had made the slides and also a video recording (later stolen) during the construction. The slides would offer something for each section, and another building specialist, JH*, who had helped with the filming and appeared in one scene, offered to produce descriptions for the scenes. The original guidelines for producing modules specified the use of educational technology and an example of this is the preparation of a list of the slide descriptions. This was carried out with the slide projector and a computer. The description was dictated by JH and typed into a data file by ST without using intermediate pen and paper: the 'team' is working. The advantage of this method is that any file record (description) can be replaced by re-typing. The scenes started from the excavated ground (biology here) and covered the uses of bricks, mortar, concrete and water. Triangles, rectangles and circle-section pipes brought in geometry and estimated quantities arithmetic, all with the purpose of measurement. Each slide contained a lot of information with the final product, the bungalows, available for all to see because the site is a local one. As buildings are being erected at most times it would not be too difficult to repeat the slides exercise in any part of the country. The complete list of slide descriptions is shown in Appendix 5.7. Further team discussions produced a selection of 38 of the slides (Appendix 5.8). The complete set of slides would have taken too much time to show while trying to maintain the students' interest. Two of the slides (Appendix 5.9) from the selection are reproduced as photographs. A black and white xerox copier could produce quite good copies from the colour photographs of the slides and these would be adequate for student use if slides and a projector

^{*} Members of the Building Department staff. Both CL and JH subsequently became involved with the author and the three were considered to be a team. CL actually produced a small module which he was pleased with.

were not available. After this the team raised two main points of criticism of the module:

- Section A seemed to be unfinished in that most uses of bricks extend beyond a single wall to a structure with several walls and there are many shapes to choose from. The private person could very well estimate, cost and build a house wall say for the garden but the industry would go well beyond this.
- 2. Energy conservation is of prime importance and receives legislative support which builders have to conform to in making sure that heat losses through walls are limited by design of wall materials: here then is SCIENCE. Something should therefore be included which relates to this through say, the U-value. The theory of the U-value uses a lot of physics and is used in design projects such as 'The Low-Energy Office' [106].

The evaluation of the U-value is carried out in stages and <u>a computer provides a useful means of checking the results</u> so this facility was incorporated in a final section of the module, together with some theory. Further deliberations about Section E showed it to be quite routine in that it resulted in plotted points, the mathematics being so difficult that an attempted explanation would not have been appreciated. However, the relationship between the mathematics (or geometry) and the technology of arch construction was thought important enough for the section to remain, being suitable for the less able who at worst could achieve a nicely plotted arch outline from the section; while the more able student could delve into the mathematics. <u>So here is something for everyone</u>. The new arrangement of sections is:

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Section Reference	Description
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S1	measurement on a building site
S2 ·	cement, mortar and concrete
S3	bricks and lightweight concrete blocks
S4	the brick requirements for a house
S5	passage of thermal energy through walls

The sections were given new references because of the changes. The example to illustrate the house in S4 is one which is built to a standard design by a large building firm in various parts of the country with some minor variations. The author visited one of the sites and looked at the architect's plans from which an estimate of the number of bricks required to build it was obtained as well as the number of doors and windows and their measurements. The information was incorporated in the module together with a copy of a picture of the house as it would appear to someone looking at new houses. As the important new sections in the module are S1 and S4 it was decided to try out these sections with the students who had carried out the initial trials, if time could be made available. The idea behind this was to support the research, but any use of students for this purpose would have to be justified on the grounds that they would benefit from the trial and that the substance. of the material taught would have to fit in with their course syllabus (this has not been a problem so far). If this were not so then the author could not use the class periods. The author approached HD at the time when the YTS students who had tried the initial module had just returned from work experience to the college for the second period of 'off-the-job' training (education as well, depending on what one could do When the request for more time was made HD . for them). remarked that ST had promised to show the students some slides on measurement and that his review of the previous period in the college brought out a concensus opinion of the students:

the module periods had been the best ones of the course.

HD suggested that perhaps the students could fill in a questionnaire to give their views on the course as a whole but this did not materialise. The second block of collegebased study involved technology which implied mathematics and a little science so HD was agreeable to ST and HD running this block as a team. Of the original class some had left but others had joined leaving thirteen for the No compulsion can be exerted to keep a student in trial. a course as education after leaving school is not compulsory as it is during the school years. Withdrawals can be for various reasons such as a student finding the course uninteresting or finding another course more personally beneficial or simply taking a job. Numbers for a research trial can therefore never be guaranteed to remain static or be completely statistically relevant.

The module was now modified by the team*at Wirral Metropolitan College and then discussed by the research team at Loughborough. The author also introduced a new module to the team based on the Oil Industry which would have a similar structure to that of the module described in this chapter. <u>The obvious success of the building module</u> means that it would be worth following up with one of a similar form.

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^{*} CL and JH: lecturers in the Department of Building ST: the author

CHAPTER 6

TRIAL OF MODULES

6.1 Introduction

The main components of the first module trial, described in . Chapter 5, can be identified as:

- (a) some slides;
- (b) written instructions and exercises: and
- (c) educational technology

The first trial had shown that the slides generate <u>interest</u> which encouraged the students to tackle the <u>mathematics</u> in the exercises and further <u>interest</u> was generated by the use of <u>computer technology</u>. Plenty of discussions were observed between students in connection with the exercises. and this is <u>evidence of interest</u>. When this first trial was discussed with the research team at Loughborough and modifications were being considered the author outlined a similar form of module based on the theme

Measurement and the Oil Industry

This chapter now describes the trials of the two modules. The author would like to acknowledge the enthusiasm and support of the research team for these trials.

6.2 Measurement and Construction

6.2.1. Organisation

As mentioned in the last paragraph of Section 5.7.6 HD proposed that his lecture periods (five, of one-and-a-half hours each), designated 'Technology' should be used with author to try out a module and show the tape/slide Measurement Programme (as promised!). Planning for the five periods is as follows:

Period	Task
1	Show 'Measurement' and
2	Continue with S4
3	Complete S4
4	Continue with Sl
5	Look at the TACBLOC information
	(omitted at first trial) and
	finally discuss the course with
	the students.

The Sections S1 and S4 were modified and are as follows:

S1: Measurement and Construction

Objective

To be aware of the measurements involved in the various stages of a construction project.

Knowledge

You require this in respect of:

(a) The estate of bungalows: from slides or pictures.

(b) Measurements which have to be made during the construction or have been made in the production of the materials used.

Tasks

Examine the project during the successive stages of construction.

- (a) View the slides or study the pictures.
- (b) Note any measurements, giving short descriptions.
- (c) Do your selected measurements involve mathematics, science or technology? Note this on your paper: for example mortar needs mathematics for the mixture ratios, there is chemistry in the setting processes and moving bricks needs technology at each stage.

Exercises

After studing the slides write answers to the following:

- (1) Identify three examples of counting measures.
- (2) Identify some important angles.
- (3) Name a brick measure which varies between manufacturers and has no standard scale but is important to the architect and client. Give some examples from structures you know or like the look of.
- (4) Find a measuring device on one of the slides which is without a scale and has three similar indicators. How is the-device used? A version is also available with a scale: explain the purpose of the scale and illustrate with examples drawn from any construction projects you have seen or know of.

(5) Name a branch of science which is needed in the early stages of the project if possible damage is to be avoided in the future. How would you treat the ground to avoid such damage?

S4: House Measurement

Objectives

After working through this section you should be able to produce an estimate for the material requirements for any of the following:

- (1) bricks,
- (2) mortar,

and (3) blocks,

by using geometry and arithmetic with appropriate approximations.

Knowledge

All lengths are in metres Types of bricks, blocks and mortar Standard brick dimensions: 0.215 x 0.065 x 0.1025 Area, percent and approximation techniques

Tasks

Study the details of the house: here are some measurements

Here is a diagram to illustrate one type of wall: can you name it?



Here are some more measurements

All measurements are external and above the damp proof course level.

Height of the roof peak above the level of the top of the side walls: 1.3

Measurements for openings in outer walls

Lower Floor

Measurements

1.3 x 1.8
2 x 1.2
1 x 0.6
1 x 1.2
1.3 x 1.8
2 x 1
Upper Floor

Measurements

Front window	1 x 1.8
Front window	1 x 1.2
Side window	1 x 1.2
Rear window	1 x 1.8
Rear window	1 x 1.2

Exercises

- 1. Calculate the area of each rectangular wall.
- The shape of the front and rear walls has a geometrical name which is related to the number of sides. Write down this name which begins with p.
- 3. Next calculate the area of the gable walls (the builder's term for the front or rear wall). You can split it up into two areas or use a subtraction. method. In either case simple trigonometry is needed.
- 4. Add up the outer areas of all four walls.
- 5. Calculate the sum of the areas of all the openings in the walls.
- 6. Now find the total area of the outside brick faces.
- 7. The next task is to convert wall area into a number of bricks using the number of bricks which will cover one square metre, which is not an exact number. Sometimes the 'round' figure of 60 is used. Ask for help with this.
- 8. From the previous calculation give what you think is a sensible estimate of the number of bricks.
- 9. The bricks require mortar which is 10 mm (0.010 m) thick between adjacent bricks. Make a sketch to show a brick in a wall and the mortar around it which

belongs to just the one brick. Calculate the volume of this mortar and then decide how you would find the volume of mortar required for all the bricks.

- 10. If the inner wall is constructed of concrete blocks estimate the number of blocks and the volume of mortar required.
- 11. There is always some waste of materials (go and have a look at a site) and an allowance must be made for this: one way is by allowing a percentage increase on the estimates, say 5%. Try to allow for this. How does the waste occur?
- 12. The bricks and blocks come from the manufacturers in packs. Look at the literature and select a brick and a block and so finally write as completely as possible specifications for:
 - (1) the brick,
 - (2) the block,
 - (3) the mortar

you would use, giving reasons. Don't forget the climate and geography! So much for the geometry and arithmetic and materials and on to a most important consideration - that of conservation of heat. The rate at which heat escapes through a wall is measured by the U-value and brings in some physics, mathematics and material considerations. Find something on heat loss (someone pays for it!) in say, the free literature provided for the public in the Electricity Board shops (usually in racks). An interesting one is 'Conserving Heat Energy' a booklet published by the Energy Efficiency Office which compares energy costs for different sources.

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First Period

As HD and the students had reminded the author on several occasions that he had promised to show some slides on 'Measurement' the time seemed opportune as it could give this next block of lectures an interesting start. The slide program Measurement of Section 5.5.3 with the synchronised sound commentary was to be used, even though it was designed for educators, because it was the only one the author had and there was not time to make up another one for students, although this had been mentioned during the discussions by the team and Professor Bajpai had pointed out that a need such as the present one might occur. This would be then a trial to show how the use of the programme could be extended - downwards in fact. The section S4 would also be attempted.

Organisation

Both HD and ST were present, HD of course because it was his teaching period and if not for the research interest ST would not have been present: it is important to emphasise that the class concerned had been subjected to a very different treatment from that which they would have experienced had it not been for the intervention of the author, and one more special treatment was to be the slide However, they had accepted all the teaching programme. variants so far and so the author (HD had not yet seen the programme) did not fear another experimental excursion even if it was designed for educators. The students were asked to sit comfortably and make sure that they could see the ST gave a short introduction to measurement and slides. pointed out its importance to them in their chosen trade. There was also a brief description of their 'interrelated' learning mode during the previous period in the college this was done very superficially so as not to give the impression that their time had been taken up with something

which might appear to be extraneous to their studies. Some commented:

we are glad to be back to these lectures.

The students watched the slides and listened to the commentary in silence and seemed to find the show quite After a while some seemed to lose their interesting. concentration and became restless, tending to look away or even move around the room. However, at not time were there signs of disruption. When questioned about it after the showing, most had little to say but one or two remarked that they could not understand it and that too many big A few said that it was interesting words were used. (many were seen to be watching with interest) but it was doubtful whether more than just interest was aroused. No attempt was made to initiate a formal discussion on the interpretation of the programme. This experience shows that for such an audience a more realistic programme would:

- (a) not last as long, suggest about ten minutes;
- (b) use a simplified commentary;
- (c) deliver the message at the beginning; and
- (d) pose some discussions at the end.

The Section S4

This time calculators were made available (Casio FX 100) on request but some students had remembered having used the computer keyboard in the calculator mode and the author was asked to run through this again. The objective of the exercise was briefly described in the opening verbal introduction as estimating (this implies modifying the results of precise calculations) the number of bricks required for the outer walls of a detached house with three bedrooms. A picture of the house and its plan for both floors were available for something to refer to. Detailed

instructions were available from the computer as before (the notes headed S4) and the program was already loaded. The student could adjust the pace at which the text was brought to the screen frame by frame using the RETURN key as instructed in the program. At most three students at any one time used a terminal. In order to overcome difficulties with the selection of a brick from the manufacturer's list and also to save time, copies of a data sheet on a brick (the 'Carlton' information sheet) were made available on the tables used for writing. There was no specific issue of papers to any student for personal possession. Rough planning was encouraged as well as rough working and it was announced that a formal worksheet was available on which to write down the solutions to problems after successfully working on rough paper. The instructions had been modified on the advice of HD so as to give the height of the apex of the roof (geometrically the height of an isosceles triangle) rather than leave the students to struggle with some unfamiliar trigonometry because he thought that they would not be able to do this; not because perhaps they had not done so at school but that the recall of this would simply amount to too much mathematics in which the purpose of the mathematics would become lost. Some students found the sentence giving the depth of the house (front to rear or side wall length) difficult to interpret and this will have to be looked at carefully: perhaps a diagram would help but these should be kept to a Between the computer screen frames, the OHP minimum. frames and the brick data sheet all necessary information was provided but some did not seem to think so until they were shown where to find what they were looking for.

Summary and Observations

 About half the students obtained a final figure for the number of bricks and copying on to the worksheet would take place later. The rough work was collected.

- 2. There was a general air of activity with both members of the team being kept busy; the rough working paper was well used.
- 3. Mathematics was much in evidence for the area of a wall, accommodating the openings (subtraction) and relating 'bricks per square metre' to an actual wall area.
- 4. <u>Alternative but equivalent mathematical strategies</u> were much in evidence, as for example when estimating the number of bricks for individual walls then adding the separate values, or combining the wall areas and then converting this once to a number of bricks.
- 5. At no time was there any class instruction on mathematical methods. This could have been boring to some as the students were of mixed abilities and so help was kept minimal and given as and when necessary. Considerable mathematics was endured without protest.
- 6. There was a practical reason for using mathematics.
- 7. <u>Interrelation between mathematics and laying bricks</u> came out in the discussions.
- 8. Some difficulties were:
 - (a) getting started;
 - (b) identifying the missing letters of the word p..... though most had probably heard it before so the recall was justified;
 - (c) transforming brick area to a number of bricks; and
 - (d) geometry.

9. <u>HD was quite surprised at the amount of mathematics</u> the students had accepted and had not expected this.

Second Period

The students continued with the S4 exercises and in the meantime the presentation of some of the information had been slightly altered to answer some of the criticisms and eliminate some common errors. Worksheets were handed out so that the exercises could be written up neatly. Most students were eager to do this. Returned work was discussed. The OHP was observed to be a focus of attention for small groups who engaged in discussions using the projection which, being large, made it much easier to involve every member of a small group. A striking case of technology relating to mathematics was the use of a figure for the number of bricks required per square metre of wall. Some technology lecturers teach that the figure must be a whole number so you take 60 which is 1/(0.225 x 0.075) rounded up. A small group volunteered to count the bricks in a measured square metre of wall. They returned with a figure of 58 1/2 bricks and some doubts about the authenticity of the figure 60. The difference in the number of bricks for the complete house was shown to one student to be about 100 bricks if the more exact figure was taken and he pointed out that this could mean the purchase of an extra pack. Someone pointed out that the two triangles of the gable ends would make one rectangle so there was no need to used the triangle area formula twice. These individual cases show that there was sensible mathematical thinking within a practical context and more could not be asked of any class. It probably never occurred to the students that they were doing mathematics and they had remarked that they hated their mathematics period (which this had now replaced).

During a discussion with a small group about the number of bricks to a pack, CL (he had suggested using the set of bungalow slides he had made and was referred to see the previous chapter) came into the room to see the author about help with his project. He took over the discussion and reminded the students that they had helped to unload bricks from a lorry and asked them to recall details of the event and in particular why the full load capacity of the truck could not be made up of bricks (the answer required was that an unloading crane was being carried). As a brick technology specialist CL brought in the practical aspects of the subject. CL asked for an explanation of the teaching method and suggested extending the exercises so as to include the bricks for the foundations and the garage. He was willing to take part in any way possible and be considered as the third member of the team. His first contribution to the module was made a few days later when the author mentioned that he would like some photographs of the students' practical work to illustrate their classroom exercise and use these in the classroom for He offered to be available when the author discussions. brough the photographer along. He made a very professional contribution which ranged from sweeping the floor to clear away debris, to setting the scenes for maximum effect. One of the photographs is reproduced on the next page and shows a practical case to illustrate the theory in the module.



Student practising building skills in the construction of two parallel and vertical walls.

Third and Fourth Periods

A return to S1, the first section, was made but this was a new one for this group and would constitute a change in activity. The students had been visited by the author at a building site where they were building a perimeter wall for the purpose of obtaining their views on the module

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They all said that they would be pleased to periods. give these and had found it interesting: this is part of evalution because 'interest' and 'liking' cannot be measured from paper exercises. The bungalow slides (these were introduced in 5.7.6 and are now required again), were projected by HD and both team members gave commentaries although most of the work was done by HD. As much discussion as possible was encouraged about the cases of measurement to be seen or implied in the pictures, and this included a measure for safety which was raised because of some of the practices seen when using scaffolding. When the colour of the roof tiles was in dispute someone who had actually worked on the site settled the point. Chemistry came up when the white colouration on the walls The term efflorescence was mentioned but was mentioned. it should be noted that the chemistry of building materials is very complex and the mechanisms of a lot of the chemical changes are unknown. A critical angle measure was for the 'fall' of the sewer pipe, the angle being critical in that it controlled the efficiency of the system; thus we have two related measures. The viewing and discussions took about an hour and this was followed by the written exercises starting with examples of measurement. This stage was the end of a period and the team discussion then took place. HD suggested that each student should have a set of photographs instead of having to look at the slide projections in a group. Also this type of student needed detailed guidance on what to look for and write He also suggested reducing the number of slides to down. about six and reducing the total viewing time. ' It was decided to bring in CL on this and he supported retaining the full number of slides, making the point that there was a lot of varied measurement in the slides (which had been selected) and something important might be missed out if you reduced the selection.

The Last Period

This period was used to go through some of the information on concrete blocks using the OHP and slides (see Information Pack) to present pictures, tables and general facts about TACBLOC, the source being a wall chart supplied by TACBLOC. There was plenty of mathematics, science and technology all on the one chart which is a good example of what is available free yet makes excellent educational technology. The guidelines for teaching in an interrelated way stress the use of educational technology whenever possible. The chart, although printed very clearly, soon deteriorates when taken out, unfolded and folded up again, so a more durable form for the information has to be found. The chart can be cut up and photocopied so that one does not have to go the expense of producing slides. A lot of the physics on the chart was difficult to understand but the students kept up a lively discussion and although there was little activity apart from taking a few notes the students said that they were not bored. This period was really a verbal one. An assessment of this type of lecture for learning outcomes would be difficult to make but would be possible if it were necessary to recall some of the The students were asked for some general information. comments on the Tuesday afternoons (when they used the module) and they can be summarised thus:

We liked the Tuesday afternoon period.

We don't like the following period (mathematics). We had to do mathematics but we didn't mind this because the computer made it interesting.

This last period was quite interesting.

The educational technology no doubt adds to the interest of what is taught and it should be noted that the computer was used in a very simple mode and it did not possess any graphics facilities at all.

Note on presentation:

At no time was any attempt made to produce good copies of a complete module, bound between covers and illustrated semi-professionally. The students never made any complaints in this direction and the author has put his 'interest' component in the educational technology. In contrast Bond [3] found that school pupils liked a module which was well presented, but he did not make use of educational technology.

6.2.2. Some Conclusions

- 1. The students found their activities during the experimental module development periods very interesting.
- 2. <u>Mathematics was generally an unpopular subject but</u> <u>mathematics and mathematical ideas within the</u> <u>environment of the interrelated approach to</u> <u>measurement were accepted and liked</u>.
- 3. Modern technology in the form of the computer was experienced in a useful way.
- 4. As yet no good quality form for the module had appeared but this did not deter the students from learning.
- 5. The hypotheses have been confirmed.

6.3 Measurement and the Oil Industry

6.3.1 Background

The topic for this module is the mineral oil industry which uses the services of the construction industry as well as bringing in shipping, engineering and general interest in Scarcely a day passes without there being some many ways. mention of the industry or its products. Distillation of crude oil ('oil' is mineral oil unless otherwise specified) produces secondary products which are fed into other industrial plants based on these. For example. most synthetic rubbers are made from the products of refined crude oil and Synthetic Rubber is a short free publication which explains the industry and jobs for technicians in a simple manner and is well illustrated. Also an important source of energy, oil is kept in the public eye by the effect of changing political situations in the oil producing countries as well as searching for and This means when taken together discovering new sources. that technology and geography are interrelated and a module could well steer the user in this direction. There is chemistry which is involved on a large scale which needs special engineering techniques which are provided by Mathematics and physics are interrelated chemical engineers. in pipeline problems and laboratory chemistry is needed to test and measure the products. Because of these facts it was decided to exploit the interrelationships between mathematics, science and technology through this industry or some part of it. There is also very strong support for education in this field, often without cost, in the form of free literature and films; for example British which is another associated industry, supplies Gas films on free loan. The films cover such subjects as agriculture and science. The module will also give opportunities for a computer to be used in a realistic way similar to the way it would be used in industry, the students

being encouraged to show initiative and inventiveness in the use of data and the presentation of information on the computer screen. Because the topic has relevance for most people the module should cater for varying levels of ability and personal knowledge; for example a student may be interested in high-performance cars and hence provide information on grades of petrol, lubricating oils and how they relate to brand names. As this is a topic with colourful and impressive advertising literature it should be possible to make a visual impact with slides or Changes to text can be made economically photographs. and quickly by having this computer stored to be read off the screen or printed as required. Being experimental it was expedient to have the text stored on a computer disc so that the text could be read off by the students and only printed off by personal request. It was decided to concentrate on one facet of the oil industry, the spherical tank, this being not as narrow a view as it seems at first sight because when extended to tanks of other shapes many products become involved such as:

> flour (in road tankers) beer cement refrigerants chemicals.

Mensuration is required from mathematics as well as geometry and the shapes of some road tankers are difficult to describe in traditional school mathematical terms, so this should give rise to some original suggestions. The module can be used for computer studies and contains a section for the use of the computer but this is not obligatory: if, however, some real and practical use is sought for a computer then the module will provide opportunities for this also.

6.3.2 The Module

Format

This is reproduced in Appendix 6.1 , and can be seen to have a very short form, although containing a lot of information. Being a first attempt it was not considered worth enhancing the presentation or trying to give it a permanent look in view of many possible modifications. This view is from experience gained with the Construction modules. Also, the opportunities arose rather quickly to try out the module so there was little time available to spend on reproductions: to this end it was fortunate that the computer presentation was possible.

The Slides

The slides came from various sources, all being connected with the industry. They were chosen so as to give a broad view of the industry starting from the search for oil right up to the many products obtained from the crude basic material and also to show the wide range of uses for the products. We are all users in one way or another. Reproductions of the slides (Appendix 6.2) could be used if a slide projector was not available. Short descriptions of the slides are as follows:

- the formation of oil in the strata of the earth;
- 2 survey methods by sound waves and examining rock formations;
- 3 transportation is by pipe and ship but we need tanks also;
- 4 a view of a complete refinery note the tanks;
- 5 a simple diagram to illustrate the distillation stages;

- 6 two spherical liquid gas storage tanks;
- 7 an 'inside' view patterns behind the substances;
- 8 the many customers lots of tanks and many shapes;
- 9 a large chemical industry feeds on oil; and
- 10 an international market exists for chemicals for the farm.

The choice of slides was such as to bring out mathematics, science and technology and any commentary must do this without trying to separate out all the chemistry or all the mathematics. For example when asking the class:

Where do we put the oil (or fluid products) until we are ready to use them?

descriptions of tanks could be asked for which bring in shape (mathematics); and perhaps the formula for the volume of an upright cylinder could be asked for as well which leads on to π The mathematical aspects can then be turned back to chemistry by asking about some of the products and their chemical compositions which consist of carbon and hydrogen atoms in proportions determined by simple mathematical formula (algebra).

The Mathematics

This can be introduced with the circle and Π It may be necessary to counter the idea that Π is 22/7 and one suggestion is to let the computer produce a value for as 4*ATN(1) that is as 4 times the angle (45 degrees) in RADIANS whose tangent is 1. Alternatively use the calculator to give a value. The formula for the volume

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of the liquid in a partially filled spherical tank will have to be accepted by most students and its evaluation step by step in order to verify the computer's work, involves simple multiplication, division and subtraction, which can be taken in stages. Working with the computer (if one is available) could give confidence to the student and make the computational aspect of the calibration task appear more interesting. It should be noted that for students who have studied mathematics as far as O-level the mathematics associated with the sphere is usually just the formula for the volume in the form $4/3\pi$ R³. So here is an approach to mensuration for a very common shape which is extremely new but of practical significance.

The General Questions

These need some wider reading or discussions with people employed in industries associated with tanks. There is literature available and libraries as well so too much information should not be provided ready to copy out. The question about the Alaskan oil depends on how much the student knows about climates in other parts of the world. Television and radio media provide a lot of information through news items and documentary programs because the oil industry is very much of concern to the countries which have oil as well as those which do not have any. Students must be encouraged to seek this information for themselves and this should not prove too difficult a task.

6.3.3 Use of the Module

6.3.3.1 The Students

Three groups of students were chosen for the first trials: descriptions of the groups for the purpose of analysis and evaluation of performances are as follows: Part-time (one day per week) students in the fourth or fifth year of a Higher Technician Mechanical & Production Engineering BTEC Certificate programme of study. Job functions could vary quite a lot from hospital laboratory, to power station technician.

Group B

Full-time students working for a BTEC Building & Civil Engineering Diploma taking two or three years to complete. This is often chosen as a route to a polytechnic or university course.

Group C

Part-time (one day per week) students in the first year (level 2) of a BTEC Ordinary Certificate in Science programme of study. Jobs were related to science in such fields as pollution control, soap and allied products manufacture and edible oils precessing.

Mathematical Education

It is not intended to give a full analysis of this but a GCE Ordinary level pass or a CSE grade 1 result are acceptable as far as mathematics entry qualifications to the courses are concerned. With reference to the calculus, here are some topics to illustrate their differences in mathematical attainment - Group C have just about met the ideas of calculus:

Group A - differentiation, integration methods partial differentiation

Group B - elementary differentiation and integration

Group C - the use of increments to obtain a rate
of change and the application to
sine/cosine

All these would receive the same module but it was not intended to take over the classroom teaching of mathematics but to invoke the use mathematical ideas as and when necessary and so make users out of mathematical practitioners. In BTEC, mathematics achievement of objectives is important and this is usually demonstrated by using techniques, but in 'module' mathematics the subject or topic area is important. As long as the student realises what is required (for example a depth-volume calibration table) a computer could be used to do the mathematics provided the student is in control and understands what the machine This would then free the student to some is doing. extent to come to grips with problem solving in practical situations as they would occur in industry. As for science, the groups have widely differing experience of Thus Group A studies Engineering Science which is this. mainly mechanics and many have never studied chemistry beyond a CSE level; Group B studies Building Science which deals with the physical testing of materials (building involves some very complex chemistry in mortars, weathering of bricks and paints and physics in the thermal insulation problem of walls); and Group C of course studies chemistry as a major subject and also physics. It is worth noting that the demands of industry do not always take into account one's level of knowledge as can be seen from Table 1 (Appendix 6.3) which shows some of the information supplied to a road tanker operator by Crane Fruehauf [107]. Inspection of this table shows a lot of chemistry, some physics and technology.

6.3.3.2 Support From Industry

Unlike for example the Construction Industry, where the materials and examples of their uses are readily available

for all to see and in fact provide each one of us with 'shelter' in some form, industry's liquid products and their containers (tanks) are usually remote in many ways to the general public. Reservoirs, for example, are often grassed over and golf is played above the surface. Water Supply and Treatment [108] illustrates in Appendix 6.4 how much the Water Industry depends on tanks of many shapes but also that it makes full use of biology, chemistry, mathematics, physics and technology. The Regional Water Authorities provide a good service to education in the form of posters, slides and illustrated information leaflets. Information on the Oil Industry's products and tanks is much less accessible to the general public because of the nature of the products and the specialised nature of the science and technology involved; hovever, the author has received a lot of assistance from industry which has helped to make the tasks and exercises presented to the students practical and realistic. The major oil companies operate special and very comprehensive educational services for schools and colleges. Shell provide posters with Notes for Teachers; Mobil [109] [110] supply excellent booklets which are illustrated with diagrams and photographs; and Esso [111] produce excellent wallcharts illustrating the chemical manufacturing side of the oil industry. The Occidental Group [112] has an Education Service which provides a really excellent booklet (prepared by the Public Affairs Department) which has some very effective overlays showing the basic construction of an oil drilling rig: but of immense educational value is the Glossary of terms for the oil industry, containing a good selection from mathematics, science and technology and all well presented. There is a recognised and official calibrator of tanks (Her Majesty's Customs and Excise Department has strict control over dutiable liquids), [113]. Consequently the author was unable to receive authentic information such as charts,

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diagrams and Institute of Petroleum Regulations [114] which contain a great deal of 'circle' geometry relating to spherical tanks. Again, the author made a tour of local industrial sites and saw a spherical tank at the site of margarine manufacturers Van Den Berghs & Jergens Ltd. and asked for information on it and any other tanks. The result was a contact with the Training Officer [115] who arranged a private tour of the factory, supplied answers to technical questions through consulting colleagues and a set of plans for certain tanks the author identified. Many more contacts and industrial visits have been made with invitations to 'come and see for yourself' which sometimes includes students. The heavy engineering industry comes into the manufacturing aspects of tanks and British Steel through their various specialists supplied much [116]. useful information.

6.3.3.3 Operation of the Module

The lecture periods for BTEC Use of Computers and Computer Assignments were chosen to use the module because these were under the control of the author and all three groups, at different levels of mathematical attainments and studying in different fields should yield a comparative study. The module would be presented in the same way to all groups except that their subjects would be used for illustrations. The slides were shown and comments and discussions from both sides were to be encouraged. The idea of the module Any student could look at the slides again was explained. by operating the projector personally. The module was available to be read from the computer screen (there were five) but printed copies were offered. Help in the way of clarification of the text was available but direct answers to questions were not, only discussions which would lead them (hopefully) to the correct solutions. Discussions between students and the seeking of answers and information outside the classroom such as in libraries or from anyone in industry, other members of staff or members of the family, was encouraged as much as possible.

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Objectives

These are distinctly for the students, indicating to them what they are to get out of the module; and those for research purposes.

Module Objectives

- (1) Make use of the computer in a practical way.
- Bring together mathematics, science and technology through the storage tank calibration task.

Research Objectives (extra to the hypotheses)

To investigate in the climate of an interrelated approach:

- the relationships between the application of mathematical principles and levels of study;
- (2) the transfer of mathematical principles to other topics; and
- (3) how the computer supports the interrelated approach.

(1) will show if the groups A, B and C can apply the principles equally well in spite of having had different amounts of mathematics education. (2) will investigate if changing the shape and hence the geometry of the tank affects the student's ability to carry out the same or a similar task such as producing a volume-depth calibration table (given any formulae required) or at least to be able to start it. Objective (3) could be investigated by determining if students are more willing to use mathematics when for example routine calculation tasks are taken over by the computer.

6.3.3.4 Initial Stages: Some Observed Attitudes

Here are some early observations:

- 1. The slides were received with interest which increased when the students were asked to make personal contributions to the discussions. Few aspects of daily lives are untouched by the oil and allied chemical industries so each person is able to make some contribution.
- 2. The slides were made available for every period, if required and students were observed to concentrate on just one slide and sometimes make notes from it. Use of the remote control cable and Unit by individual students was encouraged.
- 3. There was no attempt to enforce a presentation of the final written work and attitudes to what was considered sufficient or in good enough style varied a lot.
- 4. There were no outright protests at studying what were considered to be 'other subjects' such as chemistry by an engineer and a few words of reason settled any doubts.
- 5. Initial attitudes to mathematics in principle and practice were most consistent across the groups in that it became different from the classroom subject because of the context - it wasn't easy to separate out the mathematics required, as a separate subject.
- 6. Within the context of the brief instructions in the module there was freedom to extend mathematics or technology as desired; for

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But this was torture!7. There was some copying from the computer screen, but for a short piece of text this method of

- but for a short piece of text this method of presentation seemed acceptable and it also gave practice in the use of the keyboard.
- 8. Some students were ready to believe what appeared on the computer screen without checking.
- 9. The module appeared to suit all groups there were no cries of 'too easy' from Group A; but as indicated in (6) it is easy to amend the module instructions to suit a paricular class or even one student because <u>the interrelated</u> <u>approach does not imply specific topics or levels</u> as with individual subjects.

6.3.3.5 Assessment for Mathematics

The module only went as far as an investigation into the properties of the spherical tank, which meant that similar mathematical principles should be able to be applied to tanks of other shapes and so test Research Objective (2). By giving the same questions to the three groups of students in a formal test situation Research Objective (1) could be tested at the same time. Thus some formal test is required and to this end the

Assessment Test: Mathematical Bias

(Appendix 6.5) was constructed for research and as a formal assessment for BTEC requirements - the use of the computer was called for by the test. Some special arrangements had to be made to supervise a classroom and the computer room and the students as they moved between the two. After using a computer they were told to erase all data from the working memory and clear the screen. Calculators were available to borrow. There was no point heading the test paper with the second instruction unless the equipment could be made available for use by a student without disturbing other students.

6.3.3.6 Analysis of Results

Sixty students took the test and Table 2 shows how they were distributed.

Table 2

Group	Number	
A	14	
В	18	
С	28	
Total	60	

Each question will be considered in respect of the mathematical principles (MP) it uses and the success rate of the students in the three groups in using the MP. Research Objective (1) or RO1 will be measured by the success rates. Analysing success rates for tanks of different shapes will test RO2 between the three groups and finally some subjective views of the students will test RO3.

The analysis of the responses to the questions will now be given in the form of a table for each Research Objective.

Research Objective 1

Question 1

<u>MP 1</u> volume in each case is proportional to the height, so the calculation of volume can be simplified by recognising the common factor, which is the area of the base.

Results (no table necessary): the MP was not used by any student.

Question 2(a)

<u>MP2</u> rate of change of volume is zero at zero depth and maximum depth and the points could be identified in a sketch.

Table 3

Choup	Correct Hoo	" Connoct
Group	<u>correct</u> use	<u>» correct</u>
А	9	64
В	6	33
С	19	68
A11	34	57

<u>MP3</u> rate of change of volume is a maximum at the level of the centre of the sphere, where the surface area is a maximum.

Table 4

Group	Correctly Used	<u>% Correct</u>
А	10	70
В	7	39
С	14	50
A11	31	52

Question 2(b)

<u>MP4</u> the graph can be sketched using three main feature points - two where the rate is zero (zero and maximum depths) and the third where the rate is a maximum, at half the maximum depth. It is worth noting that the volume-depth function is easily differentiated into a quadratic form which can then be sketched very easily from a knowledge of O-level mathematics. The Higher Certificate students should be capable of this analysis but may not be able to see that this task is related to 'classroom' mathematics.

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Group	Sketched	% Sketched
А	1	7
В	4	22
С	6	21
A11	11	18

Question 3

<u>MP5</u> recognise that the cross-sectional area of the cylinder is constant. This can be stated or just used to construct the table.

Table 6

Group	Recognised	% Recognised
· A	2	14
В	2	11
С	4	14
A11	8	13

<u>MP6</u>. use percentage correctly, which can be done in a number of ways: if V = maximum volume then -

> $95\% = V \times 95/100$ or $95\% = V - V \times 5/100$ or $95\% = 0.95 \times V$

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Group	Used Correctly	% Used Correctly
A	12	86
В	15	83
Ċ	22	79
A11	. 49	. 82

The main technique used was to multiply the volume by 95/100 but other methods were finding 1% then multiplying by 95, finding the fraction 19/20 of the volume and subtracting 5% from the volume.

Research Objective 2

Question 3

The module required the student to produce a volume-depth table for the spherical tank. This idea is now transferred to the cylinder. What learning has been trasferred from the spherical to the cylindrical case? The computer was used to produce the table for the sphere, so the same method should be attempted. The calculator can also deal with repetitive calculations although not as quickly and expediently as the computer and its use is acceptable in place of the computer; for this a student could observe that equal increments of depth map to the same increment in volume.

Group	If Technique Transferred	<u>% Transferred</u>
А	9	64
B	8	44
С	15	54
A11	32	53

A common calculator expediency was to put the value of 3.14 (or whatever was being used for π) multiplied by the square of the radius, in the memory and then multiply this by successive depths.

Research Objective 3

How does the computer support the interrelated approach? The relationship between the topic area and mathematics is obvious because of the algebra and computation involved but there were no complaints about doing mathematics which seemed to be accepted as and when necessary. A lot of what would be called rote working is taken over by the computer (and of course the calculator) and the work of Brown [32] suggests that a strategy of building up a network of mathematical relationships is a better answer to the lack of understanding in children than repeating the same type of calculation many times. But mathematical relationships are just what can be built into the computer program and in such a way as to be able to see them working (make the computer print out all the computational steps together with friendly messages). Again the computer task for any of the author's modules was never for the sake of exercising mathematics but for enhancing the relationships with something physical and meaningful. Professor Bajpai uses the term Computer Enhanced Learning [117, 412] and perhaps the author can be permitted to borrow it to make his To illustrate the mathematics - physical relationship, point. question 4 requires the computation of 95% of a volume, which fact must be related to the dangers of filling the vessel without allowing room for expansion or evaporation. The computation has to be correctly carried out and this can justify the use of electronic devices. If the student can reason out how to make the computer (logically, not just by trying things) work out the volume then the machine can be left to its computational tasks. The working environment

of the computer was observed to bring about discussions as students tended to work in pairs or a number would congregate to see something interesting. It was not² possible to confine each student to a desk and so the advantages of mobility must be seen and accepted. Appendix 6.6 shows a sample of work produced by one of the Group A students who had found the module very difficult at first. He also feared exposure to the unknown (the computer) but eventually proved the volume - depth relationship for the spherical tank without help (this was not mandatory but they had done the integration, so why not use it?) after a The author found a note from him considerable struggle. after the course from which:

... Thanks very much I have enjoyed the course immensely ...

when read in conjunction with his module written work can be interpreted as the enjoyment not having come from the mathematics or computing but all that he was encouraged to bring into his submission. It is frequently noticeable that:

> a lot of practical mathematics, science and technology are brought into the students' work from OUTSIDE because the module as given (so far) to the students leaves a lot to be discovered by personal initiative. Bond's modules were however much more comprehensive, complete and professionally presented.

An interesting fact which came to light was that once a BTEC or similar course of technician studies was undertaken (excluding those with a sicence base) in, for example, Building or Engineering disciplines, there was little contact with basic science such as chemistry or physics. Any attempt to bring these subjects into a programme of

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study as such would no doubt lead to another academic and uninteresting set of lectures. One way to redress this balance is through interrelated studies.

Group C: A Special Investigation

Because these students had not had the same amount of lecture time devoted to mathematics as those in the other groups, it was decided that they could be at a disadvantage in the test through, say, not having the same command of mathematical language. It was therefore decided to interview them and make sure that their responses to questions would not suffer from, say, a lack of expression. Notes were taken at the interviews and these are now summarised.

The Interviews

In order to clarify some of the ideas used by Group C (the least mathematically experienced of the groups) they were interviewed individually. The students will be designated A1, A2, ... and their comments and responses prefixed by the number of the question to which they were related. These discussions were not tape recorded as there had not been sufficient time to prepare the students for this. So written notes were made in much the same way as in the case study of Chapter 4 with the time between one student leaving and another arriving being used to write extra notes by recalling some of the conversation. Here then are summaries of the responses of the whole group for each question.

Note that these students had just about started to receive instruction on the calculus and that their syllabus did not include anything on specific techniques.

Question 1

Used calculator (typical) Rough working first (two only) Reasoned out the graph shape. The scale of the graph is not significant. Sketched the graph from memory of the experiment for the physical modelling. Maximum rate at centre because maximum surface area. Graph steepest at 9 m because sphere widest. Point of maximum rate not determinable. Used computer print of graph. Area of surface a maximum at middle and reduces away from the middle either way. Cannot fill sphere right to top. More volume for a given depth at the centre.

Note: paper was available and explanations were sometimes accompanied by sketches, which the author encouraged.

Question 2(b)

Idea of rate of change was not properly understood. The rate graph will be symmetrical about H = 9 line because of the symmetrical shape of the sphere. The point of maximum rate is not determinable unlike the points of zero rate (H = 0 and H = 18). Maximum volume is added at the centre.

Note: Some found this difficult and did not do it but managed to contruct the sketch with further discussion.

Question 3

Used square of radius as a constant memory factor and multiplied by each value of depth (a number did this). Modified the computer program for the sphere. Worked out the maximum volume - divided by 5 - added this up cumulatively to get a series of volumes for new depths. I saw the relationship between depth and volume but carried out the working for accuracy. Used the calculator but also modified the sphere program. Wrote a program to get a table. Put value of volume for H = 2 in the calculator memory and then multiplied by 2, 3, ... using the calculator. Wrote a program; referred to notes; checked on the calculator. Only did one calculator evaluation - area of cross-section.

Values 4 times too large - used diameter instead of radius. Used calculator - no short cuts.

Question 4

Check for 95%; it must be close to the maximum. Worked out 95% of 20 m. Find 5% of volume and take from volume. Used 1.25 for 4/3 and 3.14 for π . In using the calculator I put 4 x π in the memory.

Note: Most used the calculator without short cuts. These brief notes show clearly how a number of <u>mathematical</u> <u>principles and some techniques have been used or at least</u> <u>thought about, in a non-mathematical teaching environment</u>. Perhaps when these students have made further progress with their mathematics lectures and received drill in using techniques they will not be so open about using the IDEAS of mathematics and will search their repertoire for some technique or 'the formula' as this seems to be what a lot of mathematics teaching implies.

6.4 Observations on the Construction and Oil Industry Modules

1. Traditional mathematics teaching seems to inhibit mathematical ways of thinking.

- 3. Computers and calculators are used in different ways by different people; just how is sometimes difficult to predict. These devices can remove arithmetic from mathematics and so clarify mathematical thought.
- 4. The mathematical approach to mathematical problems as contained in this module and its assessment test does not seem to depend on specific knowledge ie <u>success with mathematics when it is part of technology</u> <u>or an interesting exercise can be achieved without</u> <u>having achieved a high level of traditional knowledge.</u>
- 5. The module featured in this chapter could be considered as poor examples of eye-catching, interesting and colourful presentation. <u>This deficiency was more than</u> <u>compensated for by the well-chosen slides provided with</u> each module.
- 6. The mensuration in the Oil Industry module is nonstandard up to O-level and could easily have been introduced with the phrase 'frustrum of a sphere'; in which case the students would probably have felt that they were about to do some mathematics. At A-level, students would no doubt derive the formula first. However, without either of these academic approaches students from a wide ability and mathematical experience range were able to accept and use the essential depth-volume relationship.
- 7. <u>Both modules provide for more or less science</u> some chemistry ('sulphate' in the bricks) for the builders and organic chemistry (molecular structure) for the engineers.

- Students in both cases, were observed to make notes from the slides - another 'self-help' feature of the slides.
- 9. The hypotheses have been confirmed for two modules for students with a wide range of educational attainment.
- 10. The research team not only met for long periods of time and produced major decisions of importance but injected small yet useful contributions into the research. An example of this is the term 'Shelter' to replace 'Building' as an area of study, which was suggested to Professor Bajpai during a conference in Africa. Shelter certainly suggests a very wideranging concept and deserves more consideration. However, people are very traditional and a bricklayer is a 'builder' and so on. The author took Professor Bajpai's suggestion and asked Building Department students to discuss and come up with a term which would embrace everything from a lean-to protection for farm animals to an enclosure used by shipbuilders to that they can work undercover. With just a little encouragement from the author the term 'shelter' was soon suggested and appreciated. The point here made was further emphasised when the author was speaking to a contact from the McAlpine Construction Company. His response to the author's 'What do you make?' was 'anything from a garden shed upwards - you name it we'll build it! 'Shelter' brings together the Construction and Oil industries - it serves to interrelate them: one does not function unless it has something to build and the other cannot even erect a tank without calling a construction company to prepare the ground and lay the concrete foundations. Also, the North Sea oil operation would not function without concrete - it does NOT corrode.

11. A further exercise was suggested to the students but not written into the measurement in the Oil Industry module: carry out a simulated spherical tank calibration in the laboratory. This sounds very complicated but this is the WAY IT IS DONE IN INDUSTRY and requires very simple and non-hazardous equipment. Known volumes of coloured water are poured into a round-bottomed flask, the depth of liquid being measured along the polar axis each time. This PHYSICAL MODELLING of the mathematical relationship should give a calibration curve of the same shape as the one drawn using the computer-provided data. Thus the computer process is checked.

The experiment takes time of course and involves a number of decisions about experimental techniques to be made by the students: the author's attitude to such a (safe) experiment is to encourage two or three students to work together and see what they come up with. Some quite acceptable graphs were obtained at the pilot-study module trial.

On the next page is a photograph of the apparatus assembled by a student who performed the experiment. On the following two pages his account of the experiment with results and a graph he drew from the data are shown.


The round bottomed flask models the spherical storage tank. Note how the thread of liquid trapped in the tube is used to measure the depth of liquid in the flask. Student's Account of Experiment

Experiment of calibration and <u>I ask</u> To check the shape of the calibration urve by a practical valibration using laboratory model, a spherical flash is used as the spherical storage tank. ىرى - يېڭى بەر ئەرىيىسى بىرى مەرىيىرى Heparatus, damp stand, 2 litre flash, coloured mater neasureing rule, neasuring cylinder I decided to fill the flash up to 15 cm depth in steps of 3 cm. after filling to the required depth the flash was emptied into the neasuring uplinder . Cleaning figlingues Rule_ 415 Slack, From this experiment the following results were gained ... Deoth cm conced V Aume 0 655 1815 12 15 2165

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Graph Drawn From Student's Experimental Data

CHAPTER 7

FURTHER USES OF THE INTERRELATED APPROACH

7.1 Introduction

7.1.1 Overview

This chapter will develop the pilot studies in the use of the INTERRELATED approach and gives an account of some of its wider uses in Further Education. The needs of individual lecturers and the demands of special situations will also be considered, such as programmes of study designed for industry. Here is a synopsis of the sections of this chapter which will give the reader an overview of its many facets which are linked by the interrelated approach to education:

- 7.1 Background to module trials beyond the author's college
- 7.2 Development of modules at the author's college
- 7.3 Module at Halton College: Measurement and Building
- 7.4 Module at Halton College: Industrial Storage Tanks
- 7.5 Case Study: Education Within Industry

- 7.6 Staff Development
- 7.7 Module: Measurement and the Motor Car
- 7.8 Module: Measurement and the Pharmaceutical Industry

The tape recorder was used during the experimental situations described and transcriptions from the recordings have been used for appraisal purposes, the findings being analysed in some depth. A considerable amount of travelling was involved in meeting educational practitioners in other parts of the country, not only to persuade them to become involved in the experimental work but to give support and encouragement in developing ideas.

The author found that the effectiveness of such support can be considerably impaired by the distance factor alone. When transmitting a new idea to someone at a distance it is useful to have available a short paper on the subject and it was with this in mind, and the extended objective of much wider publicity, that the author wrote and had published the short paper [Appendix 7.1]:

> A New Approach to Teaching Interrelated Studies in Further Education

The paper was deliberately kept short so as to encourage it to be read by busy lecturers who might otherwise reject a longer paper. A response to the paper from a college in the south-east of the country is described in the section on Staff Development because a number of staff will be involved in looking at a sample of the author's modules with a view to adopting new approaches to 'integrated' teaching.

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7.1.2 Module Trials Beyond The Author's College

Sections 7.3 and 7.4 describe some uses and appraisal of the author's modules in a particular college in another part of the country.Section 7.1.3 is a brief account of some of the circumstances in which the contacts were made. Conferences are useful not only for the purpose of receiving information and exchanging views on a particular topic or theme, but also because they bring individuals together who would not otherwise have met. There is thus an opportunity to make contacts with other members of one's profession from different parts of the country (if the conference is national or regional) and explore common Such was the case when the author attended a interests. conference on Numeracy Needs [118] which was aimed at the identification of areas for Staff Development (this will be referred to in greater depth in Section 7.6.6). It was here that a first contact was made with a fellow researcher, Mike Hewitt (MH), whose main interest is Information Out of this meeting came the confirmation of Technology. the view held by the leader of the research team,

Professor Bajpai, that testing of each other's material would be mutually beneficial to the teams' research by adding experiences from different parts of the country. MH is located at Halton College, Widnes [119] which was subsequently visited by the author on a number of occasions to meet members of staff of his college with a view to module trials, or just to discuss the ideas behind, and advantages of, using modules. Some of the background to these visits, what they consised of and some difficulties encountered will follow. The author believes that such conferences etc which aim to bring together lecturers from different colleges are of prime importance when one wishes to make contact with others working in the Further Education field, beyond one's own establishment. The small number of colleges available for these purposes (compared say with schools) makes it essential to use such means for contacts.

7.1.3 <u>Pre-Trial Negotiations</u>

From the many contacts made at Halton College only a few realised positive trials of modules although it must be emphasised that the staff contacted were interested in different educational methods but were restricted by having to work to specific study programmes. The following notes show how the author persisted in his efforts and often followed leads which did not produce results. There were many visits which had to be arranged at times convenient to the author's own teaching schedule.

- During a visit to MH he introduced VM whose teaching subject is General Studies. She liked the Building module and took away some parts of modules to read.
- 2. A further meeting with VM; some of the bungalow slides were left for her to assess, which she liked but did not think that pictures within the module were very important. She might use just part of a module, but felt that the slides 'bring the subject to life'.
- 3. At a further meeting VM said that she had Food Technology classes so the author left her a copy of the Food, Science and Numbers module.
- 4. Two forms of the module were provided for VM; one short and one long, about 80 copies all told. The author was then informed that she would now not be able to evaluate the module with students but she reported that another lecturer (SH) was interested.

- 5. The first meeting with SH seemed very promising and she was keen to try out a module (she even had a BBC computer for her own use). Copies of a short form of the Building theme module with slides, Notes for Lecturers and the slides were handed over for appraisal. The author was to see her one week later in order to discuss any problems.
- 6. The author kept the appointment with SH but had to wait for one and a half hours because she was counselling a student. By this time the author had a feeling that this contact would not realise any action: this was correct because SH said that the class which was to try the module had been taken off her and replaced by another. However, she mentioned that Roland Pritchard (RP), an engineer now teaching General Studies had a class of YTS Building students and could be interested.
- 7. RP was duly contacted by the author and an interesting discussion developed on educational methods. He was keen to try out a module and the author left material for him to study. This contact had positive results which will be described in Section 7.3.
- 8. It must be emphasised that the failure of members of staff to test modules as requested by the author was usually due to the lack of time or trials being required at short notice. Ideally, plans should be laid down at the beginning of the college year but then this can also be a time of considerable change. These points were put to the author by several members of staff but, as this chapter will show, there were some trials.

Some of these points will now be elaborated on, having been set down in a concise form so that some of the difficulties encountered could be appreciated, although the final outcome was one of some success for trials. The prevalent view of a syllabus set down objectively item by item was that it could not be re-arranged and any scheme of work had to be followed as laid down, especially when this was part of a Youth Training Scheme (YTS) programme. For many lecturers traditional craft and technician courses have been severely curtailed or eliminated altogether and replaced by Youth Training Scheme courses which then provide the (usually) only major alternative professional work. However, one solution is to replace part of the syllabus by a module if it can be seen to embrace the syllabus and even provide a little more in the way of interest and relevance to a task. A 'Measurement and Building' module, varied perhaps to suit a course, seemed to be a most promising one to try out as a few lecturers had YTS Building groups. RP who had been given YTS classes was keen to try out innovatory educational methods and after some discussion asked if he could try out this module. This is a story with a powerful message for educational progress because many of the other contacts were, as they put it, 'looking for class material' and a suitable module, ready to try, would be very convenient. But with RP the educational benefits of the module were also important. The module 'Industrial Storage Tanks', based on the Oil Industry, was more difficult to place as the staff approached said that it should be used by Engineering or Science students and these were not available However, later on, MH said that he liked the at the time. look of this module for use within his Computer Appreciation scheme of work with a particular class of students who 'should try someting different': local industry (for the Halton College) is based on the use of chemicals and almost every other vehicle on the local motorway was a road tanker whilst tanks of all shapes could be seen at the various

industrial estates. MH looked at the module for its educational benefits. Most of the lecturers contacted (except for one other and RP) saw it as a piece of readymade teaching material, and perhaps this is why the author finally depended on these two for help: on reflection, this was so. At a certain stage the author had contemplated trying to make contacts elsewhere but then similar problems might have been encountered.

7.2 Development of Modules

7.2.1 Introduction

This section describes further trials of the modules with the Building and Oil Industry themes, modified as a result of the pilot studies of Chapter 6. Both modules now have a 'booklet' format which contains an Information Pack for The text should not be too long for the student students. will possibly find this rather boring and instead will prefer to become active as soon as possible(compare Bond's successful experiences in school [3] where he used very comprehensive modules). Both modules have some slides which set up the background at the beginning as well as providing information in an interesting form. The trials described were carried out in the author's college in conjunction with lecturers from other departments. Α particular research objective was to test the method of verbal assessment using a tape recorder during interviews with individual students and then transcribing these. The experience with the BTEC Science students (Section 6.3) showed that the discussions (although not recorded in that case) could bring out far more from the student than was sometimes shown by a written answer to a problem, so tape recording the discussion would improve the efficiency of the method and generate a more natural discussion atmosphere. Mathematical problems were handled in a most encouraging way during the pilot studies so the modified modules have been given exercises which become progressively more

mathematical in order to test the effectiveness of a module format in making mathematics more acceptable and thus perhaps easier to learn.

Particular objectives were to assess:

- the acceptability of mathematics under module conditions;
- (2) the contribution of the computer to learning mathematics; and
- (3) the role of the tape recorded discussion (interview).

7.2.2 Module: Measurement and Building

7.2.2.1 The Module and its Use

The module was developed from the trials of Section 6.2 and now has the format Appendix 7.2. The Notes for Lecturers and descriptions of the selected set of the slides of the bungalow project were written in conjunction with the members of the planning team, the formation of which was described in Section 6.2. The process was a gradual one with the list being discussed, alterations suggested and passed round the team by the author who then made the changes to the computer stored list. During this time CL was completing a Teaching Certificate project for a Technical Teachers' Certificate at Bolton Technical Institute [119] for which his project topic subject was based on the use of the computer; for this he asked the author for permission to use the module and the background material and development ideas, which was agreed to. He used the 'worksheet' approach for student exercises coupled with the one-page leaflet of the Carlton Brick Company [Appendix 7.3] which can be seen to contain a lot of measurement in a very compact form, well laid out and easy to follow. Although the author provided this leaflet it was CL who saw its potential and this illustrates one

way in which the team approach could work. It is worth mentioning here as a reminder that CL was one of the team responsible for producing the slides of the bungalow project and had given them to the author to use: <u>the team was in</u> action again.

7.2.2.2 The Trial Situation

The module was tried with classes of full-time BTEC Building Diploma and YTS Bricklaying students: a wide ability range The author believes that if the one for one module. module can provide learning material to span such a range of students and it is not expected that all sections will be completed by all students then the module is 'transferable'. This is desirable as new modules cannot be written for all the new situations now occuring in Further Education for schemes such as Youth Training, TVEI [120] and those funded by the European Social Fund [12]]. About forty Diploma and twelve YTS students were involved. The Building Diploma students were given the module by the author as a BTEC practical assignment for the use of a computer; the YTS students used it in a joint teaching situation (JH and ST) which provided lectures on Mathematics and Technology and Information Technology. The YTS syllabus (MSC approved) was then satisfied in respect of three subjects which were taught in an 'interrelated' way in a room equipped as a formal teaching and computer classroom: this situation was set up specifically by the author in order to test the module and was approved by JH for his students. The module was thus being used in its one form with groups of students with a wide range of backgrounds and abilities.

7.2.3 Module: Industrial Storage Tanks

7.2.3.1 The Module and its Use

The module Measurement and the Oil Industry as described under trial condition in Section 6.3 was enlarged to include

some interesting background information. Renamed Industrial Storage Tanks [Appendix 7.4], the module title brings the student into immediate contact with the central topic. The Information Pack can be made available to individual students or a few copies put out. The drawing which shows the dimensions and plate structure of a spherical tank is that of an actual one submitted for calibration to an accredited calibrating company which also supplied a typical volume-depth table. Thus a very realistic use of mathematics for technology is shown to the student and also the close connection with traditional (and common) mensuration as experienced in every school syllabus. The Volume Formulae notes deal with the three shapes for tanks and some value for \mathbf{T} is required, including 22/7 of course! Matthews and Seed [67] had some practical advice on how to counteract this deeply entrenched view of π through the results of an experiment to estimate the size of a molecule. The module concentrates on the spherical tank, just one shape of many, but formae are given for an extension of the. module to include other shapes. The photographs headed 'Tank Installations' show how conversions between units can be used, perhaps to accommodate the requirements of users in different parts of the world. The computer could be programmed in a simple way to take care of the conversions and so reduce the errors and boredom associated with repetitive arithmetic.

7.2.3.2 The Trial Situation

The module was used as a BTEC 'Use of Computers' assignment; an involvement with about thirty full/part=time BTEC Engineering (levels two to five) and twenty-five Building Diploma students, there being something in it for both specialisms because, for example, the tank must have a concrete base which requires foundations: the pipework and fabrication of the tank involves various engineering disciplines and further both sets of students had programmes of study which featured mathematics, science and technology in various forms as separate subjects. Again the 'computer teaching' situation was ideal for this experimental research because no extra curriculum time was involved and BTEC unit objectives would be met by using the module.

7.2.4 Recorded Discussions

7.2.4.1 Organisation

In the following transcriptions quotes from the interviewer and the students being interviewed are given. The atmosphere all along was kept very informal to put the student at as much ease as possible to get the best results for this important part of the experiment.

The student's quote will be indented. The responses will indicate the nature of the question but sometimes the student will be allowed to talk away from a particular theme because this is considered to be of some value. A list of prepared questions was not made obvious and was sometimes ignored when it was thought that the responses were giving information not expected but worth having.

These notes on the organisation of the interviews apply to all interviews unless otherwise indicated. The transcriptions represent a sample of the total number of students involved, with the interviews being carried out as and when students were available.

7.2.4.2 Measurement and Building

YTS Students

These questions involve the CGLI 364 Numeracy examination sample questions referred to in Chapter 3, the results

of which will be discussed during the interviews. Certain questions stand out in the population of overall scores [see Section 7.7] as having the lowest number of correct Providing the questions have been validated responses. and so deemed reasonable then one is justified in looking to the student for explanations of the poor results. The results are expressed in the form of two tables in Appendix 7.5. Table A shows the score out of 30 for each student and Table B the number of students who gave the correct response for each question. Table B shows that question 27 has the lowest overall score although the number of students who took the test is small ie eleven. JH had agreed to interview jointly with ST but would not be available from the start of the interviews and would join ST as soon as he was available. The test record numbers in Table A will serve as student identifiers for the transcriptions of the tape recordings. This number simply indicates the position in the population of students who have taken the test. They are in chronological order, with number one being the first or just one of the first group to be tested. These numbers do not follow each other in order because the students were interviewed when available.

543. How did you do number 27?

Guessed; no idea.

Start it now then: (a long pause)

Just the beginning - starting it -

Leave it and look at number 30.

No idea - did not have an idea. Worked it out - area know the method -Maths not bad at school; some parts interesting; fractions difficult and problems. How to work out was difficult. The computer has helped with maths although it can get complicated. Has what you have done helped your maths?

I did not know maths would be that important; prefer to relate to a problem.

544. Number 27; you did not give any response to this.

I did not understand the question.

How do you carpet the floor?

Work out in square feet - find length and width and area and deduct for parts What does it mean, 300 cms. wide?

There was a little discussion on this, then on the course.

Teaching through problems was interesting.

Was maths at school interesting?

Sometimes - at the end of the school period (before leaving). At the beginning of school it was not interesting - we just had sheets of sums to work from.

Any problems?

No. It was my favourite subject; Grade 2 CSE.

I know about computers - it has helped with the interest. How about maths now?

Always liked it - like it related to bricks. Course was interesting. I liked JH as well for technology.

545. You got number 27 right! not many did.

Number 30. You did not give a response.

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I knew the answer but forgot to put it down - that's all. Did you like maths at school?

Interesting.

Now asked if he liked the module periods.

Different to the way we worked at school - working out is different - he (the teacher) used his own method.

Did you like the computer?

Yes. I know how to use it properly now - not just for games.

Was the computer useful?

The computer will get it right - you have to know how to do it in your mind - the computer is too easy and does not teach you anything but having to make your mind do it means you will understand.

Give examples of uses for the computer.

It is useful if you become a foreman.

Criticise the course.

I have learnt a lot from it. The computer broke up the lesson from doing all the writing. I have learnt a lot about bricklaying and mathematics during the course.

He got number 2 wrong (subtraction) so was asked for the correct response as a parting shot! Out came the correct response. So he obviously knows it but in a written examination by getting the incorrect answer to a long or short question the effect would be to cast serious doubts on his mathematical ability.

546. He gave response A to question 27. Did you know how to do it?

I guessed it.

How about maths at school?

I liked it. I have forgotten all the trigonometry. The basic stuff is easy. Percentage if OK but you have to think about it.

What about maths on Tuesday afternoon (the module period)?

I don't like computers - I did it for two years at school and just touched it for one hour - someone broke it so all we did was write during the next two years. At first I resented technology and maths just thought the course would be bricklaying and nothing else. I can see the point in maths but prefer not to do it and just do bricklaying.

What if you worked for yourself?

I would get someone else to do the maths. <u>I just want</u> to do bricklaying and nothing else but realise that maths is important.

(Author's emphasis.)

548. He scored 15 out of 30 - very low, even getting questions 4 and 5 wrong yet said that his maths at school was alright; so the interview started with a discussion of some of the questions.

Read and try number 24. He did so and gave C, the correct response. Why did you put down B in the test?

Just guessing most likely.

Number 27; what is the response?

Β.

No. That is what you gave in the test (this then is not a guess).

How do you do it? 9×6 equals 7 -

Don't know - about 51

Do you know your tables?

No. I wasn't good at them at school.

Now for number 30. A long pause.

Don't know.

You put down C -

I guessed.

How would you start?

Find area - then divide by 9×9 .

He knows the method but does not see how to cope with the mathematics.

What maths did you do at school?

Tangents, trigonometry - sine and cosine - I have used much of this at the college. Tuesday afternoon is very interesting and I applied maths to problems which is interesting.

Have you any weaknesses?

Long division; we were not allowed to use calculators at school; never done feet and inches. We try to work in metric.

Any comments on the course?

I am quite a good bricklayer but I still have to do maths for calculating the number of bricks etc and what we do here is harder than at school because if you make a mistake you have to re-do the calculation. Teaching maths with computing and technology makes it interesting. I liked science at school. The course is a good one.

549. He got numbers 24, 27 and 30 correct and scored 26/30. He was asked about number 21.

I gave the answer as 11.2 for 57/5 and it should have been 11.4. It is so long since I have been to school I make little mistakes, see. I was probably rushing it. Which ones did I get worng?

His mistakes were in 8, 9, 11 and 21 and he now worked through 8, 8 and 11. A pencil and paper were provide and he used these as required. He knew the methods and it seems that he produced the incorrect responses through working in his head and not on paper, not having enough time and getting the correct response but failing to write it down. Now on to his schooling.

I loved it and got a CSE Mathematics Grade 1 result. I did not think we would have to do mathematics on this course which is not like school maths ('super'). We had a good teacher - he was friendly and made it enjoyable.

What about maths at the college?

Not too bad. It is too easy to make a mistake on the computer. At school we never used the computer for the course - just wrote about it: this one's better - you should teach us more about programming, which would be useful. Computers now appear to be less boring than they were at school.

Attitudes to mathematics.

I should have been doing O-level at school the teacher said. Maths at school was easy except for tangents and trig ratios. Generally maths and technology are

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interesting but the maths is harder than at school although OK.

542. Question 27. You put C - did you know how to do the question?

I think so.

At this stage JH came in (the author had asked him to look in and take part in the discussions) and from here he carried on so the quotations starting from the left margin belong to him from now on.

The cm is a school measurement not a builder's measurement. Did most not go for D? (ST - four of them.)

Did you like the course? Answer what you feel.

Maths at school was not my best subject - not interesting. Here there is more maths - I did not mind.

Why did you not mind?

Not as boring because at school we did algebra.

What was most boring at school?

Area.

What does area relate to?

Building.

So because it was applied it was more interesting - unlike 2×2 at school.

How did you feel about having to go into a classroom - back to 'school'?

I don't mind - just a bit each week.

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Can you appreciate that what you do is directly related to jobs on the building site? Also why we have to do some geometry?

Yes

550. A high score in the test (28/39); when asked about number 27 he said that he had gone astray with the units centimetres. Did he like maths at school?

Yes.

How about Tuesday afternoon?

When I don't get lost half way through I enjoy it.

Was it useful?

Yes - in brickwork as well as computing - <u>I don't like</u> computers, as they are only as good as the person who programs them.

Can you appreciate maths and technology as being necessary in your trade?

Yes.

How can we make it easier for you to learn in the workshop?

I started seven weeks late so it was hard to grasp some things which they all knew. I have been hurrying. <u>Personally I think learning maths is like going back</u> to school. We are all at different levels.

Does maths relate to bricklaying?

Maths is in everything you do.

551. Another good score, 26/30. Work through number 24 now.

I did not think I would have to do maths here.

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(JH goes through it with him but he is confused and they do not get very far.)

What was your maths like at school?

OK but I did not like it much. The first year teacher was always picking on me because I was drawing in the back of my book and he would not allow it.

Why did you draw?

Because I could not do the things on the board - like algebra and if you asked in the second year he said 'you have done it before' and so I guessed and he whacked me across the wrist because they were wrong. But in the fourth and fifth years I started to improve because I was leaving school. I have forgotten algebra but we had HD and he showed us to do what we had forgotten.

How did you feel when you had to do maths here?

School! here we go again!

But what if maths is applied?

OK.

Do you like computers?

Yes. I never did it at school. <u>I don't want the</u> computer to do the maths all the time because I like to work on paper first then check on the computer when I think my paper work is right. Sometimes it gets you down when you are in the classroom and you think it's school again.

552. You got number 24 wrong. Do it now.

The correct answer is C.

(He gets it right and rather quickly)

How was maths at school?

Alright; but I didn't like the quadratic etc.

How about using the computer?

I didn't mind but prefer to work on paper. To use the computer you have to know how to do it to check it.

Our approach to mathematics - applied to a problem - was it acceptable?

Yes, and measurement is important.

Was the time spent on technology adequate and why do we need technology?

Yes it was and we need it to see how to construct a building.

7.2.4.3 Measurement and the Oil Industry

There are two groups of students involved here, meeting on different days but essentially at the same level of studies. All have had considerable experience of further education studies and being four to six or more years older than the YTS students (a few months away from school) have considerable experience of lecturers and teaching methods as well as a variety of subjects. Job specifications vary considerably and cover the field of engineering in respect of what would be required for jobs such as stock controller, in the stores, maintenance fitter and process controller. The last involves reading meters and making changes in manufacturing processes through remote control electronic apparatus. These people were given the module booklet which launched into the world of chemistry, mathematics, physics and technology (information as well as mechanical). Here then is a brief account of what they thought of the study material and methods. They will be referred to simply as

MT1, MT2 in the following transcriptions of some of the tape recordings of the interviews with the students.

MT1

This was a good student and his written work was very well produced. He volunteers quite a lot of information and opinions, all of which have value. His comments will be given under simple topic headings as it was hardly necessary to prompt him for information!

The computer

Don't use computers a lot in the job - I'm just a controller. I type in figures and close valves and start and stop pumps. The course has cleared up a number of grey areas for me - I can now read through a program.

Mathematics

Not a weakness but you need refreshers because you It is nice to see where maths is used. not forget. We object when told 'learn this' just on a blackboard. without knowing where it is used. But in the module you see it used and it is more acceptable. I am not keen to work out a formula and have had to go back to my notes (10 years!). For, say, shipbuilding apprentices, the module lets them know that there are other industries. This is one thing I find with students here that when they've completed their apprenticeships they only know one small field.

Mathematics, science and technology

You have to be involved with everything eg using a beam involves mathematics for the mechanics and materials for the design - nothing is really isolated.

Comments on the module

I feel that with my background in the Oil Industry that it wasn't all that exciting but it has been of benefit to me.

What did you expect from the course?

The background of computers and what they are made of. In this course I was told how it works from the keyboard. When you can put in a program and it runs OK then you get satisfaction and feel in command. You can see what is done and change it. You may not get the same response from all students because to many of them the BTEC system is just an extension of school but when you have been around you have some background.

MT2

What did you think of the module?

Provided good experience of tanks - helped me to work out tank capacities. <u>A chap at work used to work with tanks</u> and I got him to give me a hand with different things. Quite a good project. A lot of background which takes quite a time to read and I would have liked to 'prettyup' my work.

Mathematics?

The % error changes with volume (when π has a different value). Enjoyed it at school. Algebra is a problem but working out rates of flow at work helps. Did not get as far as the graphs - I am not as good as some of the others. Most of maths is formulae.

I can understand 'book' maths by following the computer way of working out in orderly steps and do my practical maths this way. I like using computers and see the product. I worked through the volume formula to suit the computer and could understand it.

MT3

What did you think of the module?

<u>Too much background</u>. When looking at sections in isolation eg chemistry, you wonder what you want that for but when you work right through <u>it comes together as</u> <u>a meaningful package with all the parts fitting together</u>. We expected programming but in fact <u>we studied something</u> <u>and then looked at how the computer could help - better</u> this way.

How did you get on with the mathematics?

I have O-level grade B and BTEC level 3 passes but gave up trying to prove the formula. It was a bit basic but so is all maths if you break it down. If you write a program then you must understand the steps. The rate of increase of volume with depth graph would be like a semi-circle with the hump at the middle corresponding to the centre of the sphere. <u>I used the program TANKS*</u>:to <u>look at various volume-depth graphs for tanks and</u> compared with my plots.

Note: the program TANKS was written by the author for learning and information purposes and is made available to all.

 One the author had developed in stages to produce volume / depth tables and other information for the cuboid, cylindrical (with axis horizontal and vertical) and spherical tanks. MT4

What did you think of the module?

The background is relevant and interesting because you have to know something about your subject. It was not what I expected and the assignments were not the same as for other subjects but <u>I enjoyed it - it seemed</u> <u>like science - and I came back for more time so I must</u> have liked it.

Comment on the mathematics

I have gone as far as Level 3 - deep and hard to understand. Only got a CSE grade at school. Not a lot of maths in the module because you have one formula. For the % question I worked it out for three depths and all were pretty close but I am not sure where to go next. I have not plotted the graphs yet but I have used TANKS to see I should expect very quickly. Not too sure about the rate of increase of volume with depth.

MT5

What did you think of the mathematics?

I liked it at school and unlike for example English which depended on the teacher with maths you could get a result by working on your own and you knew if it was right or wrong. It was useful to have to make use of so many calculations. More maths here than I use at work. No difficulties but if you have a formula then it makes things easier.

What about the computer aspect?

My job is on the sales side with hydraulic pumps and I carry out a stock search by computer which is routine. I now realise that with a computer you can understand a formula because it goes through it step by step and you can see how it works. What about the module?

<u>A pretty useful way of learning maths - involved with</u> <u>other subjects - pity we can't do it more</u>. It could contain more maths such as standard deviation which we did in class and did not understand it but we did it on the computer and <u>by looking at the print out you could</u> follow it and also by reading through the program steps.

Mathematics at school and in the college?

It was one of my good subjects at school but for some reason towards the end of school life I started to be disinterested in school and maths - I found it boring. Maths here is different and is not total maths where you sit and do sums and sums all the time - it was involved in a program and you saw how it was working, not just $2 \times 2 = 4$; you saw how it could become a graph. I got lost with calculus at school.

7.2.5 Observations

The following observations are drawn collectively on the opinions and information obtained from the discussions with the students. They represent one way in which the Research Objectives of Section 7.2.1 can be commented on in a conclusive fashion. Another way is by considering written responses to constructed questions <u>but then the</u> <u>whole essence of confrontation in the form of rephrasing</u> and varying questions would be lost.

Research Objective (1)

 (a) Throughout the discussions there were plenty of frank declarations of dislike for school mathematics
but not one for 'module' mathematics.

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- (b) A general view of the mathematics was that it wasn't found to be objectionable because it was related to practical and useful situations.
- (c) The mathematics was considered as necessary and not as a subject exercise which many students had experienced in school.
- (d) The module produced activity which stimulated interest.
- (e) 'Module' mathematics was 'different' to that at school.

Research Objective (2)

- (a) Contrary to popular opinion that the computer generates instant and lasting interest many of the students were turned against it by school experiences. However, when they saw that it could show structured mathematical steps it achieved a return to favour. Thus a self-proclaimed learning machine had mathematical advantages.
- (b) The drudgery and errors associated with arithmetic for its own sake were removed by the computer and this seemed to stimulate real and worthy uses of mathematics or at any rate it was perceived by some that this could be the result.
- (c) An algorithmic approach was perceived in the form of a problem solution being broken down into simple and understandable steps.
- (d) <u>There was an overwhelming feeling that for most</u> students the computer could help with mathematics.

Research Objective (3)

- (a) There is certainly great flexibility in how the tape recorder can be used: for putting strictly formulated questions; for informal discussions or to probe thought processes.
- (b) From the point of view of time and convenience this method is not the best.
- (c) Frankness is wholly possible with the correct atmosphere and this is necessary for reliable information: thus the recorded discussion has a lot to offer.
- (d) One disadvantage is that when a student wants to talk or amplify a point a further valuable contribution can ensue.
 - (e) The method is not as dependent on the tester's interpretation of written statements.
 - (f) The method has been used in various aspects of the complete research project by the author.
 - (g) In summary the author is convinced that the method has very positive advantages over other forms of assessment.

7.3 Module at Halton: Measurement and Building

7.3.1 Introduction

As explained in Section 7.1.2 a contact had been made (RP) who was willing to try the module with a class of YTS Building students. The first meeting came about as the result of members of staff passing the author to other members of staff who they thought might be able to help when they themselves could not: this helpful attitude brought results. At the first meeting, which took place

in a classroom where he was teaching, the initial outlook for a trial did not look good as RP said that the class was a particularly difficult one in that they were of low ability, and lacked discipline. However, the discussion broadened into education in general and during this RP disclosed that he was interested in educational innovation. The full module [Appendix 7.2] was looked at and declared too long for the time which would be available and RP indicated two sections which would be more than adequate for a maximum total class contact time of four hours (two periods) which would in reality be more like two hours or just one period. There was some concern here and elsewhere that the schedule of work laid down by the YTS managing agency should be maintained, although this schedule did not exclude some flexibility: however, the wishes of the lecturer trying out a module must be accommodated. The sections B, C and D as well as Circles and Buildings were to be removed and the remaining two sets of exercises were headed A and B for continuity. After a quick appraisal the uses and advantages of educational technology were now discussed. The pattern of training for the YTS varies but in this case practical work carried out on a Monday morning provided the basis for classroom studies in the afternoon of the same day. The module sections chosen would relate to the schedule laid down for the teaching staff to operate. After RP's perusal of the module and information further discussions were necessary.

7.3.2 More Discussions and Planning

Further consideration by RP led to the decision that only one period of two hours would be available for the module and that two sections might even be a little ambitious for this period of time and the particular class.

RP I have nothing prepared for next week so we can try the module.

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ST Here are some revised notes for lecturers.

RP I will need all the information you can give me.

ST Will there be a slide projector in the classroom for the slides?

RP No. But I can get one.

The discussion was continued in the staff room ('come and have a cup of tea') as the end of RP's class period had arrived.

- RP I will have to see if the students will try the module; they don't co-operate too readily and if they won't try the module I cannot force it on them; but if the module can get them working then it will have succeeded where other devices have failed.
- ST Can I come in to record their views after the trial?

RP I only see them on Monday afternoon.

- ST Then this presents a problem. I will try to find a solution.
- RP Let me look over the module and information and perhaps we can meet mext Monday morning to see if I have any points to clarify.

The meeting took place on the following Monday morning (the trial would take place on the same day in the afternoon) in the staff room. A number of other members of staff became involved in a discussion after RP had introduced the author and the module idea. The immediate reaction was:

It won't work; where is the time coming from - all our courses have schedules - where can you fit it in?

Here again was the obsession with the rigid schedule of subject matter, regardless of education value. The discussion continued:

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The problem is getting them interested - we have tried all sorts of visual aids - yes, including the slide projector. Perhaps a new face would help.

The comments raised by RP were:

The 25 degree angle for the gable end looks too large. Are there any health and safety aspects, the present section of my syllabus? Where is the first-aid box shown on the slides?

- ST There are no toe-boards on the scaffolding safety!
- RP I won't be able to start until next week,
 - ST Can you get the use of one microcomputer?
 - RP Not in the classroom; but they move to Information Technology after this so it might be possible to do something then.

In view of the short time available for the trial of the module and the problems experienced with the class by RP, the following limited objective was aimed for:

to test the hypotheses(H2) that a module format, constructed and used within the guidelines of Chapter 5 helps to overcome antitheses to learning such as lack of motivation, poor discipline and low ability.

It appeared that not a lot could be expected from the class in the form of written communication so that an alternative assessment strategy could be required: in this respect the individualtape recorded interview of each student would be adopted providing the time could be found for the author to do this and the students would be willing subjects. Not too much success was envisaged for this group in this respect but then if a behavioural research experiment has to be restricted to an ideal situation any inferences to be made from the results would be very limited when it comes to drawing conclusions.

7.3.3 Post-Trial Team Discussions

The first task was to find out from RP if the trial had in fact got off the ground because, as he had said, if they chose not to cooperate there was little he could do. However, the least to be expected was that the slides would generate some interest and initiate some learning activity. A visit was made to the college for the sole purpose of finding out what had transpired and the following account written down in dialogue form (transcribed from notes made on the spot) also sets the scene for further developments.

- RP Two thirds did something; they were generally reluctant workers. Some settled down quite quickly.
- ST Any modifications to suggest?
- RP None.
- ST How did the slides go down?
- RP They watched them with interest. Some went back to the slides for another look. There was not a great deal of discussion.
- ST How far did they get and can they carry on?
- RP Just Exercises A and there won't be any more time next week.
- ST Any final comments?
- RP The module was something different it had a novelty appeal. It was worth trying.
- ST I would like to talk to them and record their views etc. When are they available so that I can fit this in?
- RP They are in the brickwork shop every Monday morning. If you like I will take you there next Monday and introduce you to the instructor with whom you can come to some arrangement.

7.3.4 The Recorded Discussions

The visit to the brickwork shop was duly made and the author saw the students for the first time. The instructor, who was a self-employed general building contractor engaged on an occasional basis for the sole purpose of technical instruction, agreed to make the students available for questioning on the following Monday morning and offered a small office at the end of the building for the purpose. There was a door which would shut off the office from the The idea of the questioning was put to main activity. the class by RP and there were no objections. The location was away from the main college but little extra travelling time was involved. On the following Monday morning (the author had arranged to be available) the instructor provided a list of the students present and they were called in one The purpose of the tape recorder was explained and by one. as usual there were no objections, although being recent school pupils it is likely that some had similar recent experiences. Every encouragement was given to the student being interviewed to talk freely as editing could always be carried out. The tutor (BT) also volunteered a useful contribution and he alone was a little reluctant to be recorded but this reluctance was soon overcome. The following transcriptions from the recordings will be given under specific topic headings, identified by the underlining and written at the extreme left of the page. Quoted comments will be prefixed by several spaces before the comment. The interviewer's statements start at the extreme left-hand side of the text.

Slides

Good - not seen before with bricks but have for other things.

RP said we must always wear a hat (safety) but not all those on the slides were doing so. Slides are good they make the questions easier.
Interesting though RP talks to the class as though we were A-level students - he talks Cambridge style or 'summit'. He does not speak at our level when he explains. Did the tasks from the slides.

OK. Seen slides at school but not very often. Helped us to answer the questions.

Easier having these - you know what you are doing.

Helped: interesting. They help you (after prompting).

Attitudes to Mathematics

Alright at school - no difficulties. Did not mind maths in these exercises. I did not take CSE maths at school. Liked the way of bringing maths and science together in these exercises. I would not like maths in a classroom.

Worst subject at school. Couldn't do it. Couldn't understand anything from the first year. Don't like it now but you've got to do it. Better seeing slides slides first - in school just straight into exercises from a book: boring. Took CSE exam but failed it volunteered to take it.

I did not get down to maths at school after failing the Army Careers Test. The teacher was alright. Maths is part of nearly all trades so you've got to do it.

Didn't like maths at school: not very good at it. Don't like it now. I will do it but I'm not interested in it. I'll work like this with the slides though.

Did not like maths at school - boring. It is not boring here though because it has to do with brickwork not just maths all the time like at school. I'm not interested in brickwork - joinery OK though. No grade awarded for the CSE at school. I never behaved in class and did not do the work. The first three years were alright because the teacher was strict but for the last two years the teacher was soft so we did no work. We asked for a new teacher but they would not give us one.

Not good at school. Grade 4 CSE. I did not like it. I like more practical subjects.

Attitudes to the Module

The following comments relate to the module as a whole and include the method of operation and the exercises.

I would not like to do just maths all the time. Have you done any maths since joining the course?

Not much. We learn how to use a tape measure; that's maths isn't it?

People who write these exercises come from college but we are only on a simple scheme and we can't understand some of it -

Here he read from the module -

- it's a bit mind-boggling isn't it?

In spite of this, does it mean anything to you?

Yes. It makes sense when you read it slowly and when Mr Pritchard explains it.

I would like to do more exercises of this type.

The exercises were not easy - I had to think.

They have just started computing.

Don't want to do any more exercises like this but would like computers - interesting - we use them for maths questions - we copy programs off a sheet - times and all that.

Would you have liked to have used the computer to check your working?

Yes. But it would have been hard putting the program in.

Module not like a text book - gives you maths with slides. Some bits difficult - percentage - I like a spread of questions.

Science

The students wrote little on paper about science and so this was raised through the reason for putting material into the cavity of the outer wall and also why the ground had to be treated before building commenced. Further explanations were prompted by simply waiting in silence so as to give the student time to think. However, the answers all showed original thought and were quite acceptable which indicates a possible lack of ability to express ideas through written words. Here are some responses:

Ground Treatment

Sewage treatment so there is no disease or poison in the area.

Put stuff down: clear weeds and roots.

Dig out the ground then landscape it: use weedkiller.

Treat with lime or weedkiller.

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Material in the Wall Cavity

For soundproofing and strength: to keep the heat in.

To keep the wind and all that out.

Cavity insulation.

The material is fibreglass insulation.

The Brickwork Tutor

He (BT) was given the reason for holding the interviews and was co-operative and extended his service in the form of volunteered opinions on the students in general who had passed through his hands. His main criticism of students work and attitudes lay with the changed pattern of available work - the jobs requiring the use of a level of skill repetitively had largely disappeared leaving this type of student no option but to undertake skill training.

They are not suited to the academic parts of the courses.

Don't suggest that they do sums.

I wouldn't like to teach this lot simple mathematics.

The 'slides' approach is alright;

I heard one talking last week about someone with an honours degree so he understands that there is such a thing little things you hear give you a measure of ability and intelligence. If you ask them to calculate the area of a wall they will be able to do it but you have got to let them know that there is some good reason for doing it

I wouldn't like to teach this lot simple mathematics.

7.3.5 Observations

There can be no firm conclusions because of the small number of students (12) initially involved and the limited extent of the written work submitted. Having achieved the objectives of the trial:

- (1) to get the students to attempt a module;
- (2) to involve staff in a team approach; and
- (3) to record students' frank discussions.

the followng observations are viewed as relevant:

- (1) The students were strongly motivated by the slides.
- (2) The module text should be carefully matched to the literacy levels of the students.
- (3) Successful use of mathematical ideas should not.
 have to depend on the ability to remember a formula as the means to this end.
- (4) The subject of the module was not a specialism of the operating lecturer and it also involved some technical terms which had to be learned.² More time was needed for staff development on this but in spite of these problems transferability of subjects between lecturers is possible through a module.
- (5) <u>Recorded discussions with students seem to be</u> good indicator's of difficulties and associated problems such as interpretation.
- (6) <u>Many of the students disliked mathematics at</u> <u>school yet cheerfully accepted it in the context</u> <u>of a module of interrelated studies.</u>
- (7) The research objective has been achieved within the limits stated.
- (8) The author can note at this stage that perseverance at this college was justified.

7.4 Module at Halton: Industrial Storage Tanks

7.4.1 Background

The author had a meeting with MH for the specific purpose of selecting a module for trial with one of his classes. A number of modules were produced and when shown Industrial Storage Tanks [Appendix 7.4] which had been developed from the experiences of Chapter 6, there was an immediate reaction from MH with the comment:

I like the look of this one!

MH then decided to take the module away for a few days, look through it thoroughly and then produce his ideas for using it. At the second meeting MH disclosed his plan for the trial. The following points summarise this:

- (1) There would be about twelve students taking a Manpower Services Commission supported course called Computer Appreciation, which was divided into eight units.
- (2) The module would provide something different for the Problem Solving unit.
- (3) The class meets one evening per week for three hours and part of this time could be spent on the module and part of other course exercises.
- (4) ST would show the slides and deliver the commentary.
- (5) ST would have access to the students at any time in order to hold discussions with them, review their work, make tape recordings of discussions etc, all providing that the students were willing.
- (6) After the slides had been shown MH would revise the evaluation of volumes using the Volume Formulae sheets in the Information Pack. This

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was his idea to bring to the notice of the students the essence of the topic. The formulae would be programmed into the computers.

- (7) A room would be made available for tape recording and discussions.
- (8) The students could be visited at any time in order to collect information.

7.4.2 The Trial

This took place in a room equipped with a number of computers and some desks set aside for writing which could also be carried out on the table holding the computer. MH first of all introduced the author's research programme and the idea behind it (just a reminder that he is a researcher) and the modules were issued. Each module contained a set of prints of the ten slides but MH then continued:

Stan would like your reactions to a scheme of work: please watch the slides and listen to his introduction here is something different for you

Lights out now - the students listen in silent attention as ST delivers the commentaries. The volume-depth calibration curve task was brought in at a suitable point. The local (Widnes) chemical industries fitted in well withthis introduction and examples of tanks to be seen on the roads were quoted.

MH now took over and asked the students to turn to the volume formulae. His idea was to make sure that the students were familiar with the tank volume formulae and could evaluate the volume from the dimensions. For this he made use of the computer which would mean having:

- (1) an ability to use elementary algebra for the formula; and
- (2) a facility with arithmetic for checking what the computer does.

He issued notebooks for the purpose of:

... keeping notes on what you do and work out ...

MH went through some theory and for instance said:

... remember (a recall of some previous teaching) we put in L and B for area. Let us try L,B and H and get the volume of the cuboid tank ...

He likes group working and they were observed to turn into groups in a natural way as if they had done this before. They were told to check the computer working with simple numbers using mental arithmetic as well as pen and paper, then try decimal numbers. The work went on like this for nearly an hour then they were told to save their programs on the disc and:

... you can go back to your data base programs now ...

but some kept on with the mensuration and tried a program for the cylinder.

MH The change in activity (interest) is good. Next week we'll go back to the module.

And to the class:

Take it home - read it and prepare for next week.

The time was about 8.30, two hours after ST had arrived. Here are some brief notes on this first meeting with this class.

- (1) The atmosphere was friendly encouaged by MH.
- (2) Study strategies are individual working, selfpaced to suit a mixed ability group.
- (3) Some students definitely liked to work with others.
- (4) The way MH made the introductions of ST and his module was impressive.

At the second meeting ST went along with the tape recorder and noticed that some of the notebook work was quite good. There were of course some who had done little work in the meantime but this did not mean to say that they had given The idea of the recorded discussions was mentioned up. to some of the students and there seemed to be no objections. A group of two students who worked together (Derek and Stuart or D and S) seemed to be interested in this and they had problems with the sphere. Also their educational backgrounds and age were somewhat different so that their responses to questions and difficulties could be compared not just, say, on the basis of knowledge. So it was decided to concentrate on these two (willing) subjects. The recordings would then take place at the next meeting. Meanwhile, from MH:

... and what have you brought me this week! ...

which referred to the ready supply of modules always carried by ST in case he met a potential user. Out of the bag came a copy of 'Society and Numbers' based on diet sheets [App.7.7].After a brief glance MH came out with the encouaging statement:

This is a lot of reading for these people but we are getting a lot of nurses in soon who will be taken by two friends of mine. This should be just fine for them. I will speak to them about this. Copies were duly handed over!

7.4.3 The Discussions

Some transcriptions of discussions with D and S now follow. These took place in a room set aside for the purpose by MH and equipped with desks and board as well as some computers on tables against the walls. The author feels compelled to make the point very strongly that MH had conducted the trial in a very able manner with many features worth noting. Just S came along for the discussions with D not available as he was engaged on some task which had to be finished. He had completed a part of a Engineering Craft course and has an O-level Mathematics pass. Thestudent's comments will be indented with notes and the interviewer's remarks or questions starting from the left margin.

Do you like using the computer?

Yes. But not for playing games (I have one at home) ... I prefer to have a useful task for it

How far have you got with the module?

I spent hours trying to get the spherical tank program going at home during the holiday but it would not run. I even thought about it in bed and got up, took the computer down from the top of the wardrobe, set it up and tried out yet another idea!

The module stimulated this degree of interest.

So you have of course given up?

No! I am determined to get it going.

Aren't you bored?

No. I find that the booklet (module) makes it interesting.

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Well, let us try together. There is a Commodore computer the same as yours so let us set it up and use it as you are familiar with it: it also has a printer which is useful for carrying away results to refer to at home. At this stage D wandered into the room and was curious as well as interested in what was going on (D is older than S and has children). They had both tried some graphs but only by working out the individual volume values on paper: the graphs looked quite good. The rest of this meeting was devoted to programming the computer for a volume-depth calibration table for the spherical tank, carrying out checks and running off tables of depth/volume for use at At the next meeting with the author the first task home. would be the exercise set into the text which asked the student to check the capacities of the tanks shown under the heading 'Tank Installation' in the Information Pack. Neither of the pair had attempted the exercise. This should be highlighted as an exercise with a reference number and not just appear as part of the text where it loses its impact - another slight modification for the module. The conversions to be checked were from barrels to cubic metres and the formula was worked through logically as follows, regardless of algebraic refinements because the computer does not need to have the burden of calculation eased by simplification etc.

1 bbl = 35 x 1.200.... gallons (Note: bbl represents barrel) 1 litre = 1000 cc 1 cu.m. = 1000 00 cc = 10 to power 6 (they accepted this) = 1000 litre so B bbl would be equivalent to: B x $\frac{159.109925 \times 100}{1000 000}$ cu.m. They put it into the program as: (B x 159.109925 x 1000)/10⁶

their brackets and choice of the exponential notation (S wasthe leader in this part of the exercise being more familiar with mathematical techniques than D, and also younger and closed to the school period). However during this period it was apparent that D possessed mathematical aptitudes which can be obscured if there is too much concentration on just knowledge and techniques. Science, in particular chemistry, was brought in during the conversions (using the program after typing in) because the contents of the tanks were written down after interpreting the abbreviations. With a little prompting they deduced what LNG stands for. Butane produced an almost immediate association with The computer checked conversions cigarette lighter fuel. did not agree with those given on the pictures and moreover there was no consistent pattern of error (they were asked to see if there was one). So far from this just being a 'sums' exercise it brought in geography (location of tank)² In seeking reasons for, or patterns in, the and science. anomalies the connection with formula evaluation was now very weak as the results themselves were under the microscope.

So what possible explanations for the discrepancies have we ...?

We have used a different number of decimal places for our conversion figures.

Suppose we had used 158 instead of 159.109925?

We would get lower results each time.

Perhaps rounding has done it.

And so the discussion went on until they were asked to produce a table of values with the printer so as to have something to take away for study when away from the computer. Fortunately MH's instruction had been good and they handled the equipment well. Any other conversions?

Gallons to litres.

They deduced the formula without help.

The session was ended soon after and continued after a break of two weeks. What was now wanted was some discussion bringing in science, technology etc and the following transcription accomplishes this and also brings in educational background.

- S At school I was interested in physics, chemistry and got to do Computer Studies but the teacher selected the best and was not interested in the rest so I did not like the teachers ... I could not get away quick enough.
- S I loved maths O-level pass.
- D That's why he's clever see!

Science?

- S Felt a bit poor there. I like physics perhaps because of the maths - also like experiements.
- D The nearest I got to a computer was the calculator. Thought I was OK until the exam. The teacher said that I used to do things the long way round - came nowhere so was put off it. The easy stuff is OK but I am lost on the maths of tanks.
- S Took a TEC course and worked as an apprentice fitter made redundant during the apprenticeship - and as the work was getting harder (formulae twice the length of the desk) I packed it in.
- D Never done anything like this before never been one for using my head but I can talk though. I learn to keep up with my lad of seven and can show him where he is wrong.

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What about the module?

S A challenge. I did the cuboid and the cylinder but not the sphere!

What has it done for you?

S I now realise if you have the formula you can work it out with the computer.

The background - any good?

D Mainly what you did on the slides. The slides were alright to watch. Needed something (commentary) a little more adult for me (I'm older). It was so easy to take it in the way you were telling us - it could have been a little bit harder but when I saw it all written down it all looked so difficult. Better if we had something hard at the start. I gradually saw how the computer program connected with geometry.

S and D now engage in a dialogue on the mensuration. S explains the cylinder formula and D is still obsessed with O-level maths giving S the advantage over him.

D I have tried to step through it but keep getting lost. Sitting at home I keep thinking how am I going to write it into the computer.

The dialogue continued showing that they found the stepby-step working of the computer was a great help in understanding and following mathematics and also that in spite difficulties they did not give up.

7.4.4 Observations

 The module seemed to stimulate interest in mathematics, science and technology.

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- (2) The mathematics, if extracted and presented as such would not have survived as mathematics.
- (3) The computer seems to make mathematics acceptable and encourages discussion.
- (4) The module format is powerful in respect of the wide range of subjects it can invoke in an interrelated way, such as geography.
- (5) This module can bring together people of different abilities and backgrounds and encourage them to work as a team to their mutual benefit.
- (6) The text is perhaps too long and involved for a student to be able to become involved in the tasks without first spending some time reading it. However, the author cannot recall any outright criticism in this respect from the students who experienced this 'long' form. Should there be modules of both 'long' and 'short' forms?
- (7) A glossary of terms used in the module would be a useful addition to the Information Pack.
- (8) One must be careful to distinguish between lack of mathematical aptitude and lack of knowledge of techniques.
- A few pictures can save a great deal of written or verbal explanations. Note how the Tank Installations pictures bring in -

mathematics; chemistry; mensuration; geography; and units

in an interrelated way.

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7.5 Case Study: Education Within Industry

7.5.1 Background

This case study arose through the justifiable failure of a student (SH) to complete the assignments for a BTEC Computer Assignments half unit component of a science programme. She was granted college study time for one day per week but for personal and other reasons did not apply herself to the course and the course tutor and staff found that communication with her was extremely difficult. The student was employed as science laboratory assistant by a company manufacturing pharmaceutical products, with chemistry as the base of her daily work. However, the laboratory tasks and equipment together involved her with mathematics, science and technology in a necessarily interrelated way so that these Computer technology was components became integrated. used and the laboratory was equipped with a microcomputer. The author was responsible for this student's tuition in computer studies and had to make an assessment decision which could have been a simple 'fail' one. After discussing the situation with SH the author decided that she had reasons for poor attendance and performance, one of which seemed to be a reaction against the college environment. There was no more official attendance time left as the end of the year had arrived. The discussion with the student had disclosed that she did have a genuine interest in her work and was possibly much better at learning in the work environment than the college environment. The author by this time was thinking along the lines of the student completing her studies while working by demonstrating the achievement of the study objectives through the tasks called for as part of the job. Because of the mathematics science and technology in the research laboratory a module in which all these would be interrelated would be suitable. So here was the possibility to pilot test a MODULE OF STUDY After the idea, the reality would not WITHIN INDUSTRY.

materialise until the BTEC moderator had given his approval and the student's supervisor (Dr I Jackson, hereafter IJ) had agreed to support the scheme. For supervising the study IJ would be in the best position although there would have to be occasional visits to the laboratory.

7.5.2 Setting Up an Approved Scheme of Study

One of the stated aims of the 1974 Policy Statement of the Technician Education Council was to:

... produce a much better system of technician education by greater teacher and industrial participation

A programme of study carried out within industry and with the (necessary) co-operation of industry is thus wholly compatible with this aim. It was also made clear in the Policy Statement that formal contact with teachers did not have to constitute the only mode of learning. If a scheme of work requires the use of equipment for practical exercises then the use of the industry's equipment should be investigated. This would help to give an authentic dimension to any experiments which have to be carried out and possibly designed to fit the programme. These ideas were put to IJ who was keenly interested in education and as such was a member of a Further Education Advisory He was also keen to assist the student to make Committee. progress in her studies, because from his knowledge of her and her background, he considered it worth the effort: the college staff had opposite views, however, but this did not deter the author because from the research point of view success was to be sought with a new method. The next step was to obtain the approval of the BTEC programme moderator for the author's plan: this was granted providing the author would oversee the operation of the scheme and organise the supervision inside the company by someone who

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had an interest in education. The student also agreed to the plan after the idea of the interrelated studies module was explained and displayed considerable interest in this.

7.5.3 The Programme of Study

This would be based on the work which SH was engaged on in the laboratory so long as it provided sufficient mathematics, science and technology interrelated through whatever daily tasks were prescribed. For example, if her daily task was simply to carry out the same experimental procedure so as to produce many results for statistical analysis then this would not be suitable. Science, mathematics and technology would have to be seen to be interrelated in the laboratory and requiring the use of the computer in a practical and supportive way (not necessarily to a major The module would be attacked by SH during the extent). summer vacation period of the college. This was ideal for the author because educational contact with students ceases for this period and is not normally available, but the work within industry usually carries on and certainly does so for the important pharmaceutical industry on which so many people depend in all parts of the world. The author put the idea to SH during a brief telephone conversation. She responded enthusiastically and the next step was a visit to the company to hold discussions with both IJ and SH. Work on the module had already been started by SH but the author ignored this as he first wanted to know precisely what her daily tasks involved. Her immediate commission was testing Flow rates (mathematics), physics (mechanism of filters. flow), technology (designing, constructing and operating the apparatus) and chemistry (of the different substances tested) were all interrelated by the task. The mathematics as it happened was quite simple but this was not really of much concern because there in the corner of the laboratory was a microcomputer. The laboratory was used by IJ and SH so that there would obviously be plenty of opportunities for the two to discuss the study programme. The author asked

SH to describe the work of her laboratory in the context of the whole Research and Development Unit of which this laboratory was just one part. The responses were full, knowledgeable and lucid. Notes were made during the discussions and the following extract provides background to the module.

- (1) The electron microscope is an important piece of equipment in a laboratory yet it is not explained at college.
- Much of the college apparatus is out-dated and is devoted to wet chemistry which we never do here.
- (3) A simple explanation of the chromatograph should be given.
- (4) Mathematics is the most relevant of all the subjects but the Level II unit involves a lot of repetition of O-level work.
- (5) Only a little inorganic chemistry is needed and something on lipazones would be useful - this is a new field for us.
- (6) Practical should change the college stuff is old-fashioned because industry uses instrumental methods which are often automatic. All the students agree with this.
- (7) We need practical applications for mathematics.
- (8) A final product will have passed through a range of laboratories and will have involved a variety of processes involving mathematics and science. The work of the sections is brought together.

The relevance of (6) can be judged from the author's visit to the research laboratories. The author then had a long discussion with IJ which involved educational matters. Because the work of this and the other laboratories in the Unit rely heavily on 'measurement' in its various forms (see Chapter 4) the title put to SH was:

Measurement in a Pharmaceutical Laboratory

and on hearing this IJ said:

just what I had suggested!

The module (a short document) as written by the author was presented to IJ and SH for approval: this was accepted without discussion and is as follows:

Measurement in a Pharmaceutical Laboratory

Aim

To show how measurement in a pharmaceutical laboratory brings together mathematics, science and technolgy through practical tasks.

Tasks

- (1) Write a detailed account of measurement in your laboratory which makes use of a piece of standard equipment. Give details of the context of its use such as:
 - (a) background to the use;
 - (b) relevant technology (apparatus);
 - (c) the use of mathematics and statistics;
 - (d) how science eg chemistry is involved;
 - (e) how the computer supports the laboratory work, and

(2) Describe the use of a piece of standard company software explaining the involvement of any mathematics, science and technology. Produce several examples.

Notes

(1) CONFIDENTIALITY

As your written work will be submitted for assessment by the moderator make sure that what you disclose about the work of the company has the approval of the company.

(2) APPARATUS

References to this should be supported by diagrams and possibly photographs. A brief but clear description of the mode of use should also accompany these.

(3) NUMERICAL DATA

Whether supplied by other parties or derived during an experiment care should be taken to ensure that the degree of accuracy presented is reasonable.

(4) INTERRELATIONSHIPS

At all stages mathematics, science and technology should be indicated in a relevant way. For example, if units are to change then a conversion² formula or method will be used so indicate clearly how this is done - this will not be mathematics used for the sake of mathematics but because it is called for by an experiment.

7.5.4 Operation of the Module

The author had not been restricted by the company regarding supervisory visits but this module was to receive its main supervision from within the company through IJ. However. the author paid two visits to see how the work was progressing. There was just one point of criticism about the extraction of numbers from experimental data - they had to be refined to suit the accuracy of the apparatus. The student seemed very pleased with the way she was making progress and seemed to enjoy relating her academic studies to her daily work tasks. A copy of the written work as finally submitted is shown in Appendix 7.6 and was passed to the tutor for examination by the moderator as it stood. One point on which SH could not satisfy the module requirements (and this was not obligatory) was the provision of photographs of apparatus. However, the author obtained a considerable quantity of literature from Instron Limited who supplied the company with materials testing machines, the function of one of which was to measure the strength of filter materials. This is another example of the excellent support by industry.

7.5.5. Observations

- (1) What has been described is a case study involving the work of one student. However, the opportunity arose to try a module in the declared mode and it was considered worth pursuing.
- (2) This case study reveals how important co-operation is from inside industry if the education/industry partnership is to work. In this case a supervisor with a keen interest in student education was available and willing to help. It should also be noted that the supervisor was himself very well educated and so was able to encourage the student in many ways. Students in

other industrial situations would perhaps be less fortunate.

- (3) This case study can be viewed as an experiment in 'distance learning' in which the college supplies teaching material, advice and some supervision.
- (4) The attitude of this student to learning within the college was obviously quite negative, one reason being that she considered the college equipment of little use when compared with that provided for her use by the company. <u>This raises</u> the issue of finding the best place to carry out the education: if it is within industry then the 'module' concept might be the answer.
- (5) The use of the computer to handle the mathematics for the filter project was justified because of the repetitive nature of the experiment. Little would be gained from trying to compete with the computer's mechanical computational consistency and accuracy. This use of the computer is considered by the author to enhance learning by removing the emphasis from arithmetic and placing it on the results of the arithmetic. It must also be noted that this use of the computer would have little significance in the classroom. Without the apparatus and the reasons for using the apparatus the purpose of the mathematics becomes considerably weakened.
- (6) As an attempted conclusion to this brief and limited experiment in changing the learning environment it must first be stated that <u>the</u> <u>student showed more interest in her studies than</u> <u>she had ever displayed in the college</u>. Enthusiasm and activity were very evident. The environment of work no doubt greatly increased

the motivation to study. The relevance of the module tasks to what she did in the laboratory must have contributed to the increase in motivation. There was a good balance between the mathematics. science and technology in the student's written Little motivation could have been provided work. by the format and the presentation of the module: there were no pictures in the module and no slides were provided to view. The module could be described as 'dull' as far as the presentation is concerned. Finally, the degree of interest shown by the supervisor in the project must have been of benefit to the student.

(7) Finally, the author views this case study as an example of distance learning and could be a for further cases as dictated by the needs of the pharmaceutical and other industries.

7.6 Staff Development

7.6.1 Introduction

This section describes some of the ways in which the author attempted to bring the method of 'interrelated studies' to the notice of other educational practitioners through lectures, meetings, discussions etc or simply by making modules available. Probably the most effective way of reaching as many educators as possible is by publishing a paper on the subject; the shorter the paper the more likely is it to be read by busy lecturers. Publication also ensures that there is something tangible to refer to and also someone to correspond with for further information and guidance. The author's experiences with involving others varies from making individual contacts in his college to attemtping group contacts in other districts. In Section 7.6.2 the distribution of a module to numeracy practitioners is described: in Section 7.6.3 the interrelated approach is

pursued through the tape/slide programme 'Measurement': Section 7.6.4 looks at a staff development group set up with controlling guidelines and financed by Adult Literacy and Basic Skills Unit (ALBSU) on an area basis: Section 7.6.5 is similar to Section 7.6.4 but the group is drawn from a wider catchment area; a firm response to the author's paper predicts developments in a college (section 7.6.6); and an integrated approach to the subjects of an Applied Science course indicates the need for staff development in Section 7.6.7.

7.6.2 Module: Science and Numeracy

This module [Appendix 7.7] was constructed with the help of information obtained from the Training Officer of a margarine manufacturing company [115], and was an attempt to impress on the Numeracy Sub-group of the Merseyside and Cheshire Authorities Adult Basic Education Co-ordinating Committe that numbers are not used in isolation but very often in a scientific context. Numerous example occur in everyday life from estimating the quantities of Chemical additives in food to using numbers for controlling one's food intake. The response was poor from the representatives of numeracy education in the districts of Cheshire, Knoweley, Liverpool, Sefton, St Helens and Wirral. The excuse for not being very interested in science as well as numeracy was 'I don't teach science!' so there was a lot of educating to be done. The modules were issued after the author had explained the ideas behind a module (an official allocation of time had been made at a meeting) and there had been a discussion. There were no responses from the committee members. However, science was not an entire void for the areas since at least one member had reported basic education schemes which featured science, even though the presentation was as a time-table of separate subjects. The committee did however at least discuss the module and each member accepted a copy of the module, promising to 'see if I can use it'. The author felt that he had to

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try to obtain module trials through likely agencies and this one seemed promising. This was one of the disappointments experienced by the author who feels that it must be stated.

7.6.3 The Tape/Slide Programme and Teacher Training

During a discussion with the course tutor for teacher training in Further and Adult Education at the author's college, the provision of educational technology arose. After hearing about the tape/slide programme 'Measurement' (Chapter 5) she said that she would like the students to see it and arranged for the author to take each group for one period. The students were drawn from industry (instructors and trainers), the public services and parttime and full-time education. The occupations of the students span a wide range of disciplines and are shown in the table '730 Course Occupations' which follows this It would ve very difficult to assemble such paragraph. a varied group if one tried, so the author was grateful for what looked like being a rewarding research exercise because of the potentially wide range of opinions available. Occupations were not the only diverse characteristics of the groups; academic qualifications range from that CGLI Technician Certificate to Doctor of Philosophy in Chemical The students from the three classes have Engineering. been grouped together for the analyses which start with the following table of occupations.

730 Course Occupations

1	Painter and	l decorat	tor			
2	Apprentice	trainer	with	British	Nuclear	Fuels

3 Teacher of office skills

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4	Non-practising lawyer teaching upholstery			
5	Teacher of home economics			
6	Part-time office worker (ex-policeman)			
7	Sister-tutor in intensive care unit			
8	Ex-nurse (SRN) now an adult literacy teacher			
9	Hairdresser			
10	Cookery teacher			
11	Hairdresser			
12	Dental nurse			
13	Sister tutor in hospital			
14	Bookkeeper			
15	Word processing teacher			
16	Apprentice trainer			
17	Potter			
18	Computer/electronics trainer			
19	Welder			
20	Sewing teacher			
21	Health visitor			
22	Cookery teacher			
23	Retail distribution lecturer			
24	Training officer			

25 Chemical engineer

The groups were asked to write down what they thought the programme was about as it was shown without an introduction. Most saw that measurement was being brought out and mathematics also and that these two related to their subjects in some way. There was a free discussion after showing the slides and comments were recorded and analysed. Some transcriptions from the recordings are:

- .1 Just a way of teaching a difficult subject and relating it to everyday things.
 - 2 I found it a little bit over my head I haven't met a micrometer.

3 Shows how life relates to measurement.

- 4 Everybody's life relates to measurement.
- 5 One thing has an effect on another.
- 6 One thing every subject relates to is communication; you cannot touch anything without it.
- Author: the student's comment means that all subject involve communication.
 - 7 In a college there should be communication between departments but some departments think themselves at a higher level than others.
 - 8 When teaching skills you have to relate to real life situations for the purpose of the knowledge you are giving. With a theoretical subject, eg maths, you can teach it regardless of applications such as learning all about logs without using them for anything practical.
 - 9 <u>Speech terrible! very monotone. Pictures were</u> <u>quite realistic. There was a good visual impact.</u>

Author: it can't all be good!

- 10 You can't avoid maths and the use of maths.
- 11. Maths at school is knowledge for the sake of knowledge: there are no case studies.
- 12 I measure people (a physical culture expert) and relate their measurements to diet, shape, size etc.
- 13 I have always been taught maths as a separate subject and hopefully you relate it to something.

- 14 Stop the sound commentary sometimes and give time for the message to sink in.
- 15 We should relate to other departments and their work.

The recorded discussion brought out very clearly the very positive feelings of the members of the group about not being encouraged to relate their subjects to other subjects the discussion was quite heated at times and the feelings on this could only be judged by listening to the recording. They felt the need to talk to staff in other departments, mathematicians for example, if mathematics arose. An interrelated studies module would help to bring together different subjects in a relevant way for both the LECTURER AND THE STUDENT. To summarise, showing the Measurement programme certainly stimulated discussion which soon brought in the idea of subject interrelationships. The author let the discussions run freely, injecting a minimum amount of prompting.

A development with this group would be to discuss modules involving an INTERRELATED APPROACH which would support the need they feel to cross subject boundaries. This idea could be put to their course tutor for incorporation in future training programmes. The author is sure that the tutor will respond to this suggestion with the same enthusiasm as she showed when the tape/slide programme was mentioned.

7.6.4 A Sub-Regional Staff Development Group

This group is funded by ALBSU and is still meeting It arose out of the one-day conference [118]. Relevant guidelines are laid down for the number of members of a group, the number of meetings etc. The conference was open to representatives of industry and schools because educational problems relate to all levels. Why did the author attend this conference? Simply because here was a vehicle funded by a national body, set up to identify numeracy 'needs' and which must come up with something tangible - and probably the best form would be a module of study bringing together the basic ingredients of industrial and commercial life: mathematics, science and technology. For the author to suggest this right at the beginning of the conference would be too much but it was hoped that things would develop along these lines and one must try. It was not intended to push the module idea (after all some of those present had sat round the table with the author and rejected the idea) but to perhaps 'nudge' it along or just see what transpired: opportunities were being sought to After an opening try out the idea of interrelated studies. address the conference members formed four groups, each with a leader (arranged beforehand so there was no awkward 'election') and debated numeracy needs. Then the ideas were pooled and three sets of needs were identified for which three staff development groups (SDGs) were formed. Each of these groups then formulated plans of action. At the end of the day each group leader reported back to the reconvened total The author had taken two of his partconference group. time staff along and one subsequently produced a module on¹ catering calculations while the other was already a member of the Applied Science course team (section 7.6.7). The author used the tape recorder during the discussion sessions (with full knowledge of the group) because it would be easier to transcribe from this than from written notes. The idea of a module did come out of the author's group 'Measurement Involving Metrication and Estimation' and one subject suggested was Health, which the author pointed out was related to science.*

* The author believes that the (once rejected) science and Numeracy module(Section 7.6.2) will eventually be accepted in principle because of the work of this group. This group meets regularly and is at present analysing and classifying measurement and its illustration and will then produce a module or modules with notes for teachers. Further funds will probably be available for the 1986-7 session and will be used to produce a module based on the interrelated studies idea. During the meetings of the group the author constantly reminded the members that there was too much discussion and not enough action in the direction of producing teaching material. He also recommended a move in the direction of interrelated studies modules because although talking about numeracy topics they were constantly Appendix 7.8 is a summary of bringing in applications. the first part of the work of the group and indicates a place for modules.

7.6.5 A Regional Staff Development Group

7.6.5.1 Background

Members of the Numeracy Sub-Group to which the author belonged were invited to join one of the regional staff development groups funded by ALBSU through the Regional Advisory Councils [12] the author's council is the North West Regional Advisory Council based at Manchester. The theme 'Teaching ABE in Other Topic/Subject Areas' attracted the author to one of the groups and he was subsequently elected a member. The members keep in touch between the meetings by telephone which is the only practical way to make contact because of the geographical separation: but this must be a fact if one's ideas are to be propagated The feeling of the author and tested beyond his work area. about this staff development group was that it could support the research but since adult basic education is probably taken to mean literacy and numeracy (but should also include some science and information technology) and there would be room here for a development into an interrelated approach with respect to other subjects or 'topic areas'. If materials are to be produced then again a module seems to

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be a suitable form in which to produce some teaching materials which if accepted will show a successfor interrelated studies. Each group will be required to report back to ALBSU who can consider publication and dissemination of commissioned materials, which mean a wider publicity for the ideas and materials. Thus staff development will take place on a much larger scale than could be achieved by one individual such as a researcher working without special time and resources funding. Further funding for successful applicants for the continuation of the work of the groups will be considered after April 1986. This implies that a good case must be made based on the work of the present As with the group described in Section 7.6.4 this groups. section will be incomplete because this thesis will be completed before the material has been collated.

7.6.5.2 Summary of Discussions

The first two meetings were taken up with what was to be the final part of the exercise: namely how to present the One member was very much against producing yet findings. another bundle of paper (a report) to be filed away without reaching and affecting the practitioners it is designed to help. He alone stood out for preparing a one-day workshop to display teaching materials and use it to explain the ideas to the visitors. This seemed to be putting too much into an event which could ultimately attract only a few people from the very large region so the idea of a REGIONAL group would have failed. Eventually he agreed to the production of something on paper but it must be interesting and useful. The author had produced some information on the pharmaceutical industry case study (Chapter 4) and had explained the background which is really, in the eyes of a basic education practitioner just an integration of numeracy, literacy and communication. A 'case study' was discussed in which members would produce a study based on a particular 'model' and those case studies would be submitted to ALBSU as an illustration of ABE in other topic or subject areas.

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However, the reader of this thesis should find SCIENCE an acceptable addition to the ABE list. One member remarked:

If only you had a tape recorder during the teaching periods!

They thought that the author's case study was probably quite unique and it tended to lead the thinking from this point. There were to be seven case studies conforming to the following models:

- (1) Service and Support:
- (2) Student Negotiated:
- (3) ABE with Core Work as Options:
- (4) ABE and Technical Learning:
- (5) Responding to Group Needs:
- (6) ABE and Outing:
- (7) Industry Links.

The author's model was (7) and the case study submitted was based on the module 'Measurement and the Motor Car' of Section 7.7. The four submissions were based on the following case studies:

<u>Model</u>	Case Study
1	Foundations for technical learning
. 2	Tenants' group support
5	Stimulus for writing
7	Information technology

It should be noted that Models 2 and 5 have, on the face of it, little to do with science or technology but then the

author welcomed the broader view of interrelated studies which came about because this group drew people from a variety of areas in adult education. These were discussed very briefly because the main topic was 'how to present our findings to the ALBSU' as the production of a report or teaching materials was included in the terms of reference. The case studies had many of the features of interrelated studies modules with ABE together particular subjects. It was decided that the report would take the form of a model for relating ABE to other subjects or topic areas, based on the four case studies only. More trials of the models were considered in other parts of the country (funds were available to finance these) but were quickly ruled out because of the time this would take. A member of the North West Regional Advisory Council staff was brought into the meeting because she was experienced in the production of illustrated reports of good quality: her services were provisionally booked for the setting and printing of the final report booklet. Each member took away two copies of the four models and would produce ideas on the final form by editing the copies. The next meeting would be for a full day at the end of which it was hoped to have a document ready for professional reproduction. In more ways than one, then, this project has some of the desirable features of 'interrelated studies' modules: the means to meet as a team; the funds to produce materials; and a group size small enough to be functional. The next stage after the submission of the report will be to request further funding for a second stage - an experimental and investigational one over and above just four case studies. It should be noted that the four case studies correspond to module pilot studies. The national network of staff development groups organised by ALBSU will be available for the assessment of the case studies, if accepted. The final sum of money left from the grant made to the group (a few hundred pounds) will be used to reproduce copies of the case studies which will be distributed to educational practitioners in all parts of the

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<u>country</u>. This then is one advantage of belonging to committees, study groups etc which have credence and which fund 'events'. The <u>INTERRELATED APPROACH</u> is present in all the models, broadly Adult Basic Education related to other subjects, study areas or just activities. The bound and published set of case studies will include explanatory notes and some conclusions; an extract from each of these initial case study reports is shown in Appendix 7.9.

7.6.6 A Response to the Author's Paper

As was stated in the Introduction a short paper so published as to reach as many parties as possible who could benefit from using the methods of the research would be one way to effect the trial of modules. An encouraging reply [App. 7.10] was received on behalf of the Mathematics Unit serving the whole of Southend Technical College. The author spoke to the Head of the Mathematics Unit (as a first contact) who was keen to see and also find out as much as possible about the background to the modules: he was also interested in Also the author wanted to know if other the research. members of the college staff representing other subjects might be interested. This led to the possibility of the author addressing a meeting at the Southend College. In the meantime copies of modules have been sent down for consideration with one change: a new front sheet for 'Measurement and the Oil Industry' was made [Appendix 7.11] which eliminated reference to the computer, the use of which then becomes optional. This would not put the mathematicians under any obligation to use the computer. The author indicated his willingness to visit the college in his written reply [App. 7.12] and such a visit would be given official support by the author's Head of Department in the interest of staff development for the author's college. Further developments are now awaited and if this response brings about more trials then more and extended publicity for the modules will arise. A further conversation with the Head of the Unit has disclosed that he has distributed

copies of the modules to each member of staff in the college as a whole, who teaches mathematics. When the modules have been appraised in this way a meeting will be called to explore the best way of using the modules or developing others. This course of action will take some time to produce results but the author will be informed of the outcome: considerable design and use of modules could follow.

7.6.7 Applied Science: A Case for Staff Development

There are many course funding bodies in education, distinguished by title but in reality deriving their own funds: from the citizens in one way or another (schools, colleges and universities are common examples). The European Social Fund is rather different in that it is one of the many funding agencies supported jointly by a group of countries through the Common Market. The fund has officials in the United Kingdom who are responsible for issuing allocated funds for the support of innovatory courses designed to improve the employment prospects of unemployed adults by means of education and training. The author's department is at present in the course of running the third such ESF:supported (the college meets half the expenses) course on the theme of Applied Science based on the topic 'The Oil Industry' which was suggested by the author and The author, as course tutor, determined the accepted. course philosophy, organised the staffing within budget limits, interviewed the applicants and had quite a few more functions simply because this was a non-traditional course with considerable innovatory factors such as industrial visits. Above all it was essential to steer the tuition away from the separate subject approach and exploit subject 'interrelationships' as much as possible. As can be seen from the staff list for the second course team [Appendix 7.13] they are very well qualified to teach well above the often elementary levels at which some of the subjects were presented, yet they all did so with interest and dedication. Two were employed as part-time lecturers (SC and JO) and were selected by the tutor for their contributions to 'water
engineering' and 'medicinal chemistry' respectively as both these imply mathematics, science and technology in their contexts. Certain mathematical topics were in fact common to these areas, for example the exponential function. The first course started off with mathematics being taught as such but the author then replaced the lecturer with JO which brought in science in an interesting way without neglecting the mathematics. All these innovations stemmed from the experiences gained by the author in the course of his present research. For the third and present course the author (still course tutor by request) decided to abolish mathematics as a subject and replace it by 'integrated studies' and the time-table and staffing [Appendix 7.14] are virtually unchanged except for the fact that JO is no longer in the team. SC has had module experience by producing a module 'Water' [Appendix 7.15] with the author in a team approach for a small group of six TVEI pupils from a local school. This group was particularly troublesome and the college staff were constantly complaining about them. The author suggested that we (in the college) should try to make their lectures interesting. The 'module' approach proved to be one answer to the discipline problem as can be seen from the report of a discussion [Appendix 7.16] between school and college staff. The author had asked to join the discussion group so as to be able to explain the \Box practical nature of the research being carried out by the research team at Loughborough. The module has had a few modifications made to it in the light of trials and has enabled the computer to be used to advantage. The module 'Measurement and the Oil Industry' was given to the students as a BTEC Use of Computers assignment and tape recorded comments are available as well as transcriptions. The students enjoyed the module, in particular, having to discover things for themselves. What are the lessons to be learnt from this account? Well, in Further Education one must be prepared for innovation. Separate subjects (as in school) for the whole course would not be very interesting and hence the module. Also industry demands changing roles for its workers and a broad base of ability: hence the 'interrelated' approach is ideal.

7.7 Module: Measurement and the Motor Car

7.7.1 Background

The module was introduced into a Mode A Youth Training Scheme for a Mechanic and Auto-Electrician programme of study. The Managing Agent (MA) was the Motor Agents Association through a Co-ordinator who operates over a wide region ranging into the north-west area of the country up to the Scottish border, eastwards to Derby, southwards into North Wales and also Ulster. The Co-ordinator, who is based at Chester, is responsible for the satisfactory operation of the schemes under the guidelines laid down by Generally, the work-based the Manpower Services Commission. component of training ('on-the-job') takes place at garages where the repair and servicing takes place and the educational component which is mainly conducted in classrooms ('off-the-job') takes place in colleges of further education. However, the choice of venue for the latter component rests The author was asked to provide entirely with the MA. teaching for the Information Technology component for a group of students placed by the Co-ordinator at the Wirral Metropolitan College. Section 3.4.7 of the Training Programme:

(4 days) Hands-on experience in the operation of a simple computer and computer programs.

does not convey too much information to an intending lecturer yet it does provide tremendous scope for exploring new fields and testing new methods for anyone who is interested enough to try. The author was shown a letter from the Co-ordinator which contains the following:

.... In order that we can satisfy MSC requirements regarding the content of the various parts of the course I would appreciate a scheme of work being

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submitted by the staff: this is especially important for the Computer technology. In some cases this part of the course has been subjected to criticism by the MSC

and in view of this the author decided to discuss the course with the Co-ordinator, after dealing with most of the requirements thought to be necessary with the help of a visit to a large garage where some of the students worked. Some points from the discussion are:

- (1) In a certain Lancashire town the students had not had a talk on banking.
- (2) The MAA had been very severely criticised last year because a lot of time had been spent playing computer games in the name of information technology learning.
- (3) We have great difficulty in getting lecturers to cross subject boundaries and talk to each other.
- (4) Assessment by examination is important to keep the students working.
- (5) In 1986 there will be a regional conference for representatives from all the college to discuss their schemes.

The idea of interrrelated studies was explained by the author with a view to this helping with the problem of crossing subject boundaries and the idea was well received, and a module planned for trial with the class was mentioned.

7.7.2 The Module

This was originally planned with a view to testing the use of basic mathematics in practical situations within the

context of the retail motor garage and also to evaluate mathematical performances. In view of the conversation with the Co-ordinator it was decided to extend the scope so as to involve science as well as perhaps technology. since the motor car makes use of a great deal of science even the car owner who claims to be 'non-technical' cannot help being involved with science when there are problems! The support for educational modules can be quite excellent and also sometimes free, waiting to be collected; examples are the 'The Product Explained' booklets which are freely available in the showrooms of Vauxhall-Opel dealers. Electronic Instruments, for example, brings in electricity, temperature, pressure and graphs of different kinds as well as numbers and a mixture of the two systems of units. The module [Appendix 7.17] is a short one mainly because there was not much time left for the students to use it but also not too much time available for the preparation. Bond [3] also used a module with the same title in schools but his module related to many aspects of the manufacture of the car, providing general interest without demanding too much mathematics. In order to reduce the amount of paper involved and to facilitate the examination of students' work by external agencies the worksheet format There are many good photographs, drawings was invoked. etc available for the subject to use in the construction of such modules, and the author is grateful to the Ford Motor Company for assistance in this direction.

7.7.3 Use of the Module

There were originally fifteen students in the class but three had left just after the course started. The module was issued on the day before the last Information Technology period of two hours thus allowing time to be spent on it at home. With a view to this a short verbal explanation of what was required was given. Not all the students were present at this briefing but copies of the module were left for them in case they came in late. The next day only

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eight students attended the author's class (the first of the day) and few had made an early start on the module. However, there was plenty of time within the period to complete it. Most understood what to do and they helped the others. They were told to use the computer for the table and for the computations but calculators were provided.

7.7.4 Assessment of the Students' Work

The assessment scheme is outlined in Notes for Lecturers included with the module but this would be varied or replaced according to the use of the module. Each worksheet was allocated the same marks but these could be weighted differently. Worksheet 1 tests the ability to relate parts of the car with appropriate mathematics and science. Worksheet 2 tests the selection and use of arithmetical techniques in meaningful situations as well as requiring subjective judgements to be made, which are not easy to assess with precision. Table 1 analyses the questions of Worksheet 2.

Question	
(Worksheet 2)	Technique
1	Division
2	Division and multiplication
3	Multiplication
4	Subjective judgement
5	Subjective judgement
6	Subtraction and percentage
7	Addition

The mathematics qualifications of the students were mainly in the middle band of the CSE grades but none of the

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mathematical techniques called for were new to any of the students - they were just not being called for as in formal mathematics teaching. The mean percentage score for each question in shown in Table 2 and alongside the question is the number of a question from the multiple choice set [App. 2.1] to which it corresponds, in brackets. At the beginning of the course each student took the multiple choice test and this is now used to judge progress, bearing in mind the small size of the sample. Also included in Table 2 is the percentage score (in brackets) for the corresponding multiple choice question: the table is followed by an explanation. It can be seen that out of the four question which have reasonable correspondences to the multiple choice questions three show distinct increases in scores. The indication then is that after working through the course the students have improved in certain topics as shown by the Worksheet 2 results when compared with the multiple choice test results. The fourth question (6) shows a diminished overall score but then the students found this difficult to interpret. The next step would be to have the module tested more widely so as to increase the size of the sample for analysis and to obtain feedback from other lecturers concerned with the To this end the module and results of the course. assessment have been submitted to the YTS Co-ordinator (Table 3, Appendix 7.18) and it is hoped that the large area of the country he is responsible for will yield further data.

Table 2

Question	<u>Mean % Score</u>
7 (25)	92 (58)
3 (17)	85 (50)
5	63
4	75

1	(21)	46	(42)
2		63	
6	(24)	8	(24)

Explanation of the table

Out of the seven questions for worksheet 2, four (7, 3, 1 and 6) have been identified as corresponding to questions out of the multiple choice set. For example, question 7 corresponds to multiple choice question 25 which is shown as (25) in the first column. The second column contains the mean score for a Worksheet 2 question (for example 92% of the class obtained the correct result for question 7) with the corresponding multiple choice question mean score alongside in brackets (for example multiple choice question 25 was successfully answered by 58% of the class).

The YTS Programme includes numbers and their applications intended as a learning objective for the practical component of the training and the students have a 'mathematics' period which from their accounts is formal and The very low mean score for Question 6 uninteresting. arises from the fact that few students attempted it. probably because they did not understand it and this is supported by some their comments. The subjective judgement questions (4 and 5) were answered quite well. There was not a lot of time left after the work was collected in but there were no complaints about the questions. The little time left was devoted to a short recorded appraisal as outlined in the next section.

7.7.5 Recorded Discussion With the Students

The tape-recorder was produced and the students were asked to gather round and talk about the author's section of the course. <u>As this was sprung on them without warning some</u> <u>seemed to be about to object but it was explained that</u>

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recording was an efficient way of making sure that all the important comments were captured. A transcription of the recording now follows.

This was a group discussion because fifteen minutes was the maximum time available which included time for setting up the equipment. It was not possible to question each member of the class but just to wait for someone to speak. Prompting was used to make sure that the time was used most efficiently. The first student recorded came to the front and spoke very clearly and forcibly as if he had a definite point to make.

The following is a transcription of the comments:

- 1 What we have learned has been very interesting and that is that you don't need to know just about mechanics but about physics, science and chemistry. The computer bits are very helpful - we'll be in the Parts Department at work.
- 2 At the start of this course I did not like computers but I like it now. At work you need to know about computers for sales and stores. It has helped my maths a little although I am not very good at it and I like it a little more now.
- 3 The maths in the module was a bit difficult. I'm not the sitting-down type but like to get out. I am very good with my hands but not at maths.
- 4 Our maths lecturer writes a lot on the board. He doesn't explain and doesn't teach us. He keeps coming round saying 'haven't you done that yet?' and just writes the answers on the board without an explanation.

- 5 We are expected to know the formula for the problems in maths but we didn't do a lot in school. It is easier now that we have the book [122] because it explains things.
- 6 In the book the science is all in the maths.
- 7 We would like more time with computers.
- 7.7.6 Author's Comments
 - 1 The mathematics in the module and in the computer applications seemed to be acceptable and was attempted without objections.
 - 2 Probably if the mathematics had been introduced without the context of the computer and the module, the interest observed throughout would not have been maintained. But if the students are interested in their work success is more likely with a diet which would be unacceptable in other circumstances such as a formal mathematics lecture.
 - 3 Once again the module demonstrated the advantages in being free to help individual students, knowing that they have some prepared text which enables them to work individually.
 - 4 The tape-recorded discussion was short but the students could be interviewed later in the year, perhaps when they have had time to appraise the module and its effects.
 - 5 <u>The realisation of the close relationships between</u> <u>science and motor mechanics and mathematics came</u> <u>through very strongly</u>.
 - 6 <u>Further testing of the module is required but on</u> reflection it was worth trying even for such a small sample.

7 It is obvious from the responses to question 6, Worksheet 2, that this question proved very difficult yet it requires no more than an understanding of the applications of the concept of percentage. In future versions of this module there will have to be a modification of this question or perhaps a special worksheet aimed at teaching the applications of the idea or some comprehensive notes with worked examples.

7.7.7 Report to the Co-ordinator

The author sent a report on the course to the Co-ordinator which contained a copy of the author's paper (Appendix 7.1) a brief outline of the interrelated approach to the use of the computer as a means of bringing together mathematics, science and technology, the syllabus, the module and the final assessment results. A verbal reply was received from the Co-ordinator because he was particularly anxious to discuss the course with which he was very pleased and also future developments. During the discussions he made the following points:

- (1) The author's package has been well digested and understood:
- (2) Would you accept three classes next time because I want to move some to your college?:
- (3) Under new Manpower Services Commission rules there will be increased teaching time allocated to Information Technology:
- (4) Perhaps you can work with the Engineering Department:
- (5) Generating an interest in mathematics is important:
- (6) Your suggestion of using the module more widely is a good one - I would like to see a conference on this and other teaching approaches for the whole of my region:

- (7) Perhaps we can meet next week when I will be in the vicinity of your college at the Wirral Careers Convention;
- (8) 'Integration' of subjects is still a great problem in many colleges - some WILL NOT integrate.

The author's response to this latter suggestion was to disclose that he would also be there and as it happened for the same session (afternoon) to which Mr Watkinson the Coordinator, responded 'I look forward to meeting you and having a useful discussion'. The author will offer to set up the conference and so propagate the idea of interrelated studies. Finally, to bring the beginning of the account closer to the end it must be noted that though the module was introduced for the purpose of research, it proved to be a useful contribution to a new subject.

Finally, here has been a most beneficial use of an interrelated studies module: the teaching approach ('integration') required by the Youth Training Scheme has been adequately demonstrated and the students have enjoyed using the module and have been able to accept the mathematics.

7.8 Module: Measurement and the Pharmaceutical Industry

7.8.1 Background

This section is a consequence of the case study reported in Chapter 4. The author has kept in touch with educational developments at the plant and has discussed with the Personnel Director possible developments from the courses which were described in the case study. During the period of preparation of a report on the courses which the author ran on the company's premises, the rough notes from which most of Chapter 4 was written were perused again and one important fact stood out at this time which was perhaps of little importance during the exercise. This was that the

management policy was to capitalise on the experience gained and institute some sort of programme of education in order to keep up the momentum of the author's work. Since then. of course, some more experience had been gained in the construction and use of study modules and further that the interrelated approach would also fit in well because of the very close relationships which had been demonstrated between mathematics, science and technology and the production line tasks. A module was therefore constructed [Appendix 7.18] which was based on the types of problems which the workers would have to deal with [App: 4.3], and also include some designed to extend some of the more able workers. The module would make use of the slides and photographs which were taken on the production line: the black/white versions copy very well and make good substitutes for actual photographs or colour slides.

7.8.2 Discussions With the Manufacturing Manager

The module and author's report were passed to the Manufacturing Manager who discussed it with the author. The following points summarise the discussions.

- (1) The idea of starting a structured education/ training scheme for production workers had been first raised some ten years ago and possible action discussed at various times since then. Attempts to remedy mathematical deficiencies had taken the form of providing some mathematics books obtained from local primary schools. Then the author's publicised Basic Mathematics provision took over.
- (2) There should be more projects of this kind within industry.

- (3) There are practical difficulties encountered when trying to fit such a course into the production scheme, especially when production expands (as with this company) and it becomes difficult to fit courses into production schedules.
- (4) The Report has been accepted.
- (5) A worker is more likely to discuss personal problems with an outside lecturer than with a member of the staff and such discussions lead to an early solution of the problems.
- (6) The idea behind the module and its format is good but some of the questions will have to be made more appropriate to current practice.
- (7) Possible errors due to written instructions not being very clear (as highlighted in the report) have been reduced by using a computer to print them: the format is then fully under control.
- (8) The whole problem of further training is to be looked at in 1986 as and when time becomes available and the author will be asked to advise and assist in this task.
- (9) For future recruitment the possession of a pass at the Ordinary GCE level in Mathematics would probably be required for applicants before they would be accepted into the production team.

(10) The entry test [App. 4.4] remains unchanged.

7.8.3 The Module.

The module will now be considered in more detail with some explanations of why items have been chosen.

FRONT SHEET

The objectives may not be fully appreciated at first but give the student reasons for using the module. The workers are able to consult the supervisor and are also allowed to consult with each other. The photograph is applicable to the industry as it shows an Automatic Weighing System [123] for tablets. Science is well represented by weighing and chemistry for the tablets, with mathematics used for evaluating an average weight, standard deviation and coefficient of variation. Information and communication are brought in by the computer which stores the tablet sampling data which is processed into information and produced on the printer on demand. Technology is represented by mechanics and electronics. All these are interrelated by the task of checking on how accurately and reliably the plant is working by sampling a number of tablets placed in each of the sixteen 'flasks' as they are called.

EXERCISES A

- This is a pre-cursor to (2) and is intended to show that the error should not be treated absolutely.
- (2) This is a development of (1), the student choosing a balance.
- (3) The graph brings a range of reading errors together. This is one kind of graph but another kind (line) is also seen in the photograph (P11, the last one of the set included in the module) of a computer print of information obtained from the apparatus on the front sheet. Why produce a graph?
- (4) A typical type of production problem small weights and large weights.

Biology, chemistry, units, ratio and percentage are brought together.

EXERCISES B

(5)

- (1) Sensible representations of quantities (not all the decimal places from the calculator are required) must be demonstrated; a scheme of work (planning) and communication with other workers through the information on the label are some learning points here.
- (2) Some recall from Exercises A would help here.
- (3) The question is asking for the selection of a balance. There is a difference between estimation (using gross weight and a value for an individual tablet weight) and finding the actual weight of one tablet (which one?).
- (4) Necessary information is that 1 litre of water weighs 1 kg. Volume to mass conversion is involved as well as science and communication.
- (5) Knowledge of volume-mass-specific gravity-density interrelationships are required here and the opportunity arises to explore these. Note the approximation.
- (6) Working out individual constituents would require ratio.
- (7) Friability is a good application of percentage because it only involves one physical quantity weight.

NOTES

These refer to just a few simple but important ideas needed for the exercises. The production worker is not likely to have access to textbooks unless the family has children at school and in any case the particular information required is not usually obtainable in a small unit. Mass and weight are two terms which are to a great extent used interchangeably and so it was felt that some note on this was justified.

NOTES FOR LECTURERS

Anything used for weighing is technically called a balance so this term has been adopted although 'scale' will be used. Units always give rise to difficulties but fortunately each industry seems to adopt some system so one can concentrate on this. The use of any calculator in the correct manner for any but the most simple and routine of tasks requires some understanding of scalar algebra and if different models are used then some instruction on each model could be necessary.

THE PHOTOGRAPHS

These were extracted from the set taken on the production line. They were produced in three forms:

as black/white photographs in two sizes;

as black/white transparencies for an overhead projector;

and as colour slides from which photographs could be made.

The author made a selection from the larger photographs and mounted them and attached captions. The pictures required for the module were made as photocopies from the black/white photographs and no difficulties have been experienced in extracting information from them. Even the computer print [P11] can be read quite easily. A total of forty-eight pictures of the production line equipment and processes were obtained.

7.8.4 Trial of the Module

A situation where the module could be tried under the guidance of the author was sought. A class assignment for twelve BTEC Science programme students for their two halfunits 'Use of Computers and Computer Assignments', level 2, seemed appropriate. They had been asked to produce a piece of software to convert a volume (value typed in by the user) to a mass. Some science and mathematics discussions were needed to this apparently simple exercise for the following reasons:

the students seemed to have forgotten the density/ volume/mass relationships;

they did not appreciate that relative density (specific gravity) could be an alternative to density;

some thought the exercise very trivial until the above options were pointed out; and

the program must allow the user a choice of units.

There then followed an excursion into the physical relationships just outlined and memories started to return because after all, nothing more than GCE Ordinary level Physics or General Science at most was being recalled. After this in came mathematics for the quantitative relationships and then some examples using the information from Table 1 (Appendix 6.3) which brought in some more science in form of chemical names. It was pointed out by one student that the term specific gravity was old-fashioned and that relative density is now used (certainly more in line with the definition). However, the table is of recent publication by one of the largest producers of transportable storage tanks in Europe. So here is another example of industrial practice or terminology being out of line with the current teaching practice in schools and other educational establishments. The scene having been set in terms of mathematics and science interrelationships by this volume conversion exercise and most students having finished it, the module was introduced and the photographs shown. possible use for the conversion program was within the module and the link was appreciated. The specific objective (3) on the front sheet of the module was reinforced by the following verbal instruction:

.... make use of the computer only where you think it is justified because it has some advantage over other methods. Use simple programs, preferably those you have written

7.8.5 Observations

The students soon became engrossed in the exercise, pausing occasionally when they were in difficulties, in particular The reason for the difficulty here is with Question 1. that they have not been able to appreciate that the ratio of a fixed number to a variable number becomes smaller as the variable number increases, probably because of the technological setting of the question. The mathematics involved can be classified as 'basic' yet there have been complaints about the elementary level. It is worth no mentioning that some of the students have not completed the volume conversion program so the two can progress at the same time because they are related. The calculator has been used more than the computer which is an indication that the module should be of use in situations where access

to a computer is difficult or no computer facilities exist at all. In the pharmaceutical industry exercises of the types in the module would be solved frequently so the speed and accuracy of the computer is appropriate to the industry. The use of the computer for a task which could occur in an industrial situation such that the student has been involved in producing the program (and so understands it), must give confidence in, and more sensible use of, a computer.

The students were given the alternatives to the printed pictures of the balances - the sticks and overhead projector transparencies <u>but they unanimously decided that they</u> <u>preferred the pictures</u>. The exercises, of course depended on the pictures and so this trial shows how the module could be used within industry (as is intended) in a realistic way. The author's department has received two more requests for courses related to the chemical industry and experiences with the module should be useful.

CHAPTER 8

SUMMARY, RECOMMENDATIONS AND SUGGESTIONS FOR FURTHER RESEARCH/DEVELOPMENT

8.1 Summary

This thesis is a record of certain practical steps taken to counter the uninteresting and unhelpful way in which mathematics is seen to be taught. The teaching of mathematics in isolation from other subjects and from practical applications to which it is naturally related is seen by the research team as undesirable - by the author in Further Education and by Bond [3] in schools. The interrelated approach to teaching mathematics was supported by guidelines for the production of, and strategies for, the implementation of modules of study for students, and supporting notes, information, etc, for lecturers. The author's case study on the Pharmaceutical Industry related to the teaching of mathematics but it turned out to be inseparable from science and technology, thus dispelling the idea of 'mathematics existing in isolation'. There was also a very strong suggestion that the workers were really using mathematics because of MEASUREMENT and this was supported on looking back at the case study in Chapter 2 'Mathematics Related to Industrial Training' which was to illustrate some of the mathematics required in Further Education. The author developed the topic of Measurement as a basis for constructing modules of study for particular teaching needs for example, to provide useful applications of the computer for YTS and BTEC syllabuses. However, at the same time it soon became apparent that apart from using the computer, mathematics was being involved in such a way that the students enjoyed it or at least did not object to it. This contrasted in many cases (as is recorded on sound

tape) to the dislike of mathematics as experienced at school. Further to the benefit derived from mathematics being found acceptable, other subjects such as chemistry and physics could be brought in, not as such but by the context of the module topics - chemicals in the atmosphere affect bricks ('Building' module) and the engineer should know something of the nature of the liquid gases stored in the tanks he constructs/designs ('Industrial Storage Tanks' module).

Of special importance is the flexible way in which any component (mathematics, science or technology) of a module using the 'interrelated' approach can be varied to suit the ability level of the students. Thus, if capable, a student should be asked to use some algebra to transform a formula; if not, the result of the transformation is given. This is possible because the development of mathematical techniques is not the ultimate objective of the module: using the mathematics and appreciating what it does are more important. The use of the computer to take care of uninteresting and repetitive computation is a great help in this direction and the account of the interviews of students with different levels of mathematical backgrounds (Chapter 6) (using the same module) about this 'feel for mathematics' (not how many formulae they could remember) confirmed this view.

Opportunities arose to use the 'interrelated studies module' technique in respect of the new requirements of industry for a broad base of training for its workers - for the YTS the 'integrated' approach to theory and practice is most important; this then relates to the observations and analysis of section 1.2. The modules 'Measurement' and the 'Motor Car' were used to bring together information technology, mathematics and technology for YTS motor vehicle trainees. The success of this module is demonstrated by the very favourable response from the regional coordinator who in fact was grateful that someone had responded to the call for an 'integrated' approach to education and training. It is important to note that the

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author has decided on careful reflection that this module and what it has contributed to Youth Training Schemes <u>would</u> <u>not have arisen without some of the ideas suggested by the</u> <u>research team</u>.

To return briefly to the <u>pharmaceutical industry</u>, the case study (Chapter 4) was left without a firm plan of action for future education and training. 'When the module 'Measurement in the Pharmaceutical Industry' was submitted at a later date, to the company concerned (after trial in the author's college) it was received, accepted and treated as a contribution towards the company's new training plans. It should be pointed out that many of the outcomes from the use of modules have <u>definite promise for future use and can be considered as</u> <u>a response to 'A New Training Initiative' [1].</u>

The ideas, trials and findings of the experimental components of the work behind this thesis would be limited in the benefit they could bring to educators in all parts of the country or the world if confined to a few trials within the author's college. While Professor Bajpai has supported the research team in taking the ideas to different parts of the world and trying them out, this thesis does report in full on what the author has contributed in this direction. First, the Measurement tape/slide programme was used with educators for the purpose of 'staff development' in the field of inter-They found it stimulating and discussions related studies. took one group a long way towards the idea of an interrelated approach to teaching. Although not many trials were recorded the programme has great potential for further use, perhaps in a modified form. The trials with students (in a college of Further Education) showed that the programme was not perhaps suitable for them but the idea is worth pursuing.

The second approach to staff development made by the author was to join such groups, set up and funded by national bodies, so as to be able to introduce the research team's ideas and make contacts for trials. Working in other geographical areas did not prove easy but the use of the interview (with

the tape recorder) proved to be a great advantage in assessing what the students had got out of the module. A good deal of dedicated support is required from others in order that these 'external' trials should be successful and the author did in fact (eventually) find a source of such support, for which he is grateful. Perhaps the obvious way to enlist the help of others is by writing about one's experiences in a publication read by the target population, taking care to invite those interested to contact the author of the paper. The author did feel that, in spite of some success with trials in other parts of the country. he would like to reach further or at least explore the possibility and so tried and succeeded in having a short paper published. A response to this (from Southend Technical College) has much potential and it is hoped that further responses will be forthcoming.

8.2 Recommendations

These will be stated briefly.

- 1. <u>The module of interrelated studies has a definite and</u> important role to play in present and future education and training schemes for the Further Education sector.
- 2. The three hypotheses (H1, H2 and H3) of section 5.6.2.1 which a module was aimed to test have, as far as this thesis reports, been adequately confirmed.
- 3. A module can be devised to encompass a group of subjects within an education scheme (eg for the YTS or BTEC students) so that it <u>supports the overall education</u> <u>programme</u>, makes it more meaningful and does not consume extra course time.
- 4. Mathematics becomes more acceptable through the module approach to those inclined to resent it. This can be demonstrated by listening to groups of students discussing their problems. <u>The reason for this is the relationship</u> of the mathematics to a topic or theme of concern and

interest to the students.

- 5. 'Measurement' is an important and useful theme on which to base a module.
- 6. <u>The support of industry and commerce is vital to the</u> <u>success of a module</u>. Information in the form of leaflets and fact sheets brings reality and relevance to the subject. <u>Also the direct contact with industry ensures that current</u> <u>industrial practice is invoked</u>.
- 7. <u>A few slides</u> to set the scene for a module are very powerful in that they create interest, provide (if chosen with care) a lot of information presented in a compact form and can be used at random by students. Even one good slide can be of great help.
- 8. Educational technology offers considerable support to a <u>module</u>. It can take many forms (slides have been mentioned in the previous item) such as pictures, models, literature, overhead projector transparencies, the electronic calculator or the computer. It is up to the individual lecturer to select equipment to suit the module, providing this is available. <u>Physical modelling of mathematical</u> relationships should not be excluded.
- 9. The author has made considerable use of the computer but only with simple self-written programs: <u>in no way could</u> <u>he have produced anything as professional as the excellent</u> <u>MIME material. But the 'simple' can still be 'useful'</u>. The computer has been found very useful in the preparation of printed module material, changes being made very easily when required. <u>The students have derived great</u> <u>benefit from the way the computer carries out the solution</u> of a mathematical problem 'step-by-step' so that they can <u>follow what is happening</u>. The ability to deal with tedious computation is also welcomed and enables applications

to be studied without the burden calculations bring. Also the computer can carry out complex calculations (beyond the students) and deliver meaningful results: for example, in producing coordinates to plot the points for a brick arch template. <u>If just a simple application</u> is seen to be of benefit then the use is fully justified.

- 10. A small team is more productive than an individual when producing a module and a satisfactory start is a team of two. Other members can be added gradually.
- 11. Considerable success has been achieved by using the module approach with low mathematical abilities or antagonism towards mathematics. The acceptability of mathematics in these circumstances has sometimes amazed the author.
- 12. The value of the recorded interview for assessment purposes goes beyond that of some written appraisals. It helps to produce a more accurate picture of the student and helps the lecturer to assess the module.

8.3 Suggestions For Further Research/Development

The author's work has many facets which could suggest useful topics for further research. Of immediate necessity are the following suggestions.

- The production of modules for BTEC and YTS programmes. The accounts of trials in the thesis relate to information technology as the subject used but modules within other subjects, eg physics, should be tried.
- 2. Produce modules for the GCSE (replacing O-level and CSE examinations eventually) COURSEWORK component. This carries 20% of the total marks. Modules for Mathematics (and other subjects) would appear to suit this component and the author has had initial discussions with Examination Board officials: they say 'try it out'!

3. An investigation could be instigated into how the ideas propounded in this thesis could be effectively disseminated in colleges of further education. One suggestion would be via a professional centre for mathematical education established at a university or college of further education which would have facilities for:

static displays lectures/seminars advisory teachers reprographics.

4. The involvement of lecturers in further education providing in-company support for industrial/commercial training departments has merit. Further research with detailed case studies would be of great value.

Since commencing the writing of this thesis two firms have asked the author's department to submit details of courses for production workers and professional staff. The proposed courses specified a list of subjects and the results from Chapter 4 suggest that a standard set of procedures should be investigated, starting with personal interviews and a review of the company's activities. An interrelated approach to accommodate the subjects seems to be indicated. When a plan of action has been formulated it could be submitted to other companies who wish to undertake education and training.

5. Throughout the course of this research project, the computer has played a prominent part in the modules produced. Further development in this respect would be of benefit. For example, the ideas within the module 'Industrial Storage Tanks' could be extended to include tanks of other shapes. The author has produced some

software to support this, with the help of local industry. More industries could be brought into the picture. A module could be used for dealing with the topic of mensuration within schools: cooperation with Rod Bond is the first thought in this direction.

- 6. The findings of the author and Bond have highlighted different attitudes and approaches between teachers in schools and those in further education. A comparative study of methods and philosophies would be of value especially in view of the current trends in prevocational education, eg TVEI, CPVE: schemes which are run jointly by schools and colleges of further education.
- 7. Practical work is appealing to students as shown by their response to using the computer. Further investigation into the development of practical assignments involving a range of equipment would be valuable.
- 8. The research programme has shown that an interrelated approach to teaching has much appeal to students of all ages. Further development work would be valuable into how this approach could be adapted to many other common topics eg:

shelter transport food leisure.

9. An investigation into further use of audio-visual aids within the classroom would merit consideration. The tape-slide programme devised during the course of the research programme was well received by both students and teachers. Further development using this medium would be useful. In addition the video recorder can be an effective teaching aid and should be exploited in future work based upon an interrelated approach to teaching.

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APPENDIX

1.1

-312-

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APPENDIX 1.2

Examples of the Output from Computer Program 'Tanks'

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6 What is 24 317 expressed in words?

- Twenty four thousand three hundred and а seventeen.
- Two hundred and four thousand three ь hundred and seventeen.
- Twenty four thousand three hundred and Ċ. seventy.
- d Two hundred and forty three thousand and seventeen.
- 7 A man earns £2.20 per hour for a 40 hour week. Overtime is calculated at time and a half. In a week he earns £101.20. How many hours overtime does he work?
 - 3. a
 - 4. ь
 - 5. c
 - d 6.

A Chinese restaurant takes £145.85 for food served 8 on the premises and E262.44 for take-away food. What are the total takings?

- £408.29. a
- ь £407.29.
- £407.19. c
- đ £398.39.
- Three lengths of timber 3.5 m, 2.33 m and 4 m, 9 are needed to repair a wooden garage. What is the total length of timber required?
 - 2.72 m. 2
 - 5.87 m. ъ
 - 9.83 m. ¢
 - 27.2 m. d
- 10 Pocket money was distributed among 3 children as follows
 - to Tom
 - to Dick
 - to Harry

What fraction of the money was left over?

a

- ь ts -
- ¢ 12 -
- d Nothing.
- Eggs cost 32 p per dozen. A recipe uses 3 eggs , 11 The eggs cost
 - 7 p. а
 - ь 7 ÷p.
 - δρ. ¢
 - đ 9 p.

- 12 A party of students goes on an outing and the total bill comes to £36.60. If the college pays 2 the bill the Local Authority $\frac{1}{2}$, and the students pay for the rest, how much do they have to pay?
 - £6.10. а
 - £9.15. ь
 - E12.20. с
 - d £24.40.
- A lady weighed 12 st 4 lb. She dieted and reduced 13 her weight to 10 st 7 lb. How much weight did she lose? (14 lb = 1 st.)
 - 11 15. а
 - ь 1 st 7 lb.
 - с 1 st 11 lb.
 - 1 st 13 lb. đ
- A ferry leaves England at 23, 05 on Tuesday, It 14 arrives in France at 01, 52 on Wednesday, How long was the journey?
 - 1 h 57 min. а
 - 2 h 47 min. ь
 - 22 h 53 min. с
 - 24 h 57 min. d
- There are approximately 2 + cm in an inch. You 15 want to buy a pullover, size 42 in. What size will this be in centimetres?
 - 44.5 cms. а
 - Б 63 cms.
 - 84 cms. с
 - 105 cms. d

Day	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Total
No of pints	.3	4	4		5	6	4	30
			<u></u>					

Fig 0043

- 16 The table in Fig. 0043 shows the number of pints of milk delivered to a house in one week. How many pints were delivered on Thursday?
 - 2. 3. 4. С
 - d
- - a
 - ь
 - 5.

l

CITY AND GUILDS OF LONDON INSTITUTE SUBJECT: NUMERACY SAMPLE ITEMS Paper: 364 - 1 - 01

The sample items that follow illustrate the kinds of questions included in the examination question papers for this subject. They should not, however, be considered representative of the entire scope of the examination in either content or difficulty. An answer key is provided.

In the examination question paper, syllabus topics are covered by items in approximately the percentages shown below.

2 hours		60 items in question paper
	Addition, subtraction,	
	multiplication and division, tables	
	and place value	20%
	Decimals	10%
	Fractions	6%
	Decimal/fraction conversion	2%
	Standard units	10%
	Tables of figures	6%
	Orders of magnitude,	
	estimation etc	5%
	Ratio and proportion	5%
	Averages	2%
	Percentages	10%
	Alaebra	2%
	Properties of shapes	3%
	Perimeter, area and volume	
	of richt-angled figures	5%
	Graphs, charts and diagrams	7%
	Combination items	7%
	Orders of magnitude, estimation etc Ratio and proportion Averages Percentages Algebra Properties of shapes Perimeter, area and volume of right-angled figures Graphs, charts and diagrams Combination items	5% 5% 2% 10% 2% 3% 5% 7% 7%

NOTE: CALCULATORS WILL NOT BE PERMITTED IN THE EXAMINATION

1	180)7 ÷ 626 =	4	Div	ide 25)5750)
	a	1121.		а	23.	
	ъ	1421.		ъ	203.	
	c	2423.		c	230,	
	d	2433.		d	2300.	
2	Sub	tract 780	5	Wh:	at is the tota	I Cost of
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				2 11	s of beans a	t 18 o per lb
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	d	736.		ъ	67 p.	
				с	77 p.	•
				đ	87 p.	4
3	Mul	tiply 273				
		<u>× 8</u>				
	a	1624.				
	b	1664.				
	с	2164.				

d 2224.

Imperial (in)	1	12	20	36
Metric (mm)	25.4	304.9	508	914,4

FIG. 0121

Fig. 0121 shows a conversion table from imperial 17 lengths to metric lengths. The equivalent of 8 inches ŝ¢

- 152.4 3 164.3 b 203.2
- Ç d -
- 406.4.

Which one of the following is nearest to 24.8 x 13? 18

- 25. а
- 32, b
- 250. С
- 320. đ

The number of people attending a football match 19 was 21 585. How would this be reported by the press, to the nearest hundred?

- 21 500. а
- b 21 580.
- 21 600. С
- 22 000. d
- A man works for 40 hours and earns £60. How 20 much would be earn if he works for 50 hours at the same rate?
 - £48. а
 - £70. ь
 - £75. с
 - d £108.

A bus covers a journey on different occasions in 21 the following times: 10 mins, 12 mins, 11 ± mins, 11 $\frac{1}{2}$ mins, 12 mins. What is the average time for the journey?

- 11.3 mins. a
- 11.4 mins. ь
- 11.5 mins. с
- d 11.6 mins.
- How much interest is baid at 7% p.a. on a sum of 22 £120 deposited for a year in a building society?
 - £8.40. а
 - ь £12.70.
 - £16.30. ¢
 - £24.00. d

- How much V.A.T. at \$% would be charged on an 23 item costing £16?
 - 48 p. 2
 - £1.28. 5
 - £1.48. c
 - đ £2.00.
- 24 A shop buys a carpet at £3 per metre length and sells it at £3.45 per metre. The percentage profit is
 - 1.5% 8
 - 13.5% b
 - 15% с
 - 45%. d
- A saleman's salary is calculated by the formula 25 SALARY = BASIC + COMMISSION, What is the commission if SALARY = £1580 and BASIC = £1390?
 - £190. а
 - b £290.
 - С £810.
 - £2970. - d



FIG. 0202

- The ladder resting against the wall in Fig 0202 26 makes an angle of 60° with the ground. The angle x at the top is
 - 30° а
 - 50° ь
 - 50° с
 - 90°, d
- What length of carpet 300 cms wide is required 27 to cover a floor 9 metres x 6 metres?
 - 180 metres. а
 - 72 metres. - b
 - ¢ 24 metres.
 - 18 metres. đ



FIG. 0125





•



29 According to the graph in Fig. 0215, 35° C is the same temperature as



30 Carpet tiles are to be Isid in a rectangular room as shown in Fig. 0203. The tiles measure 9 inches by 9 inches, (12 inches = 1 foot). The room will need

a	19 til	es
"	54 til	es
с	56 til	es

- đ 84 tiles.

				ANSW	εR	KEY
1	d	11	c	21	b	
2	d	12	С	22	а	
3	đ	13	С	23	b	
4	C	14	b	24	¢	
5	d	15	d	25	a	
6	а	16	с	26	а	
7	ь	17	c	27	d	
8	а	18	đ	28	b	
9	с	19	С	29	C	
10	đ	20	c	30	d	

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If you have an enquiry about these cample items please write to TSD, City and Guilds of London Institute, 46 Britannia Street, London WCIX 9RG

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APPENDIX 2.2

Program 1

```
10
      Rem-----MULCHWR, 4
 20
      D"HOW MANY QUESTIONS";
 30
      Input Q
 40
      Dim Nam$(24),Gceo$(0),Cse$(0),Ans$(Q-1)
 50
      D"FILENAME":
      Input Fil$
 60
      Open\1,27+0\Fil$
 90
140
      Gosub 500
150
      2"NUMBER OF STUDENT RECORDS= ";N--1
170
      @"RECORD OR BYTE--(R/B)";
      Input W$ : If W$="B" Then 370
180
190
      @"RECORD--NEG TO END";
200
      Input R
210
      If R<O Then 530
      If R+1>Nr Then Gosub 480
220
      @"NAME---";
270
280
      Input Nam$
290
      @"GCE0---";
300
      Ingut Gceo$
310
      @"CSE---";
320
      Input Cse$
330
      a"RESPONSES----";
340
      Input Ans$
350
      Fut\1,R\Nam$(-1),Gceo$(-1),Cse$(-1),Ans$(-1)
360
      Soto 199
      @"TO WRITE A CHARACTER----RECORD (NEGATIVE TO END), BYTE <<<<<'<</pre>
370
390
      Input R, B
410
      If R<O Then 530
430
      Dim B$(0)
440
      @"DATA---";
450
      Input B$
460
      Fut\1, R, B\B$(-1)
470
      Goto 370
430
      Fut\1,0,0\Str$(R+1)
490
      Return
500
      Get\1,0,0\Nr$
510
      Nr=Val(Nr$)
520
      Return
530
      Close
540
      End
```

Rem---- MULCH.PRO 1 Rem 24 JULY '84 2 10 @"DPEN\3\ at keyboard if printer output is required. ESC first." Input"FILE NAME---",Fil\$ 40 45 Ng=Val(Fil\$(8,Len(Fil\$))) 47 3 No • - - -8 B 🚬 🤉 · · · · 50 R1=27+Ng 55 2 RL Open\1,R1\Fil\$: Get\1,0,0\Nam\$(-1) : Nr=Val(Nam\$(-1)) : @ Nr-1;" Student Records* 60 70* Rem-----SF(NQ,2) holds score 0 to NQ with frequency of the score 80 Dim Sf(Ng,2) 85 Rem---90 Dim Nam\$(24), Ans\$(Nq), Ans(Nq), Resp(Nq), Gceo\$(0), Cse\$(0), X\$(Nq), Resp(Nq, 5) Dim A(Nq, 2), B(Nq, 2) 130 135 140 Dim B(Nq+1), A\$(0), Sq(Nq+1) Rem----MENU 150 **JUSELECT THE FROCESS AND TYPE THE NUMBER"** 160 170 a"-----_____ ----180 ລ จ" 190 O. CLOSE ALL FILES AND STOP EXECUTION" 200 ວ" 1. READ THE ANSWER KEY: THIS IS IN RECORD O" 210 **ଇ** " 2. SCORE, FREQUENCY TABLE" **ə**" 3. READ THE RESPONSES" 220 4. READ THE NAMES.GCEO & CSE QUALS. AND SCORES" 5. DBTAIN A SUMMARY OF THE SCORES FOR EACH QUESTION" 6. DISTRIBUTION OF THE RESPONSES" ۵. 230 ຈ" 240 **ଇ**" 250 270 Э 300 @"REMEMBER:::::ANSWER KEY IN RECORD O" 310 a a"NUMBER <<<<< "; 320 330 æ 340 input D : D=D+1 350 Un D Goto 470,480,6000,920,1230,1870,3830 Close : Stop 470 480 F=0 : 5=0 : Goto 990 860 Rem:::::::::PRINT ANSWER RESPONSE KEY. 890 Rem::::::::::: RECORD CONTAINS THE ANSWER KEY 920 a"FIRST , SECOND RECORD NUMBER"; Input F,S 930 980 æ Rem FILE OPEN AT 60 990 For R=F To S 1000 @"RECORD::::";R;"::::"; 1020 Get\1, K, 27\X\$(-1) 1030 For B=0 To Nq-1 : @ Val(X\$(B,B)); @"-"; 1050 1970 1080 Next B 1090 Э Next R Rem CLOSE AT 470 DNLY 1130 1210 1220 Goto 150 Rem-----SCOKE FOR EACH STUDENT 1230 For X=0 To Nq : Sf(X,1)=X : Sf(X,2)=0 : Next X @"FIRST RECORD (NEG. WHEN FINISHED), SECOND" 1235 1240 1259 Input A,B 1255 If AKU Then 150 Dim Scor(Ng) 1260 1270 RemissFILE ALREADY OPEN

1280 GetV1, ONNam*(-1), Gceo*(-1), Cse*(-1), Ans*(-1) 1290 X\$(-1)=Ans\$(-1) 1320-For R=O To Nq-1 : Scor(R)=O : Next R @"CUTPUT TO PRINTER (Y/N) ?"; Input Q\$: If Q\$="Y" Then 1550 1300 1340 1350 Э -② Tab (4); "NAME"; Tab (28); "D-LEV."; Tab (36); "CSE"; Tab (44); "SCORE/"; Nq; Tab (59); "SCORE %" ③ Tab (4); "----"; Tab (28); "----"; Tab (36); "---"; Tab (44); "-----"; Tab (59); "-----" 1360 1320 1380 Ð 1390 For R=A To B : Get\1,R\Nam\$(-1),Gceo\$(-1),Cse\$(-1),Ans\$(-1) 1400 Scor≠Ó For K=0 To Nq-1 : If Val(X\$(K,K))=Val(Ans\$(K,K)) Then Scor=Scor+1 1419 1420 Next K 1430 Sp=(Int(Scor/Ng#1000+0.5))/10 1470 a) R; Tab (4); Nam\$; Tab (28); Gceo\$; Tab (36); Cse\$; Tab (44); Scor; Tab (59); Sp 1480 Next R 1510 ·ə Input "PRESS << RETURN >> TO CONTINUE ".C\$ 1520 1530 Goto 1240 Rem--PRINTER OPENED AT keyboard - see line 10 1550 1570 1580 1600 For R=A To B : Get\1,R\Nam\$(-1),Gceo\$(-1),Cse\$(-1),Ans\$(-1) Scor=0 1610 For K=0 To Ng-1 : If Val(X\$(K,K))=Val(Ans\$(K,K)) Then Scor=Scor+1 1620 1630 Next K Sp=(1nt(Scor/Ng#1000+0.5))/10 1640 2121 1.650 1660 3\3\Tab (4);R; Tab (10); Gceo\$; Tab (20); Cse\$; Tab (27); Scor; Tab (37); Sp 1670 Next R 1690 Rem FILE CLOSED AT 470 1700 Goto 150 Rem::::::::PROFILE OF RESPONSES 1860 1870 H=0 1870 For R=1 To Nq-1 : Sq(R)=0 : Next R Rem FILE UPENED AT 60 1900 Get\1,0,27\X\$(0,Nq-1) 1910 Input "GROUP OF RECORDS--FIRST , SECOND (NEGATIVE IF NO MORE) ?", F, S 1920 1930 If FKO Then 2030 1940 H≃H+S-F+1 1950 For R≠F To S Get\1, R, 27\Ans\$(0, Nq-1) 1960 1970 For B=0 To Ng-1 : If Ans\$(B,B)=X\$(B,B) Then Sq(B+1)=Sq(B+1)+1 1980 Next B 1970 Mext R 2000 Goto 1920 2010 Rem FILE CLOSED AT 470 2030 Input"OUTPUT TO PRINTER (Y/N)?? ",Q\$ If Ds="Y" Then 2210 2040 2050 Input"FIRST QUESTION, SECOND ?", F, S O"PROFILE OF RESPONSES FOR QUESTIONS ::::::::;F;" TO ";S 2060 2070 :2 2080 .ə 2070 @"NUMBER OF STUDENTS' RESPONSES PROCESSED:::::::::;H 2190 ລ 2110 @ Tab(2);"@UESTION";Tab(13);"CORRECT";Tab(27);"% CORRECT" 2120 @ Tab(2); "-----"; Tab(13); "-----"; Tab(26); "-----For R=F To S 2120 2140 X=(lnt(Sq(R)/H#1000.0+0.5))/10 2160 @ R, Sq(R), X

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2170
          Next R
2180
        Rem CLOSE AT 470
2190
        Input TYPE ANY NUMBER TO CONTINUE----",C
2200
        Goto 150
        Rem--FRINTER OPENED AT LINE 10
2210
        Input"FIRST QUESTION, SECOND ", F, S

a)3/ : a)3/ : a)3/ "PROFILE OF RESPONSES FOR QUESTIONS:::::::;;;;;; TO ";S
2220
2230
2240
        9/3/
2250
        a\3\"NUMBER OF STUDENTS' RESPONSES PROCESSED::::::::::;H
2260
        องวง
        @\3\Tab(2); "QUESTION"; Tab(13); "CORRECT"; Tab(26); "% CORRECT"
2270
2280
        @\3\Tab(2); "-----"; Tab(13); "-----"; Tab(26); "------
2300
          For £=F To S
          9/3/
2310
          @\3\Tab(2);R;Tab(13);Sq(R);Tab(26);(Int(Sq(R)/H$1000+0.5))/10
2320
2330
          Next R
2340
        Rem CLUSE AT 470
2350
        Goto 150
                              For L=1 To 5 : Resp(K,L)=0 : Next L : Next K
3830
          For K=1 To Nq :
3840
        H=0
3845
        Rem FILE OPENED AT 60
        Get\1,0,27\Ans$(-1)
3847
        Input"FIRST RECORD (NEG. TO END) RECORD, SECOND", A, B
3850
3860
        1f A<0 Then 3970
        H=H+8-A+1
3870
          For R=A To B
3880
3885
            For K=0 To Nq-1
3890
            Get\1, R, 27\X$ (-1)
3700
            D=Val(X$(K,K))
            If D=0 Then Resp(K+1,1)=Resp(K+1,1)+1
3910
            If D=1 Then Resp(K+1,2)=Resp(K+1,2)+1
If D=2 Then Resp(K+1,3)=Resp(K+1,3)+1
3920
3930
            If D=3 Then Resp(K+1,4)=Resp(K+1,4)+1
If D=4 Then Resp(K+1,5)=Resp(K+1,5)+1
3940
3950
            Next K : Next R : Goto 3850
3960
3970
        ລ
3980
        Input "FIRST QUESTION (NEG. TO STOP ), SECOND ?", F, S
3990
        If E<O Then 4120
       Input"OUTPUT TO PRINTER--(Y/N)--",Q$ : If Q$="Y" Then 5000
9 : 9 : 9 H;" STUDENTS ";" ** INDICATES THE CORRECT RESPONSE"
3795
4000
4010
       4920
        ລ
4030
        ລ
        2"QUEST.";Tab(13);"RESP. 1";Tab(26);"RESP. 2";Tab(39);"RESP. 3";Tab(52);"RESP. 4";Tab(65);"NONE"
4040
        Dim A$(68) : A$(-1)="-"+A$(-1) : @ A$
4050
          For R=F To S
4060
4070
          9 R; Tab (13); Resp (R, 2); Tab (26); Resp (R, 3); Tab (39); Resp (R, 4); Tab (52); Resp (R, 5); Tab (65); Resp (R, 1)
4080
          0">>";Tab(13#Val(Ans$(R-1,R-1)));"###"
          ∂ A$
4090
          Next R
4100
       Goto 3980
4110
       ∛ : Goto 150
4120
       Rem----SUBROUTINE FOR ORDER OF QUESTIONS
4200
4210
        Dim A(Ng,2),8(Ng,2)
4220
          For I=1 To Nq
4230
          Dim B(Ng,2)
4240
          A(1,1)=Sq(1) : A(1,2)=I
4250
          Next I
          For J=1 To Ng-1
4260
4270
            For K=J+1 To Ng
```

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           If A(J,1)>A(K,1) Then 4310
4280
4290
           A=A(J,1) : A(J,1)=A(K,1) : A(K,1)=A
4300
           A=A(J,2) : A(J,2)=A(K,2) : A(K,2)=A
4310
           Next K
4320
         Next J
         For 1=1 To Nq : B(I,2)=I : B(I,1)=A(I,2) : Next I
4330
         For J=1 To Ng-1
4340
4350
           For K=J+1 To Nq
4560
           If B(J,1)>B(K,1) Then 4390
4370
           B=B(J,1) : B(J,1)=B(K,1) : B(K,1)=B
4380
           B=B(J,2) : B(J,2)=B(K,2) : B(K,2)=B
4390
           Next K : Next J
4400
         For 1=2 To Ng
4410
         If A(I,1) = A(I-1,1) Then B(I-1,1) = A(I,1)
4420
         Next I
4430
       Return
       Input"FIRST QUESTION (NEG. TO STOP ), SECOND ?", F, S
4580
4790
       If F<0 Then 5120
5000
       9/1/ : 9/3/
       2/3/H; " STUDENTS "; " ## INDICATES THE CORRECT RESPONSE"
5005
5010
       5020
       9/3/
5030
       9/3/
       Dim A$(68) : A$(-1)="-"+A$(-1) : 2 A$
5035
5037
       9/3/A$
5040
       @\3\"QUEST.";Tab(13);"RESP. 1";Tab(26);"RESP. 2";Tab(39);"RESP. 3";Tab(52);"RESP. 4";Tab(65);"NO
5045
       2131A$ : 2131
         For R≈F To S
5060
         ə\3\R; Tab (13); Resp (R, 2); Tab (26); Resp (R, 3); Tab (39); Resp (R, 4); Tab (52); Resp (R, 5); Tab (65); Resp (R, 1
5070
5080
         @\3\">>";Tab(13#Val(Ans$(R-1,R-1)));"##"
5090
         @\3\A$
5100
         Next R
5110
       Goto 4980
       Goto 150
Rem---SUBROUTINE FOR ORDER OF QUESTIONS
5120
5200
       Dim A(Nq,2),B(Nq,2)
5210
5220
         For I=1 To Nq
5230
         Dim B(Ng,2)
5240
         A(I,1)=Sq(I) : A(I,2)=I
5250
         Next I
5260
         For J=1 To Ng-1
5270
           For K=J+1 To Ng
5280
           If A(J,1)>A(K,1) Then 4310
           A=A(J,1) : A(J,1)=A(K,1) : A(K,1)=A
5270
5300
           A=A(J,2) : A(J,2)=A(K,2) : A(K,2)=A
5310
           Next K
5320
         Next J
5330
         For I=1 To Nq : B(I,2)=I : B(I,1)=A(I,2) : Next I
5340
         For J=1 To Ng-1
5350
           For K=J+1 To Ng
5360
           If B(J,1)>B(K,1) Then 4390
           B=B(J,1) : B(J,1)=B(K,1) : B(K,1)=B
5370
           B=B(J,2) : B(J,2)=B(K,2) : B(K,2)=B
5380
5390
           Next K : Next J
         For I⇒2 To Nq
5400
5410
         If A(I,1)=A(I-1,1) Then B(I-1,1)=A(I,1)
5420
         Next I
5430
       Return
6000
              -----SCORE-FREQUENCY TABLE
       Rem---
         For X=0 To Nq : Sf(X,1)=X : Sf(X,2)=0 : Next X
6020
       O"FIRST RECORD (NEGATIVE TO RETURN TO MENU), SECOND";
6060
60B0
       Input A, B
6090
       If A(0 Then 150
6100
       Dim Scor(Na)
       Rem:::FILE ALREADY OFEN
6120
       Get\1,0\Nam$(-1),Gceo$(-1),Cse$(-1),Ans$(-1)
6140
       X$(-1)=Ans$(-1)
6160
         For R=0 To Ng-1 : Scor(R)=0 : Next R
6180
6300
       ລ
         For R=A To B : Get\1,R,27\Ans$(-1)
6320
6340
         Scor≂ú
           For K=0 To Nq~1 : If Val(X$(K,K))=Val(Ans$(K,K)) Then Scor=Scor+1
6360
6380
           Next K
6385
         Sf(Scor, 2)=Sf(Scor, 2)+1
6390
         Next R
       Input"output to printer Y/N ",Q$ : If Q$="Y" Then 6600
6392
       @ P-A+1; " students"; "
@"Score". "Frequency"
@"----". "-----"
6393
                              ::: ";Nq;" questions"
6397
6399
        For 1=0 to Ng : @ Sf(T,1), Sf(T,2) : Next T
6400
       9 : Goto 6000
6420
       @\3\B-A+1;" students";" ::: ";Nq;" questions"
6600
6610
       5/3/
       @\3\"Score", "Frequency"
@\3\"-----", "-----"
6620
       9/3/"-
6630
         For T=0 To Nq : ∂\3\Sf(T,1),Sf(T,2) : Next T
664Ŭ
6650
       0\3\ : Goto 6000
```

APPENDIX 2.3

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Table 1

Groups of students who have taken the CGLI type numeracy test

Group	Description
1	1 - 53 Laird Apprentice School Sept. 1982
2	54 - 65 Craft Plumbers
3	66 - 65 Craft Bricklayers
4	84 - 106 Craft Joiners
5	107 - 122 Hotel & Catering Yr1
6	123 - 139 "
7	140 - 155 "
8	156 - 168 Hotel & Catering Yr2
9	169 - 182 "
10	183 - 196 "
11	197 - 212 "
12	213 - 229 Prep. 'O' Maths
13	230 - 245 'O' Maths F/T Gr.4
14	246 - 253 SLA
15	254 - 261 Eng. Diploma
16	262 - 272 Science Technicians Level 1
17	273 - 282 'O' Maths F/T Group 3
18	283 - 292 Build. Dip. B
19	293 - 305 Build. Dip. A
20	306 - 322 YTS Mech.Eng. MTYA
21	323 – 340 YTS Mech.Eng. MCY1A
22	341 - 359 YTS Mech.Eng. Sheet metal
23	360 - 378 YTS Mech.Eng. Craft
24	379 – 396 YTS Mech.Eng. Welding
25	397 - 413 B.S. (Training, Education, Safety) Craft
26	414 - 425 B.S. (Training, Education, Safety) Craft
27	426 - 448 CITB YTS Bricklayers
28	449 - 465 'O' Maths F/T
29	466 - 479 'O' Maths F/T
30	480 - 488 New Opp. For Women (NOW)
31	489 - 498 Mech.Eng. Yr.1 Craft
32	499 - 504 Science Lab. Assistants (CGLI+)

App. Tech.

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REF.	0-LEV	CSE	SCORE/CO	SCORE %
480	-	_	29	96.7
481	С	-	27	90
482	-	-	26	86.7
483	- .		23	76.7
484	-	-	30	100
485	-	-	27	90
486	-	-	24	80
487	C	-	29	96.7
438	-	-	27	96.7

PROFILE OF RESPONSES FOR QUESTIONS:::::::1 TO 30 NUMBER OF STUDENTS' RESPONSES PROCESSED::::::::::504

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QUESTION	CORRECT	% CORRECT
1	128	94 9
1 7	400	70.0 PL 7
र र	455	91.9
4	406	80.6
5	476	94.4
6	496	78.4
7	295	58.5
8	493	95.8
9	462	91.7
10	353	70
11	322	63.9
12	340	67.5
13	316	62.7
14	403	80
15	425	24.3
16	443	87.9
17	420	83.3
19	394	78.2
19	400	79.4
20	333	76
21	275	54.6
<u></u>	37B	75
23	273	54.2
24	196	38.9
25	741	67.7
26	395	78.4
22	205	40.7
28	400	/9.4
29	218	43.1
30	217	43.5

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504 STUDENTS ## INDICATES THE CORRECT RESPONSE

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QUEST.	RESP. 1	· RESP. 2	RESP. 3	RESP. 4	NONE
1	4	3	9	488	0
>> <u>-</u>		• •	E	. **	0
2	U	14		400	0
3	11	8	22	463	0
>>	_			**	
4	73	8	406	17	0
>>	_	-	**		•
5	7	9	12	476	O
5	496	o .	e , .	** र	0
>>	**	v	0	9	v
7	40	295	40	116	12
>> .		**			
8	483	16	1 -	4 /	0
>>	**				_
9	6	28	462	6	2
10	71	54	44	र 5.र	14
>>	<i>7</i> L	34	* 4	**	14
11	43	106	322	28	5
>>			**		•
12	79	47	340	29	9
>>			**		_
13	14	144	316	27	3
14	53	403	** 24	17	7
>>		**	-1	X 7	
15	14	17	38	425	10
>>				**	
16	16	25	443	14	6
>>		_ /	**	. –	
17	17	36	420	13	18
19	5	49	4 . ДД	394	12
>>	5	77		**	• 2
19	15	30	400	47	12
>>	•		**		
20	12	81	383	10 ·	18
>>			**		
21	108	275	69	30	22
>> 77	378	4.4 	75	13	37
>>	**	71	22	15	37
23	45	273	69	78	39
>>		**			
24	58	90	196	113	47
>>			**	·	
25	341	27	15	67	54
/) 76	4 # 705 ·	17	20 .	17	. 61
20	-940	17	28	13	21
>>	**				
27 55	63	91	59	205	86
28	9	400	15	**	_
>>	,	11	12	26	54
29	28	31	318	45	4.7
>>			**	69	o∠
30	56	80	70	219	79
>>	-			11	

APPENDIX 2.4

TECHNICIAN EDUCATION COUNCIL

Standard Unit

1.	UNIT TITLE:	MATHEMATICS

- 2. UNIT LEVEL: I
- 3. UNIT VALUE: One DESIGN LENGTH: 60 Hours

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4. PROGRAMMES:

The guidelines produced by Programme Committees indicate the standard units for possible incorporation in their programmes. This unit has been devised as a common unit for use in a wide variety of programmes, and is intended as a replacement for the unit Mathematics I U75/005.

- 5. PRE-REQUISITE UNITS:
- 6. CREDITS FOR UNIT:

GCE 'O' level grade A, B or C or C.S.E Grade 1 in Mathematics.

- 7. AIMS OF THE UNIT:
 - a) To consolidate basic principles and establish a common base for further progress, taking into account the wide variety of approaches to Mathematics previously encountered at earlier stages in education.
 - b) To give the student a facility in the language of mathematics as a preparation for further studies in the mathematical techniques relating to Science and Technology.
- 8. SPECIAL NOTES:
 - a) It is expected that students will have attained the following objectives from the Mathematics Bank of Objectives in their previous education. Colleges should, however, ensure that students have attained a reasonable degree of proficiency in them, making good the ground, where necessary, by adjusting the starting point of the unit, using learning packages etc. but the testing of these objectives will not form part of the assessment of the main unit. If colleges find that students entering technician programmes have serious deficiencies in the topics li/sted below, it is recommended that additional time should be devoted in order to cover these objectives.

LEVEL I MATHEMATICS

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UNIT CONTENT 10.

The unit topic areas and the general and specific objectives are set out below, the unit topic areas being prefixed by a capital letter, the general objectives by a non-decimal number, the specific THE GENERAL OBJECTIVES objectives by a decimal number. GIVE THE TEACHING GOALS AND THE SPECIFIC OBJECTIVES THE MEANS BY WHICH THE STUDENT DEMONSTRATES HIS ATTAINMENT OF THEM. Teaching staff should design the learning process to meet the general objectives. The objectives are not intended to be in a particular teaching sequence and do not specify teaching method but, for example, practical work could be the most appropriate teaching method for the achievement of the objectives.

ALL THE OBJECTIVES SHOULD BE UNDERSTOOD TO BE PREFIXED BY THE WORDS: THE EXPECTED LEARNING OUTCOME IS THAT THE STUDENT: -

- Α. Arithmetic Operations
- AA
- Evaluates expressions involving integer indices 3. and uses standard form.
 - Defines the terms base, index, power, reciprocal, in terms of $a^{n}(a > 0)$. 3.1

 - 3.2 Applies the following rules, where m and n are positive integers.
 - $a^{m}a^{n} = a^{m+n}$

$$\frac{a^{m}}{a^{n}} = a^{m-n}, (a^{m})^{n} = a^{mn}.$$

- Deduces that $a^{O_{\pm}}$ 1 for all a, and that $a^{-D_{\pm}}1/a^{D_{\pm}}$. 3.3 Expresses a denary number in standard form 3.4
- (scientific notation) e.g. 1.234 x 10.⁵ Converts to normal decimal form a number given
- 3.5 in standard form.
- 3.6 Adds, subtracts, multiplies and divides two numbers given in standard form.

AA 4. Evaluates expressions involving negative and fractional indices and relates indices and logarithms.

- 4.1 Applies the rules in 3.2 where m and n are negative indices.
- 4.2 Applies the rules in 3.2 where m and n are fractional indices and recognises that $a^{1/n} = \frac{n}{a}$
- Evaluates expressions which combine positive, 4.3
- 4.4
- negative- and fractional indices. Defines the inverse of $a^{X}=y$ as $x=\log_{a} y$ Recognises that only positive numbers have real 4.5 logarithms.

APPENDIX 3.1

QUESTIONNAIRE

Note for class lecturer

At a recent Faculty 2 Burton Manor seminar it was agreed to obtain students[†] opinions on the issue of prepared lecture notes, data, tables etc. At the same time their views on the use of mathematics and computing at work could be obtained, so as to furnish us with data for the design of teaching schemes in two important areas. Would you please put the completed questionnaires in the large envelope in the staff room. This project has official approval. Thank you.

S. Turner, Science & Maths Dept.

YEAR

No

QUESTIONNAIRE

CCURSE

DEPARTMENT

Please tick the appropriate box

44	DODIG YOU TIKE CO FECEIVE:
	(a) all, some, no, ready made lecture notes?
	(b) just copies of diagrams, tables stc.?

2. Is there a subject particularly suited to the issue of prepared notes?

3. Would you like to receive a lecture summary covering a period of absence?

4. Brief description of your job:

Does it require any mathematics (e.g. counting, calculation etc.)?

5. Is there a computer at your place of work?

6. If your job is associated with computing in any way, please indicate how:

7. Do you think that some college experience of computers would be useful?

 Yes
 No

APPENDIX 3.2

STUDENTS' PREFERENCES FOR PREPARED NOTES BCJ2D----12 RECORDS 3----25%----WOULD LIKE A COMPLETE SET 9----75%----WOULD LIKE SOME 0----O%----REQUIRE NONE BP2D----15 RECORDS 4----15%----WOULD LIKE A COMPLETE SET 19----70%----WOULD LIKE SOME 4----I5%----REQUIRE NONE ECJAD-----11 RECORDS 5-----13%----WOULD LIKE A COMPLETE SET 29----76%----WOULD LIKE SOME 4----11%----REQUIRE NONE BT2----21 RECORDS 8----14%----WOULD LIKE A COMPLETE SET 46-----78%----WOULD LIKE SOME 5----8%----REQUIRE NONE EHTD2S----13 RECORDS 9----13%----WOULD LIKE A COMPLETE SET 56----78%----WOULD LIKE SOME 7----REQUIRE NONE EHTES1D----20 RECORDS 21----23%----WOULD LIKE A COMPLETE SET 64-----ROULD LIKE SOME 7----8%----REQUIRE NONE STUDENTS' FREFERENCES FOR FREPARED NOTES _____ ST3A----22 RECORDS 1----5%----WOULD LIKE A COMPLETE SET 17----- WOULD LIKE SOME 4-----18%----REQUIRE NONE STHC1----9 RECORDS 3-----10%----WOULD LIKE A COMPLETE SET 24----77%----WOULD LIKE SOME

4-----REQUIRE NONE

E. R. Squibb and Sons Limited

Reeds Lane, Moreton, Wirral, Merseyside L46 1QW Telephone 051-677 0171 Telex 629103

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26th Aug<u>ust</u>, 1981

Head of Department Science & Mathematics, North Wirral College of Technology, Borough Road, BIRKENHEAD.

Dear Sir,

I note from y our Prospectus that you run a number of courses dealing with basic mathematics.

We have a number of Operators within our Company who require on-site training in basic weights and measures and mathematics at a fairly elementary level.

Would it be possible for one of your lecturers to visit the Company with a view to discussing this further with Production Management and myself, and to establish whether an in-Company programme could be arranged.

We will, of course, be prepared to pay fees on a scale that you have deemed to be appropriate.

Y ours faithfully

D T PALMER Personnel Development Manager

No. Description of Slide.

Avery Floor scale, maximum 250kg, accuracy 0.5kg using a rider 1 2 As for P1 : reading accuracy increases towards maximum reading Avery Floor Scale (electric), maximum 1000kg, accuracy 0.2kg 3 4 The estimate of the weight must not go beyond the reading accuracy 5 Toledo Floor Scale 8180, digital Another 8180 6 7 8180 information the operator needs to know 8 A Sample Reading from the 3180. What values can the last digit take ? 9 Avery Floor Scale, maximum 500kg, accuracy 1kg 10 As P9, reading in progress Salter Floor Scale, maximum 100kg, accuracy 0.5kg 11 12 As P11, reading to the nearest half division 13 Tiamulin powder being weighed 14 The label for P13 : note biology, mathematics and physics are involved 15 A closer look at P13 : note the clear instructions Avery Floor Scale, maximum 50kg, accuracy 0.1kg 16 As for P16 : the instructions arein metric units only 17 18 As for P16 : note the separate tare scale and dual units 19 As for P16 : note the dual units and how the instructions imply addition 20 Salter Floor Scale, maximum 30kg, accuracy 100g 21 As for P20 : note the dual units but 'g' occurs only once 22 Avery Bench Scale, maximum 50kg, accuracy 0.05kg 23 As for P22 : note all units in kg; estimation is to one division 24 Toledo Eletronic Platform Scale, maximum 60kg, accuracy 0.02kg 25 As for P24 : note the term 'accuracy' Instructions for P24 : note the term 'readability' 26 27 Avery Bench Scale, maximum 36kg, accuracy 0.02kg 28 As for P27 : note mixed units and the direct reading tare scale P27 weighing alkathene (another name is polythene), used as ointment base 29 Sartorious Bench Scale : maximum 18kg, accuracy 0.0001kg 30 Avery Bench Scale, maximum 12kg, accuracy 10g (mixed units again) 31 Sartorious Mechanical Balance : maximum 1000g, accuracy 0.01g 32 Sartorious Electronic Balance : maximum 1200g, accuracy 0.01g 33 As for P33 : note clear informtion; a '+' here but a '-' in P33 34 Mettler Balance :maximum 800g, accuracy 0.1g 35 As for P35 : note the subdivision of 0.1g 36 37 Sartorious Balance, maximum 200g, accuracy 0.1mg 38 As for P37 : note how it is being used to find the average tablet weight 39 Stanton Balance, maximum 10g, accuracy 0.002g : note the technology 40 As for P39 : note the spirit level (physics) 41 As for P39 : the essential information is not always on the front -42 Mixer for pill ingredients : timed operation : proportions to be uniform 43 The computer processes tablet information and it only deals in numbers 44 The computer prints out information - here sttistical 45 Automatic tablet weighing by C.I.Electronics 46 As for P45 (the Inquisitor) : mechanical handling of tablets 47[.] Testing solubility of tablets ; artificial stomach acid ; this is biology 48 Friability = 0.65 : an example for the operator

Sample of Pharmaceutical Industry Production Line Problems

 A container is to be packed with 75000 tablets of average weight 200mg. Show how you would do this and select a scale from the list.

200mg = 0.200kg 75000 tablets would weigh 75000 x 0.200kg = 15.0kg

Put container on scale and tare up or weigh the container

So add tablets by hand until scale reads 16.3kg Select scale P9, P10

2. Find the average weight of one tablet from the total weight of a known number of tablets sampled from the production line.

Balance used : '37, 38 Number of tablets in sample : 30 Weight of 30 tablets = 6.5732g (to 0.1mg)

Average weight of 1 tablet = $\frac{6.5732}{30}$ g

= 0.2191

= 219mg to nearest mg

Tablets are coated in pans then unloaded into trays. з. The number of tablets has to be calculated and entered on a log sheet, and this is done at several stages.

The batch consists of one full and one partially full, tray. Weight of one full tray with tablets = 17.6kg Weight of tray = 1.4kg Weight of tablets = 16.2kg

Weight	of	partially	filled	tray	=	9.7kg
Weight	of	tray			=	1.4kg
Weight	of	tablets			=	8.3kg

Weight of one tablet = 0.836g Estimate of number of tablets in batch

 $= \frac{16.2 + 8.3}{(0.836/1000)}$

 $= \frac{24.5}{0.000836} = 29306.22...$

= 29306 tablets

NOTE

We only have an estimate : the measure is a 'count' - one by one!

4. A cream is being mixed in the pharmacy. Calculate the amount of cream base to be added to the key ingredients. All entries must be written in the log.

400kg of prepared cream is required.

Ingredients : 4 1 water 4 kg 400g neomycin 0.400 kg 400ml perfume (so small - ignore)

Total 4.400 kg

Base to be added = (400 - 4.400) kg = 395.600 kg or 395.6 kg to 0.1 kg

Select suitable scales for the appropriate weighings.

- 5. How are specific gravity, weight (kg) and volume (1) . connected by formulae?
 - $SG = \frac{W (weight)}{V (volume)}$

equivalent to : $W = V \times SG$ equivalent to : $V = \frac{W}{SG}$

Note:

(1) SG is just a number, no units

(2) The formulae can be called 'algebra'

6. What volume of alcohol of SG 0.895 will weigh 50 kg?

$$V = \frac{W}{SG} = \frac{50}{0.895} = 55.865$$

Ans. 55.9 to 0.1 litre

.

7. A consignment of 100 l of ointment of SG 1.07 has been ordered. What will the expected weight be?

W = V x SG kg = 100 x 1.07 kg

= 107 kg

This will be entered on the log sheet by the operator.

8. In the testing room one of the tests measures how easily a tablet loses weight by coming into contact with other tablets, boxes etc.

The measure is the coefficient of friability (F)

F = loss in weight x 100 original weight

= a%

See P47 - top left for the card showing this to the tester.

The tablets (say 20) are agitated in a drum for a fixed time.

Given: original weight = 6.05 g final weight = 5.93 g

Calculate F

$$F = \frac{6.05 - 5.93}{6.05} \times 100$$

= 1.98

= 2% to nearest 1%

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APPENDIX 4.4

Entry Tests

places.

.1.

Express 188 grammes, as Kilogrammes. 2. Perform the following calculations, mentally:-3. a) Express 0.95 as a percentage. Express 0.07 as a percentage. b) c) Express 0.156 as a percentage. ā) Multiply 3.85 by 100. Divide 176 by 100. e) Express 76% as a decimal fraction. £) Express 6.25% as a decimal fraction. g) Express 0.125% as a decimal fraction. 'n) 12 + 13 + 98.5 + 0.78 + 63.94. Add:-Divide:- 782 by 16. 5. Multiply:-196 by 42. 6. 7. Express 18 as a decimal fraction. 8. Express, numerically, THIRTY NINE Milligrammes:as milligrammes, (to 2 decimal places). a) Ъ) as grammes. c) as Kilogrammes.

Express One Kilogramme, numerically, to two decimal

APPENDIX 4.5

Notes	for	Stu	den	ts
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Interpretation of Numbers

We use the 'base 10' or DENARY number system.

Each digit of a number has a value 10 times that of one to its immediate right.

Each digit of a number has a value one tenth that of one to its immediate left.

Example



The tens are written as 80 (8 of 10).

The hundreds are written as 600 (6 of 100).

Note that the zero is used to position the digit.

We may write this number in terms of its constituent parts:

H.	T	U	
		3	
	8	0	
6	0	0	
6	8	3	

Note that a number by itself is meningless because the whole number system was based on the relationship between a measure of a physical quantity and a number.

Fractions

If our smallest unit of measurement is too large we divide it into ten parts (base ten again) and so each part is one tenth of a unit i.e. the idea of a fraction of a unit now arises. We cannot show tenths by just placing anothe digit to the right of the unit digit so we use a 'dot' or DECIMAL point to separate the whole number part from the fractional part. We still go down in value by a factor of ten.

Example

The actual interpretation of the 7 is:

7 tenth parts of 1 whole unit and can be written 7/10 Example

23.45 5 hundredths tenths 3 units 2 tens 1/10 1/100 10 1 3 2 5

2

The Place Zero

If we break down the decimal or fractional part of a number into its constituent parts then in the case of 56.598 we cannot write 9 to represent hundredths because this already means 9 units. So we insert one zero before the 9, starting with a decimal point. Thus:

56.598 equals 56 plus .5 plus .09 plus .008 and breaking it right down,

50.
6.
• 5
.09
.008
56.598

Named Units of Measure

Weight:

,

l kg	equals	1000g		
lg	51	1/1000 kg	or	•001: kg
lg	n	1000 mg		
l mg	11	1/1000 g	or	.001. g

Volume :

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1	litre	equals	1000 ml		
l	ml	88	1/1000 litre	or	.001 litre

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PERCENTAGE

Meanino

(a) Number of cases in every hundred. GR(b) The rate per cent.

Tachnical Use

There are two ways of using the term and these will be described and the method set down in steps.

(1) P percent of N (P% of N)

N is a given number and we want to find P hundredth parts of N.

Example 21% of 500 = 105

Step 1Find 1/100 part of 500 (N) $\frac{500}{100}$ = 5 = 1% of 500Step 221% = 21 of 1/100 parts= 21 x 5 = 105

As one calcutation

 $21\% \text{ of } 500 = 21 \times \frac{500}{100} = 21 \times 5 = \frac{105}{100}$

This could have been written in the following ways to give exactly the same value:

 $\begin{array}{r}
 21 \times 500 \\
 1 & 100 \\
 21 \times 500 \\
 100 & 1 \\
 21 \times 500 \\
 100 & 1 \\
 21 \times 500 \\
 100
 1$

(2) <u>A expressed as a percentace of B</u>

B is divided into 100 parts. We want to find how many of these parts there are in A; this is then the percentage that A is of B Example 50 as a percentage of 240.

Step 2 How many times does 2.4 go into 60? $60 \div 2.4 = \frac{50}{2.4} = \frac{500}{24} = 25$

So <u>60 16 25% of 240</u>

As one calculation

50 is <u>60</u> x 100% of 240 240

60 is 25% of 240

This could be written in the following ways to give exactly the same value:

 $\frac{\underline{60}}{240} \times \frac{100}{1}$ $\frac{\underline{60}}{240} \times \frac{100}{240}$ $50 \times \frac{100}{240}$ $\frac{\underline{50}}{1} \times \frac{100}{240}$

R-0-B-0-T-I-C-S



APPENDIX 5.1
APPENDIX 5.2

Descriptions of slide bank for selecting the MEASUREMENT programme SLIDE NUMBER Description 1 CAR INSTRUMENTS 2 LASER BEAM 3 ELECTRON MICROSCOPE WEIGHING CELLS 4 5 LEAK DETECTION GAUGES BY BATY 6 7 TACHOMETERS TACHOMETER DIGITAL READOUT WITH TAPE MEASURE 8 9 ... MEASURES OF OUR SERVICES... NPL TODAY'S TECHNOLOGY WITH YESTERDAY'S INSTRUMENTS - 10 11 DIAL INDICATORS NFL-DIAL ACCURACY 12RECOVERY OF SILVER-WRITTEN DETAILS WITH MEASURES 1 \mathbb{Z} 14 MEASURING MACHINERY NOISE 15 THE LOGO B/TEC . TIME-BIG BEN WITH QUARTZ CLOCK 16 17 TIME & TEMP. IN STEAM PROCESSING (SPIRAX-SARCD)) LUMP OF COAL 18 19 CULTURE PRODUCTION-OLD BUILD. +NEW TECH. 20PENICILLIN TANKS STORAGE TANKS 2122 GASES 23 OIL RIG LINEAR SCALES & ELECTRONIC INSTRUMENT 24 25 INTEGRATED CIRCUIT

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7

	26	INDUSTRIAL LOAD CELL WEIGHING-DEFIANT
ŀ	27	DRUMS BY METAL BOX CO.
	28	SCHOOL LAB GROUP
	29	FERTILISER EXPANSION @ BANDAR, IRAN
	30	CHEMICAL FLANT
	31	STEEL CONTAINER PRODUCTION PLANT
	32	COALITE'S MANY PRODUCTS-PHARMACEUTICALS ETC.
	33	HANDLING CYLINDRICAL VESSELS
	34	STEAM TURBINES-CALCULATIONS .
	35	THROUGH TO EUROPE BY FERRY TRAINS (BULK LOADS)
	36	FACETS OF ICI
1	37	USES OF SILICA
	38	SEGMENTS OF ORANGE -
	39	VOLUME SMALL
	40	VOLUME LARGE
	41	TEC TRAINING-PRINTING INDUSTRY
	42	TEC TRAINING-BUILDING INDUSTRY
	43	TEC TRAINING-CIVIL ENGINEERING
:	44	TEC TRAINING-MECH. & PROD. ENGINEERING
I	45	TEC TRAINING-THE WOMAN ENGINEER
	46	TEC TRAINING-ELECTRICAL ENGINEERING
	47	TEC TRAINING-SCIENCES (BOY & GIRL)
:	48	TEC TRAINING-ELECTRONICS
·	49	NETWORK OF PIPES
	50	ROUNDTEST RA2-MITUTOYO-ROUNDNESS MEASURER
	51	AS 50 WITH ELECTRONIC CONTROL UNIT
	52	ROUNDTEST RA2-WRITTEN DETAILS-4 MEASURES
	53	ROUNDTEST RA2-4 MEASURES ONLY (SEE 52)
	54	LAB. WEIGHING-ELECTRONIC READOUT
		AS 54 WITH MEASURING CYLINDER PRESENT

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56 RULER, MICROMETER & CALIPERS CHILD'S PLAY TO USE COMPLEX MEASURERS 57 MEASURING A PROFILE 58 APPLICATIONS OF TECHNOLOGY INCLUDING SPACE MODULE 59 CRUSADER-MICROCHIP CONTROL FOR MACHINE TOOLS 60 CRUSADER-PANEL CLOSE-UP 61 SINGLE CLOCK GAUGE 62 MITUTOYO MICROMETER-DIGITAL & VERNIER READINGS 63 AS 63 WITH PAPER READOUT 54 65 GROUP OF MITUTOYO CLOCK GAUGES ANOTHER VIEW OF 65 66 BRITISH TELECON LEAFLET DESCRIBING MEASUREMENTS 67 68 DIFFERENTIAL MEASUREMENT-SYLVAC LINEAR PROBE 69 3-D MEASUREMENT NPL LINEAR ACCCELERATOR FOR HIGH ENERGY DOSE CALIBRATIO 70 NPL POSTER-POLLUTION OF ENVIRONMENT 71 ENERGY-UKAEA 72 LENGTH MEASUREMENT-WITH DIGITAL READOUT BY TRIMOS 73 TRANSDUCER-THEORETICAL DIAGRAM 74 MOVING HEAVY LOADS AT TOUCH OF BUTTON-FUCHS 75 76 AS 75: MOVING A PIPE SECTION THICKNESS OF BUTTERFLY'S WING (MIKROKATOR BY JOHANSSON) 77 BUTTERFLY FLIES AWAY UNHARMED 78 79 DIGITAL MICROMETER-SONY DETAILS OF 79 80 HARPIST : TECHNOLOGY, MEASUREMENT & MUSIC 81 CAR PRODUCTION LINE - A LOT OF MEASUREMENT 82 MPL POSTER ON ATMOSPHERIC POLLUTION-TOTAL VIEW 23

84 AS 83 (NPL POLLUTION POSTER)-NO CAPTIONS

85 AS 83 (NPL POLLUTION POSTER)-CAPTIONS ONLY

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ł	86	SECTION OF 83
:	87	SECTION OF 83
	88	SECTION OF 83
	89	SECTION OF 83
,	90	NPL POSTER-UNITS-ALL WRITTEN
	91	PART OF 90
	92	PART OF 90
ł	93	PART OF 90
	94	CONCORDE (FRENCH) IN FLIGHT - SEE 103
	95	COMPUTER GENERATED 3-D CONTOURS
	96	COMPUTERS
	97	CABBAGE-NATURAL SOURCE OF IRON
,	98	FENNEL-NATURAL SOURCE OF IRON
	9 9	BROCCOLI-NATURAL SOURCE OF IRON
:	100	TOMATDES-MEASURES OF SHAPE, TASTE, COLOUR,
1	101	HIGH SFEED TRAIN
!	102	HOVERCRAFT
	103	CONCORDE (BRITISH) ON THE GROUND - SEE 94
	104	SIMPLE BUILDING - PLENTY OF MEASUREMENT
1	105	MEASUREMENTS ETC. FOR 75 (MOVING HEAVY LOADS)
	106	'MEASUREMENT' LOGD - WHITE ON BLACK
	107	MEASUREMENT' LOGO - BLACK ON WHITE
	108	'MEASUREMENT' STATEMENTS-1 PER LETTER-W ON B
	109	MEASUREMENT' STATEMENTS-1 PER.LETTER-B ON W
	110	GROUP OF MUSICIANS

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APPENDIX 5.3

incup of slides for the tape/slide programme

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ROUP	NUMBER	BANK NUMBER	DESCRIPTION
	1	106	'MEASUREMENT' LOGO - WHITE ON BLACK
	2	108	'MEASUREMENT' STATEMENTS-1 PER LETTER
	3	16	TIME-BIG BEN WITH QUARTZ CLOCK
	4	20	PENICILLIN TANKS
	5	56	RULER, MICROMETER & CALIPERS
	6	63	DIGITAL/VERNIER MICROMETER
	7	<u></u> 4	AS 63 WITH PAPER READOUT
	8	49	NETWORK OF FIFES
	9	69	3-D MEASUREMENT
	10	77	THICKNESS OF BUTTERFLY'S WING
	11	78	BUTTERFLY FLIES AWAY UNHARMED
	12 .	51	AS 50 WITH ELECTRONIC CONTROL UNIT
	13	21	STORAGE TANKS
	14	40	VOLUME LARGE
	15	31	STEEL CONTAINER PRODUCTION PLANT
	16	27	DRUMS BY METAL BOX CO.
	17	54	LAB. WEIGHING-ELECTRONIC READOUT
	18	55	AS 54 WITH MEASURING CYLINDER PRESENT
	19	75	MOVING HEAVY LOADS AT TOUCH OF BUTTON
	20	76	AS 75: MOVING A FIPE SECTION
	21	82	CAR PRODUCTION LINE
	22	4	WEIGHING CELLS
	19 19	100	TOMATOES-MEASURES OF SHAPE, TASTE.COLOUR
	<u>2</u> 4	97	CABBAGE-NATURAL SOURCE OF IRÓN

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FENNEL-NATURAL SOURCE OF IRON BRODCOLI-NATURAL SOURCE OF IRON HARPIST : TECHNOLOGY, MEASUREMENT & MUSIC MEASURING MACHINERY NOISE CAR INSTRUMENTS HIGH SPEED TRAIN HOVERCRAFT CONCORDE (FRENCH) IN FLIGHT - SEE 103 CONCORDE (BRITISH) ON THE GROUND - SEE 94 INTEGRATED CIRCUIT 0 NPL POSTER-UNITS-ALL WRITTEN $\odot 1$ PART OF 90 PART OF 90 PART OF 90 SCHOOL LAB GROUP 4Q TEC TRAINING-PRINTING INDUSTRY TEC TRAINING-BUILDING INDUSTRY TEC TRAINING-CIVIL ENGINEERING TEC TRAINING-MECH. & PROD. ENGINEERING TEC TRAINING-ELECTRICAL ENGINEERING TEC TRAINING-ELECTRONICS TEC TRAINING-SCIENCES (BOY & GIRL) GROUP OF MUSICIANS SEGMENTS OF ORANGE

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APPENDIX 5.4

Commentary

C1: 40

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SLIDE COMMENTARIES

-1-

Number		
(1)	Measurement is fundamental to everyday living. The organisation of society and in particular the technological development of villages, towns, cities and mathematics, science, technology and vocation are closely interrelated through measurement. The slides will illustrate this for TIME, LENGTH, VOLUME, MASS/WEIGHT, SOUND and SPEED and conside some special aspects of vocation and technology before a concluding statement.	
(2)	The very letters of the word emphasise its significance	
TIME		
(3)	Observation of the planets, sand flowing from glass to glass, rotating wheels powered by a spring, electronics chart the technological developments in the measurement of time.	
(4)	Plants grow and the human body functions to time the growth of the penicillin culture is carefully time-controlled with mechanical and electronic technology. Various vocational skills are involved	
LENGTH		
(5)	Here are three instruments for measuring length. The rule (commonly called a ruler) would be used by anyone but the other two belong to the craftsman. Note that the vernier brings in the important idea of ratio	

- (6) This micrometer gives a digital reading using electronics as well as a direct mechanical scale reading.
- (7) A more permanent record is available on a roll of paper.
- (8) These pipes carry liquids in measured amounts and their installation involved many measurements of length.
- (9) We live in a 3-dimensional world: here we show measurement in three directions. Maths would calculate measurements from these, to give volume.
- (10) The wing is clamped so gently that the butterfly flies away, leaving a record of its wing thickness. Technology has been involved: the
 (11) biologist and the butterfly are pleased.
- (12) The roundness tester ... how round is round...?
- (13) The volume of liquid chemical is measured automatically and indicated on a dial.
- (14) The inside and outside of the tank requires the use of special paints for protection.
- (15) Vocation, technology and measurement together with the mathematics of production schedules, transport, etc, interrelate in this plant for producing steel containers.

(16)

A range of containers can be produced from steel or plastics, to customers' specifications. Note the metric measurements. Many industries are linked by one type of container.

MASS/WEIGHT

- (17) Precision weighing in the laboratory interrelates vocation, technology, (18) physics, biology, chemistry...
- (19) Heavy weights can be moved precisely into any position by the touch of a button. Vocation backed by technology is illustrated by production line workers. Electronics controls the movements.
- (21) On the car production line interrelationships exist for physics in design technology, paints to combat corrosion and of course mathematics for counting of components to feed the production line to the solution of complex equations when designing the suspension system.
- (22) To weigh large masses the load cell is used. This is compressed by the load and electric charges are generated and their magnitude gives a measure of the weight. Physical principles and mathematics are used in the design, technology in the manufacture and an operator will read the weight on the electronic digital scale.
- (23) "Some tomatoes, please"
 "Which kind?"
 The simple tomato illustrates measures of shape, mass, colour, flavour
 and biologically nutritional components. An interesting indirect
 measure is that of the country of growth...
- (24) Cabbage, fennel, broccoli ... some of nature's sources of iron. The chemist will use a variety of technologies to analyse the various
 (25) important constituents and express the results as mass percentages. The horticulturist will apply science to obtain regular good quality
 (26) crops. The manufacturing chemist will supply fertilisers ... tending the crops is an important vocation ... marketing implies counting and costing ... important basic mathematics. And if someone somewhere in the world does not have access to nature's natural source of iron the pharmacist will supply some in tablet form ... The actual masses of essential constituents are very small and it is necessary to understand and be able to manipulate the appropriate metric units of mass.

SOUND

(27)

·· (28)

مہ د

The skill of the harpist provides us with sounds pleasing to the ear and technologically the instrument must be constructed in a precise way. Music is an important vocation and a musician's hearing must be good... but not all sounds are welcome and those we find unpleasant or unwanted we call noise. Too much noise of the wrong kind (low frequency) can permanently damage the ear and legislation limits noise levels to safeguard the health of workers in many vocations.

Here the latest technology is being used to measure machinery noise on a meter, behind which lies much mathematics and physics in the design and calibration.

SPEED

- (29) We combine basic measures to form new ones ... time and distance combine to give speed. Each car has a speedometer and also instrument which measure for example temperature, volume of petrol, the charging state of the battery and the rotational speed of the engine in revolutions per minute...
- (30) as for the modern high-speed train which also has an instrument to measure the angle of tilt ... air-conditioning is provided in very war climates for the comfort of the passengers and this implies measuring instruments for temperature, humidity and air flow for each passenger compartment.
- (31) Not an example of high-speed travel but one travels above rough seas or uneven ground. Speed of air flow, motors, forward speed are some important rate measures involved.
- (32) Is Concorde on the move ... it should be with so much mathematics and physics in its design which culminated in very advanced technology. Speeds measured are vastly greater than those on land or sea. A formidable list of vocations for operating the service can be identified ... cleaner, hostess (also giving some medical service), clerk, technician, pilot, tester of planes and constituent materials...
- (33) ... in the air and on the ground. To work out the stresses in the structure of the plane the mathematician has to solve hundreds of equations...

TECHNOLOGY

- (34) The heart of applied electronics technology is the tiny integrated circuit consisting of thousands of components mounted on a chip of silicon. The design requires minute, exactly measured added impuritie so clinical cleanliness and also special technology for handling minut components through optical viewers are very important considerations. Particular attention must be paid to the medical care of the operators eyes to avoid strain. Special chemical methods are used to measure the purity of the silicon and of the gold connecting wires.
- (35) The National Physical Laboratory is internationally known for the calibration and checking of all kinds of measuring instruments. Here
 (36) are some data on various basic and derived measures. A wealth of technology is utilised in the Laboratory and the measures are such that all branches of science are involved. Skilled operators and technicians are an essential part of the service and the organisation has its own vocational training scheme...

VOCATION

(39) ... which starts with a good school background in which science education is very concerned with measurement. After school technician training schemes are nationally controlled by the Business/Technician Education Council.

-3-

Some technical vocations are in:

ing
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- (41) ... building construction
- (42) ... civil engineering
- (43) ... mechanical and production engineering
- (44) ... electrical engineering
- (45) ... electronics
- (46) ... and sciences.

CONCLUSION

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- Every industry requires teamwork to produce the finished product. If
 they wish to achieve harmonious, efficient production then the parts of any industry must come together as naturally as nature brings together the segments of an orange.
- (48) Within schools throughout the world, to teach mathematics, science and technology in separated isolation may prove to be a worthless, meaningless exercise for many. If we can prove to our students that what we are asking of them is relevant to their existing and future experiences then we may generate both enthusiasm and interest. By relating our work in schools to actual everyday things we cannot treat subjects in total isolation. The products of today's society requires a marriage of science, mathematics and technology. For many students within schools an interrelated approach may be the way forward - the way in which their curriculum takes on a new exciting look. If, using this approach, we can arouse curiousity and generate interest then we will have achieved a great success in communicating through INTERRELATED STUDIES.

-4-



Slide No.10 The wing is clamped so gently that ...



<u>Slide No.11</u> .. the butterfly flies away, leaving a record of its wing thickness. Technology has been involved: the biologist and the butterfly are pleased. APPENDIX 5.5

Extract

from

tape/slide

commentary

-355-



Slide No.47

... and every industry uses more than one vocation. Harmonious and efficient production within an industry requires the parts of that industry to come together as efficiently as the members of a musical group. And what of teaching? Throughout the world students experience subjects taught in isolation instead of the teaching being related to everyday things which would bring together disciplines such as science, mathematics and technology



Slide No.48

... as naturally as nature brings together the segments of an orange. The products of today's industry requires this marriage of many different subjects, and for many students within schools and colleges such an interrelated approach may be the way forward - the way in which their curriculum takes on a new and attractive look. If, using this approach, we can arouse curiosity and generate interest then we will have achieved a great success in communicating through INTERRELATED STUDIES.

APPENDIX 5.6

Information Pack For Building Students

Description

COMPOSITION AND MANUFACTURE

Mortar	Mortar consists of a binding material or materials, and an aggregate mixed with water. Where required or specified additional ingredients such as plasticisers, air entraining agents, retarders, or colouring pigments may be added. For special purposes, mortars containing materials such as latex are now being used.
Binding Materials	Normally the binding material is cement and for best results cement and lime.
Cements	Ordinary Portland cement is used for most purposes, but rapid-hardening Portland cement or Portland blast-furnace cement can be alternatives.
	Sulphate-resisting Portland cement is sometimes necessary for work below ground level in sulphate-bearing soil and occasionally in very wet conditions as a precaution against sulphate attack on the cement in the mortar.
	High alumina cement should never be used in mortar for brickwork.
Limes	Lime may be hydrated lime but lime putty imparts better working properties to mortars.
Aggregates	Aggregates are usually natural sand or crushed stone. They should be well graded and free from harmful salts. Quality of the sand affects both final strength and moisture movement of the mortar.
Colouring agents	All pigments should conform to the requirements of BS 1014 and be accurately proportioned. Plant mixing ensures even dispersion throughout the mix and therefore uniformity of colour. Coloured mortar can be supplied to blend or contrast with all types of bricks.
Mortars	Mortars must be either mixtures of lime and sand to which ordinary Portland cement and water are added on site or retarded cement:sand or cement:lime:sand mortars ready-for-use and requiring no site preparation.

Mortar mixes

When using ready-mixed lime:sand for mortar the following table gives the required site additions of cement.

Mortar designation	Mortar by volume cement:lime: sand	Ready-mixed by volume lime:sand	Site mixing cement to ready mix	
			by volume	by weight kg/tonne
i ii iii iv v	1: ¼:3 1: ½:4½ 1:1:6 1:2:9 1:3:12	1:12 1:9 1:6 1:4½ 1:4	1:3 1:4½ 1:6 1:9 1:12	250 170 125 88 65

Volume yield -

1 tonne of ready-mixed lime:sand for mortar when mixed with ordinary Portland cement will lay approximately 1000 bricks.

Ready-to-use CLM mortars - standard mix is a type iii mortar.

Volume yield – 1m³ of CLM will lay approximately 1700 Fletton type frogged bricks or 1900-2900 solid or perforated bricks.

Bricks

Bricks are walling units not exceeding 337.5mm in length, 225mm in width or 112.5mm in height. They are produced from a range of materials – clay, concrete and a mixture of lime and sand or crushed stone or a blend of both. These last types are referred to as either calcium silicate bricks, sandlime bricks or, where appropriate, flintlime bricks.

Varieties of bricks

Facings

These are bricks intended to provide an attractive appearance. They are available in a wide range of strengths, colours and textures. While satisfactory for ordinary exposure conditions in general walling, not all are suitable for conditions of extreme exposure.

Commons

Bricks suitable for general building work but having no particular claim to provide an attractive appearance are described as 'commons'. The term covers a wide variety of bricks and is not a guide to quality. Many common bricks have excellent properties.

Special quality

These bricks are durable when used in situations of extreme exposure where the structure may become saturated and be frozen, e.g. retaining walls, sewage plants or pavings.

Engineering

Engineering bricks have a dense and strong semi-vitreous body with a guaranteed minimum strength and maximum water absorption.

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Description

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Shapes of bricks	A wide variety of shaped bricks is available, including those with splayed or rounded edges etc.	
	Forms in regular production are described in BS 4729.	
Types of bricks		
	Solids These are bricks in which any holes passing through, or nearly through a brick do not exceed 25% of its volume or where a frog does not exceed 20% of the volume of the brick.	
	Perforated In this case, holes passing through the brick exceed 25% of its volume.	
	Cellular Bricks in which the holes are closed at one end and have a volume greater than 20% of the volume of the brick.	
Finishes of bricks	In addition to the general description 'Facings' for bricks intended to have good appearance, a variety of other terms is also used.	
	Sandfaced Sand is incorporated on the surface during manufacture, affecting both the colour and the texture.	
	Rustic A texture is imposed mechanically on the face of the bricks, producing a variety of patterns.	
	Multicoloured A variation in colour which may occur from brick to brick or across the faces of individual bricks.	
Names of bricks	Some types of bricks which are made predominantly in one district have acquired recognition of this in their names, e.g. Staffordshire blues, Leicester reds, London stocks, etc.	
	Flettons This name is applied to a type of brick made in the Peterborough, Bedford and Buckingham regions from the Lower Oxford clay.	

Blocks	Blocks are walling units exceeding in length, width or height the sizes specified for bricks. For external use they are generally produced from clay or concrete.	
Varieties of blocks	Facings Concrete and clay blocks of suitable quality to provide an attractive appearance.	
	Commons Blocks suitable for internal use or when rendered for external use.	
	Specials BS 4729 states thickness, height and length tolerances for special blocks. For irregular shapes a method for measurement should also be specified.	
Types of blocks		
	Solids These blocks have small cavities which act as finger-holds for ease of handling, otherwise, as the name implies, they are solid.	
	Hollow Blocks which have cavities passing right through.	
	Cellular Blocks that have cavities which are effectively closed at one end. The closed end is faid uppermost on the wall to provide a good bed for the next run of mortar.	
ACCESSORIES Mortar		
Tilcon Bonding Additive	General purpose bonding agent. For further details contact Tilcon mortar regional sales offices or mortar factories — refer to pages 169-171.	
Bricks		
Wall ties	When the two skins of a cavity wall are built completely separately they are often not properly stabilised and wind loads on one are not transmitted to the other. To overcome this, all cavity walls are normally linked together with wall ties.	
	Wall ties must be strong enough to make the skins of brickwork deflect together, especially when the walls are subjected to strong winds. Special ties are required for walls built with a cavity of more than 75mm. All ties must be embedded at least 50mm into each skin of a wall.	
	A kink or twist is incorporated in all wall ties to break the path of water which may try to pass across the tie. The ties should slope slightly to the outer leaf of a wall. Clearly, mortar droppings must not be allowed to collect on a tie, or water may pass across by capillary action. Clean, properly laid ties do not allow water to cross the cavity.	
Reinforcement	Reinforcement can frequently be successfully incorporated into brickwork to overcome low tensile resistance. When selecting reinforcement, account must be taken of the space available to accommodate it. If used in a bed joint, then there is limited space and this may require only thin reinforcement. However, if a special bond is being employed to accommodate vertical reinforcement, the space is not a limiting factor. The various types of reinforcement are covered by British Standards.	

Damp-course materials Building Regulations and ordinary good building practice demand that a damp-course be inserted in all walls at ground level to prevent moisture from the ground rising through the wall. Vertical damp-courses are also used to prevent moisture passing across walling materials.

In addition to being durable a damp-course must be sufficiently impermeable to prevent the passage of water and at the same time robust to resist damage by building labour. The horizontal damp-course should be laid on a bed of mortar and then further covered with mortar. This ensures that the dampcourse is not punctured or cracked during laying. Some materials, particularly the bitumen-based sheets, become very brittle in cold weather and are thus easily damaged.

The damp-course should not be bridged with mortar.

Damp-course material should comply with the requirements of BS 743.

Masonry

Tilcon Masonry Cleanser

A pre-mixed ready-to-use solution designed to remove most stains from brickwork etc. Refer to Tilcon Product Data Sheet No. 3.

SIZE AND SHAPE Bricks

The overall size and shape of bricks is limited to some extent by the nature of the raw materials, the design of buildings and partly by method of use which requires that the weight and shape of a brick make it easy to pick up in one hand while using a trowel in the other.

Standard Sizes

Clay bricks to BS 3921

The standard format is 225 x 112.5 x 75mm which assumes a 10mm mortar joint, thus the work size of the brick is $215 \times 102.5 \times 65$ mm.

The dimensional tolerances permitted by the Standard are:-

Specified dimension	Overall measurement
	off 24 bricks

mm	mm
65	1560 ± 25
102.5	2460 ± 45
215	[·] 5160 ± 75

Concrete bricks to BS 1180

The standard format which assumes 10mm mortar joints is:-

Co-ordinating size	Brick size	
mm	mm	
300 x 100 x 100	290 x 90 x 90	
200 x 100 x 100	190 x 90 x 90	
200 x 100 x 75	190 x 90 x 65	

Calcium silicate bricks to BS 187

The standard format is 225 x 112.5 x 75 which assumes a 10mm mortar joint, thus the work size of the brick is 215 x 102.5 x 65mm.

The dimensional tolerances permitted by the Standard are:-

Work size	Maximum limit of
	manufacturing size
mm	mm
215	212 to 217
102.5	101 to 105
65	63 to 67

Modular size	To meet the requirements for dimensional co-ordination some manufacturers are producing bricks in dimensions more directly related to the preferred 300 x 100mm.
	The format sizes of these include:-
	300 x 100 x 100mm 300 x 100 x 75mm 200 x 100 x 100mm 100 x 100 x 75mm
Other sizes	These are also available from certain manufacturers. Thin bricks have always had a strong visual appeal and some facing bricks of less than 65mm height are still obtainable. Generally the tendency in recent years has been to develop larger than standard units with a view to increasing the speed of building. These are usually perforated to reduce weight and probably shaped to retain ease of handling. Some units are greater than the standard width of 102.5mm and have proved useful in calculated loadbearing brick structures.

Blocks

The width/thickness of blocks or their work size is the full width of the wall and, unlike bricks, they do not require the addition of a 10mm mortar joint to obtain a standard format.

Standard sizes

Clay blocks to BS 3921

Decidention	Work size mm						
Designation	Length	Width	Height				
300 x 62.5 x 225 300 x 75 x 225 300 x 100 x 225 300 x 150 x 225	290 290 290 290 290	62.5 75 100 150	215 215 215 215 215				

NOTE: In addition, half blocks, 140mm long, and three quarter blocks, 215mm long, should be available for bonding.

The permissible deviations in sizes of individual blocks for work sizes are:-

less than	125mm		± 2.5៣៣
	125mm	to 225mm	± 3.0mm
more than	225mm		± 5.0mm

Concrete blocks to BS 2028: 1364

Diast	Length x	height	Thickness
BIOCK	Co-ordinating size*	Work size†	(Work size)
ΤΥΡΕ Α	mm 400 × 100 400 × 200	mm 390 × 90 390 × 190	mm 75, 90, 100, 140 and 190
· · · · · · · · · · · · · · · · · · ·	450 x 225	440 x 215	75, 90, 100, 140, 190 and 215
	400 x 100 400 x 200	390 × 90 390 × 190	75 , 90, 100, 140 and 190
TYPE B	450 x 200 450 x 225 450 x 300 600 x 200 600 x 225	440 x 190 440 x 215 440 x 290 590 x 190 590 x 215	75, 90, 100, 140, 190 and 215
TYPE C	400 x 200 450 x 200 450 x 225 450 x 300 600 x 200 600 x 225	390 x 190 440 x 190 440 x 215 440 x 290 590 x 190 590 x 215	60 and 75

- NOTE 1 Blocks of work size 448mm x 219mm x 51, 64, 76, 102, 152 or 219mm thick and 397mm x 194mm x 75, 92, 102, 143 and 194mm thick will be produced in lengths as required.
- NOTE 2 If blocks of entirely non-standard dimensions or design are required the limits of size or design shall be agreed. Such blocks shall then be deemed to comply with this standard provided they meet with the other requirements.
- * Co-ordinating size. A size of the space, bounded by co-ordinating planes, allocated to a
- component, including the allowance for joints and tolerances.
- 1 Work size. A size of a building component specified for its manufacture to which its actual size should conform within specified permissible deviations.

DENSITY/WEIGHT Mortar

Turo of mortor	Density kg/m³					
Type of montar	Wet bulk	Set and air dried				
LSM ready-mixed lime:sand With air entrainment	1,850 - 2,000 1,700 - 1,850	1,800 - 2,000 1,650 - 1,800				
CLM retarded	1,700 - 1,900	1,550 - 1,750				
LSM paving	1,850 - 2,000	1,900 - 2,000				

Bricks/Blocks

The weight of standard size bricks will vary appreciably, both with the type of material and dependent upon whether the brick is solid, perforated, hollow or cellular. The range is approximately from 2.0 - 3.2kg. For most purposes it is more useful to consider density of brickwork/blockwork.

Density of bricks and blocks

Туре	kg/m³
Aerated concrete blocks Lightweight aggregate blocks	500 - 1,000 800 - 1,500 1 475
Dense blocks Calcium silicate or low density solid bricks Concrete bricks Medium density perforated clay bricks High density solid clay	1,500 - 2,300 1,700 2,000 - 2,250 1,925 2,250

APPEARANCE

Mortar

Where coloured mortars are specified, only colours guaranteed by the manufacturers should be employed as coloured mortars made with inferior pigments are liable to fade in sunlight or leach from exposure to rain. Tilcon uses only those pigments which will last the lifetime of the building – and that guarantee is endorsed by the manufacturers of the pigments.

It is recommended that the bricks or blocks are bedded in the coloured mortar rather than just pointing. To obtain continuity of colour throughout a large area of masonry it is essential that the consistency of the mortar and the state of the units should be constant, otherwise variations in shade can occur.

When the mortar, bricks and type of joint have been chosen it is advisable to erect a site panel. Tilcon will arrange to deliver free sample bags of coloured mortar to build these. The panels must have a dpc at their base and a good coping. With this type of construction the panel will take up to one month to dry out and present the correct colour of the mortar.

Butterley Building Materials Itd

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				SIZ	ES	x 65 mm	BHT — kg	J. J.	ESCENCE	ORPTION -		k Q'm ^a	ALF BRICK kg/m*	VITY AT 5% — k velue	×	m*/mIn.	ATION	
WORKS	BRICK NAME	TYPE AND TEXTURE	SERIAL NUMBER	215 x 102.5 x 65 mm	215 x 102.5 x 50mm	PACK SIZE 215 x 102.5	AVERAGE PACK WEIG	TYPICAL COMPRESSI STRENGTH N/mm*		TYPICAL WATER ABS % by weight	AVERAGE WEIGHT PER BRICK -	DENSITY OF BRICK	WEIGHT PER m° OF H WALL WITH JOINT —	THERMAL CONDUCTI MOISTURE CONTENT WIM*C	THERMAL RESISTANC -R value - m"CM	SUCTION RATE kg/	AVERAGE % PERFOR	
OLABY	Windsor Grey	Handmade	02/16	•	•	500	1000	15.0	NIL	26.0	2.0	1396	153.0	0.65	0,158 [.]	3.42	NIL	
	Cotswold Blend	Handmade	02/32	•	•	500	1000	15.0	NIL	26.0	2.0	1396	153.0	0.65	0.158	3.53	NIL	
	Golden Brown	Handmade	60 033	٠	•	500	1000	15.0	NİL,	28.0	2.0	1396	153.0	0.65	0.158	3.48	NIL	
	Tudor Golden Russel	Handmade	02/34	٠	•	500	1000	16.0	NIL	26.0	2.0	1396	153.0	0.65	0,158	3.48	NTL	
	Red Multi	Handmade	02/58	•	•	500	1000	22.0	NIL	21.0	2.1	1466	159.0	0.65	0.158	3.03	NIL	
	Tudor Purple	Handmade	02/06	٠	•	500	1000	16.0	NIL	24.0	2.0	1396	153 0	0.65	0,158	3.13	NIL	
	Sandringham Red	Handmade	@253	٠	٠	500	1000	22.0	NIL,	21.0	2.1	1468	. 159.0	0.65	0,158	3.42	NIL	
DESFORD	Darley Grey Multi	Wirecut Rustic	044/15	٠	•	500	1000	35.0	NIL	22.0	2.0	1396	153.0	0.78	0,131	1.22	18.0	
	Sandstone Mixture	Wirecut	044/159	٠	•	500	1000	35.0	NIL	22.0	2.0	1396	153.0	0.78	0.131	1.62	18.0	
	Golden	Wirecut Mullinuf	044/169	٠	•	500	1000	40.0	NIL	22.0	2.0	1396	153 0	0.78	0.131	1.49	18.0	
	Old English Greystone	Wirecut	044/14	•	•	500	1000	35.0	NIL	22.0	2.1	1468	159 0	0.76	0.131	1.35	18.0	
	Old English Russet	Wirecul	014/47	•	•	500	1000	40.0	NIL	22.0	.5'0	1396	153 0	0.78	0.131	1.58	18.0	ļ
	Old English County Mixture	Wirecut	044/80	٠	•	500	1000	40.0	NIL	16.0	2.1	1466	159.0	0.78	0,131	0.25	18.0	
	Old English Bull Multi	Wirecut	044/170	٠	•	500	1000	40.0	NIL	22.0	1.9	1326	147.0	0.78	0,131	0.55	18.0	
	Old English Brindled Red	Wirecut	044/88	٠	•	500	1000	40.0	NIL	16 0	2.0	1396	153.0	0.78	0.131	0.76	18.0	
HEATHER	Red	Wirecut Rustic	07/83	٠		500	1175	33 0	NIL	17.0	2.35	1640	174.0	0,84	0.122	2.33	12.0	
····	Barton Brown	Wirecut Rustic	07/43	٠		500	1175	33.0	NIL	17.0	2.35	1540	174.0	0.84	0,122	2.42	12.0	
	Nottingham Red	Wirecut Rustic	07/81	٠		500	1175	33.0	NIL	17.0	2.35	1640	174.0	0 84	0,122	2.03	12.0	
	Burghlay Red	Wirecul Rustic	07/87	•		500	1175	33.0	NIL	17.0	2.35	1640	174.0	0 64	0.122	2.21	12.0	
	Chamwood Brindled Red	Wirecut	07/151	٠		500	\$175	33.0	NIL	17.0	2.35	1640	174 0	0.84	0.122	2.22	12.0	
	Charnwood Red Multi	Wirecut	07/154	•		500	1175	33.0	NIL	17.0	2.35	1640	174,0	0.84	0.122	2.32	12.0	
	Charnwood Mixture	Wirecut	07/155	٠		500	1175	33.0	NIL	17.0	2.35	1640	174.0	0 54	0.122	2.28	12.0	

General Information

Butterley Building Materials Limited is one of Britain's major manufacturers of facing bricks with an annual output capacity exceeding 400 million bricks. The range includes high quality facings with a superb choice of tones and textures, numbering over 90, and a whole spectrum of colours, Included are other Butterlev specialities such as special shapes, purpose made bricks, engineering bricks, clay pavers, refractory products, handmade briquettes, brick slips and Aglite building blocks.

Serial Numbers

The prefix tetters O and S refer to Ordinary Quality and Special Quality respectively as described by the British Standard for clay Bricks and Blocks (BS 3921: 1974).

Durability

Brickwork durability will vary according to the degree of exposure to the elements, the characteristics of the bricks, and the composition of the mortar.

In conditions of severe exposure where brickwork may remain saturated for long periods and exposed to the action of lost, such as occur below a damp proof course, in silts and copings and earth retaining walls, careful attention should be paid to the choice of brick.

It is generally advised therefore to follow the recommendations of Table 4,1 of the Code of Practice for Walling (CP121, Part 1: 1973) which details the minimum quality of bricks and mortars for durability.

Mortars

The selection of the correct type of mortar for any particular purpose is very important and can depend on several factors, i.e. the required final strength, rate of hardening, degree of exposure and aesthetic quality of the brickwork.

Dimensions and Approximate Weights

STANDARD TACBLOC DIMENSIONS AND BLOCK¹/WALL² WEIGHTS At Equilibrium Moisture Content (3% v/v)

		WORKS FACE SIZE (mm)									
	590	x 215	590 >	< 190	440 :	x 215	440 x 190				
BLOCK/WALL ACTUAL THICKNESS mm	BLOCK Unit Weight kg	WALL ³ Area Weight kg/m ²									
215	18.00	159	15.90	161	13.40	161	11.85	162			
200	16.75	148	14.80	150	12.50	150	11.05	151			
190	15.90	140	14.05	142	11.85	142	10.50	143			
150	12.55	111	11.10	112	9.35	112	8·30	113			
140	11.70	104	10.35	105	8.75	105	7.70	106			
100	8.35	74	7.40	75	6·25	75	5·50	76			
90	7.55	67	6.65	67	5.60	67	4.95	68			
75	6.30	56	5.55	56	4.70	56	4.15	57			

Loadbearing Properties

WALL CONSTR	WALL CONSTRUCTION			ACTUAL STOREY HEIGHT				
		2·400m	2.500m	2.600m	2.700m			
• Outer Lear	inner Lear	kN/m	kN/m	kN/m	kN/m			
Cavity Walls 103 mm Brick or 100 mm Block	100 mm 150 mm 190 mm 215 mm	56 71 80 85	55 70 78 84	54 69 77 83	53 68 76 82			
Single Leaf Walls	75 mm 100 mm 150 mm 190 mm 215 mm	27 47 69 78 85	25 45 67 77 84	23 • 44 66 76 83	22 43 65 75 82			

Notional Fire Resistance of Walls

Loadbearing Single Leaf Walls

Finish ³	Minimur notional	n thicknes period of	s (mm) wit fire resista	h/without ince of	finish for		
	. 6 h	4 h	Зh	2 h	1½ h	1 h	½ h
None	215	180 -	140	100	100	90	90
VG	180	150	100	100	90	90	90

1 - To nearest 0.05 kg 2 - To nearest 1 kg/m² 3 - Including set mortar joints @ 2000 kg/m³ density ENQUIRIES ARE INVITED FOR OTHER SIZES

Loadbearing Cavity Walls

None	150	150	140	1 100	100	90	90

Non-loadbearing Single Leaf Walls

					_								_
None	: EO	i 100	1	75	!	83	1	0 P	:	<u>e n</u>	:	50	

APPENDIX 5.7

Descriptions of the full set of slides of the bungalow project			
Slide	Description .		
1	Footings:bad ground:concrete has to be extra wide		
2.	Note extra depth of footings : reclaimed land		
3	What is the function of the cabin ?		
4 · .	Footings again		
5	Note the bank of soil. Kill or remove the vegetation - why ?		
6	Obligatory polythene under raft:step in footing & raft		
7	View down footings;note the sloping site		
8	General view of raft:note polythene sticking out		
9	Two service ducts on to the raft		
10	Sewage channels-curvature of pipes-T junction		
11	T-junction:burning round pipe for malleability		
12	Sewage pipes:variety of measurements		
13	Gully:top end of drain-note polythene again		
14	Trench showing pipe connection : note access to clear blockage		
15	Manhole. Identify the falls; 1:40 for 100mm and 1:60 for 150mm		
16	Note build-up round manhole:a closer view		
17	Sewer with large manhole to collect all sewer pipes		
13	The 'drop' using the plank is illegal		
19	Long run of pipe : plastic push-fit joint, with lubricant		
20	Trench blinding should be consolidated in layers		
21	All blinding in : loose fill for flexibility : note concrete 'bench'		
22	Trench fill		
23	Motal CATWIC lintels:start of the 'soldier' arch		
24	Bricklayer putting in the arch		
25	Note rust-treated lintels & wall plate in background		
26	Blocks on wall, carried by linte)		
27	Soldier andn with CANNIC		

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28 ·	Window opening:hole for what?
29	Seating for springer at gable end
30	View down soldier arch:wall plate & asbestos seal for cavity
31	Chimney
32	Combination frame-inside view:black spot is damp course
33	Window frame:note pivot-type and slot vents at top
34	Window louvres to prevent condensation
35 -	Starting the inside walls
36	Inside view
37	Blockwork : toothed ends : partition wall indents (1/2 width for in
38	General view-indents etc.
39	The whole back:note wall plate on top and toothed ends
10	Indents for a wall dividing houses
71	Internal walls
¥2	Part of truss:chimney breast-bottom part with off-setting
13	Flue liners .
14	Fots
15	Fireplace opening with lintel
16	Chimney breast
¥7	Flue liners:rebating at join so that condensation runs into chimney
18	Set of chimney breast flue liners
19	General view of inside walls:chimney stack
50	Completed chimney stack:note corbelling and offsets
51	Another view of chimney stack
52	Corner being built
53	General view:note that 4 courses of bricks measure 300 cm
54	Scaffolding:arches & gable end:dark brickwork still wet
35	Note the fibreglass - why is it used ? Bricks have been wasted
56	Scaffolding
57	Bricklayer plumbing the corner (what has this got to do with angles
58	General view of site
59	Cavity wall : wall plate : asbestos board seal at top : 'hollow' bi
50	Fibreglass insulation

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Peak going up
Upper end of gable-'pike' or 'peak'
Brick ends cut off
Trusses:CATNIC:flue liners
Roof trusses
Trusses in gable end:note racked back
General view :completed pikes and trusses in position
General view
Gable end showing springer
Gable end & elevation showing springer and eaves
View of soffit
Completed roof showing plaster & plasterboards
Labourer mixing plaster 'bank' or 'pile'
Close-up of floating (dubbing-on)
Applying floating coat
Plasterer filling hawk: 'devil-floating' scratches for adhesion
Foil-backed plasterboard for thermal insulation -
View of plasterboard in position
Cowing in roof space
Fireplace opening with throating:note lintel
Wiring carried down walls to outlets
Roof trusses:see connections and straps for stability (e.g. in wind)
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APPENDIX 5.8

Descriptions of the Chosen Set of Bungalow Slides

Slide Description

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1	Footings:bad ground:concrete has to be extra wide
2	Note extra depth of footings : reclaimed land
3	What is the function of the cabin ?
4	Note the bank of soil. Kill or remove the vegetation - why ?
5	General view of raft;note polythene sticking out
5	Sewage channels-curvature of pipes-T junction
7	Sewage pipes:variety of measurements
з	Trench showing pipe connection : note access to clear blockage
7	Manhole. Identify the falls; 1:40 for 100mm and 1:60 for 150mm
10	Sewer with large manhole to collect all sewer pipes
11	Trench blinding should be consolidated in layers
12	Metal CATNIC lintels:start of the 'soldier' arch
13	Bricklayer putting in the arch
14	Window opening:hole for what?
15	Chimney
16	Window louvres to prevent condensation
.7	Inside view
18	Blockwork : toothed ends : partition wall indents (1/2 width for in
.9	General view-indents etc.
20	Flue liners
21	Fots
22	Chimney breast
23	Flue liners:rebating at join so that condensation runs into chimney
<u>}4</u>	Corner being built
15	General view:note that 4 courses of bricks measure 300 cm
16	Scaffolding:arches & gable end:dark brickwork still wet
:7	Bracklayer plumbing the conner (what has this got to do with angles

Cavity wall : wall plate : asbestos board seal at top : 'hollow' binds Fibreglass insulation

Peak going up

Brick ends cut off

General view :completed pikes and trusses in position Gable end & elevation showing springer and eaves Completed roof showing plaster & plasterboards Labourer mixing plaster 'bank' or 'pile' Foil-backed plasterboard for thermal insulation View of plasterboard in position



Extract from slides of the Bungalow Project

The footings: the vegetation in the mound of soil must be suitably treated (biology is involved here).



A general view of the site. Note the different shapes - here is some geometry.

Measurement in the Dil Industry

Know) edge

The search for oil starts with measurement, the geologist leading the way. Once detected or suspected beneath the ground or sea bed a sample must be obtained. Analysis of samples brings in physical and chemical measurements with mathematics in the form of statistical analysis. Having located an oil reservoir a decision to start extraction will depend on the estimated quantity in the reservoir and the technological problems involved in the extraction. Natural gas (mainly methane) and water ar& usually found with the oil, the liquids being held in rock. The gas itself may be worth extracting without the oil and thus a 'natural gas' field would be the result of the search. Chemical analyses and pipework technology involve mathematics, science, technology and vocation in an interrelated way by the many measurements involved. The Alaskan oil fields were most difficult to exploit and new technologies had to be developed. Why?

Tasks

View the slides and:

- (1) Name five measurements which would be necessary during the search;
- (2) Name some substances you might expect to find in the drill sample;
 (3) Name four principal chemical elements in the sample and give some of their chemical and physical properties
- (4) Name some of the products of the primary distillation of crude oil, classifying each as solid, liquid or gas. Give a chemical formula if you can.
- (5) What types of machines are involved in the movement of liquids ?

Study Objectives

This module of study will consider the nature of, methods of storing and uses of some gaseous products associated with crude oil and involves the Chemical, Construction and various facets of the Engineering Industries, all of which have a part to play and cannot be considered as isolated. Students of building, engineering or science subjects could use this module and each could make a particular contribution. For example a storage tank has to have firm foundations and this involves the use of concrete which must be resistant to spilled chemicals. The particular type of vessel used for storing liquid gases in bulk which is known as a HORTONSFHERE will be a major component of this study.

Exercise

Typical gases involved are:

- (1) liquid petroleum gas or LPG;
- (2) liquid natural gas or LNG;
- (3) propane and butane which are separated from LPG (how?);
- (4) liquid mitrogen (how cold ?).

Why this concentration on LIQUEFACTION ? Make reference to sea transport.

We now take a look at the problem of producing a depth - volume calibration curve for the tank and see that it is possible to program a computer so that the tedious calculations are taken care of expertly. The program is short.

Producing a Calibration Curve

To investigate the volume calibration of a spherical liquid das storage tank in terms of the depth of liquid it contains Introduction

The depth of liquid is measured along the vertical axis of the sphere. The volume of liquid is computed by using a mathematical formula
which relates the volume to the depth: thus calculation is involved.
A smooth graph is then drawn connecting depth to volume : note that the
volume is an INDIRECT measurement, depending on the fundamental measurement of the depth of the liquid.
One application is storing liquid butane or propane which are crude oil distillation products.

Theory

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D = the diameter of the vessel

H = the depth of liquid measured along the polar axis

V = the volume of liquid in the vessel

- P = the value of pi as found from a computer system
 - = 3.14159265 to 8 decimal places

It can be proved that:

 $V = P \times H \times (D/2 - H/3)$ cu.m. if all dimensions are in metres

The depth of liquid is found practically by dipping or using a float with an electrical indicator as in the petrol tank of a car.

Program

- 1 Write and test this as a first stage for one value of H and then make changes to give you a table of values for various values of H :see 2 below
- 2 Use FOR--NEXT-- to give V for a range of H values.

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- 3 Adjust the output values of V with the INT function to give V correct to two decimal places.
- 4 Use an INFUT statement so that the user can choose any diameter

Exercises

1	Draw a simple diagram to illustrate the vessel and its dimensions.
2	Why is the diameter more practical than the radius as a volume measure ?
3	State some factors which would limit the choice of metals for the shell
	and find an approximate value for the thickness of the metal wall.
4	Discuss some scientific and physical principles which would be applied
	in the siting and design of the vessel. View the slides again
5	What technology would be involved in the construction of the vessel?
6	Draw a calibration curve from the computed data. Plot V against H for D=16
	Make the computer draw a graph for you using FRINT TAB().
7	What would be the % error in V if 3.14 is used for pi ? Would this
	be constant for any volume ? Explain your answer.
8	Use your graph to read the volume when the height is 4.5 m. Check this
	by using the formula
9	What do vou notice about the shapes of curves for various diameters ?
10	Why is the vessel not a perfect sphere inside and how does the shape
	change as the volume of liquid is increased? Name the new shape.

APPENDIX 6.2

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Illustrations From The Set Of Slides For The Oil Industry

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Slide 2

Slide 1



-378-

Slide 4





Slide 6








APPENDIX 6.3

Table 1 - Crane Freuhof

Product	Alternative Names	Tank Material Specification	Discharge Method	Tank Cleaning	General Information	Min, Extra Information to Tank Maker
Ethylene Dichloride	Dichloro- ethane Dutch oil Dutch liquid	Stainless steel 304. Phenal formaldehyde resin lining if carbon steel used	Pump	Flush thoroughiy with water, steam and rinse	S.G. 1-2554 Inflammable Flash point 70°F	
Formaldehyde	Oxy-methylene Formalin Formalith Formi- caldehyde	Stainless steel 321 minimum. Insulation may be required depending on operating conditions	Pump or air pressure	Wash thoroughly with water, or steam	S.G. 1-075 to 1-081 Flash point 130°F	Operating conditions
Glycerin	Glycerine Glycerol Glycyl alcohol	Stainless steel 304 or Aluminium. Insulation recommended	Pump or air pressure	Steam	S.G. 1·265 Should be kept above 64°F for easy flowing. Sets solid at 50°F	Ultimate use of product

Product	Alternative Names	Tank Material Specification	Discharge Method	Tank Cleaning	General Information	Min. Extra Information to Tank Maker
Hydrochloric acld	Muriatic acid Chlorohydric acid Hydrogen chloride Spirits of salts	Mild steel or aluminium with rubber or phenol formal- dehyde resin lining	Gravity or air pressure	Flush thoroughly with water	S.G. approx. 1-19 Highly corrosive Poisonous fumes	Actual S.G. and concentration
Hydrofluoric acid	Hydrogen fluoride anhydrous	Consult tank maker about material and lining	Air pressure	Lime slurry or soda ash as neutraliser	S.G. approx. 0-99 Highly cor- rosive, poisonous and highly dangerous. Will attack glass. Produces severe burns	Actual S.G. and concentration



Providing the PURE water we need brings together:

BIOLOGY	-	for treatment
CHEMISTRY		for analysis of contents
PHYSICS	-	to design the technology
TECHNOLOGY	-	to effect the processes
MATHEMATICS	-	to bring all the above together

Assessment Test: Mathematical Bias

Support your answers with reasons and explanations. Use any computer and your notes.

- 1. Three liquid gas tanks are described as follows:
 - (a) Spherical: diameter 5m
 - (b) Cylindrical: diameter 5.5m, height 3m
 - (c) Cylindrical: diameter 4.5m, height 4m

Arrange these tanks in order by volume capacity.

- 2. (a) Sketch a graph of maximum depth of liquid against volume for a spherical liquid gas container. Indicate two points on the graph where the rate of change of volume is zero and the point where the rate of change of the volume with depth is a maximum. If the diameter is 18m state the depth at which the rate is a maximum and relate this depth to the geometry of the sphere.
 - (b) Sketch a graph of the rate of change of volume against depth of liquid using your answers to (a) to guide you.
- 3. A cylindrical liquid gas storage vessel with plane ends perpendicular to the axis has dimensions: diameter 4m and height 10m. Produce a table of volume against depth of liquid for depth from 0 to 10m. in steps of 2m.
- 4. A liquid gas storage vessel is never filled completely: why not? If the vessel is spherical with a diameter of 20m and the amount of liquid is restricted to 95% of the maximum volume find to the nearest cubic metre the maximum permitted volume of liquid it may hold.
- 5. The external diameter of a spherical liquid gas vessel is 5m and the thickness of metal can be assumed to be a constant 5cm. Calculate the volume of metal needed to construct the shell. If the density of steel is 7800 kg/cm and that of liquid butane 800 kg/cm, work out the weight of metal and weight of liquid butane when the depth is 3m.

APPENDIX 6.6

This work was handed to the author after the student had worked through the module on 'Measurement in the Oil Industry'.

The module was a short one containing very little information but in spite of this it can be seen that the student has obtained a lot of what he required through his own efforts and has also involved other people.

In case the reader should think that this is a most able student, he experienced some difficulties throughout the period. As he explained, he found the module very interesting and obviously was considerably motivated by it, as he indicated in a letter he left for the author.

Sample of Student's work refer to The formula given below for calculating the volume of liquid in a spherical vessel of known diameter and depth of the liquid, can be proved by the use of calculus. Calculate liquid volume of spherical vessel:- $V = \pi \times H \times \left(\frac{D}{2} - \frac{H}{3}\right)$ · . .. ----Proof of the above formula: 2 --------- -----· · · · - - · · · · · ···· · · —~ X -- · <u>-</u> A sphere can be generated by rotating the area bounded by the serii circle and $x^2 + y^2 = R^2 \quad (y \ge 0)$ about the `x'-axis. When this area is rotated completely about the 'x'-axis, the volume of the sphere is formed, <u>V, is given by:-</u> $V = \int \pi y^2 \, dx$ and $y^2 = R^2 - x^2$ this becomes: $V = \int_{-p}^{R} \pi (R^2 - x^2) dx$

R By bringing into consideration the depth of liquid required, by utilising the variable H. <u>From:</u> $V = \int_{-\infty}^{R} TT(R^2 - x^2) dx$ $\frac{ave.}{V} = \int_{R-M}^{R} \left(R^2 - x^2\right) dx$ e now have <u>Integrat</u> $V = \left[\frac{R_{x}^{2} - \frac{x^{3}}{3}}{3} \right]_{R-H}^{R}$ $V = \pi R^{2} \left[R - (R - H) \right] - \frac{\pi}{3} \left[R^{3} - (R - H)^{3} \right]$ $V = \pi R^{2}(H) - \frac{\pi}{3} \left[R^{3} - (R^{3} - 3R^{2} H + 3R H^{2} - H^{3}) \right]$ $V = \pi R^{2} H - \frac{\pi}{3L} 3R^{2} H - 3RH^{2} + H^{3} / \frac{1}{3L}$

-387- $V = TT \left(\mathcal{R} H^2 - \frac{H^3}{3} \right)$ $= \pi H^{2} \left(R - \frac{H}{3} \right)$ as $R = \frac{D}{Z}$ n <u>f-inally</u> he $V = \pi H^2 \left(\frac{D}{2} \right)$... ---- -• -- • . . . ___ -----. ·- · • ---·· ---

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The diameter is always more practic -al to measure than the radius 2. due to the fact that the radius is some point in space which would be so difficult and inpractical to locate. By measuring the diameter you are working to definite fixed datums that can be checked reasonably easily and accurately. Some factors which would restrict the choice of metals for the vessel -s shell, are as follows:-3) a) Difficulties in rolling or forming the metal plates. b) Means of joining the formed metal plates together using specialised welding processes continually i.e. T.I.G. welding. c) Pre and post heating after or prior to walding taking place and the amount required. d) Type and degree of plate edge preparation. Strangth to weight ratio of material if cheaper material is used where it's a) strength is lower than that of tungst -an alloy steel, or some high tensile alloy steel then you need to increase it's thickness which means the supporting structure requires strangthan f) Cost of the material has to be assessed against the cost of other manufacturing considerations, some of which are mentioned above.

-391some physical and scientific which would be applied siting and design of the 4. Discuss priciples in the vesse/. Physical Considerations. Size and number of vessels require for installation, area of site. a) b) Practical distance from refinery so that plant equipment, pipes, pumps, pump houses costs incured in building installation due to distances the pipes have to cover, and types of valves inlin c) Location is dependent upon transpo -tation facilities, road, rail road and for deep anchorages for large supertant <u>Scientific Considerations.</u> a) Due to explosive risk in storage of volatile liquids and gases, tanks needed to be sited away from areas where large numbers of personnell, buildings, explosive hazards. b) Pressure relief values (braather) are connected usually to main flore line to burn up excessive vapou c) Blast walls are built around stavage vessels when in close proximity to main plant, etc. Auto malic sansors (heat) are located on each tank if they sanse, heat, smoke or excessive vapours, they will open values at base of tank, to $\mathcal{D}.$

ntid) enable safe discharge of storad liquid through large bore pipe to lan underground storage tank some distance away from danger area, after discharge of liquid sensors will close value at tank to make amargancy discharge system safe. Due to high pressures of tanks usually around 5 atmospheres a e) spherical construction is the strongest due to hoop stress built up by pressure on the shell. Design of joints should allow welding to be done from one side only (outside) allowing full root penartration to be possible, preheat and post heat is done from inside vessel by means of large relectric heater, which are magnetically clamped in position. 9) All parts of vessels structure and supporting legs are 100% inspected using X-Ray equipment. Welds and metal plate sections are subject to Lloyds certification. h) Fire safety systems should be avident in storage areas with discharge positions in close proxima to tanks. All parts of equipment earthed! Ŋ. Water cooling rings may be fitted around top of vessels to discharg e cooling water over tanks to maint -ain safe temperaturs in not climates \mathbf{i}

-393-5) WHAT TECHNOLOGY WOULD BE INVOLVED IN THE CONSTRUCTION OF THE VESSEL ore many technologies used There construction of the storage the following list is a brief of those technologies. in the vessel, summary SURVEYING SURVEYING. Layout of site, measurement of excavation for laying of foundation and shuttaring for tanks, submerged pipes and structural locations, etc. CIVIL ENGINEERING. Responsible for Egpe and construction of site foundat -rons from recommendations and in agreement with surveyor and structural engineer, construction of blast walls and ancillary buildings. CHEMICAL AND STRUCTURAL ENGINEERING. Can be responsible for the design of the storage vessel and supporting structure together drafting up manufacturing specifications to the required standards. The chemical angineer will also design and specify for plant layout. WELDING ENGINEER Responsible for the preparation of vessels plate edges prior to welding. Type of welded joints used and processes and equipment. Also inspection of all welded joints and testing using X-Ray process.

-394-To calibrate tariks vary accurately so that volumetric measurements conbe accurately taken for known depths of liquids. Devising accurate means of gauging for readings to be taken AND PLANT ENGINEERS Installation of all pipework and their supporting structures, pumps, valves and other ancillary equipment. METALURGIST. Responsible for devising or recomme -nding the type of metal and chamic -al structure to meat the require -ments and liase with foundry to produce the material in plate form. . .

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-395-6) <u>COMP</u> PROGRAM 1\$ @ CHR \$ (26) 20 P = 4*ATN (1) 30 INPUT "DIAMETER PLEASE ____ Ø TO S 40 IF D=0 THEN 5\$ INPUT "INCREMENT OF DEPTH____ 6 6 H = 2 Ø 70 V = P # H / 2 # D/2 - H /3) 8ø@ H, V, 9¢ END Use FOR-NEXT to give V to range of H values.) 1\$ @ CHR \$ (26) 20 P = 4* ATN (1) 30 INPUT DIAMETER PLEASE Ø TO STON 4\$ IF D=\$ THEN 24\$ 50 INPLIT "INCREMENT OF DEPTH_ 6\$ FOR H=\$ TO D STEP 5 70 V= P* H/2* (D/2 - H/3) 100 @ H, - V. $||\phi||$ NEXT H //.

Adjust the output value of V with the INT function to give V correct to two decimal places. In art the following into the program. listing. 80 REM --- V TO 3 DECIMAL PLACES 9\$ V1 = (INT (1\$\$\$ * V+\$.5)/1\$\$\$) 100 A, V, V1 A useful addition to the program would be the ability to produce a graph from values of V and H This can be inserted into program as follows:-11\$ DIM Q\$ (10) _ 120 INPUT "DO YOU WANT A GRAPH ____ (Y/N); Q\$ 13\$ IF Q \$ = "Y" THEN , 17ø 140 IF Q\$ = "N" THEN 230 159 GOTO 140 16\$ INPUT "SCALE FACTOR . , K 17\$ FOR H=Q TOD STEP S 218\$ V= P * HAZ* (D/2-H/3) 19\$ V= V/K 2\$\$ @ = TAB (V); "*" 21\$ NEXT H 220 END 12.

6) DRAW A CALIBRATION CURVE FROM COMPUTED DATA 7HE 'V' AGAINST 'H'. PLOT ATHRIMETIC FORMULA $V = P \times H^2 \times \left(\frac{D}{2} - \frac{H}{3} \right) cum.$ V= VOLUME (METRES³) P= Pi (CONSTANT) = 3.14159265 H= HEIGHT OF LIQUID IN TANK. D = DIAMETER OF SPHERE (METRE COMPUTER FORMAT OF FORMULA $V = P * H \wedge 2 (D/2 - H/3)$ * DENOTES MULIPLICATION SIGN. POWER A DENOTES DENOTES DNISION Using the above computer forma listing a table of values from 05 metres to 20 metres for values of H' and calculate volume accordingly. P.T.O. for data listing: /3

<u>IME (M³)</u> 6 VOLL 7.330.5 30.369 1.0 67.151 1.5 117.286 2.0 3.0 25*4 · 4*69 4.0 435.634 5:0 654.498 6.0 904·779 1/80./92 7.0 8.0 1474.454 1781.283 9.0 2094.395 10.0 2467.507 11.0 2714.336 12.0 3008.599 /3.0 14.0 3284.011 35 3 4 . 2 9 2 _____/5.0 3753./56 16.0 17.0 3934.321 18.0 4071.504 4121.639 18.5 4158.421 19-0 4/8/.070 19.5 20.0 4188.790 P.T.O. FOR GRAPH OF THE CALIBRATION CURVE 14.

-398-

6) CURVE FO 70h4400 -4200 -..: ----- 3900 3800 -_____ _____ *0*0 · ...; (2)3) らい -_____ Ć V ; -.. ļ 1100 -...... ____ t 14 16 HEIGHT 1:5

-400-7) WHAT WOULD BE THE % ERROR IN V IF 3.14 IS USED FOR Pi? WOULD THIS BE CONSTANT FOR ANY VOLUME ? EXPLAIN YOUR ANSWER. WHEN. $P_{MOD} = TC = 3.14$ $P_{i} = TC = 3 \cdot 14 \cdot 159265$ Using % Charge = Pi - Pi MODIFLED x 100 $% Change = TT_o - TT_m \times 100$ % Change = 3.14159265 - 3.14 × 100 3.14159265 0.00/59265 × 100 3.14/59265 × 100 % Change = % Change = 0.000506956 × 100 % Change = 0.050696% Say % Change = 0.051% As the value of pi is a constant it, acts as a constant throughout each calculation when using the stated equation, therefore using the two values of pi for values of H and D there will be a constant % changa.

Using formula check the volume for 4.6 M depth of liquid contained in sphere from the curve plotted on the graph. 8) Graph result. $4.6 M depth = 560 M^3$ Calculated result. ----- $V = P \times H^2 \times \left(\frac{D}{2} - \frac{H}{3}\right)$ -- $V = 17 \times 4.6^{2} \times \left(\frac{20}{2} - \frac{4.6}{3}\right)$ -----------V=TT×21.16×(10 - 1.5333) V= 66.476/0055 × 8.4666666 V= 562·83098 $V = 562.831 \, \text{m}^3$ The graph on question 8 did not appear to it's scale and was be accurate anough due B difficult to read, so I graph to a larger scale and accuracy of result. redrew the for ease of reading





ntd.

ELECTRO THERMAL SENSOR Although this article is directly aimed at the motorist it seems to be a most promising method that could be applied to large storage tanks which would be easy to install and accurate in readings token and relayed to a remote indictor gauge or dial.

Fuel sensor improves accuracy

A new type of fuel sensor using Du Pont's Kapton has been announced by VDO. This should result in more accurate and reliable gauging for the driver, whilst suitability for high volume production combined with the ability to be used in irregular shaped tanks should ensure its popularity with industry.

The design operates on the electro-

thermal principle. The sensor basically consists of a number of thin film resistors which are laminated between two sheets of Kapton polyimide film. A current passing through the resistors heats them; those which are immersed are cooled more by the liquid than those above the surface. This creates a resistance differential which changes as the fuel level fluctuates. Electrical



circuitry translates this varying differential into appropriate signals for the fuel gauge and the on-board trip computer.

The sensor substrate is 50μ m thick Kapton. The iron-nickel resistors (about 10μ m thick) are sputtered on followed by copper conductors of about 1μ m. Sensor and conductor structures are produced by means of photolithography and the whole system is then clad with a second layer of polyimide for protection. Finally, crimped contacts are pierced through the two foils.

The new sensor should make its appearance in production cars in the mid-eighties. The motorist will benefit in two ways. The dashboard fuel gauge will be more precise than at present, especially in the nearly full and nearly empty ranges. The system will also be less prone to failure.

A major advantage to the automotive designer results in the flexibility of the complete sensor. Fuel tank shapes and locations have undergone much change in recent years to maximise space in compact cars and to accommodate 'crumple zones' for greater crash safety. The flexible film should be able to adapt to almost any shape of tank. Circle 455

-405-9) MEASUREMENT OF LIQUID DEPTH. <u>Dipping</u> It is not difficult to measure depth of liquid in a tank. For this a gradua -ad dip stick or steel tape with a weight on it would be lowered until weight touches the bottom of tank. On drawing the tope or dip stick up the depth of liquid is read off by noting the height of the top edge of wetted part of tape or dipstick. For viscous liquid the measuring aide may be smeared with oil or liquid soluble paste which will absorbe the liquid and mark the depth of liquid. ____ VAPOUR - TIGHT TANKS. Where vapour - Eight tanks are concerned the opening of the tank to the atmosphe when dipping, would be dangerous and would lead to the loss of valuable vapours. In such cases the dip-weight and tape enclosed in a vapour tight "veiving-box, fixed to the top of tank and operated through a gate-value. It is thus possible to operate the dip-tape by an externed wheat and to record the liquid level wheel and to record the liquid level. through the glass - fronted veining-box. Alternativaly, vapour-tight tanks are fitted with glass gauges, particularly when tank volatile liquids like propane, butane and are under higher pressures. Such tanks are spheriodal or spherical in shape. Float type gauges similar to that in a car may be used with gauge remote from Eank.

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-406b) EXTERNAL STRAPPING METHOD In this process external circum ferences of the tank are measured by passing a graduated steel tape round the tank or, in other words "strapping". If the circumference of the tape exceeds the length of the tape, vertical or horizontal lines (depend -ing on whether measuring longi Ludinally or laterally) are marked onto the tank shall and the tank is "stranged" tank shall and the tank is "strapped in section. Allowances should be made for obstructions which may raise the tape from the tank surface. From these the gross volume of the tank can be determined. Further allowances of volume should be made for internal ladders, manholes, eEc. DIAMETER METHOD. . c) Tank calibration by measuring internal diameters is widely used in the United Kingdom as an alternative to "stropping. In this process, the tope is unsopported throughout it's length, but allowance is made for sag. The tension is adjusted to 4.5 kg (1016s approx) by means of an ingenious automatic device A large number of diameters is taken at different positions in each tier, and the volume thus can be calculated, from the average tier diameter so obtained. Subject to all necessary precautions baing taken, the results obtained by the "strapping" and internal diameter methods should agree closely.

-407-9. TANK CALIBRATION. By calibration" we mean the whole process of compiling the tables which tell us how much liquid is in th Eank. There are three well known metho of tank calibration which may be carri out safely, they are as follows:-WATER-FILLING METHOD. a) By means of well-calibrated standad measures, or by a suitable meter, wat may be measured into the storage tank. After each measured batch of water has been added, the resulting \bigcirc depth of water is noted. By continue the process until the tank is full the required table is obtained. For accuracy any change in temperature during the operation must be suitable allowed for. The time for this process long, so it is more suitable for small tanks and commonly used for calibration "HORTON" spherical and spheroidal-shaped \bigcirc tonks used for the storage of vary light volatile petroleum products. It should be noted that due town (fresh) having a density of a 1000kg/m³ as against butane whose density is 800 kg/m³ there may need to be a corrective factor allowed for in calib -tron due to distortion brought about the greater density of the water.

10) .

SOME INDUSTRIAL USES OF PROPANE AND BUTANE. C3 H8 -42.2°c, boiling point at PROPHNE - 0.5°C pressure BUTANE $C_4 H_{10}$ Propane and butane, are used aithar separately or in a mixture, as gaseous fuels for domestic as well as for industrial fuels for domestic as well as for industrial purposes, but are transported or stored as liguids. They are the hydrocarbons on which the "bottled gas" buisness is based. The physical property which makes propane and butane so well adapted for being sold in cylinders or steel bottles is that upon compression of gases to a higher pressure, they are easily, at ordinary temperatures and ot comparative low pressures converted into linuids low pressures converted into liquids. ~ This makes it possible to have in liquia form, in a comparitively small and light /vessel. PROPANE. Is used in industrial plants, in large quantities, as fuel in various types of furnaces employed for special purposes, and it is used for annealing, heat treating, baking enamels, for metal cutting. It is pure and contains no undesirable constituents which makes it ideal for the heat treatment uses. BUTANE Is heavier than propane, and is mostly used in domestic appliances in a market that is rapidly expanding in europe. 24

-409-PART.2.) Name five measurements which would be neccessary during a search for oil or gas. The five measurements are:-1) Longid Eude. } satellite used for accu 2) Latitude. 3) Depth of field. - Siesmic. 4) Area of field. 5) Estimation on volume of field. \bigcirc 2) Name some substances you might expect to find in the drill some a) Rocksalt if saltdome structure b) Impervious shale. c) Oil, water or gas impregnated pervious sandstone. () d) On some occassions sulphur. e) Coprocks: - Gypsium Ca So₄ 2HzO Anhdrite Ca Sof f) Clayminerials, Alumina Silicates. 25.

Name the four principle chemical elements in the sample put these and some of their properties into your data table. 3) CARBON ; C2 - -HYDROGEN ; Hz -- ---OXYGEN ; Oz CALCIUMA ; Ca Name some of the products of the primary distallation of crude oil, clossifying each solid, liquid or gas, give chemical formula if you can. 4) - liquid KEROSINE____ - liquid DEISEL OIL LUBRICANTS - liquid WAX - solid FUEL OIL - liquid BITUMEN - solid Some products of catalytic cracking METHANE. (CH4) <u>Boiling Point</u> H -161.5°C н — с — н

Acontid) GAS FOR KA BOILING (C_3H_B) -42·2°C ROPANE H H - c-- c -- H 4- C-H H (C4 H10) BUTANE -0. HHHH C - C - C - C - HHHHH (Cz HG) -88.5 \bigcirc

-411-



-412-

-413- (414,415) 6) Propane and butane are seperated from L. P.G. by catalytic cracking this involves heating the L.P.G. at certain "precise" temperatures in the distillation tower and toppi off the required gas. (see diagram 7) Liquid nitrogen (N2) How Cold! Liquid nitrogen is stored at -195.8° and all gases are liquid fied were possible to make storage and hand -ing ecconomically possible due to the expensive production vessels for containing an amount of un pressurised gas. This concentrat on liquid fication is particularly prominent in the transportion of gas by sea. As shipping costs of enormously high, ships are designe to carry as much liquid as is safely possible, therefore liquidfrace of gases being the only economic way of transportation and storage

-416-<u>REFERENCES</u>, BOOKS. HOW IT WORKS SERIES, VOLS, 3, 5 and 6. BY MARSHALL CAVENDISH. TECHNOLOGY_LEVEL. 3. COURSE BOOK. OPEN UNIVERSITY. PETROLEUM HANDBOOK COMPILED BY MEMBERS OF STAFF OF SHELL PETROLEUM COMPANY. "HOW THINGS WORK BOOK ZOFZ. VARIOUS ATHORS. BY MACMILLAN PRESS. REFERENCES PEOPLE. MR. S. TURNER. WIRRAL TECH . MR. CLACK. " MR. G. COTTER. RETIRED EX-SHE STAFF MEMBER. MR. B. BOLTON. F.G.S. B.SC. B.A.

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FURTHER EDUCATION MATHEMATICS BULLETIN

THE MATHEMATICAL ASSOCIATION

AUTUMN 1985

A NEW APPROACH TO TEACHING

INTERRELATED STUDIES IN FURTHER EDUCATION

STANLEY TURNER

SCIENCE & MATHEMATICS DEPARTMENT

WIRRAL METROPOLITAN COLLEGE

<u>A NEW APPROACH TO TEACHING</u> Interrelated Studies in Further Education Stanley Turner

(Science and Mathematics Department Wirral Metropolitan College)

The structure of most courses or programmes of study follows the pattern of a series of separate subjects taught in isolation which can be uninteresting and boring to the students. Organisationally this is true of the eleven school years which lead to the GCE Ordinary level certificate, a vital pre-requisite for many jobs and further or higher education opportunities. Certificate requirements are laid down subject by subject regardless of whether desirable relationships have been established between subjects, such as good English practice being used to support the writing of accounts of scientific experiments. In the world of work, however, subjects do not exist in isolation, but several subjects are interrelated through a task which usually involves, or actually is, measurement. Inter-relationships commonly occur between mathematics, science and technology through measurement: for example, the Pharmaceutical industry production worker has to estimate (measure) quantities of tablets, produce measured quantities of base ingredients (chemistry), perhaps using specific gravity (physics). The calculation of quantities and the final processing of the ingredients bring in mathematics and technology.

The education of technicians comes under the control of the Business and Technician Education Council, an amalgam of their precursors, the Technician Education Council and the Business Education Council. The new education and training force at the craft level is the Youth Training Scheme (now to have a second level). The guidelines for the operation of the TEC (1979) (1) stated:

MOST TEC PROGRAMMES CONSIST OF UNITS WHICH ARE SELF-CONTAINED AND SEPARATELY ASSESSED COMPONENTS, and in the Report on Mathematics in Further Education (2) HMI commented:

> UNLY IN A FEW CASES WERE THERE ANY ATTEMPTS TO RELATE MATHEMATICS TO ANY OTHER SUBJECTS OF THE CURRICULUM OR TO THE MAIN DISCIPLINES OF THE COURSES.
In the Manpower Services Commission document which introduced the proposed Youth Training Scheme (3) it was stated that:

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THESE AIMS REQUIRE AN EFFECTIVE INTEGRATION OF SKILLS, KNOWLEDGE AND EXPERIENCE

Thus for technician education the new system has kept the traditional diet of separate subjects criticised by HMI, but the scheme for the new era in craft training attempts to be more realistic and cross boundaries. Somewhere in further education perhaps part of the time allocated to a course can be dedicated to the idea of interrelated studies so as to create more interest in and relevance for, say, mathematics or a branch of science. The idea has been developed and tested by a small team at Loughborough University of Technology. Modules of study with notes for lecturers which have been tried and developed are:

MEASUREMENT AND THE CONSTRUCTION INDUSTRY

AND

MEASUREMENT AND THE OIL INDUSTRY

BIEC Certificate and Higher Certificate students have found the modules interesting and enjoyable. The modules have been found particularly useful as assignents for the BIEC half unit Use of Computers at level two because using the computer is not an end in itself and must be associated with a real task which implies some general context.

The Construction module has been used with YTS and Building Diploma students. The Oil Industry module has relevance for Building, Engineering and Science students and, anyway, why shouldn't engineers know something about the chemical nature of liquid gases when servicing the storage tanks? This module has concentrated on the storage tank, its construction, calibration and simple physical modelling (computer checked).

A final point is that excellent support has been obtained from all facets of industry, with offers to make slides and supply real information for excercises. If you are interested in trying the modules or discussing them against the background of your teaching requirements please do not hesitate to contact me.

REFERENCES

- 1. A Guide to TEC, June, 1979 Technicign Education Council 76 Portland Place LONDON
- 2. Norris E, July, 1982 Mathematics in Further Education HMI Joint Report Department of Education and Science LONDON P5
- 3. A New Training Initiative: A Programme for Action, December, 1981 Department of Employment HMSO p7, section 25

THE FURTHER EDUCATION MATHEMATICS BULLETIN. THE MATHEMATICAL ASSOCIATION AUTUMN 1985.

APPENDIX 7.2

Module 'Measurement and Building'

The student will label (and could decorate) the front sheet: neatness should be encouraged (sample enclosed).

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Introduction

Bricks, mortar and concrete are simple yet important basic building materials which make structures of many different shapes and sizes. The structures which protect something or someone can be classified under the term 'shelter'. Many other materials and services are related to any one building project, from planning to heating. Have a look at the block diagram. If we concentrate on measurement then this is needed and used in many forms from simple counting to the application of some complex mathematics in order to estimates quantities. Science comes into the picture as for example when walls or concrete surfaces have to be given protection in chemical environments or where there could be some exposure to radioactive materials. Technology is naturally related when the use of materials is considered as in the case of plastics.

... ...

Objectives

After working through this module of study you should :

- appreciate how mathematics, science and technology are related to measurement;
- (2) understand how simple mathematics is used in a practical way for measurement.

Knowledge

The various stages of a building project.

Tasks

- (1) View the slides of the bungalow project.
- (2) Note any measurement.
- (3) Find applications of mathematics, science and technology.

Exercises A

- (1) Give ten examples of counting measures.
- (2) Name a branch of science which is related to the preparation of the ground before building starts and state why certain: treatment is often necessary.
- (3) Find the measurement of an angle without the use of a scale.
- (4) Identify the types of bricks used. Name some brick measures.
- (5) Name the material in the cavity space of the outer walls ? State its purpose and that of the cavity.
- (6) Name two types of triangles which can be seen on several slides.

Exercises B

- _____
 - (1) Identify some mortars and note their particular uses and any special properties. State the mixture ratios in each case.
 - (2) Describe some changes which take place during the setting stage of concrete, and state any disadvantages which these may have.
 - (3) A bulk consignment of 200 cu.m. of TILCON ready-mixed mortar is to be made up at the factory. Work out the measured quantities of the base ingredients required. Assume ratios for the constituents. What extra weight would this add to a building and how would the architect take this into account ? Try to construct a computer program which will work out the volumes of the constituents for any bulk quantity and gbiven ratios.

Exercises C

- (1) What is the function of concrete before walls are erected? How is it used in the projects you have seen ?
- (2) Explain how certain measurements must be made before the concrete is actually used. Give a numerical example and refer to the building site.
- (3) Why and how, is concrete work sometimes protected on a site ?
- (4) You are required to produce a specification for concrete starting with the basic constituents: make a procedure list showing constituents, ratios, densities and weights. Try to write a computer program to give the quantities of each constituent for an input of the ratios and volume required.
- (5) How does TACBLOC differ from bulk concrete ?
- (6) What change takes place at stage 2 in the manufacture of TACBLOC ? Name the gas produced and state its purpose. purpose.
- (7) Describe measurements you would make to compare the densities of aerated concrete in block form with brick. By referring to the literature obtain a check on the expected results. Are there any factors e.g. moisture content, which could affect accuracy and should therefore be taken into account ?. If possible carry this out in say the brickwork shop.

- List the measurements you would need to know in order to estimate the number of bricks required to build a wall.
- (2) Describe a method by which the volume of mortar required to build a a wall could be estimated if the number of bricks required is known.
- (3) A wall measures 12m by 4.5m and is one brick thick (0.1125m). Estimate the weight of the wall assuming that set and dried mortar and bricks have the same density, namely 2000 kg/cu.m.

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- (4) Explain why the climate should be considered before selecting a a brick for a building.
- (5) Circular shapes are quite common in brick structures. Describe some examples and make sketches of what you can see as you travel about in your daily life. You might like to try some of the section 'Circles and Buildings' if you have time. The mathematics of circular shapes is complex but points for plotting the outline can be easily produced by a computer and used to construct a framework of wood.
- (6) What advantages would TACBLOC or any similar lightweight block have over brick during the actual building of a wall ? : also, would there be any structural advantages to be gained when building with bricks and blocks, rather than building entirely with bricks ?





Front window Front door (inclusive of all glass) Side window (one) Side window (two) Rear window Rear door (including glass)	1.3 X 1.8 2 X 1.2 1 X 0.4 1 X 1.2 1.3 X 1.8 2 X 1
UPPER FLOOR	MEASUREMENTS
Front window Front window Side window Rear window Rear window	1 X 1.8 1 X 1.2 1 X 1.2 1 X 1.8 1 X 1.8 1 X 1.2

Front to rear length (side of house) : 9.1 Measurements for openings in outer walls

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LOWER FLOOR

All measurements are external and above DPC level



Tasks -----Study the house picture and plans, then try to work through the exercises. Here is a diagram to illustrate one type of wall : can you name it ?

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MEASUREMENTS

House Measurements

Exercises E

- 1 Calculate the area of each rectangular wall.
- 2 The shape of the front and rear walls has a geometrical name which is related to the number of sides. Write down this name which begins with p.
- 3 Next calculate the area of the gable walls (the builder's term for the front or rear wall). You can split it up into two areas or use a subtraction method. In either case simple trigonometry is needed.
- 4 Add up the outer ares of all four walls.
- 5 Calculate the sum of the areas of all the openings in the walls.
- 6 Now find the total area of the outside brick faces.
- 7 The next task is to convert wall area into a number of bricks using the number of bricks which will cover one square metre, which is not an exact number. Sometimes the 'round' figure of 60 is used. Ask for help with this.
- 8 From the previous calculation give what you think is a sensible estimate of the number of bricks required. Why would you want to order extra bricks ?
- '9 Bricks come in packs. Look at the literature and select a brick and find out how many there are in a pack.
- 10 How many packs of bricks would you order ?
- 11 Think about the same series of steps to give you an estimate of the number of blocks and hence packs to order.
- 12 Write down as completely as possible specifications for :
 - the brick ;
 - (2) the block;
- and (3) the mortar

you would use, giving reasons. Don't forget the climate and geography ! So much for the geometry and arithmetic and materials and on to a most important consideration - that of conservation of heat. The rate at which heat escapes through a wall is measured by the U-value and brings in some physics, mathematics and material considerations. Find something on heat loss (someone pays for it !) in say, the free literature in the Electricity Board shops, for example :

A Guide to Home Heating Costs Conserving Heat Energy 25

Shape and form contribute pleasure as well as utility to buildings and structures. The casual student of architecture can find many examples of how the designer has permitted art to play a major role in determining the final form. A common shape used extensively in buildings is that of the circular arc, either alone or in combination with other shapes. Some examples are :

> Doorway arches Passageway arches Bridges Window arches Bay windows Industrial chimneys Power station cooling towers

Describe and criticise some examples you have seen.

Measurements

The measurements associated with circles make use of a very "important number called 'pi' because this is the Greek letter chosen as its symbol. The value is not exact but can be found as an approximation to any number of decimal places. The ancient Chinese knew that the value was about 3. The value correct to five dcimal places is 3.14159. The area of a circle is given by the formula :

area = pi x the square of the radius

A Problem Using Pi

An industrial brick chimney has the shape of a hollow brick cylinder 90 metres high with an internal diameter of 5 metres and a thickness of 0.3 metre. Calculate the volume of the brickwork and its mass if the average density of the bricks and set mortar is 2000 kg./cu.m. The cost of building the chimney increases with the height - why do you think this is ? Take the value of pi to be 3.142. To find the mass (or weight) use the formula :

Volume = mass multiplied by density

Plotting the Dutline of a Circular Arc

The shape often consists of part of a circle i.e. just an arc and in building terminology the distance between the ends of the arc (a chord of the full circle) is called the SPRINGING LINE and if this is horizontal the vertical distance above this line of the highest point of the arc is called the HEIGHT of the arc. If the brick structure to be built is say an arch for a doorway then an outline structure in wood must be made to act as a guide for the bricks and to hold them in position until the mortar has set. The first step in the construction of the frame is to make its outline on paper or stiff cardboard. A number of methods are "used but here is one that requires the plotting of points and joining them up. The following diagram illustrates the method.



≈ 3.63m to 2 dec.places

Here are some sets of data for arches so that you can plot the points for the outlines on graph paper to scale, then join them up into a smooth curve. Plot points on both sides of O using the same values of x and y. Work out the radius in each case and check your plotted outline by using the calculated radius to draw part of a circle which you can put over the plotted outline to see if the two match.





* Length	of springing lin	ne = 5	Height d	of arch = 2
	× -	<u>Y</u>		
	0 .25 .5 .75 1 1.25 1.5 1.75 2 2.25 2.5	2 1.99 1.95 1.89 1.8 1.67 1.52 1.31 1.04 .66 0		
Radiu	us = 2,56			
* Length	of springing lin	e = 4	Height c	of arch = .5
	× _	¥ _		
	0 .25 .5 .75 1 1.25 1.5 1.75 2	.5 .49 .47 .38 .31 .23 .12 0		
Radiu	1s = 4.25			
* Length	of springing lin x -	e = 7 Y -	Height o	f arch = 1.5
	0 .25 .5 .75 1 1.25 1.5 1.75 2 2,25 2.5 2.75 3 3.25 3.5	1.5 1.49 1.47 1.44 1.4 1.34 1.26 1.17 1.07 .94 .8 .64 .46 .24 0		

Radius = 4.83

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Notes For Lecturers

Introduction

The slides are important because they should generate interest and act as a focus for attention. There could be plenty of class discussion and if possible the students should be allowed to operate the projector at a later stage in order to view particular scenes. There is little that cannot be seen locally where building is taking place and the students should be encouraged to look at as many building sites as possible.

The Exercises

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These can be selected or the complete module worked through. Questions are posed which do not always have one clear answer and because of this they should invoke discussions between students which should be encouraged. Bricks, mortar and concrete sound a very simple trio yet their use involves physics and some very complex chemical changes as well as requiring the application of mathematics such as geometry : the technology behind the use of the materials should also not be forgotten. Here are some notes on the exercises.

Exercises A

1 Examples are number of packs of bricks, rolls of polythene, labourers.
2 Biology - vegetation needs to be killed or else ! Tree roots too.
3 Using a spirit level or string line.

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4 Common. facing.

5 Glass wool - thermal insulation. The real purpose of the cavity is to act as a moisture barrier.

6 Right-angled, isosceles. -

Exercises B

1 See mortar information e.g. coloured mortar.

2 Loss in volume (1/3) and drying.

3 If ratio is 1:1:6 then volumes are 1/8, 1/8 and 6/8 of 200. Added weight due to mortar which when dry has an approximate density of 2000kg/cu.m. The volume of mortar will be worked out (10mm thick for a standard brick : 215mm by 65mm face, 112.5mm deep). They should draw diagrams.

Exercises C

- 1 Provide a base for the walls. Foured into the trenches perhaps.
- 2 You must know the volume to order therefore the dimensions of the trenches.
- 3 From, rain with polythene sheeting.
- 4 Cement, sand and coarse aggregate and some water. The program is not essential but some may be able to do this and find it motivating and some professional help may be available in your college. The industry
- is very much aware of the uses of computers.
- 5 Light in weight volume for volume; easy to cut and drill.
- 6 Hydrogen gas produced driven off to leave voids.
- 7 Measure dimensions, calculate volumes. Weigh each one and calculate each density from : weight/volume.

Exercises D

Number of bricks per square metre, mortar thickness and brick dimensions.
 Say : volume of wall - volume of bricks. Assume standard bricks.
 Weight = volume x density.
 Exposure to salt- or chemical- laden atmosphere needs consideration.
 This one may interest some of the more able students.
 Fewer units to carry and lighter ones too, so time is saved during

construction. After, it is easy to clad TACBLOC i.e. drill it and attach materials or fittings. These are just some points.

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Exercises E The house plan and dimension sheet should be used with these exercises. The calculation ignores extra pillars and does not take account of what happens at the corners when walls merge but in spite of this it should make the student think about just how an economic estimate of materials is arrived at even if it is for building a private earder wall

is arrived at, even if it is for building a private garden wall.
1 Geometrv.
2 Folygon - many sides.
3 Area of triangle = 1/2 × base × height.
4 Addition.

- 5 These again are just rectangles.
- 6 Subtract from total area.
- 7 Number of bricks per square metre :

This is 1/(0.215 + 0.010)(0.065 + 0.010) (add 0.010 for mortar)

= 59.259 to three decimal places.

- 8 Round up to a whole number. Add some for waste say 6%.
- 9 The number per pack varies a lot.
- 10 Divide number of bricks by number per pack and ROUND UP.
- 11 The dimensions of a block will have to be selected but the mortar bed is still 10mm (0.010m). See TACBLOC information.
- 12 Type, name, manufacturer, weight, mortar mixture ratios etc. The estimation of U-values is important and involves a lot of science as well as technology for using insulating materials.

The Slides

The following are brief descriptions of the slides which were made at various stages of the construction. The students should be encouraged to contribute verbal descriptions which should generate some dialogue. between students. Encourage the students to describe what they see.

- 1 The footings for the walls which are wider than usual because the ground had been filled in with rubbish etc.
- 2 The footings are also excavated to more than the normal depth.
- 3 Note the bank of soil which should be removed completely or well treated to kill the vegetation which will find its way anywhere.
- 4 Any suggestions as to what could be in the soil ?
- 5 This is a general view of the concrete raft which forms the base for the structures. The bungalows form a terrace and the complete raft is stepped because of the slope of the ground.
- 6 Sewage channels. Note the curvature of the pipes which must mean doing some geometry for the design. A T-junction can be seen.
- 7 Sewage pipes implying a variety of measurements. The supplying of water and removal of waste constitutes a large and very important industry, servicing private and commercial users.
- 8 This trench has a pipe with a branch which does not have a port through which a blockage may be cleared.
- 9 A manhole. Note the 'fall' or gradient of the pipe which has to be correctly adjusted as follows (some science here) :

gradient	pipe diameter
1 in 40	100 mm
1 in 60	150 mm

10 Sewer with a large manhole to collect all the sewer pipes.

- 11 The pipe in a trench is covered with loose gravel, which has the dual function of being flexible and so allowing the pipe to move slightly, and also easy to excavate if the pipe has to be exposed for maintenance. The loose material is called 'blinding' and should be consolidated in layers.
- 12 Note the metal lintel and the start of the 'soldier' arch, so called
 because the bricks stand upright.
- 13 Here a bricklayer is actually building the arch.
- 14 This shows an opening for a window. Ask about the angles involved (90 degrees) and two measurements (length and height) which have to be accurate.
- 15 A chimney. The cross-section is a square.
- 16 Window louvres. Ask what they are for (to prevent condensation).
- 17 An inside view of the walls. Ask what they see.
- 18 Some block walls, not as dense as brick and they do not support the the main weight of the roof. Note the toothed ends and indents for a partition wall.

19 A general view of the inside.

20 These are liners for the flues.

- 21 Chimney pots. What are they made from ? (clay).
- 22 A chimney breast.
- 23 The rebating (grooved lip) on the flue liners is inclined so that any condensation inside runs back into the chimney.
- 24 A corner being built what angles do we have ? (90 degrees).
- 25 A general view of the walls. Note that four courses (rows of bricks) contribute 0.3 m of wall.
- 26 Scaffolding and a gable end wall what shapes can be identifie ? ! (an isosceles triangle and a rectangle, giving symmetry). The dark brickwork is still wet.
- 27 Bricklaver plumbing the corner (making a true right-angle).
- 28 Cavity wall : note the wall plate and asbestos board seal at the top.
- 29 The cavity is filled with fibreglass why ? (to give thermal insulation)
- 30 The apex or 'peak' or 'pike' (depends where you come from) being built note ranged ends.
- 31 The brick ends are cut off with a special electric saw ('whizzer').
- 32 Completed peaks and trusses in position.
- 33 Gable end and elevation showing the eaves.
- 34 The completed roof showing plaster and plasterboards.
- 35 A labourer mixing a plaster 'bank' or 'pile'. What is essential ? (water !).
- 37 Flasterboard backed with metal foil (for thermal insulation).
- 38 The roof space. What shapes do you see ? (triangle, rectangle).

APPENDIX 7.3

CL's Attempt At A Module

WORKSHEET

B-R-I-C-K-S by C-A-R-L-T-O-N

Your Tasks :

- (a) Study the Carlton information sheet.
- (b) Attempt the following exercises.

Exercises

(1) Complete the following information :

(a)	Individual	brick weight	15	• • • • • • • • • • • • • • • • • • • •	кg

- (b) Length of one brick is mm
- (c) Depth of one brick mm

(d) Estimated number of bricks for a wall 6.5m long ...

(2) How many bricks are there in one pack ?

(3) Calculate the weight of one pack of bricks : (convert to tonnes).

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(4) The estimated number of facing bricks for a certain detached house is 7800 : how many packs of Carlton bricks would you order ?

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TECHNICA	L DETAILS	OF C	ARL	TON	FACING	G BRICKS
Loadbearing Class B.S. 3921 1974	Water Absorption	Crushing Strength Ibf/in [±]	Crushing Strength N/mm ⁺	Suction Rate kg/m²/min	Brick Weight Ib	Brick Weight kg
9.0	7%	9,000	61.5	1.00	5.6	2.55

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Liability to Efflorescence : Nil to Slight Thermal Conductivity : Information available on request

THE ABOVE SPECIFICATIONS COVER THE RANGE OF FACING BRICKS SHOWN OVERLEAF

Carlton bricks are available in Metric sizes only.

METRIC SIZES : 215 mm x 102.5 mm x 65 mm

Tolerances: 24 bricks measured overall shall be :--

	Dimensior	Not less than	Not more than
-	215 mn	n 5.088 m	5·232 m
-	102-5 mm	n 2.424 m	2·496 m
	65 mm	n 1.536 m	1-608 m

Details of other metric sizes manufactured available on request.

Good brickwork

It is good practice to always ensure that brick stocks on site, and bricks in construction are adequately covered during bad weather, especially when there is heavy rain immediately after bricks are laid. These simple precautions will go a long way to minimising the unsightliness of various forms of staining and efflorescence.

Further details

- (a) All facing bricks are produced on one of the most up-to-date tunnel kilns in the country.
- (b) Weekly output of $\frac{1}{2}$ million facing bricks.
- (c) Strict quality control processes are observed each day at various times and at all stages of production.
- (d) Competitively priced for QUALITY of facing brick offered.
- (e) All facing bricks are polythene shrink wrapped in packs of 504 and dispatched to site on vehicles equipped with off loading systems.
- (f) Samples of all colours are readily available and one of our representatives will be pleased to call on you, without obligation, at your invitation.

ADVICE & ASSISTANCE ALWAYS AVAILABLE BY RINGING BARNSLEY 711521

Carlton Main Brickworks Ltd.

HIGH STREET - GRIMETHORPE - Nr. BARNSLEY - SOUTH YORKSHIRE - S727BG

T<u>ELEPHONE</u> – BARNSLEV 711521

MEASUREMENT AND THE OIL INDUSTRY

Industrial Storage Tanks

General Objective

After working through this module you should appreciate that industrial tasks involve measurement through which mathematics, science and technology are interrelated.

Specific Objectives

- (1) To use mathematics as required by measurement
- (2) To identify applications of science and technology
- (3) To make use of the computer in the solution of routine
 - problems which are related to production tasks

How to Use This Module

Study the notes and photographs then try the exercises. Discuss any difficulties with your lecturer or another student.



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INDUSTRIAL USES OF TANKS

Industries Based On Oils

'Mineral oil provides fuel and base chemicals for use in most industries. Edible oils such as palm oil are the basis of margarines and many other food products. All these industries bring together chemicals and engineering technology as the subject which is known as chemical engineering. The search for mineral oil starts with measurement, the geologist leading the way. Once detected or suspected beneath the ground or sea bed a sample must be obtained. Analysis of samples brings in physical and chemical measurements with mathematics in the form of statistical analysis. Having located an oil reservoir a decision to start extraction will depend on the estimated quantity in the reservoir and the technological problems involved in the extraction. Natural gas (mainly methane) and water a usually found with the oil, the liquids being held in rock. The gas itself may be worth extracting without the oil and thus a 'natural gas' field would be the result of the search. Chemical analyses and pipework technology use mathematics, science, technology and vocation in an interrelated way by the many measurements involved. The Alaskan oil fields were most difficult to exploit and new technologies had to be developed. Try to explain why there should be these difficulties by referring to the different climatic conditions experienced when working in the Middle Eastern fields. The edible oils however are comparatively easy to obtain as they are extracte physically from vegetable crops which are specially grown for the purpose.

Background to the Mineral Oil Industry

View the slides or if these are not available look at the black and white prints of these : look at the Information Pack.

- (1) Name five measurements which would be necessary during the search;.
- (2) Name some substances you might expect to find in the drill sample;(3) Name four principal chemical elements in the sample and give some
- of their chemical and physical properties
- (4) Name some of the products of the primary distillation of crude oil, classifying each as solid, liquid or gas. If possible give a chemical formula and some industrial uses for them.
- (5) What types of machines are involved in the movement of fluids ?
- (6) Name the two chemical elements which are combined in different proportic to form the many different hydrocarbon substances which are found in the oil and also derived from it.
- (7) Identify some tanks and their uses.

Exercise : Tank Capacities

Look at the photographs of tanks headed Tank Installations in the Information Fack. Study these and note the different shapes, capacities, products stored, units of volume and geographical locations. Here are some equivalent units :

> 1 barrel'(bbl) = 159.109925 litres = 35 gallons = 35 x 1.20092615 American gallons

Make a table with columns for : -

Product Stored Capacity (bb1) Capacity (litres)

using a computer program for this which also converts barrels to litres.

Tanks and Mathematics

Tanks are used to store and supply fluids when required which means that the quantity pumped out and the amount left has to be measured to a certain accuracy which is extremely important if Excise duty is payable ; in this case regulations stipulate the method and accuracy of the calibration methods. The cuboid, cylinder and sphere are the commonest shapes for tanks and the design, manufacture and calibration call for some quite complex mathematics. Some mathematical formulae are given for reference (Information Pack) : note the importance of the circle. Ferhaps the spherical tank is the most unusual one to be seen and of the three, the most dificult to manufacture. Its main application is storing gases in liquid form.

Typical gases involved are:

- (1) liquid petroleum gas or LPG;
- (2) liquid natural gas or LNG;
- (3) propane and butane which are separated from LFG (how?) ;
- (4) liquid nitrogen (how cold ?).

Why this concentration on LIQUEFACTION ? Make reference to sea transport. Making a large spherical metal container demands a great deal of specialised technology : suggest why the shape is so important. Pictures of some tanks [Information Pack] show their geographical locations, contents, shapes and capacities in two units. Study these and try to write a program to give you the diameter of a spherical tank as the output when the volume is typed in as the input information. To do this you must first re-write the formula which gives the volume of a sphere in terms of the diameter to read D = etc. where D is the diameter. This involves 'algebraic transposition and the computer will not do this for you. Having done this test the program using a corresponding pair of diameter/volume values. Next select some of the spherical tanks shown and estimate the diameters from the pictures. Now use the program to check your estimate of the diameter in each case. How good an estimator are you ? Compare yourself with some else. Spherical tanks are by no means as common as cylindrical tanks yet they play an important part in storage in the petrochemical and associated industries and can be seen in many countries. The designers and manufacturers of such tanks apply science to the selection of the metal for the shell, to operational safety measures, the maintenance of the sphere and its associated equipment and of course in the design and calibration. What follows is a simple investigation of the mathematics involved in the calibration with the help of a computer. A similar method is used by the organisations which specialise in and are officially recognised calibrators.

A Case Study : The Spherical Tank

One of the first requirements of a user of such a tank is some method of estimating accurately the volume of liquid from the measured depth of the liquid in the tank. A similar but far less accurate measurement is required to find the amount of petrol in the tank of a motor car. The Institute of Petroleum lays down stringent calibration procedures and an extract of these is available for you to see : note what a lot of 'circle' mathematics is involved [Information Pack]. The depth of liquid can be 'dipped' with a rod and this depth fed into a mathematical formula which gives the volume. Let us investigate the relationship between depth and volume.

The Mathematics

The depth of liquid is measured along the vertical axis of the sphere. For a sphere of known internal diameter values of depth are substituted in the volume formula, thus giving a table of depth/volume values. The depth can be given values from zero up to the diameter, in uniform steps. A smooth graph is then drawn connecting depth to volume : note that the volume is an INDIRECT measurement of the volume, depending on the fundamental measurement of the depth of the liquid.

Theory

D = the diameter of the vessel H = the depth of liquid measured along the polar axis V = the volume of liquid in the vessel P = the value of pi = 3.14159265 to 8 decimal places

It can be proved that:

 $V = P \times H \times (D/2 - H/3)$ cu.m. if all dimensions are in metres

If your maths is that good, can you prove this formula ?

A practical method used for checking the calibration is simply to insert a dip-stick and measure the length which is wetted by the liquid (suggest a safe liquid to use for this calibration) of known volume. Once in sevice a float is inserted in the tank which causes a change in electrical resistance of a circuit as the depth varies and this is transmitted to a dial which is situated away from the tank. How is the volume of petrol measured in the tank of a vehicle ? The formula for the volume will probably not look at all familiar but replace H and D by 2 x R and simplify. Can you recognise what you have and explain why this value of H gives it ?

A Computer Program

- 1 Write and test this as a first stage for one value of H and D=10. Then use pen and paper to see if you agree with the computer (or is it the other way round ?) : make several checks.
- 2 Adjust the output values of V with the INT function to give V correct to two decimal places.

3 Use an INPUT statement so that the user can choose any value for the diameter D. Again check with the formula - you must not accept the results from a machine you have programmed without checking.

4 Now modify the program using the FOR and NEXT statements to give a table of volumes for a range of depths. What is the upper limit for H ? Add an INPUT statement so that the user is asked for the maximum depth of liquid.

Exercises : The Spherical Tank

1 Draw a simple diagram to illustrate the vessel and its dimensions.

2 Why is the diameter more practical than the radius as a volume measure ?

3 State some factors which would limit the choice of metals for the shell

- 4 Discuss some scientific and physical principles which would be applied in the siting and design of the vessel. View the slides again
- 5 What technology would be involved in the construction of the vessel?
- 6 Draw calibration curves from the computed data for D=5, 15 and 20
- 7 What would be the % error in V if 3.14 is used for pi instead of the more accurate value ? Is this be constant for any volume and diameter ? Try one or two calculations for V evaluated using both values of pi. Can you deduc with algebra that the % error is always constant ? You may need help.
- 8 Use your graph to read the volume when the height is 4.5 m. Check this by using the formula
- 9 What do you notice about the shapes of curves for various diameters ?
- 10 The vessel changes shape as it is filled. Can you see describe and name the new shape the sphere takes as the volume of liquid is increased.
- 11 When the tank is calibrated (by specialists in this field) the internal diameter is found by measuring the length of a band of material which is place round the outside along the equator and also through the 'poles' from which lengths the diameter is calculated. Can you see how to do this Here are some actual data :

Internal diameter	18838	ភាព
Plate thickness	38	ጠጠ
Weight empty	448	tonnes
Weight full	3948	tonnes
Mean circumference	59.381	m

The internal volume is found from the weights empty and full, water being used as the calibrating fluid. Calculate the mean internal diameter and from this the theoretical internal volume. Then calculate the internal volume from the weight of water which fills the sphere. Compare the two and comment on the values.

- 12 Find a section of the graph which appears to be approximately straight and try to explain why this is so by referring to the change in the surface area of the liquid with depth (the area = 0 for depth =0).
- 13 Check the shape of the calibration curve by a practical calibration using a laboratory model in the form of a round-bottomed flask. Your physics lecturer will guide you in this but try to plan the experimental details for yourself.
- 14 The spherical tank which holds the hydrogen gas at the Van Den Berghs and Jurgens Margarine works has an internal diameter of 50 feet and is supported by ten steel columns which keep it off the ground. This information can be read off the construction blueprint which also states that the load on each column when the sphere is filled with water is 210 tons and 30 tons when filled with hydrogen gas. Use this information to calculate the actual internal volume of the sphere and compare it with a value obtained from your computer program. Also note that the density of the hydrogen gas is very small and that imperial units are used. Explain why there is a discrepancy between the internal volume based on filling with water (an official method) and the theoretical value using 50 feet as the internal diameter. You will need to consult data tables for the density of water and then convert the weight of water ONLY ? to volume.
- 15 In your program for the depth/volume calibration table for the spherical tank the volume of liquid is computed each time the depth is increased (you have typed in the increment). You have also typed in the final depth. The table also starts from depth zero. Now suppose the diameter of the tank is, say, 10m and you want the volume for a depth of 2.7m and no more values after this. What step value for depth could you put in so that the output contains the volume for a depth of 2.7m ? If you modify the program so as to set the initial depth at a value other than zero by means of an input statement, what values would you give for the three variables (initial depth, increment and final depth) so that the output consists of just the one value of volume corresponding to the depth of 2.7m ? Is it possible to do this for any value of depth ? Try this for some more values of depth.

INFORMATION PACK

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Photographic illustrations of the Mineral Oil Industry
 Tank installations

3 Spherical tank dimensions and plate structure

4 Mathematical formulae relating to tanks

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TANK INSTALLATIONS







ARRGT. OF SPHERE PLATES.

Volume Formulae

2

Note: The dimensions given are for internal measurements. If the external dimensions and the thickness of the material (T) are given instead then T or 2T (you decide which) must be subtracted in order to obtain the internal dimensions.

<u>Cuboid</u> Maximum volume = LBH



Cylinder: axis horizontal



H

The circle illustrates any section perpendicular to the axis. The depth of liquid is y. The volume of liquid = shaded area (segment) multiplied by H.

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When the level of the liquid is below the centre then: segment area = area of sector AOB - area of triangle OAB When the level of the liquid is above the centre then: segment area = area of sector AOB - area of triangle OAB Trigonometry is required to find angle AOB in degrees

area of sector
$$AOB = \frac{angle AOB}{360} \times area of circle$$

Sphere

Consider a section by a plane passing through 'poles' i.e. the highest and lowest points, N and S in the diagram. This section will be a circle and the shading represents the extent to which a sphere is filled with liquid of depth y measured in the vertical direction from S. The formula for the volume of liquid in terms of y and the diameter D has to be derived with the integral calculus and if your mathematics does not extend to this the proof would not be a useful exercise.



Volume of liquid = $\pi y^2 (D/2 - y/3)$

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APPENDIX 7.5

Table A

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<u>Table B</u>

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REF.	0-LEV	CSE	SCORE/30	SCORE %	QUESTION	CORRECT	% CORRECT
542		3	22	73.3	⁵ . 1	11	100
543	_	2	22	73.3	2	10	90.9
544	-	3	22	73.3	3	11	100
545	 	2	25	83.3	4	8	72.7
546	_	2	26	86.7	5. 5.	10	90 . 9
547	-	?	21	70	6	11	100
548	[.]	4	15 `	50 🦾	7	7.	63.6
549	-	1	26	86.7	8	10	90.9
550	.	2	28	93.3	9	10 -	90.9
551	_	3	26	86.7	10	6	54.5
552	-	1	28	93.3	· 11 ·	6	54.5
	· .		•	•	12	9	81.8
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					19	10	90.9
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					23	10	90.9
					24	8	72.7
					25	8	72.7
					26	11	100
					27	4	36.4
					28	11	100
					29	7	63.6
		1.		ļ	30	21	190.9
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APPENDIX 7.6

-453-

'Measurement In A Pharmaceutical Laboratory'

Measurement in a Phannacy habitation.

instran <u>l'iniversal Testing Instrument</u> (model 1122) The above named instrument can be used far a vanety of tests and experiments. In this experiment it is being used to measure the resistance to an applied farce. The resistance is quien by a filter that has been used in previous experiments. The results will share if there is any significant particular contamination of the filter. The filter is removed from an infusion administration unit and attached to a Bedan - Dichnisch syminge. The syminge is placed who the well of the metal base plate and held upright so it is set in a vertical posistion = (see chagram belaw)



The instrument is then started up and when the crosshead reaches the plunger it will depress it into the barrel at a speed of 50 mm min⁻¹ with a full scale deflection of 0.1 KN and a full scale load of 0.08 kg.

Three différent kinds of sample were used, (i) unadulterated filter (ii) pre-used with water

(iii) pre-used with uitravaevous solution to be tested.

Each is tested in duplicate.

The instrument is connected to a graph-plotter, this gives a face / time curve whilst the crosshead is in notion. The examples given are not connected with this experiment but are typical readouts.



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The force / time curve is converted to a digital readout. This readout is converted who units of energy and after applying a suitable convertion far the syringe alone, it represents the amount of work done against the filter resistance. <u>Calculations Involved</u>.

To convert the display reading with the final described units of energy, it is of course necessary to multiply this reading by an appropriate conversion factor. This factor is dependent on the conditions of the test. To obtain the integrated value directly : into units of work or energy, the formula is :-

XXLXS 10,000

Where - E = energy in Kg. mm - L = full scale load in Kg S = vate of sample extension (crosshoad) = integrator readin  $\times$ 

Results Obtained

Each fitter was tested three times, a typical set of results is as follows -Full scale load 0.08 kg Crosshead Speed 50 mm. nui" Filer pre-used with water. (A) uitegrator readings (i) 5437 5569 (uí) — (ini) 5472 B Julie pre-used with water. uitequater readings (1) 5520 (ii) 5603 (in) 5491

© 7 the pre-used with intravaenous solution. integrator readings (1) 5650 (1) 5642 (iii) 5597 Filter pre-used with uitravaenous solution Ø intégrator reachings (1) 5588 (ii) 565Z (iii) 5 6 17The energy value for each nichisidual reading has to be calculated and also the mean energy value for each sample filte. Due to the repetition undued during calculation, a small computer . program could be written and used the calculate the results. PIP UTI.DAT 5 PRINT THIS PROGRAM IS DESIGNED FOR USE WITH RESULTS FROM THE INSTROM 10 PRINT MODEL 1122, PLEASE ENTER DATA WHEN ASKED. 20 REM SET COUNTERS 30 J=0 40 C=0 50 FOR I=1 TO 50 60 PRINT:PRINT:PRINT 70 INPUT'INPUT FULL SCALE LOAD IN Ks";L ( BO INPUT'INPUT CROSSHEAD SPEED IN mm/min';S 90 INPUT'INFUT INTEGRATOR READING';X 100 .E=(X/10000)*L*S 110 J=J+E 120 INPUT DO YOU WANT TO ENTER HORE DATAT(Y/N) ;cs 130 IF C\$="Y"THEN C=C+1:PRINT'ENERGY IN Kg/mm IS";E:NEXT I 140 IF C\$="N" THEN C=C+1:PRINT"ENERGY IN Kg/mm IS";E 150 PRINT:PRINT'THE MEAN ENERGY IN Ks/mm 18*;J/C 160 PRINT: PRINT: INPUT'DO YOU WANT TO ENTER MORE DATA '; B\$ 170 IF P\$="Y"THEN 20 180 END Ready







0	Ready	
Ģ	RUN UTI.DAT THIS PROGRAM IS DESIGNED FOR USE WITH RESULTS FROM THE INSTROM MODEL 1122.PLEASE ENTER DATA WHEN ASKED 	
0		
Ō	INPUT FULL SCALE LOAD IN K@? 0,08 INPUT CROSSHEAD SPEED IN mm/min? 50 INPUT INTEGRATOR READING? 5650 DO YOU WANT TO ENTER MORE DATA?(Y/N)? Y	
0	ENERGY IN KS/mm IS 2.26	
O	INPUT FULL SCALE LOAD IN KM? 0.08 INPUT CROSSHEAD SPEED IN mm/min? 50	
0	INFUT INTEGRATOR READING? 5642 DO YOU WANT TO ENTER MORE DATA?(Y/N)? Y ENERGY IN Kg/mm IS 2.2568	
О.		
0	INFUT FULL SCALE LOAD IN Kd? 0.08 INFUT CROSSHEAD SPEED IN mm/min? 50 INFUT INTEGRATOR READING? 5597 DO YOU WANT TO ENTER MORE DATA?(Y/N)? N	
0	ENERGY IN Ks/mm IS 2.2388	
Ģ	THE MEAN ENERGY IN Kg/mm IS 2.25187	
G	DO YOU WANT TO ENTER MORE DATA? Y	
9	INPUT FULL SCALE LOAD IN KS? 0.08	
0	INPUT INTEGRATOR READING? 5588 DO YOU WANT TO ENTER MORE DATA?(Y/N)? Y ENERGY IN Kg/mm IS 2.2352	
G		
0	INFUT FULL SCALE LOAD IN Kg? 0.09 INFUT CROSSHEAD SPEED IN mm/min? 50 INFUT INTEGRATOR READING? 5652	
0	NO YOU WANT TO ENTER MORE DATA?(Y/N)? Y ENERGY IN Ks/mm IS 2.2608	
0		
0	INPUT FULL SCALE LOAD IN K⊴? 0.08 INPUT CROSSHEAD SPEED IN mm/min? 50 INPUT INTEGRATOR READING? 5617 DO YOU WANT TO ENTER MORE DATA?(Y/N)? N	
Ģ	ENERGY IN Kg/mm IS 2.2468	
$\mathcal{O}$	THE MEAN ENERGY IN Ka/mm IS 2.2476	
~	DO YOU WANT TO ENTER MORE DATA? N	

# The Build System.

The build program allaws a user to write a Bisic program by answering a series of questions describing the data. It is especially useful for managing data which is list arentated. Typical BUILD applications include starage of information about memos, inamtenance of marking / address lists - the variety is endless.

Before actually numing the Build Pragram' you must think about the system you want to create You varst be able to answer the following questions What hund of data is it ? (eg memo's) Do I want other people to new this data? How many pieces (fields) are associated with each record? What do these fields look like? Mow long are they? Do they cartain alpha + numeric characters? Do they cartain dates?

Do I would to sart an any of these fields?

Access to the build program is obtained by logging into your account fran your terminal. Once you are logged in, type the word Builts and answer the questions as they are asked.

The funct result is not one but several programs. A whole system will have been created which will allow you to add to a data base, print out the file cutents, edit, search and sort the data. The entre system which you will generate is made up of basic programs which can be listed and if you want to, they can be modified to meet any additional requirements for special data handling.

H unit through of the program connect be clobalized, but here are some examples of completed products. FIP CAPTO-BAT CAPTOPRIL INTERACTIONS WITH INFUSION SOLUTIONS SOLUTION HEAN merel DEV FROM HEAN DEV FROM INIT. TIME SZECTROBE 1.0604 02 0.000 0.92 Macl 1.0136 0.72 -4.412 01.25 1.0279 2.32 -3.062 00.00 1.0302 1.012 -2.842 07.05 LACTATE 1.0637 0.322 -0.22 01.12 1.0322 0.932 -2.52 03.16 0.92 1.0655 02 -0.22 01.12 1.0322 0.932 -2.52 03.16 0.92 1.0652 0.252 0.000 Nacl 1.0322 1.012 -4.962 00.00 Nacl 1.0322 1.012 -2.922 03.65 0.92 1.0652 0.252 -2.022 03.65 SOLUTION 1.0332 0.252 -2.022 03.73 RINGERS 1.0664 1.452 -2.082 01.00 1.0653 02 -2.252 07.03 0.452 1.0665 0.4642 -1.602 01.27 1.0666 0.4642 -1.602 01.27 1.0609 0.252 +0.722 03.29 1.0609 0.252 +0.722 03.29 1.0609 0.252 +0.722 03.29 SolutION 1.0454 1.462 -1.602 01.27 1.0609 0.252 +0.722 03.29 Solution 1.0454 1.462 -1.602 01.27 1.0609 0.252 +0.722 03.29 Solution 1.0454 1.462 -1.602 01.27 1.0609 0.252 +0.722 03.29 Nacl 1.0466 0.6432 Nacl 1.0466 0.6432 No.00 Nacl 1.0454 1.462 -1.602 01.27 1.0609 0.252 +0.722 03.29 1.0609 0.7527 +1.082 O fram a Migh Cedamaance trequid Chromatogyraphy(HPLC) experiment CHLORTETRACYCLINE/TIANJLIN MINERAL OIL BATCH.MD 49 50 56 02333 51709 1 49 50 56 02333 51709 1 49 50 56 02333 51709 1 49 50 56 02333 51709 1 24 29 69 06336 51709 3 Shurphy printing cut the batches of vew materials Mad were used to made up the funded product batch			-402-			
H unu through of the program counset be clotained, but have are some examples of completed products. PIP CAPTOLBAT SOLUTION MEAN mEXAL DEV FROM HEAN DEV FROM INIT. TIME SUBJECTROSE 1.0604 02 0.5% Mach 1.0136 0.7% -4.41% 00.00 0.5% Mach 1.0136 0.7% -4.41% 01.05 1.0277 2.3% -3.06% 03.08 1.0277 2.3% -3.06% 03.08 1.0327 1.74% 07.05 LACTATE 1.0637 1.74% 0.02% 03.08 1.055 0% -0.2% 03.05 1.055 0% -0.2% 03.56 0.9% 1.0635 0.25% -0.2% 03.56 0.9% 1.0655 0% -0.2% 03.56 0.9% 1.0655 0% -0.2% 03.56 0.9% 1.0665 0.25% -0.2% 00.00 Mach 1.0323 1.01% -4.66% 01.48 1.0647 0.30% -2.25% 07.33 RINGERS 1.0604 11.45% 00.00 1.0451 1.032 0% -2.25% 07.33 RINGERS 1.0604 11.45% -0.69% 07.03 0.45% 1.0656 0.66% -1.60% 01.02 1.0645 1.15% -1.60% 01.27 1.0645 1.15% -1.60% 01.27 1.0650 0.25% -0.69% 07.03 0.45% 1.0686 0.66% -1.60% 01.02 1.0690 0.25% -0.72% 03.29 1.0600 1.777% +1.08% 05.13 CHLORIETRACYCLINE/TIANJLIN HYDROGEN FUNATE PREMIX CHLORIETRACYCLINE/TIANJLIN HYDROGEN FUNATE PREMIX A 2 45 50 0.6336 51789 2 24 2						
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PIP ASSIG.DAT

## PHARMACEUTICAL FORMULATION ASSIGNMENTS

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1 . 1 1 . 1 1 . 2 1 . 3 1 . 4	NYSTATIN PASTILLE 200,000 UNITS ISSUE DEVELOPMENT PROTOCOL MANUFACTURE 2 MORE PHASE 3 STABILITY BATCHES ISSUE GUIDE FORMULA	2/84 2/34 9/84	M.D.WARD
1.5 2.1 2.2	NYSTATIN PASTILLE 100,000 UNITS ISSUE GUIDE FORMULA	2/84	M.D.WARD
2.3 3.1 3.2 3.4 5.4	TIAMULIN/TRIMETHOPRIM PIGLET SUSPENSION ISSUE DEVELOPMENT PROTOCOL MANUFACTURE 3 PHASE 3 STABILITY BATCHES ISSUE GUIDE FORMULA	2/84 3/84 10/84	I, BROWNING
4.1 4.2 4.3	NADOLOL INJECTION ISSUE DEVELOPMENT PROTOCOL ISSUE GUIDE FORMULA ISSUE CSFM	2/84 10/84 12/84	I.M.JACKSON
7.4 5.1 5.2 5.3 5.3	CAPTOPRIL INJECTION ISSUE DEVELOPMENT PROTOCOL ISSUE GUIDE FORMULA	2/84 10/84	I.M.JACKBON
6.1 6.2 6.3 6.4	TIAMULIN/CHLORTETRACYCLINE FEED PREMIX ISSUE DEVELOPMENT PROTOCOL PACK OFF,PLACE ON TEBT PHASE 3 STABILITY LOTS ISSUE GUIDE FORMULA	2/84 2/84 7/84	I.M.JACKSON
8.5 7 7.1 7.2 7.3 7.4 7.5	ECONACORT CREAM ISSUE GUIDE FORMULA I. D.MENT PROTOCOL FOR REVISED FORMULATION MANU. 2 PHASE 3 STABILITY LOTS(R.FORMULATION) ISSUE AMENDMENT TO GUIDE FORMULA	2/84 2/84 3/84 9/84	I.M.BROWNING N.D.WARD
7.6 8.1 8.2	FUNGILIN ORAL SUSPENSION ISSUE GUIDE FORMULA	3/84	K.D.WARD
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9.2 9.3 9.4 9.5 9.6	ISSUE DEVELOPMENT PROTOCOL PLACE ON TEST 3 STABILITY LOTS ISSUE GUIDE FORMULA	4/34 Open Open Open	

Print out of projects, project cantents, who they are assigned to and when each part should be delivered by

#### Ready

# PIP POLK.DAT CAPTOPRIL INTERACTIONS CAPTOPRIL CONC. WITH EACH IS 27.5 ms/ml biluted down TO GIVE 3 DIFFERENT CONCENTRATIONS

INTERACTION	CONCENTRATION	STABILITY
0.45% NaCl		4 C 32 C R.TEMP 40 C
•	0.01m≤/ml	
	0.005 mg/ml	
•	0.02mg/m1	
0.9% NaCl		4 C,32 C,R.TEMP,40 C
	0.01 ms/ml	
	0.005 ms/ml	
	0.02 mg/ml	
5% DEXTROSE + 0.9% NaCl		4 C,32 C,R.TEMP,40 C
· · · · · · · · · · · · · · · · · · ·	0.005 mg/ml	•
	·0.01 ms/ml	
	0.02 mg/ml	
LACTATE SOLUTION		4 C+32 C+R+TEMP+40 C
	0,005 ms/ml	
	0.01 mg/ml	
	0.02 mg/ml	•
RINGERS SOLUTION		4 C,32 C,R.TEMF,40 C
	0.005 mg/ml	
	0.01 mg/ml	
	0.02 mg/ml	· .
PHOSPHATE SOLUTION		4 C,32 C,R.TEMP,40 C
<pre></pre>	0.005 mg/ml	· · · · · · · · · · · · · · · ·
4	0.01 mg/ml	<i></i> •
· ·	0.02 mg/ml	
FRUCTOSE SOLUTION		4 C,32 C,R.TEMP,40 C
	0.005 mg/ml	
	0,01 ms/ml	
	0.02 ms/ml	

O hayout of products an stability.

Electronic Maul System

This system is durided into three functional areas These are :- i) identifying yourself to the mail system

- (1) senduig messages
- (11) receiving messages

Communication via the mail system is by namecode. <u>Sencting Messages</u>

To send a message on this system, dog nito your account and type seno. then follow the instructions. The program requires that you enter the nonnecode of the person to whom you are sending the message To " send a massage to several people, all three messages are typed, separating them by commas.

This feature creates a file in the account you are logged into which keeps a list of namecodes and will .... antomatically upon login, check to see is messages are pending for the designated namecodes. It message prints, inclicating the presence or absence of a message for each namecode in the list.

Prefixing the word future to your list of O nanecodes allows on message to be created and held for future delivary. The message is hept in a file in the senders accounct until the date it is scheduled to be sent.

HELLO RSTS V7.2-04 RSTS/IDL Job 19 <Local> KB19 05-See-84 01:49 PM User: 51,26 Password: 1 other user is logged in under this account SEE NEWS FOR DETAILS OF THE NEW 'BROWSE' COMMAND. THE ON-LINE TIME SHEET SYSTEM SHOULD BE USED FROM WEEK ENDING 10/8/84. NO MANUAL TIMESHEETS SHOULD BE SUBMITTED FROM THIS DATE. THERE HAVE BEEN SOME SUBTLE CHANGES TO THE TIMESHEET DATA ENTRY FROGRAM IF YOU HAVE ANY QUERIES, PLEASE CONTACT RIV. SAFETY ...SAFETY ANY ONE INTERESTED IN LEARNING HOW TO USE THE FIRE EXTINGUISHERS WILL BE GIVEN TRAINING . IN THE INTEREST OF SAFETY IT IS A GOOD IDEA TO LEARN HOW TO FUT OUT A FIRE. FLEASE LET GRAHAM JONES OR RIV KNOW BY ELECTRONIC MAIL SO THAT WE CAN MAKE ARRANGEMENTS WITH THE FIRE DEPARTMENT.....THANKS RIV ***** TO THOSE PEOPLE WORKING ON TIAMULIN/CEPHRADINE PROJECTS PLEASE USE PROJECT CODE KXV-840 FOR TIMESHEET DATA. GMP AND SAFETY REQUIREMENTS DICTATE THAT LABORATORIES SHOULD BE CLEAN AND TIDY A MESSAGE IS PENDING FOR IJAC () is an example of a message that is sent to every . PDPII user. This message prints out an logui. @ The computer then goes on to print that there is a message penduig for IJAC (namecode) By typing RECEIVE a REC, ITAC can receive the message.

## APPENDIX 7.7

Contents

- * Notes For Lecturers
- * Text For Students
- * Information Sheets .

Science and Numbers

Raw Materials

Flow Diagram of Margarine Production

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Some Facts About the Works

Floating Fertiliser Plant



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Taxt For Students

#### Science and Numbers

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Study the information sheet headed 'Science and Numbers'. This presents information on three products, each of which uses basic mathematics in some form. Here are some exercises based on the three products.

- Name the main raw material which is used to make cottage cheese and one other ingredient not stated in the list which occurs naturallyand causes us to complain when we have too little and when we have too much.
- Is 110g exactly equal to 4oz ? If not suggest a statement to give a clear indication of any approximation involved.
- 3. List the protein, fat and carbohydrate weights in cottage cheese as percentages of the contents. What is the significance of the statement on calories ?
- 4. Chemistry and biology come into the manufacturing processes of all. these products : give some illustrations of this statement.
  - 5. A person's diet sheet states that 2oz of figh is one portion for a meal. What instruction would you give to the person who wanted to eat this portion as sardines if (as the picture shows) there are four identical fish to a tin ? Assume that there is no scale available. If possible state the accuracy of the method you recommend to obtain the portion.
- Examine various tins of sardines to see how clearly the type of oil is specified. Pay particular attention to the description 'edible'.
- 7. Find some references to biology in the Sensodyne toothpaste information Apart from supporting 'good health' what other effect does using the toothpaste have ?
- 8. In the name STRONTIUM CHLORIDE HEXAHYDRATE pick out two chemical elements. Give the name of a geometrical shape which begins with HEX and state the meaning of this part of a word. What does a word beginning with HYDR usually relate to ? Hydrant is one example.
- Find two references to percentage in the Sensodyne information. A ratio or proportion is also given : restate this as a percentage.
- 10. The Sensodyna output of the unit shown is 50 000 tubes per week for each of five weeks. Calculate the total volume of the bulk ingredients in litres for this period.

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Read through the four information sheets on margarine. The manufacturing process starts with raw materials of which six sources are shown. You may be aware of the 'butter versus margarine' debate and to support the respective cases information is often published in advertisements. The discussions centre on using one or other of the products on health grounds. Can you sift out the evidence and perhaps draw your own conclusions ?

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Here are some questions and tasks :

- The written information on each of the raw materials contains at least one reference to a percentage. Extract this information in each case and write a brief explanation for each value.
- Write a summary of the uses of the constituents of the raw materials such as, for example, palm oil being used in soap manufacture.
- 3. List as many brands and as many types of margarines as you can discove It is useful to work in small teams and pool your findings. How can you obtain a quick estimate of the relative popularities of the common brands by looking at the shelves in shops ?
- 4. List the additives put into the oil and state which are simple chemicals. Is anything taken out unchanged ?
- 5. Name the gas used for hardening the oil. This gas is one of two chemical constituents of a very common substance which nature provides and which makes us complain if we have too much and also if we have too little ! All living things would die without this and a large national industry regulates the supply and tests it for purity. How much does each person use on average per day ?
- 6. The quantities of the vitamins A and D added to table margarine produced in Great Britain have been laid down by law. It must contain between 27 and 33 international units (i.u.) per gram of vitamin A and 2.8 to 3.5 i.u. per gram of vitamin D.

1 i.u. of vitamin A = 0.0006 mg

1 i.u. of vitamin D = 0.000025 mg

Calculate the quantities of each vitamin per packet of household margarine and also the total quantities required in the factory for an output of 36000 packets.

1 mg = 0.001 g

7. Flan and carry out a survey of the relative use of margarine and tutter. You can only sample a small section of the population and will have to take a cross-section of the population for iges and occupations. This will bring you into contact with STATISTICS. Discuss this with your lecturer.

••• 3.1 ų, structur. Jumbar いうたい Most jobs relate to some branch of science either directly or indirectly but in the broader context of the communicy science affects most people in their daily lives. An office job requires knowledge in the field of computer science, a bricklayer uses a variety of dements and building dood products is confronted with them the perfor who buy food products is contronted with the module performance food products is contronted with the sciences in the contents of packaged foods. Numeracy relates to all the sciences in the mix, for the gardener to treat the soil correctly and for the bake the mater appropriate gardener to the soil correctly and for the bake the measured period of time at a measured and controlled temperature. Thus interrelate branches of science and numeracy. Studying mathematics or a branch of science can be made more interesting if the subjects appear to occur insturally. Through the study of a the mutural is immediately relevan of the gases found with mineral oil and the natural gas which we burn in homes as a fuel and extended the natural gas which we burn of the organic molecules in terrested i an example is the mathematical of the organic molecules in the relationship petween the number of the organic molecules in the relationship petween the number of the organic molecules in the relationship petweentical structur-of the organic molecules in the relation atoms. Thus simple algebra L. nł. <u>p</u> 即前用 > <u>></u>-時 計長 実現 11 £ -1 11 0 L M N Q. ·r t 見し Ψ L,  $\frac{v}{0}$ ភ្ ·• 1 1995 a is the broad topic area chosen as a basis for the study of schuleracy. After a general introduction through some common for ducts the module will concentrate on some superine synertic of margarine ate to mutrition as well as the manufacturing promases. Fre draation sheets can be given to individual schudents of a synero or a superior of the found to a superior of a synero interaction sheets can be given to individual schudents of a synero or a superior of the source for class use. The fourthar versus margarine of association as well as that the contained for class use. The fourthar versus margarine of the order versus margarine. The order of the containe of the shear of the containe of the shear of the containe and the source of the second of the containe of the second of the fourthan of the containe of the second of the second of the containe of the second of the containe of the second o taking 1 1 0 ..... ы С Ур • U .. 41 Ū o the text pra≬oriba .... and numer arithmetic 113 Cations . 124401 CI. **4**5no ព្រ ផ្ 2 science parcentage in appl **らくきちくはきく** Ψ· 0 ig thro cises щ the four rules C ہے. in working 3 the exerc ormation the interrelationships between Ľ ល ប្រ ប្រ ប្រ ų. C such that i completing -++ U an ability to apply understanding of 0100001t Գ 0 an appreciation jectives -----products the module w relate to mutrition a information sheets ca provided for class us information through th information through th .. ម ព and ゆいたいゆうた かつひ Vrampol. demonstrate ni i ob jectives di scussions Some Study Ob С 0 C 1i Introducti 1000 1000 L n This is 41 12 ÷j. ងៗ τ ÷ 64 0170M ênd B The 単日 บ 12 พั C -e-t

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## Some Definitions

It is not always possible to write perfect or even meaningful definitions without some examples to illustrate them, but quite often ideas are built up through common use and exposure by the media. An example is 'nuclear energy' which most lay people accept with some understanding without having any knowledge of nuclear physics. The following definitions are suggested for discussions with the students and can be given dut or modifieat the discretion of the lecturer.

#### Science

The ordered arrangement of discovered knowledge, including the methods by which the knowledge can be increased and cetails of how the truth of the knowledge can be tested.

#### Mathematics

One definition is the study obtained by bringing together sets of assumed rules (axioms) in alogical way. There is no completely satisfactory definition. Numeracy is a much newer version of mathematics, of course.

# Chemistry

The study of the composition of substances and of the changes in composition which they undergo either naturally or artificially in the laboratory. Chemists divide all chemicals into two classes : organic or inorganic. Organic is the term applied to substances consisting of molecules that are formed from carbon, mainly with oxygen and hydrogen. All other chemicals are inorganic such as silicon (the 'chip') and the many common metals. Organic molecules are the main constituents of living and dead (mineral oil ?) animal and vegetable matter.

# Physics

The study of electrical, luminescent, mechanical, magnetic, radioactive and thermal phenomena such that there are changes in energy but no chemical changes are involved.

# Siclegy

The study of living systems such as plants or animals or bacteria and the way in which the systems interact with the environment.

## Bistschrology

Examples of this occur in the making of alcohol, cheese and vinegar where molecular changes are brought about by the use certain substances called enzymes : an extension of this technique is 'cenetic engineering'.

# Technology

Fut simply technology is the means whereby science becomes practical. Many examples of new technologies being used are found in the bil industry where for example the new methods of using long runs of large pipes had to be developed. The motical field is also right in new technologies e.g. the (mail scanners. The replacement of metals by plastics in dany applications calls for new technologies.

# Using This Module

The food industry has many facets from transport (including shipping) to chemistry and so almost any objective for the study could be singled out. However, as has been stated numeracy is a major component within any study unit involving science. There is another possible objective in the form of using a computer system for the provision of information under the control of the operator, by storing the text for the student using READ and DATA. This gives practice in kayboard skills and enables the lecturer to make rapid changes to the information, perhaps to suit students with different abilities. More questions, data etc. can be added to raise the level from introductory so as to accommodate more able students. Perhaps a useful application within industry would be in an 'induction' capacity for new employees or employees who are required to change their working situations. Contributions to the module by many members of staff would ensure the best possible material being produced.

# Acknowledgements

The author would like to thank Mr. D. L. Harding, Training Supervisor, who organised and provided the information requested with the help of members of the staff of Van Den Berghs & Jurgens Limited. The very comprehensive personal tour of the works conducted by Mr. Harding was most valuable in providing a bridge between industry and education.



Why do teeth become sensitive?

Why do teeth become sensitive? Ine normal nealiny tooth has a hard outer layer called enamel which protects the sensitive winner layers of the footh from being hurt by heat, cold shoot flavours and touch. This enamelitayer covers the part of the tool which is normality erobsed - the crown. The rest of the footh (the rooth is covered by the gum. Ih gap, however small, appears between the crown and the gum. Ih at this single, gap, cold, taske fouch) can reach the sensitive twing tissues of the tooth. This often results from faulty toothorushing, gum recession, gum disease, etc.

Active ingredient; strontium chloride hexanydrate 10% in a pressantly fravoured cleansing dentifice base.

What happens next?

VVRBL RADDERS N8X17 Because it is painful to brush sensitive techt property this may be neglected and the resultant lack of good or al hygiere can lead to serious tooln and gum disease, with eventualicss offseth. Forunatery the remedy is index. Regular brushney with Sensodyne locinoaste, using a scill testure of locithorush such as the Sensodyne Gentie, can tree you from the bain of locithorush such as the Sensodyne and bacteria can be removed. Techt and gums can thus be restored to normal good health.

Directions: To be used daily in place of ordinary toolhoeste. Statford-Miller Ltd., Halleki, Herts, England.



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Own 30% of demistry region in OOTh Daste does Swe 30% of demistry region of Sensorian Econociase, and scientific studies have shown that regular daily use of Sensoryne helps 9 out of 10 optimits

Substantiated and the second and a special angle over (called storts un choose for socials the service call of the toct, which has occome exposed, to prevening partial stream reacting the nervel back in the toom. The effect or Sensoryne is prograssive, which a tew calls incur wind that correct brushing is much more comprovide and that host, coid and acid toods and onwe are holonger.

for sensitive teeth

paintus. From them on, rousing dairy use of Sensodyne will get - and keep - your technicary crean and tries from blaque, because Sensodyne has ename-poissing properties superior to most prohesy. toothcastes.

How the Sensodyne Gentle Toothbrush helps The sempore Ganes is becausy designed to sensitive feelth Univer and toolnorughes which can damage ouns it has the review haments with sale rounged to sto ge in os sine criwics and clear area described and decri without hairming teeth or gums.



# FLOW DIAGRAM OF MARGARINE PRODUCTION



Designed and Printed by Van den Berghs & Jurgens Ltd., Britain's Principal Producer of Margarine, Cooking Fats and Oils.

### SOME FACTS ABOUT THE WORKS

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The Bromborough factory is the biggest of the Company's four production units: the others are factories at Purfleet in Essex and Needham Market in Suffolk and an edible oil refinery at Silvertown in London. It is indeed one of the large: margarine works in the World.

#### History of the Company

The Company's name reflects a story unique in the history of the margarine industry, for it was two butter merchant families - the Jurgens and the Van den Berghs - who in 1871 in Holland took up the invention of a French scientist (whi invented margarine in 1869) and became the first to make and market the product on a commercial scale, so founding the margarine industry; they remained compet leaders of the industry for more than fifty years, but eventually joined forces 1927.

The first factory on the Bromborough site, however, was built by Sir William Le for his Planters Margarine Company and it commenced production in November 1918 This replaced the margarine factory at Godley, Cheshire, which Lever had acquir in 1914 but which was not really suitable for the expansion which scon became necessary. Since Lever owned a great stretch of land along the River Mersey at Bromborough adjacent to his oil refinery and hydrogenation plant and having goo road and rail links to all parts of the country, it was logical for him to choc part of this as the site for his new factory, which now occupies some 40 acres.

Planters' outstanding achievement was the production, in 1927, of the world's first vitaminised margarine, VIKING BRAND: this was a breakthrough of the utmos importance to the entire industry and established margarine as a food in its ow right.

In 1929 the Margazine Union, which was mainly comprised of the Jurgens and Van den Berghs and their associated companies, joined with Lever Brothers to form the Unilever combine. One result was that the margarine factory at Bromborough, after being reconstructed and modernised, was taken over in February 1932 by Van den Barghs & Jurgens, a British company with headquarters in London.

Ouring the period of Government control of the industry in the UK (a wartime measure which lasted until 1954) the factory produced about one third of the country's entire margarine ration.

### Oil Refinerv

The oil refinery was extensively modernised in 1956 and is one of the largest edible oil refineries in the World.

Crude edible oils, which are our basic raw materials, are shipped from all parts of the world to the Sromborough Dock installation one and a half miles down river from the factory, and are transported by road tanker and pipeline to the Refinery as required.

Bromborough Dock, opened in 1931, is operated by the Unilever service company UML Ltd., and has an oil storage capacity of approximately 150,000 tonnes.

### Modernisation

In the 1960s the Works was again completely reconstructed at a cost of nearly 16 millions. Further improvements in the edible oil refinery and margarine processing areas of the factory have been carried out, and the product warehouse and packaging materials storage facilities have been improved and enlarged since 1970.

#### <u>Employees</u>

The Works employs a total of 1200 people, just under 900 of whom work on shifts. Since it stands almost on the river bank, most employees live within an area stretching from Sirkenhead to Ellesmere Port, many of course living in Bromborough bay and the ajoining parts of the Sorough of Wirral.

#### Products

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The Bromborough Works produces the following well known brands of margarine and cooking fats :- FLORA, STORK SB, SOFT BLUE BAND, SOFT SUMMER COUNTY, STORK, KRONA, ECHO margarines, OUTLINE low fat spread, SPRY, COOKEEN, WHITE CAP, and WHITE FLORA cooking fats as well as specialised products for the baking, catering and confectionery trades and the food manufacturing industry, for UK and export markets

#### Marksting

Marketing operations (selling, advertising, etc) are carried out by specialist divisions of the Company operating from Head Office, at Burgess Hill in Sussex: VAN den BERGHS DIVISION, which sells to the domestic consumer, mainly via the retail trada:

CRAIGMILLAR DIVISION. which markets ranges of margarines, shortenings, oils and other catering products to hospitals, schools, the forces, caterers and bakers: LODERS AND NUCOLINE, which sells a complete range of adible oils and fats to the IQ .... food manufacturing industry in home and export markets.

## Measurement Involving Metrication, Estimation and Calculation

## Introduction

This work has been produced by a Staff Development Group of basic mathematics education practitioners in Merseyside, funded by the national body, ALBSU (Adult Literacy and Basic Skills Unit) based in London:

## General Aim_

To investigate the application of measurement in the following aspects:

- 1. Length
- 2. Weight
- 3. Volume/capacity
- 4. Area

## Specific Objectives

- 1. To recognise that measurement is a fundamental task of everyday life.
- 2. To appreciate that the formulation and solution of problems requires the use of communication and understanding.
- To select and apply to problems the skills of estimation and calculation, where appropriate.
- 4. To incorporate the use of simple mathematical aids where applicable.
- 5. To produce, test and evaluate interesting materials as pilot studies.
- 6. To enable other practitioners to develop, test and evaluate similar materials along suggested guidelines.

## Guidelines

- <u>Getting the Sense</u> Understanding the aspect of measurement to be considered through practical experience.
- 2. <u>Vocabulary</u> Considering the terms that are used in the specific context.
- Metric Units
   Listing the metric units and their abbreviations used, and selecting the relevant one for each task.
- 4. <u>Tools of Measurement</u> An awareness of the tools available and how to use them.
- <u>Estimation</u> Using a variety of skills to pre-judge, compare and approximate.
- 6. <u>Mathematical Skills Needed</u> Looking at the particular skills needed for each aspect.
- <u>Imperial Units</u>
   Looking at the imperial units used and their abbreviations. Gaining a sense of equivalence of metric and imperial units and the use of conversion graphs or calculators to convert if necessary.
- 8. Everyday Use and Application Relating to normal everyday situations.

## APPENDIX 7.9

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Case Studies: Adult Basic Education In Other Topic Areas

## DEVELOPING A.B.E. THROUGH OTHER TOPIC AREAS

## Basic Education as a Foundation for Technical Learning

## 1a) History/Development

In Stockport College, in common with other colleges, there had been concern for some time over the problems students, especially Day Release Craft Students, faced on coping with their courses. Although it was rarely an explicit reason, it was suspected that literacy problems were causing students to drop out or fail their courses, despite adequate practical ability or technical knowledge.

Funding from the European Social Fund during 1983-85 provided the scope for research into the problem and subsequent developmental work.

Many students in F.E. spend the major part of their day writing. In most cases this time is not used constructively to develop literacy skills - reading, writing, spelling - but on the contrary often reinforces any difficulties in these areas and correspondingly obstructs the learning of other topics.

The integration of the aims of developing basic education whilst teaching other subjects, technical or academic, can enhance the learning process. Whilst giving relevance and some important to the learning of literacy skills, that in turn can increase the effectiveness and develop the deeper understanding of the technical content.

The integration can be achieved by the combination of techniques widely used to develop basic education skills whilst focusing on the content of any other subject area.

The process of actually writing down notes dictated or copied from the blackboard is seldom an opportunity for learning. The learning takes place either in subsequent reading of the notes or reinforced verbally by the lecturer in class.

Many lecturers believe that the natural reluctance of students to acknowledge a literacy problem or seek positive help to overcome one, is a sign either that the problem does not exist or that the student does not want or need to overcome it

#### Student Orientated/Negotiated Model

#### la. History/Development

This. account traces the development of a basic education group. It had started as a Drop-In, meeting every morning of the week. Students came through the usual referral services and had very little in common. However as a group, through working together it will be seen that over a period of two years they developed the self confidence in order to determine the ways in which they wished their literacy work to develop.

The group was very mixed ranging from one or two 16 yr. olds on (then) Y.O.P. courses, through young married mothers and unemployed fathers, to a number of middle aged people. Three or four were West Indian, one was Jewish (not orthodox) all were local people. The Group Register records that there were in all fifteen people in the group, but in fact there were usually eight or ten in attendance depending on the day. However as the group developed for some projects there were days when all fifteen came and brought their friends as well.

1b. Aims of the Model

Like any other ABE group it aimed to help group members to become independent as readers and writers and as people.

1c. Context

A nice quiet warm room where you could make coffee, put your feet up, stick things on the wall, have a discussion etc. It had easy chairs as well as tables and chairs.

1d. Nature of intervention of the ABE Worker

The ABE tutor was responsible for the group. The forms her interventions took varied, though a noticeable, characteristic feature was her persistent attempt to place greater levels of responsibility upon the group.

2. Case Study Details

It isn't possible to describe the detailed description of how the group progressed. In its place there are mentioned below some of the 'crucial points.' However it should be recognised that they took place against a background of movement made up of much smaller changes.

One of the things the group regularly did was to bring in the weekly local rag. They'd lock for jobs, people they knew, local events etc. On a particular morning there was a headline which read "Schools Caned". It was about the European Commission on Human Rights decision to ask Britain to ban the cane in its schools. Two or three of the group were indignant about the way in which their children had been treated, citing lurid cases. Cthers were equally adamant that teachers needed sanctions. The argument went on for some time. Eventually as the group worked its way through the article some of the group were so incensed that they decided to write to the paper. Everything else was swept aside and while half the group continued with its normal work five of the group drafted a letter. At the end of the session it was read aloud and those who wanted to signed it.

### A.B.E. and other subject areas : Social outings.

#### 1.(a). <u>History/Development</u>

The centre on which this case study is based is relatively small, friendly place wherein a pleasing rapport is evident between the various A.B.E courses, including an E.S.L. class. There are usually two different classes going on in a large hall divided by a curtain, and the students have become familiar to each other and enjoy mixing in the coffee bar.

A mini-bus is at the centre's disposal and we have taken advantage of this with various trips, initially during class hours, to museums, libraries, market towns ...etc. These were enjoyed by the students, but still had the suspicion of an academic purpose, like the dreaded school trips forced down the throats of bored youths.

A trip to the theatre seemed a good way of breaking this mould as it could more easily be accepted as a social 'treat' (several students were excited by the prospect) while still providing a potential stimulus. Visits to the Library Theatre's lunch-time programme had the economic advantage of costing only 50p a head, but tended to be 'bold', 'experimental' (i.e. obscure) and full of 'realistic' language, which caused some students to become uncomfortable.

Thus, we decided to promote the cause of theatre as a popular night out, and chose more accessible productions. People were encouragingly eager to pay more (though still half price) for shows which captured their interest and provided what was seen more as a social outing with no apparent connection with classwork.

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Adult Basic Education in Other Topic Areas Industry Linked Model Topic Area : Information Technology

1 (a) History

Some form of instruction in the field of information technology in educational courses is now almost mandatory because of the rapid development of the technological aspects of microelectronics (the use of many very small components packed into a small space) and the consequent availability of cheap microcomputers which are designed to be operated by non-technical staff. The BTEC system of technician and allied education is based on a programme of study composed of subject units at particular levels, which start at Level 1. There are units which deal with the use of the computer and these appear in programmes for :

- (a) science based industries;
- (b) engineering based industries;
- (c) building construction based industries; and
- (d) office based industries.

There is a lot of overlap between industries as for example with the Water Supply Industry which uses chemistry, biology, engineering and building. The industries included in (d) are for example concerned with community organisation and transport, which do not actually manufacture. In all of these can be identified the use of or the awareness of the need to use some form of computer. The model to be illustrated has been developed from teaching to a syllabus based on the use of the computer and which use involves the following components:

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a real and practical task for the computer; communication with written and spoken words; and some use of basic mathematics. MATHEMATICS INNET

Science and Mathematics Department,

Wirral Metropolitan College,

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Essex County Council

Southend College of Technology Carnarvan Road Southend on Sea Essex SS2 645 Telephone 353931

Our Reference APH/RT

Your Reference

10th February, 1986

Dear Mr. Turner,

Mr. S. Turner,

Borough Road, Birkenhead,

L42 90D

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#### INTERRELATED STUDIES IN FURTHER EDUCATION

I was most interested to read your article in the Autumn Bulletin of the Mathematical Association's Further Education Section. I am sure you are correct in questioning the wisdom of separately assessed BTEC Mathematics Units and, by all accounts, BTEC itself plans a major initiative on this in the very near future.

Meanwhile, the 'Modules of Study' on measurement, which you describe in your article interest me greatly. We at Southend, like most other FE Mathematics Lecturers, feel an increasing need for integrated learning/teaching packages while time to prepare such aids seems to diminish.

I would be interested to try these Modules; no doubt they would also stimulate some useful staff discussion on the theme of integrated studies. If you could supply me with copies or advise me as to where they might be obtained and at what cost, I would be most grateful.

Yours sincerely,

A. P. Harrison

A.P. HARRISON MATHEMATICS UNIT LEADER

> Principal P & Powell BSc MSc FRSA Unit Leader A P Harrison BSc MSc

## APPENDIX 7.11

MEASUREMENT and the OIL INDUSTRY

General Objective

After working through this module you should appreciate that industrial tasks and problems can bring together mathematics, science and technology in an interrelated way.

Specific Objectives

- To use arithmetic, algebra, geometry and trigonometry.
- (2) To decide where science and technology have to be considered.
- (3) To use simple physical laws in the solution of the problems.



# Wirral Metropolitan College

ST/YHK

APH/RT

24th February 1986

Mr. A.P. Harrison, Mathematics Unit Leader, Southend College of Technology, Carnarvon Road, Southend-on-Sea, Essex. SS2 6LS



Principal J.H. Jackson BSc, CEng, FlMechE, MBIM

Associate Principal F.D. Farguson, BSc, CChem, EEng, FRSC, FiChemE Borough Road, Birkenhead Wirral, Merseyside L42 90D Telephone: 051-653 5555

Dear Mr. Harrison,

I have enclosed three modules:

(1) Measurement and the Motor Car

(2) Measurement and the Oil Industry, and

(3) Measurement and the Pharmaceutical Industry

for you to appraise. There has been a lot of development work behind these and they have been altered on several occasions to accommodate new information. As regards use (1) has been used with YTS Motor Mechanic students, (2) with BTEC students persuing Building, Engineering and Science programmes, at the Ordinary and the Higher level and (3) with BTEC Science students.

I have sets of slides which correspond with the pictures in Modules (2) and (3) and will be pleased to let you have copies if you decide to go ahead with trials; I can also send you masters of the sheets so that you can make copies.

I am interested to know what you think of these modules and perhaps will learn something of how your students take to them as they have been well received in the north.

I look forward to meeting you and some of the college staff and provide some background if this will be helpful.

Yours sincerely,

S. Turner Head of Mathematics Department of Science & Mathematics.

# APPENDIX 7.13

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# Applied Science Course Team

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Title	Code	Main Discipline	Other Interests
Mrs '	SC	Mathematics,Computing	Water Engineering
Dr	AD	Chemistry	Polymers,Radioactivity
Mr	DM	Organic/Analytical Chemistry	Electronics
Dr	JO	Medicinal Chemistry	Mathematics,Computing
Mr	GJ	Chemistry	Safety & Lab. Practice
nr	NR	Biology	Environmental Biology
Dr	RS	Fhysics	Mathematics
nr	LS	Mechanical Engineering	Industrial Liaison
nrs	SMT	Biology	Biotechnology
nr	ST	Mathematics	Information Technology
<b>f</b> ir	SCT	Chemical Engineering	Energy

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## TIMETABLE FOR SCI-TECH COURSE

Μ	BIOTECHNOLOGY 9.00 am 12.00 Noon (SMT)		
Tu	INTEGRATED STUDIESCOMPUTER STUDIES9 - 11.00 am.(SC)11 - 12(ST)		
W	PHYSICS 9.00 am 12.00 Noon (RS)		
Th	CHEMISTRY 9.00 am 12.00 Noon (DM/AD)		
F	INDUSTRIAL VISITS 9.00 am 12.00 Noon (EH)		



## COURSE LECTURERS:

NAME	TITLE
CROWDER, Susan	Mrs.
DOWDING, Anthony	Dr.
HARRISON, Edward	Mr.
MARROW, David	Mr.
JELLY. Grenville	Mr.
SMITH, Raymond	Dr.
THURMAN, Shirley	Mrs.
TURNER Stapley	Mr
TURNER, Stewart	Mr.

REF

SC

AD

EH

DМ

GJ

RS

ST

SCT

SMT

### MAIN DISCIPLINES

Mathematics, Computing Chemistry Mathematics, Computing Organic/Analytic. Chemistry Chemistry Physics Biology Mathematics, Computing Chemical Engineering

## OTHER INTERESTS

Water Engineering Polymers, Radioactivity Engineering Electronics Safety & Lab. Practice Mathematics Biotechnology Education Energy

APPENDIX

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## APPENDIX 7.15

# STUDY MODULE

# WATER



THE WATER CYCLE



## CONTENTS

Lecturer's Notes

Using the Module

Student's Text

Appendices

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- A Mathematical Objectives
- B: The Water Cycle
- C Catchment Area Maps
- D Hydraulic Diagram
- E Information Sources

## Lecturer's Notes

## Introduction

Employment in the water supply and treatment can take many forms and it is not always realised that here we have a large and important industry which is itself a vital part of other industries. This module shows how some quite complex mathematics has to be utilised even though it commences in a simple way and takes the concept of 'rainfall' which everyone must use many times over. Some mathematical objectives are given in Appendix A.

## Using the Module

At school levels it is suitable for fourth year and upwards potential OSE grade 3 pupils or better. In further education where the FREC Use of Computers unit at Level 2 has to be studied the computer espects could be usefully explored. Some careful attention will no coubt have to be paid to the conversions between units and it is not likely that few students will be familiar with the heaters. There will thus be different emphases for different groups of students but the fourie is important and it should be realised that without water many inductries would have to shut down.
# Student's Text

#### Introduction

Our water supply is taken for granted until it fails due to there being insufficient rain and general interest then usually extends as far as hearing reports on the state of our local reservoir and waiting for a favourable weather report. This study will show something of the organisation and technology behind the water supply but primarily how it relates to mathematics.

#### The Water Cycle

View the WATER CYCLE diagram from the overhead projector and make your own copy of this. Note some of the scientific terms used such as radiation, flow, evaporation and transpiration. Use a library to find out what these terms mean. Here is a brief explanation of the diagram:

> Water evaporates from the surfaces of the sea, lakes, rivers, streams and even puddles. This water forms clouds which are blown by the wind across land masses. The clouds form rain or snow. This rain or snow falls on to the ground (a small percentage evaporates as it falls) and what is not absorbed by the ground flows away into streams. The water which is absorbed partly feeds vegetation and partly penetrates deep into the ground to form underground wells and channels.

#### -491-

The vegetation transpires and so water rises upwards again. The underground channel waters flow towards the sea. The water which has formed streams feeds the rivers through these streams and the rivers then flow into the

sea; and so the cycle starts all over again. What becomes of this cycle in desert country ?

## Rainfall Intensity

We use the term 'rainfall' and measure it in inches or millimetres if the metric system is used. The term in itself is useful for most everyday purposes because it refers to the rainfall gauge which is a collector of rain and has a standard size. So rainfall can be compared between areas, countries or times of the year by referring to records. However we need the quantitative definitio which brings in mathematics because we shall eventually want to calculate the size of a pipe which will carry away the surplus water during a storm; otherwise, there will be flooding.

> Abbreviation for Rainfall Intensity is RI RI = volume of rain falling on unit area of land The rain gauge measures the depth of this volume So the linear measure of rainfall is really one of volum However, TIME must come into this definition and so the RI becomes a RATE i.e. a volume of water per day or per hour or per second etc. One must be careful to specify the time.

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#### Exercises

- 1 Show that one inch of rain falling on an area of one acre is equivalent to one hundred tons.
- 2 Convert a rainfall of one inch to millimetres.
- 3 The total rainfall for a 24 hour period at the Manchester Meteorological Weather station was given as 5.9mm for a 24 hour period. Assuming that this rainfall value is maintained for 18 days, calculate the total rainfall in metres for this period. 4 In which country is the rainfall greatest ?

# Using Rainfall Intensity

The aim of the rest of this study is to ultimately work out the size of pipe required to remove the surplus rainfall on a given area of land during a storm. The complex engineering mathematics will be avoided by using prepared graphs or a computer program as an alternative method which should give the same result.

## Storm Data

Time	interval(hours)	Time interval(minutes)	RI
	0.08		7.1
	0.25		9.8
	0.33		13.4
	0.42		25.4 59.7
	0.58		59.7
	0.67		25.4
	0.83		_a_8
	0.92 1.00		8.0 7.1

RI is in ma per hour

1 Copy this table

<u>.</u>...

2 The first column gives the time at which the RI is measured 3 The total duration of the storm is one hour, measured from time 0 4 Convert each interval to minutes and put this time to the nearest minute in the middle column (how do you change to minutes?)

- 5 The water engineer assumes that the RI at the end of each interval is the value over the whole interval
- 7 Use this table to draw a HYTEOGRAPH, by plotting time on the horizontal axis and RI on the vertical axis. This will be a 'stepped' graph, rather like a histogram, but it is not. Most of the graphs drawn at school are of the 'x-axis, y-axis' type but quite often an industry has its particular methods for the representation of data
- 8 Having drawn the graph observe that the RI varies considerably over the hour so one value which would represent al the values is required. Such a value is called an AVERAGE and one average which is easy to calculate and useful is called the ARITHMETIC LEAN or simply the MEAN VALUE

10 There are 12 values of RI so now calculate the mean value and make a note of it underneath your table Note that each value corresponds to one period

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When you have completed the calculation check it on the computer

# Calculation of Catchment Area

So far we have seen where the water comes from and how we measure and represent the rate at which it is delivered to the land surface. In practice we need to intervene to prevent flooding and this means providing adequate drainage for excess storm water as otherwise there would be damage to agricultural land and populated areas. To carry away the excess storm water an OUTFALL PIPE is provided. The size of this pipe depends on two natural factors:

(1) The area draining to the pipe - the CATCHMENT AREA; and (2) The average amount of rainfall i.e. RAINFALL INTENSITY

# Calculation of Catchment Area

The engineer uses the HECTARE for area as the square metre is too small as a unit of land area. How many square metres in one hectare?

You have three maps, each with a marked catchment area, the boundary lines having arrows pointing inwards. Each small square represents 625 sq.m. In working out how many small squares there are within each catchment area you will find that you will have to divide the area into rectangles, triangles and somehow estimate what is left.

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The following geometrical fact may be useful to you



Area of the triangle = 1/2 area of the rectangle

## Rate of Flow in the Pipe

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This is the volume of water in cu.m flowing each second out of the pipe.

Let A catchment area in hectares

" I rainfall intensity in mm/hour

" c a number without units, the COEFFICIENT OF RUN-OF

" Q the rate of flow in cu.m/sec

Then 
$$Q = \frac{A \times I \times c}{360}$$

The coefficient c takes care of the fact that not all the rain falling on the land runs off : some evaporates and some is absorbed into the ground. So c will have a value less than one. If 50% of the rain which falls is carried away by the outfall pipe then c will have the value of 0.5. If 40% of the rain evaporates or is absorbed then what is the value of c?

# Your Results

Assume the value of c to be 0.5 in each case and complete the following table for each of the three maps:

A (hectares)	Imm/h	С	Gm ³ /s
		· · · · · · · · · · · · · · · · · · ·	
· ·			

Copy this table

# The Size of the Outfall Pipe

This has to carry away the water at the rate at which it drains into the pipe, which is Q. The velocity at which the water will flow and the 'steepness' or GRADIENT of the pipe will also be interrelated to Q. We can choose two out of the following three variables :

GRADIENT of the pipe

VELOCITY of the water in metres per sec.

RATE OF FLOW in cubic m. per sec

and the third variable will automatically be fixed because the three are closely interrelated. So the first decision is for the selection of of known data. Before this, however, it is necessary to be quite clear about the difference between velocity of the water and the rate of flow of the water. The velocity is the speed along the pipe of each molecule of water and any matter with it and is measured as 'distance per unit time'. The rate of flow = volume of water moved per unit time

= volume of 'section' of water moved per unit time

- = area of cross-section x length moved per unit time
- = area of cross-section x velocity (volume per unit time)

The rate of flow is determined by the rainfall intensity and the catchment area as we have seen and for this to be adequate in the pipe, the pipe must have a large enough diameter and the gradient will determine the velocity. So given the rate of flow and the gradient we should be able to work out the required pipe diameter based on an average rainfall. The results of applying mathematics with some practical experience of rainfall to the problem have been put together in a set of graphs which can be entered with any two of the variables in order that the third or or unknown one can be read off. This set of graphs is called a HYDRAULIC DIAGRAM and solutions to problems requiring a few equations are often presented by similar NOMOGRAMS in order to by-pass complex mathematics, providing the accuracy which can be achieved is satisfactory. The computer, which is an eager and faithful 'mathematics' workhorse can also be used to produce the results by solving equations at great speed and you will be given the opportunity to use the program FIPE.ASS to do this and so check the use of the hydraulic diagram.

Exercises on Flow in Pipes



Before you go ahead with the estimation of pipe size (diameter) you must make sure that you understand the difference between rate of flow and velocity and are able to connect these. So here are some examples.

1 In the cylindrical pipe shown water is flowing at a velocity of

5 cm/sec. What is this velocity expressed in m/sec ? The pipe is circular

. •

in cross-section and has a diameter of 550 mm. Calculate the rate of flow of water through the pipe.

> 5cm/s

Area of a circle = pi x (diameter squared )/4 Take pi = 3.142 Area of cross-section = 3.142 x 0.550 x 0.550 /4 = 0.23761375 sq.m In one second volume of water flowing through the pipe = area of cross-section x velocity in m/sec = volume rate of flow in cu.m/sec = 0.23761375 x 0.05 = 0.012 cu.m/sec to 3 decimal places 2 A pipe has a rectangular cross-section as shown. Water is flowing with a velocity of 25 cm/sec. Calculate the rate of flow of water in the pipe.



The pipe shown is trapezoidal in cross-section (can vou give an example of such a pipe - it could be open). The height of the pipe is 250 mm which is the shortest distance between the parallel sides. The velocity of the water in the pipe is 1 m/sec. Calculate the rate of flow of in the pipe.

Area of a trapezium =  $1/2 \times (\text{sum of lengths of parallel sides}) \times \text{height}$ 



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#### Using the Hydraulic Diagram

Refer to you copy of this. Select a gradient say 1 in 100 and find the point marked 100 on the gradient axis

Change your rate of flow into cu.m/min by multiplying by 60 Enter this value on the vertical axis and read across until

You will now be between or just on one of the lines marked in mm These are the pipe diameter lines and if you are between two which diameter will you select?

Now find the pipe diameter for eac of the three catchment areas and record the results in a nest table with an explanation of how you entered the hydraulic diagram.

#### The Computer Program

Here is an example of the data you enter and the output on the screen:

# PROGRAM TO ESTIMATE PIPE SIZE WHAT IS CATCHMENT AREA IN HECTARES ? 2.75 WHAT IS RAINFALL INTENSITY ? 20.7 WHAT IS THE REQUIRED GRADIENT OF THE PIPE, 1 IN ? 300 FLOW IN PIPE = 1.078125 CUBIC METRES PER SECOND

FIFE DIAMETER = 375 MM GRADIENT =1 IN 300

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# Appendix A

#### authematical Objectives

The objectives are such that in working through the text and completing the exercises together with additional ones required to emphasise important points, the user would demonstrate an understanding of and an ability to apply:

1 The four rules of arithmetic

- 2 Calculation of areas of rectilinear shapes
- 3 Conversions between units
- 4 The concepts of rate of flow and velocity, along a pipe
- 5 Substitutions into a given formule, with due regard to units

6 Graphical ideas

7 The concept of an average value



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#### REGIONAL WATER AUTHORITIES IN ENGLAND & WALES

Anglian Water Authority Ambury Road Huntingdon PE18 6NZ (tel: Huntingdon 56181)

Northumbrian Water Authority Northumbria House Regent Centre Gosforth Newcastle upon Tyne NE3 3PX (tel: Gosforth 843151)

North West Water Authority Dawson House Great Sankey Warrington WA5 3LW (tel: Penketh 4321)

Severn Trent Water Authority Abelson House 2297 Coventry Road Sheldon Birmingham B26 3PU (tel: 021 743 4222)

South West Water Authority 3 - 5 Barnfield Road Exeter EX1 1RE (tel: Exeter 50861)

Southern Water Authority Guildbourne House Worthing Sussex BN11 1LD (tel: Worthing 205252)

Thames Water Authority New River Head Rosebery Avenue London EC1R 4TP (tel: 01 837 3300)

Welsh Water Authority Cambrian Way Brecon Powys LD3 7HP (tel: Brecon 3181) Wessex Water Authority Wessex House Passage Street Bristol BS2 OJQ (tel: Bristol 290611)

Yorkshire Water Authority West Riding House 67 Albion Street Leeds LS1 5AA (tel: Leeds 448201)

#### APPENDIX 7.16

#### THE TECHNICAL AND VOCATIONAL EDUCATION INITIATIVE (TVEI)

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#### JOINT SCHEME : SPECIAL MEETING

#### BRIEF REPORT ON ONE STAGE OF THE COLLEGE CONTRIBUTION

#### BACKGROUND

(a) <u>General</u>

The Wirral Metropolitan College, Science and Mathematics Department, runs a joint teaching scheme with several local schools. Course components allocated to the College (by decisions arising from joint discussions) have been selected so as to utilise to the full the expertise and experience of the staff and the specialised equipment: in particular, relationships of the theoretical course material to industrial practices is considered to be of prime importance.

## (b) Details of College Schemes

There are two schemes:

#### 1. Weatherhead High School

The subjects are Biology and Chemistry at BTEC Level 1. The assessment is internal with appropriate external moderation. Allocation of time: blocks of 16 weeks, 1 subject per week,  $2\frac{1}{2}$  hours per subject.

2. The Henry Meoles School

The City and Guilds 687 Science Industries Foundation Course is followed, which has an external examination. Ability level of students: about CSE Grade 3 or 4.

There are five subjects: Chemistry, biology, mathematics, physics, biology and applied science. Allocation of time: 5 blocks of approximately 6 weeks, 1 subject per week,  $2\frac{1}{2}$  hours per subject.

#### The City and Guilds 687 Course

The suitability of the students for the course or the course for the students had arisen on several occasions as a result of the unsatisfactory behaviour of the students. This special meeting is the result of these doubts.

Comments and remarks of some staff involved are now recorded, the relevance of which will be highlighted later.

NAIÆ	FUNCTION	REFERENCE
Dr. Bill Atkinson	Co-ordinator of Scheme at The Henry Meoles School.	BA
Dr. Mike Cowd	Co-ordinator of Scheme at Wirral Metropolitan College.	MC
Mr. Nigel Walls	Course Lecturer for Chemistry, Wirral Metropolitan College.	IW

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NAME	FUNCTION	REFERENCE
Mr. Stan Turner	Organiser of the Mathematics' block teaching.	ST
Mrs. S. Crowder	The Mathematics Lecturer.	SC
PERSON	COMMENTS	
NW	Some firm remarks about lack of discip disinterest, particularly in Science.	line and
MC	Personal doubts about their suitability courses.	y for science
BA	The students, however had opted for sc had personally chosen the 687 course. MC now, that perhaps the subject was no choice.	ience and he I agree with ot the best
MC	I think you would like to say somethin,	g, Stan.
ST	I had given the matter some thought and to replicate formal mathematics within Something mathematically useful yet in different and special (otherwise why co must be offered. We have been develop: study at Loughborough under Professor 1 mathematics, science and technology are a relevant way, the teaching being base theme. Among the industries suggested for providing suitable employment were	d did not want the College. teresting, ome to the College?) ing modules of Bajpai in which e interrelated in ed on some central in the 687 Scheme :
	Water Treatment and Sewerage.	
	Knowing that SC had access to the pract these industries and was keen to use to was offered the teaching block (5 perio develop a module of study. A room equ Computers, class desks, white board and was provided. SC was the main develop in a team of three (SC, ST and a pract water engineer who could provide auther	tical aspects of eaching aids, she ods) and asked to ipped with Tandy d overhead projector er of the module ising independent ntic data).
ВА	The pupils were dreading the idea of " more of the stuff"; but their experience minds and they liked using the compute having their photographs taken for pub	mathematics' - "yet ces changed their rs and in particular licity purposes!
ST	Here are their work folders after only module is 'WATER').	2 periods (the
ВА	They have done a lot of good work and	this surprises me.
ST	Well, the ideas behind the module were in such a situation where there is dis to a subject. Also, the organisation teaching periods for each subject is no convey the idea of a unified objective	developed to help like or indifference into separate of the best way to for a syllabus.
		/

At this point SC came in from a teaching period and joined the discussion and was congratulated by BA.

SC Are they really interested in Science?

BA Just what we have been saying but they seemed to be interested in what you were doing with them even though they did NOT want to do mathematics: this they have been making very clear during the past few weeks at school.

The formal atmosphere of the meeting then dissolved and the participants dispersed. Reflections on the above discussions which were carried out in a very frank and informal way, showed clearly that here was another example of a very common situation; students with an unpalatable subject diet. One answer is to allow for the injection into the curriculum of small modules of interesting study programmes, using interesting methods.

#### NOTE

The module 'Water' in its present form will run for five weeks, each Monday from 1.15 to 4.00 with a 15 minute break. Dates of meetings are:

29th October, 1984, 5th November, 1984, 12th November, 1984, 19th November 1984 and 26th November, 1984.

There are six students in this pilot scheme.





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# WORKSHEET 1

# WORKSHEET 2

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# Comparisons

SERVICE	Audi	Opel	Renault	Voivo
Price, inc VAT & Tax, £	14,191	13,994	13,440	13,648
Insurance Group	7	7	N/A	7
Group Test mpg	24.4	20.3	21.0	20.2
Fuel grade (stars)	4	4	4	4
Tank capacity, gals	17.6	16.5	15.8	13.0
Service interval, miles	10,000	9,000	5,000	6,000
No of dealers	380	710	360	270
Set brake pads (front) £*	39.63	25.70	20.47	30.47
Complete exhaust £*	187.01	63.59	194.30	199.75
Front wing panel £*	89.26	61.52	44.62	111.97
Oil filter £*	3.82	3.98	4.92	6.76
Starter motor f*	122.00	65.55	193.04	102.49§
Windscreen £*	104.65	92.57**	73.44**	129.10
*inc VAT but not labour cha	rges			
Sexcharige				

Notes for Lecturers

# Introduction

The module could be used for a variety of subjects such as communication, information technology, mathematics, science etc. It is however also very useful as a means of crossing several subject boundaries and so bringing the subjects together in a natural and realistic way. Additions, deletions or changes could be made such as substituting information for other vehicles. A computer could be used to produce a neat table for Worksheet 1 with the advantages of being able to correct errors and make changes very easily. Similarly, the computer could be used to help with the mathematics needed for Worksheet 2. Notes and solutions to the problems now follow for each worksheet.

#### Worksheet 1

The motor car realises the application of many branches of science as well as a lot of mathematics. However, the science, mathematics and also technology are interrelated through a task such as investigating a defective battery and so the isolation of subjects is not apparent. The diagram labels call for initiative from the student and the result must look neat and tidy. The table will help to draw together classroom science and the physical parts of a motor car.

#### Suggested Marking Scheme (25 marks)

Labels : 10 if 20 or more; reduce this by the number fewer than 20

Table : 10 if 5 or more entries; reduce this by the number fewer than 5 Neatness : 5; a discretionary allowance - look for the use of a ruler

#### Worksheet 2

1 A brief explanation of average as a 'representative value' may be necessary. Value = (24.4+20.3+21.0+20.2)/4 ; accept 21 or 21.5.

2 Expected cost = (500/20.2) x 1.89 pounds = 46.78 pounds.

3

17.6g = 17.6 x 4.55 1 = 80.08 1 16.5g = 16.5 x 4.55 1 = 75.075 1 15.8g = 15.8 x 4.55 1 = 71.89 1 13.0g = 13.0 x 4.55 1 = 59.15 1

4 Here are some comments :

The Renault requires twice as much servicing as the Audi The Audi and Opel should cost less than the other two to sevice If you travel a lot 5000 or 6000 miles will soon be covered

5 The Opel because there are many more Opel dealers

6 To the nearest 1% the figures are for :

Audi (37.63 - 20.47)/20.47, then x by 100 giving 94% Opel (25.70 - 20.47)/20.47, then x by 100 giving 26% Volvo (30.47 - 20.47)/20.47, then x by 100 giving 49%

7	In o	rder :	43.45	, 29.6	8, 25.	39, 37	.23	
Suggested Marking Scheme (25 marks)								
Question	:	1	2	3	4	5	6	7
Mark		2	4 ·	4	2	3	6	<b>4</b> ·

#### Information Technology Mechanic and Auto-Electrician Course Wirral Metropolitan College Borough Road, Birkenhead

# Final Assessment

Name Code	Comp.Test(/50)	W/S1 (25)	W/S2(25)	Final %
M 1	38	7	14	59
M 2	33	20	9	
M 3		23	Ģ	66
M 4	14	18	10	42
M 5	28	14	12	54
м 6	41	23	17	81
M 7	23	6	7	36
M 8	27	5	14	46
M 9	42	12	18	72
M 10	30	13	14	57
M 11	39	7	18	64
M 12	39	16	13	68
M 13	19	22	21	62

The module Measurement and the Motor Car was given given to the class on the day before the last class period of the course to enable the students to supplement the last lecture period with homework (optional). In order to obtain some general appraisal of the course a short class discussion was held for ten minutes and a request for more time for the subject came through very clearly. The approach has been to involve communication, mathematics, science and technology in a practical way and this has been discussed with the organising lecturer for General and Communications Studies. Perhaps an 'integrated' approach could be devised in association with the MAA. The module requires further testing, amending if necessary in the light of further trials at a number of establishments, before being considered reasonably validated for general use. Ok

#### APPENDIX 7.18

Measurement and the Pharmaceutical Industry 

General Objective 

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After working through this module you should appreciate that production tasks involve mathematics, science and technology.

#### Specific Objectives _________

- (1) To use arithmetic as required by measurement.
- (2) To identify applications of science and technology.
- (3) To use a computer as a problem solving aid when you

think that there would be some advantage in doing so.

How to Use This Module _____

Study the notes and photographs then try the exercises, making further reference to these as necessary. Discuss any difficulties with your lecturer or other students.



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Exercises A

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- (1) An operator uses P9 to weigh a laboratory sample and produces a reading of 6.046g. Give the reading error as a percentage of the reading to two decimal places and to the nearest 0.05%.
- (2) Select a balance (sometimes referred as a 'scale') from the photographs and work out the reading error (E) for a set of readings across the range as a percentage of the scale reading (R). Make a table of values as follows :

Reading (R)	Reading Error (E)
5	0.4

where the first line is for P5 reading 5kg,  $E = 0.02/5 \times 100 = 0.4$ .

- (3) Draw a graph of R against E and from this try to decide at which part of a scale the reading error would be a minimum and in the light of this state how you would try to select a scale in order to minimise this error. Repeat the exercise for another balance.
- (4) Look at P7. The mixture being weighed is to be increased by 1/4 % in weight by adding a certain substance. What reading would this be brought up to after the addition is made ?

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(5) The following table shows the results of measuring impurity levels in a laboratory atmosphere. The elements are represented by their chemical symbols. The quantity of impurity is given as so many mg per kg of atmospheric dust. Re-write the table with full names for the elements and the impurity expressed as a percentage of 1 kg of atmospheric dust.

ţ	Element	Mg/kg dust	Element	Mg/kg dust
	Al	3,000	Mg	2,390
	As	55	Mn	116
	Br	23	Na	2,950
	Ca	2,690	Ni	70
	Cd	3	Pd	1,150
	C1	2	РЬ	2,150
	Co	9	S	20,000
	Cr	39	Sb	15
	Ců	213	Sn	10
	F	1	Sr	14
	Fe	3,250	Ti	258
	I	3	v	259
	к	7,920	Zn	1,6540

Trace Element Levels in Dust From the Laboratory Atmosphere

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Exercises B

 (1) You are required to make up a consignment of 75000 tablets of given specification, these being available in bulk. The average weight of one tablet is 200mg. Describe how you would do this. Here are some points for your guidance :

(1) calculate the bulk target weight;
(2) decide how to carry out the weighing;
(3) specify the containers e.g. for size;
(4) write down a suitable label format.

- (2) A sample of tablets is drawn from a recent production run. There are twenty-nine tablets in the sample and their total weight is 6.57g. Use the photographs to select a balance to carry out the weighing. Now calculate the average weight of one tablet stating the accuracy of your estimate.
- (3) Tablets are coated in pans then unloaded into trays. The number of tablets has to be estimated by calculation and then entered on a log sheet. Here are some weights (what would you have used to obtain these ?) :

Weight	of	one full tray with tablets	17.6kg
Weight	of	the empty tray	1.4kg
Weight	of	a partially filled tray	9.7kg
Weight	of	the empty tray	1.4kg

Estimate the number of tablets in the total batch if the average weight of one tablet is known to be 0.836g. Is it possible to find the exact number of tablets instead of relying on an estimate ? (4) A cream is to be mixed in the pharmacy. Calculate the weight of the base to be added given the following information :

Weight of cream required	400 kg
Water	4 litres
Neomycin	400 g
Perfume (ignore this weight)	400 ml

Select suitable scales for the weighing operations and finally write out the specification in a form suitable for entry in the log.

- (5) The specific gravity of alcohol is given as 0.895 and from this information you have to find the volume to measure out in order to make up a weight of 50kg. Find this volume to the nearest 0.1 litre.
- (6) A consignment of 100 litres of ointment has been ordered and the specific gravity is to be 1.07. What weight will you expect this to have ?
- (7) Friability is a standard tablet test and is designed to measure how easily a tablet chips or disintegrates due to movement of the tablet before it is consumed (suggest how this could happen). The friability apparatus agitates a small sample of tablets in a drum and the weights of the tablets before and after the agitation are recorded. F the friability is calculated from the following formula :

loss in weight F = ------ x 100 (F is a percentage) original weight

If 20 tablets weighing 6.05g are reduced to a weight of 5.93g after agitation in the friability drum calculate F to two decimal places and also to the nearest 1%.

Before attempting the following questions spend some time studying P11 which shows how experimental data from measuring apparatus can be processed by a computer and presented as useful information i.e. using suitable English words. Pay particular attention to the section starting BATCH PERFORMANCE...

- (8) Name some of the tablet properties measured and explain how one of these is carried out (not in great detail).
- (9) Count the number of dashes in the line diagram at the bottom of the page (there are 7 lines) and deduce from this count how many tablets were tested. Name the tablets.
- (10) State the most and least common weights recorded and also how many tablets belong to each category.

(11) Estimate the average weight of one tablet.

(12) Check the computer's calculation of the coefficient of variation which is given by the formula :

standard deviation coefficient of variation = ------ x 100 mean value

and note that this is a percentage.

. .

(13) Criticise the presentation of the information by the computer and suggest ways of improving this.

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Notes

Percentage

Fercentage makes use of basic mathematics in order that changes in unequal quantities can be compared as if the quantities are the same. Another use is to compare two quantities on the basis of one being a hundred. Applications are to be found in many fields such as engineering, politics, science and commerce. Counting the number of times it is used in one edition of a newspaper can be quite instructive : a similar exercise can be carried out for radio or television news broadcasts. In spite of the widespread use and teaching in schools the use of percentage can cause difficulties. The following notes are not an exhaustive treatment of the subject and so further reading may be necessary. It is important to try to develop an understanding of the concept rather than how to apply it mechanically without appreciating what is achieved.

#### Some Terms

or

Fercentage is just a number, not a quantity. Thus 15g as a percentage of 150g is how many one-hundredth parts of 150 there are in 15 and this is the comparison between 15 and 150 as if 150 has become a hundred. The symbol % is used to stand for 'per cent' or 'per hundred' and the statement may be written in two equivalent forms:

> 15g as a percentage of 150g is 10 15g is 10% of 150g

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#### (a) Mass and Weight

Many applications of percentage in the chemical and allied industries as well as others relate to changes in weight or mass and sometimes these terms are used to mean the same thing. A few words are necessary here in order to help the user understand the difference between the terms. The weight of a body is experienced because there is a gravitational force acting on all matter which tends to pull it towards the centre of the earth. If not for this force objects would not readily stay where we put them down. Now the studies of physics (a science) show that the force of gravity on matter is related to its mass or 'quantity of matter' and it does not necessarily follow that the larger a body the more 'mass' it has since the molecules could be packed together very closely i.e. the body could be very 'dense'. Hence the term density arises but leave this and return to mass and weight. When we weigh a body we read a weight of say 5.8kg but this is really the mass and if we are interested in the actual force of gravity (weight) we should multiply by a number (about 9.8) to convert mass to weight. However it is acceptable to use mass or weight as alternatives for a balance reading providing we understand that we only require a value for the mass. The statement :

#### the mixture weighs 234kg

implies that the mass is 234kg and the force of gravity pulling on the mixture is 234 x 9.8 newtons. An engineer designing bridges and structures would require the force on a mass.

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and a more modern name is relative density. Although the specific gravity is a ratio and therefore just a number without units since the density of water is 1 kg/litre the specific gravity is numerically equal to the density in these units. For example what would be the weight of 101itres of carbon tetrachloride if its specific gravity is 1.592 ? The answer is 1.592 × 10 kg = 15.92kg.

The mass per unit volume Units for density vary with the field of application. Builders use kg/cu.m., chemists sometimes use g/ml and pharmacists use kg/litre. Another term, specific gravity has been found useful and is defined as:

the density of a substance

specific gravity = -----

as:
(1) Finding P % of A First find 1% (one hundredth) of A then multiply by P. Example : an order for 20000 tablets is to be increased by 5%; find the increase.

Two important ways of using the idea will be considered.

1% = 20000/100 = 200

 $5\% \Rightarrow 200 \times 5 = 1000$ 

.1% = 70/100 = 0.7

 $12\% = 0.7 \times 12 = 8.4$ 

1/100 of 38 = 1% = 0.38

increase = 1000 tablets.

Using Percentage

reduction in the period = 8.4 months. (2) A Expressed as a Percentage of B First find 1% of B and then see how many times this divides into A. Example : the temperature of a controlled production process must not change by more than 5% up or down. The operator observes

Example : a service contract period of 70 months is to be reduced by

12%; find the reduction in the period.

a drop from 38 deg. C. to 35.7 deg.C. Is this acceptable ? drop in temperature = 2.3 deg: C.

2.3/0.38 = 6.05 approx. so the change is not acceptable.

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Example : 37 out of 500 light bulbs fail the 'life' test : what is this as a percentage ?

37 37 as a percentage of 500 = ----- × 100 500 37 × 100 = -----500 = 7.4 exactly

Note that the calculation has been carried out in a form different from that laid down by the definition of what we mean by one number as a percentage of another. However no rules have been broken as the rules of algebra have been used correctly. An example of equivalent forms of arithmetic is  $3 \times 4 = 4 \times 3$  which would probably be acceptable. Using algebra it can be shown that A divided by (B/100) which gives A as percentage of B, is equivalent to (A/B)  $\times$  100. Thus the following statements are equivalent :

Α ---- x 100 в (A x 100)/B . • Example : What is the percentage increase in weight when 20 litres of alcohol of SG 0.95 are added to a mixture weighing 540 g ? . the increase in weight = the sweight of alcohol ... = 20 x 0.95 KG = 17 kg this as a percentage = (19/540) x 100 increase = 3.5% to 1 decimal place 

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B/100

Notes For Lecturers

Introduction

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This module exploits the way that mathematics, science and technology are interrelated through tasks. This approach is contrary to the traditional treatment in educational establishments of separate subjects in isolation. Many of the production line tasks are concerned with chemistry and physics applied to materials which are then processed using technology with measurement being carried out at various stages and usually involving mathematics. The mathematical needs of production receive particular emphasis in this module through the exercises but this is not to the exclusion of science and technology. Working through the module should serve to strengthen the understanding and show the correct use of mathematical skills in a practical and relevant way for those working in the production field. An example of a production task is estimating the friability which brings together technology for the apparatus, physics for the tablet construction and mathematics for the calculation. Further examples of tasks which relate to mathematics are :

(1) correcting a weight for the tare value;

(2) converting between units;

(3) estimating the weight of an additive;

(4) converting volume to weight with specific gravity; and

(5) estimating the weight of a large number of tablets.

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The Information

This consists of reproductions of photographs of production line equipment, mainly balances, notes on percentage, density and specific gravity; The photographs are referred to as P1, P2, P3, ..... up to P11 and each one has a short descriptive caption. The final one (P11) is from the computer print of P10 and is needed for one of the exercises. In using this the student comes close to the computer in a practical way and has to study and try to interpret the output information in order to answer the questions. The camera film used to produce these photographs was processed into the alternative forms of colour slides, black/white photographs in two sizes and black/white transparencies for use with an overhead projector. These alternative forms are available as required. The notes deal with percentage, the application of which often gives rise to problems and density and the related specific gravity: it would appear that the particular field of application seems to determines the units, not an agreed system such as the SI. Thus in Building density is in kg/cu.m., in science it can be g/ml and in pharmaceutical production, kg/litre. '

#### The Exercises

These can be changed or varied to suit particular emphases which may be considered necessary and there are available a total of forty-eight photographs to support alternative questions. However, the involvement of some or all of the three elements (mathematics, science and technology) should always be emphasised in order to remain close to the reality of the production line tasks encountered. The questions are not set as routine exercises in mathematical techniques and therefore will require some assistance which might materialise from student/student or student/lecturer discussions. For 'lecturer' one can read 'supervisor' or 'instructor'. Even though some of the problems have not been experienced practically it should be possible to discuss them with someone who has had the relevant experience, the discussion serving to advance learning on both sides.

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#### The Use of Calculators

It is difficult to give efficient class instruction on this unless each person has one and they are all the same model. There are minor differences between models such as the number of significant figures, rounding and the algebraic logic used, which are sufficient to impede class instruction. Therefore it would be better to offer individual help as it is needed. However, sensible use of the calculator requires all users to abide by a minimum of rules as follows:

estimate an approximate answer to the calculation;

(2) try out a version of the calculation with simple numbers;

(3) check the answer from (2) without the calculator; and

(4) use the calculator for the actual arithmetic.

As the understanding of the use of any calculator requires a good knowledge of algebra, a routine approach is probably the best recommendation for someone who has little knowledge of algebra and would be alienated from the use of the calculator by such an academic approach.



FLOOR SCALE MAXIMUM READING : 1000 kg READING ACCURACY : 0.2 kg ELECTRONIC DIGITAL READINGS



CLOSER VIEW OF THE CONTROLS IN P1

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FLOOR SCALE MAXIMUM READING : 1000 kg READING ACCURACY : 0.2 kg SITED FOR USE WITH THE TABLET INGREDIENTS MIXER



CLOSER VIEW OF THE SCALE IN P3 THE SCALE IS OPTICALLY MAGNIFIED

P4



BENCH SCALE MAXIMUM READING : 36 kg READING ACCURACY : 0.02 kg BULK ALKATHENE IS BEING WEIGHED : AN OINTMENT BASE



SHOWING THE MAIN & TARE SCALE MARKINGS OF P5 NOTE TWO UNITS - GRAM AND KILOGRAM ON THE DIAL



BENCH SCALE WITH ELECTRONIC READING MAXIMUM READING : 1200 g READING ACCURACY : 0.01 g = 10 mg



BENCH SCALE WITH OPTICAL MAGNIFICATION MAXIMUM READING : 0.8 kg = 800 g READING ACCURACY : 0.1 g = 100 mg THE SCALE IS OPTICALLY MAGNIFIED



LABORATORY TYPE BALANCE MAXIMUM READING : 10 g READING ACCURACY : 0.002 g = 2 mg THE MOVEMENTS OF THE PARTS CAN BE SEEN DURING WEIGHING.



## WEIGHING A TABLET

A small number of tablets are selected from a production run and weighed. The computer extracts data from the results and processes them using statistics.

3. **PII** x 1112* -+ 10 NEMI - 587-4 TETOET VELOUT SEA C3222-1-1-1- +4 57#F-FET- 4-4 -543-WIGHTS DUTSIFE TAT LINIT (DEW NO. 1 17) S372 SPETLES FETESTER (FFIN N2+) NONE DRIMS RESTAFTEDCEFIM NO+ TO EFUI NO+) RUNE *********** 451 455+8 475+2 -2 States -ł 494.5 ------499.4 ************************* 502.9 512+1 ----517.7 587+3 526.9 EACH EASI FEFFESENTS 2 TAPLET(S) `. FATCH TEFIORIANCE TEST · HI AFILI TY VALLE I VALUE L'I SINTEGFATION 15 75 RAFALESS ı 5 I CELET DE NEAN ė ō CLEFF. VAF. LUEFICATION 10 100 12 79 7 €9 . TO SALAR ACTUAL & VALUE FOF THIS FATCH 53 NIMPER OF FRIABILITY FESULTS FECORDER 13 NIMPER OF RISINTEGRATION FESULTS FECOFDER 7 •• • • SUMMARY FOR PAY NO. 4 MYTOSTATIN URAL NYCOSTATIN DEAL LATE STAFTED 22/9/81 SUMMARY CATED 25/9/81 TAKE-DEE NO. 2 580052 ND. OF SAMPLES 10 TFFGET VEIGHT 504 NO. FER TEST 27 S TANE . FEV. 4. J HEAN 503.8 VEIGHTS DUTSICE 'A' LINIT (DEUN NO. 1 VT) I TFIFT -+ 04 SMITLES FETESTED (DELH NO.) CULFF. VAL. +8 FILMS FESTAFTEDICELM NO. TO DELH 110.) ••••• 2 495.E 495.2 --474.8 -----499.4 -----. 0. 0 ----\$ 19.5 *** 513.1 \$17.7 -----Sec. 3 521.9 FACH FAST FEFSESDITS & TAHLET(S)... الع**لا** 1- 1- ماريكة موجود المتركة الأوليد (

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THE PROCESSED DATA FROM THE COMPUTER IN P10

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LOUGHBOROUGH UNIVERSITY OF TECHNOLOGY LIBRARY AUTHOR/FILING TITLE TURNER L G ACCESSION/COPY NO. 010808/01 CLASS MARK VOL. NO. LOAN COP; 29. 15. JAN 88 14 101 3 07. 通道 p4.1. . 62 - 5 DEC 1989 2 0 MAR 1987 1 1 FEB 1991 OI. MY 27. MAY 87

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# GCSE: THE 16-PLUS EXAMINATION IN MATHEMATICS

by

## LEONIE GAY TURNER B.Sc.

A Master's Dissertation submitted in partial fulfilment of the requirements for the award of the degree of M.Sc. in Mathematical Education of the Loughborough University of Technology, 1986.

Supervisor: G. B. SIMPSON B.Sc.

C by LEONIE GAY TURNER 1986

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DECLARATION

I, Leonie Gay Turner, declare that the contents of this dissertation, 'GCSE: The 16 plus examination in Mathematics' are entirely my own work.

L. G. Turner

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Caroline, for typing the manuscript with such care,

my family, to whom especial thanks are due for their support and unending patience.

#### ABSTRACT

On June 20th 1984, Sir Keith Joseph, the Secretary of State, announced that a single unified system of examinations at 16 plus to be known as the General Certificate of Secondary Education, would be introduced with effect from 1988, and would replace all other examinations at this level. Seven clearly defined grades would be awarded and national criteria were to be drawn up for syllabuses and assessment procedures to ensure that all groups of examining boards awarded the same grade to the same level of performance and made similar demands of candidates attempting to attain equivalent qualifications.

Throughout the 1970's there had been criticism of the dual system of examinations at 16 plus, which existed in the form of the General Certificate of Education (GCE Ordinary level) and the Certificate of Secondary Education (CSE). GCE examinations had been established in 1951 in the context of major changes in education and the provision of secondary education for all. These were single subject examinations under the direct control of the Universities; they were intended to be academic and used for University selection, and so were devised for only the top 20% of the ability range.

Increasing pressure for a lower-level examination which would be regarded as a qualification rather than as part of a selection procedure, resulted in the introduction in the 1960's of the CSE boards, who devised syllabuses and examinations for the next 40% below the most able.

The dual system which arose caused many problems with divergent courses and lack of comparability of standards, but the most severe criticisms were that the system was elitist and divisive and against the aims of comprehensive education which was being introduced throughout the country.

This dissertation attempts to place in a historical context the issues which led to the call for a unified system and then discusses the role of examinations in society. The failings of the current system are examined, and the change in attitude which led people to believe there was a need for radical changes in assessment procedures is discussed in Chapter 3.

The philosophy of the GCSE is considered, firstly in general terms, and then with particular reference to Mathematics. The fundamental changes which will be involved in switching from one system to another are studied; draft syllabuses from each of the examining groups are compared and specimen papers are analysed where available.

The dissertation ends by suggesting possible implications for the future of the introduction of the GCSE.

Chapter 1

Historical background

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#### 1.1 General Introduction

Written examinations are a comparatively new innovation in the English educational system. The Chinese are reputed to have used this type of examination for selective purposes as long ago as the beginning of the Christian era (53) (43). Whereas in England, these examinations have become used on a large scale only in the last hundred years. Before then oral disputations had sufficed. Confidence in this system was supposedly maintained by conducting these examinations in public, thereby demonstrating the suitability of the applicant for his chosen role. The disputations were in Latin, however, and so there was a limited audience by whom the examinations could be judged to be fair; patronage was commonplace.

In the mid-nineteenth century, the spirit of free competition swept through many different areas of life. There were changes in Parliament and political offices, in the Church of England, and in laws and the administration of law courts. The Corn Laws had a tremendous influence on the economy and encouraged free trade throughout the world (33). Fair competition began to oust patronage, and this attitude was carried into the field of examinations too.

In 1827, Bentham attempted to introduce some measure of standardisation into the disputation method of testing prospective Civil Service entrants, by publishing an "Official Questions Book" containing questions and the required answers. Candidates were expected to purchase the book and memorise its contents; other answers were considered to be unacceptable (53).

During the nineteenth century, the provision of schooling increased in many countries including the United Kingdom, and the numbers of candidates subsequently presenting themselves for examination, caused the traditional oral system to collapse. In Boston, in 1845, the examining Committee found themselves having to cope with an entry of over 7000 candidates. They resolved the problem by setting a written paper which they thought would be a fair and searching test, and speedy for administration purposes.

As yet, no-one had suggested the idea of simultaneous examining, and possible leakage of questions posed a further problem, which forced the Committee, armed with copies of the paper, to rush as quickly as possible from one examination centre to another.

The nature of mathematics itself, however, had caused an earlier break-away from the disputation method. The earliest European written paper on record is a mathematics paper set in 1702 by Trinity College, Cambridge (53). Thereafter, the difficulty of the subject and the shift in emphasis which made ability to solve problems a more greatly desired asset, ensured the continuing use of written examinations in Mathematics.

### 1.2 The situation before 1917

The new attitude favouring fair competition put emphasis on ability, merit and efficiency, and called for some means of measuring attainment. As a result of requests from schools and other interested parties, the Oxford Delegacy of Local Examinations was founded in 1857, to provide a means of examining at the time of their leaving school, pupils who were not going on to University, and to demonstrate the degree of their success ( 6). In fact, external examinations had been introduced at the secondary school level somewhat earlier, by the College of Preceptors who began examining in 1850 (33). However, the association with the Universities was preferred because it gave added prestige to the qualifications.

The Oxford Delegacy examined for the first time in 1858. It offered papers at two different levels and received entries from eleven different towns, totalling 750 Junior candidates and 401 Senior candidates, only about one-third of whom gained a certificate. Cambridge quickly followed suit, by founding the Cambridge Syndicate early in 1858, and holding its first examinations only six months after those of the Delegacy. These were taken by 297 Junior candidates and 73 Senior candidates, and over two-thirds gained a certificate. The Cambridge examinations were held at eight

different centres, and their status and prestige was enhanced by the management arrangements: a Presiding Examiner arrived at the local railway station wearing academic dress and carrying a locked box containing the papers; he was then escorted by the Mayor to the examinations centre (6). Hence the examinations became known as the 'Locals'.

Not wishing to be outdone by the formation of these two examining bodies, London University made its matriculation examinations available to external candidates. Although intended only for matriculation purposes, these qualifications became a recognised passport to many different professions, and consequently there was a great increase in the candidates who presented themselves and who actually had no desire to go to University. To combat this, London University began to develop separate school examinations, although the matriculation examinations continued to be taken by many who regarded them as a higher qualification.

Between the years 1858-1911 these three external examination systems were to influence the school curriculum greatly. They provided a stimulus to learning and gave a definite goal to be attained. However, there were already criticisms based on the disruption caused by the lengthy period of examinations for three different bodies.

Other examining boards were founded, not only by Universities but by unassociated organisations. The Society of Apothecaries introduced the first professional qualifying examinations. There were written papers for solicitors, for entry into the Civil Service and into military and naval training establishments. In 1847, the Union of Lancashire and Cheshire Institutes started examinations for working men who had left or who had never been to school. In 1856, the Royal Society of Arts (R.S.A.) introduced examinations to encourage Mechanics' Institutes to pursue serious courses of study. One examining body after another was established. There were no so many in existence that the 1868 Report of the Schools Inquiry Commission (Taunton Commission) warned against "the dangers of an uncontrolled proliferation of examinations" (53).

It reviewed all the existing schemes of public secondary school examinations and recommended that a central authority be set up to simplify and oversee the examining system.

At this time no university of professional body would accept the qualification of another authority and sometimes candidates were entered for one set of papers after another. The Taunton Commission suggested that some kind of equivalence be established. It also considered that the majority of pupils were suffering from lack of attention and an unsuitable curriculum, whilst a few privileged pupils were coached for examinations which were too difficult for all but the most able. It proposed a qualifying rather than a competitive examination for which all pupils aged fourteen or fifteen years could be entered. The existing College of Preceptors examinations were not generally accepted because the association also examined teachers, and it was felt that this system might be subject to bias (26). The Oxford and Cambridge Joint Board which was now in existence, catered for schools rather than individuals, but was almost exclusively used by the public schools and was generally unavailable to the rest of the education system (6).

The Taunton Commission was ahead of its time, and although some of the problems it highlighted were remedied by the Endowed Schools Bill in 1869, no central authority was set up. The trend for examining for purposes of selection continued and papers were introduced for technical subjects (later to become the City and Guilds examinations of the London Institute), for commercial subjects (Pitman's College), for post-school education, all in addition to a plethora of other university examinations (53).

In 1895, the Bryce Commission reiterated the view that a central authority was needed to compare and draw up correspondences between the results of different examining bodies. It also advocated that the authority work to establish the acceptance of these qualifications as entrance requirements for the Civil Service Commission, professional organisations, teachers' training

colleges etc. The 1899 and 1902 Board of Education Acts were important steps towards realising this goal, but the full benefit of this reform was not felt for many years when the Civil Service was persuaded by the Secondary Schools Examinations Council to accept correlation between qualifications.

Two more important examining bodies were founded during this time. In Wales the demand for more grammer schools led to the establishment of the Central Welsh Board in 1896. In the northern counties, the four universities of Manchester, Liverpool, Leeds and Sheffield collaborated to set up the Joint Matriculation Board to hold examinations similar to those for London University Matriculation.

Once again the multiplicity of examinations was the subject of comment in a government document, when the Report of the Consultative Committee in 1911 criticised the current system, which offered schools the choice of over a hundred different schemes. The aims of the scheme were wrong it claimed; the Committee reported that less than a quarter of students entering the London University Matriculation Examination went on to university. Suggestions for changes were made, and following discussions with the Board of Education, the universities and other interested parties, steps were taken which led to the simplification of the system and the introduction in 1917 of the single system of School Certificate examinations and Higher School Certificate examinations.

## 1.3 1917: the School Certificate Examination

1917 also saw the establishment of the Secondary Schools Examination Council. Its purpose was to ensure the success of the School Certificate Examination by co-ordinating the work of the various examining bodies and correlating standards, and to try to obtain widespread acceptance of the certificate by universities and professional bodies. The Council was established by the Board of Education, and acted in an advisory

capacity, but as it had no power to enforce its recommendations, it did not maintain its importance as an educational influence, once its initial purpose was fulfilled.

The new School Certificate Examination was designed for sixteen-year olds who had followed at least a two-year secondary course; whole forms were to be entered rather than a few individuals. It was intended to be a qualifying examination indicating the successful completion of a broad general education rather than a competitive examination to be used for selection purposes. In order to ensure diversity of study, subjects were grouped, and candidates were required initially to pass in three main groups, namely, English subjects, foreign languages, and science and mathematics (6) (26). The standard needed to pass was "such as might be expected from a pupil of reasonable industry and ordinary intelligence in an efficient secondary school". To obtain a certificate, candidates had to pass in not less than five subjects, including at least one from each group. Later a fourth group, including music and art, was introduced. A Higher School Certificate was also introduced for eighteen-year old pupils.

The Board of Education helped to establish these certificates, firstly by making a regulation specifying sixteen years as the youngest age for examination, and secondly by providing a grant per capita for schools taking the approved examinations.

The success of the reform was assured when universities accepted a combination of School Certificate and Higher Certificate for matriculation purposes, instead of imposing their own separate papers. This recognition gave the certificates prestige.

There was now in existence a single set of dual purpose examinations. Firstly, they were qualifying examinations, and secondly, they could be used for selective purposes. However, initially the certificates did not record passes or grades of attainment in individual subjects, but only the number of credits obtained, so they did not particularly distinguish between a weak and an able candidate. Employers were anxious to ascertain the
calibre of their prospective employees, and soon began to realise that the Matriculation Certificate indicated a higher standard, being that of university entrance (33). This in turn affected the candidates who were anxious to obtain the best qualification they could, and once again, many more people entered for matriculation examinations than ever intended to go to University.

In an attempt to distinguish between the more able and weak but successful candidates, several boards introduced 'Distinctions' awarded to only the top 2% to 3%. However, some schools then concentrated their efforts on these pupils, ignoring the needs of others. The Secondary Schools Examinations Council, therefore, gradually persuaded the examining bodies to abandon this system. Yet soon after, in 1939, the Council reversed its policy by introducing a new 'very good' standard in each subject comprising about 10% of the candidates. Other levels were 'credit', 'pass' and 'fail', covering the next 40%, 30% and 20% of candidates respectively.

The inflexibility of the School Certificate requirements meant that about 30% of candidates who failed did so because of only one subject. As there was no possibility of adding an extra subject later, some candidates were forced to mark time and repeat work in order to satisfy matriculation requirements. For example, a boy with seven credits and a pass in Spanish still failed to satisfy the matriculation requirements of London University (26). These requirements varied from one university to another, and were generally a combination of School Certificate and Higher School Certificate qualifications which were so inflexible that they imposed rigid constraints on the school curriculum. The Secondary Schools Examinations Council could have avoided this by offering two levels of examination, one of which was known to be of similar standard to matriculation, but offering a wider choice of subjects. However, this was not done.

The Spens Report (1938) of the SSEC stated that "The School Certificate Examination... now dominates the work of the schools, controlling both the framework and the content of the curriculum".

It also found that an artificial gap was being created between fifth and sixth year work. As so many pupils' aim was to attain a Matriculation Certificate irrespective of any university ambitions, many pupils who only reached School Certificate standard felt that they had failed (52). Although the School Certificate had originally been intended to indicate a broad general education, combinations of subjects which were later accepted did not do so. For example, English, History, English Economic History, Economics, Geography and Botany was one accepted selection (6). There was also a fear that the new compulsory English Language qualification (1938) had resulted in an unconscious lowering of standards in order to enable more candidates to succeed. Further reform was necessary, and the committee recommended that the grouping of subjects be abolished, that increased use be made of school reports and that the School Certificates be regarded as only the first stage of matriculation requirements (52). The advent of the Second World War prevented any immediate reforms from being instituted.

## 1.4 The Norwood Report and the 1944 Education Act

During its existence, the Secondary Schools Examinations Council had increased cooperation between examining bodies and schools in three different ways. Firstly, and importantly, it had allowed teacher representation on its committee, the proportion being five teachers out of its twenty-six members; secondly, teachers had been given the opportunity to submit their own syllabuses, although almost no-one availed themselves of this provision. Thirdly, the committee permitted heads to submit estimates of candidates' expected performance. The latter became increasingly important during the war years when it was sometimes impossible for candidates to sit or complete examinations as a result of air raids or loss of staff.

In 1943, the SSEC in the Norwood report, argued the case for and against examinations, and suggested radical changes in the

examination system, including the possible abolition of external examinations in favour of an internal assessment conducted by teachers who were familiar with the work of individual pupils. The 1944 Education Act, proposing secondary education for all, '/ was forthcoming, and it could be seen that the School Certificate would act as a great barrier between grammar schools and secondary modern schools as it would be beyond the reach of most pupils attending the latter. Assessment by teachers themselves would fulfil all the requirements of local employers, and only those pupils intending to pursue further study needed a system of external examinations. This had to be provided in order to prevent a recurrence of the situation where each professional body and university had set their own testing procedures.

After the war, the reconstituted SSEC, containing no School Certificate Examination representatives, reiterated the plea for the abolition of subject grouping, and it suggested instead that individual subjects be certificated. This would give a clearer picture of a candidate's degree of success. It would also remove restrictions from the school curriculum as some subjects would no longer be compulsory teaching for grammar schools (52). This idea of a new qualifying examination which was to become known as the General Certificate of Education was conceived in 1947. Like its predecessor it was to be taken in two stages, the Ordinary level at sixteen years of age, and the Advanced level at eighteen years of age. Separate scholarship examinations were to be set for the competitive purposes of gaining awards and some university places.

# 1.5 The General Certificate of Education (GCE)

In this context of major changes in education and with the provision of secondary education for all, GCE examinations came into being in 1951, replacing both the School Certificate and the Higher School Certificate. The subsidiary examinations of the Higher Certificate had no equivalent under the new scheme. GCE papers were single subject examinations as had been

suggested, passes even in only one subject being certificated. The examinations operated on a pass/fail basis with no distinctions or credits being awarded and with the pass standard being set at that required for a 'credit' on the School Certificate. There was no longer an examination for those who would have reached the pass standard on the School Certificate. The new pass standard for Ordinary level GCE examinations was known to have been set deliberately high to discourage the majority of pupils from entering; it was envisaged that candidates would be from only the top 20% of the ability range. In this way the examinations could be used by the Universities for purposes of selection and, in fact, all the examining boards for the GCE were at that time under the direct control of the universities. The imposition of a minimum age limit of sixteen years when the statutory minimum leaving-age wasififteen years was also intended to discourage secondary-modern pupils from attempting the examination.

Originally it was intended that candidates should only present themselves for the Ordinary level examination in subjects which they did not propose to study further. Otherwise Ordinary level examinations were to be by-passed and a candidate.'s preferred subjects be taken directly to Advanced level. With this in mind, provision was made to award a failed Advanced level candidate an Ordinary level pass, if appropriate, on the basis of work produced in the Advanced level paper. However, this produced problems of how to assess an Ordinary level pass from an Advanced level attempt. Some candidates who might pass at the Ordinary level stage, might then find the more complex work beyond their ability, and produce a negligible amount of evidence of any understanding or knowledge on the more difficult Still other candidates entered for Advanced level in the paper. mistaken belief that it was an easy route to obtaining an Ordinary In practice, the official policy of by-passing was level pass. only followed by a few schools, and candidates from these centres could often find themselves disadvantaged when, with comparatively few Ordinary level passes and at a pre-Advanced level examination stage of their career, they submitted applications to Universities.

It was the function of the SSEC to ensure comparability of standards between Boards, and also to determine the nature of the GCE examination and its syllabuses. Practical skills alone were insufficient and a general criterion for deciding whether a subject area was suited to GCE purposes was whether or not it could be studied further. Originally Examining Boards could not change syllabuses without first obtaining the approval of the SSEC.

The abolition of grouped subjects gave a greater freedom of choice to the individual and the examination period became extended. To compress the examination time-table as much as possible, it: was usual for schools to limit the number of subjects which could be taken. In fact, many schools continued to follow School Certificate groupings as matriculation requirements of 5 0-levels and 2 A-levels including English Language, a foreign language, and mathematics and science, imposed constraints on the curriculum.

Apart from complaints about the extended examination period, there were objections to the age limit, many grammar school pupils being ready for entry before the age of sixteen; to the abolition of subsidiary subjects, which had been removed because the last three years of school became overcrowded with examinations; to the concept of by-passing which could leave an unsuccessful Advanced level candidate with too few qualifications to be a true reflection of his potential; and also to the pass/ fail system (6).

The main advantages were that a candidate who was unsuccessful in a subject at Ordinary level, could re-sit the papers involved without interrupting his progress towards Advanced level. However, there were also objections to the single subject examination on the grounds that a candidate could accumulate passes one at a time and if so, may well have a less agile mind and less ability to cope with a volume of knowledge than one who can pass several subjects in one attempt. Also, for early school-leavers, certification of even one subject meant that employers had to look carefully at a certificate to ascertain the calibre of an

applicant. This proved fairer than the previous system where a good prospective employee who had reached the required standard to pass in all but perhaps one compulsory subject, might be turned down by virtue of having failed to obtain a School Certificate (⁶).

Two more examining bodies were established in the 1950's. The universities of Bristol, Reading and Southampton were founder members of the Southern Universities Joint Board for School Examinations, and were later joined by the University of Exeter. Perhaps more significantly, it was decided that, although there were already eight GCE examining boards in existence, provision should be made for the examination of courses of a more technical nature. Such courses, for example building construction, were not included usually in grammar schools, but were often run by technical schools and technical colleges. The pressure was such that the Associated Examining Board (AEB), the first non-university controlled body, was set up and produced syllabuses and examinations for all the more usual subjects together with an impressive list of technical and practical subjects, knowledge of which could be utilised in commerce or industry. The figures for entries to the AEB in 1959 were as follows:-

21411 candidates entered 51570 subjects from 660 centres comprised as fóllows:

Grammar schools Secondary modern schools	1024 4621
Secondary technical schools	3485
Further education	7811
Private and external	. 1823
H.M. Forces	
	21411

Although the Board was unlike any other in its catering for practical subjects, it is interesting to note the large numbers entered from secondary schools other than grammar schools. Other boards had entries from these schools too. These prestigious

O-level qualifications became the key to entry to the better-paid professions and so were sought after by pupils from all kinds of backgrounds. The more able secondary modern pupils attempted GCE examinations in perhaps four or five subjects. Still others would strive for a single O-level qualification in their best subject. The O-level syllabuses were not suited to these children as they had from the outset, been intended to be highly academic. By 1959 approximately one-third of O-level entries were from sources outside grammar schools. There was an obvious need for lower-level examinations which would provide a certificated qualification more suited to these pupils.

# [1.6 The call for an alternative to the G.C.E.

As long as sixty years ago, there had been investigations into courses followed by secondary pupils who were not in grammar schools, and in 1926, the Hadow committee concluded that a qualifying examination should be introduced for these pupils to furnish them with some proof of their academic attainment (52). The economic climate of the 1930's and the war years of the 1940's prevented any such provision being made.

The demands for an alternative lower-level system of examinations continued with the onset of the G.C.E. The pressure increased until, in 1955, the then Minister of Education issued a document, Circular 289, expressing his opposition to the introduction of any new national system. Secondary modern schools were to prepare any suitable pupils for GCE examinations but to avoid establishing GCE courses purely for the sake of acquiring an academic reputation; this was not the prime function of this type of school. This Circular had so little effect that it was necessary to reiterate the reasons for rejecting a second national examining system in Circular 326 of July 1957. However, the Baloe Committee was set up one year later with the following terms of reference: "To review current arrangements for the examination of secondary school pupils other than by GCE examination, to consider what developments are desirable, and to advise the Council whether, and if so, what, examinations

should be encouraged or introduced and at what ages and levels". (43).

Figures for 1958 show that over half of the pupils in secondary-modern schools took some kind of external examinations before leaving school. Many of these examinations were totally unsuitable, but the figures reflect the strength of public opinion at the time, and in 1959, the Crowther Report recorded the degree of pressure from parents and others for another examination with national validity. The problem of multiplicity of types of qualification was returning, and so when the Beloe Committee submitted its report the following year, it could see no alternative but to recommend the setting up of a new lowerlevel examination system.

# 1.7 The Certificate of Secondary Examination

Like the GCE, the new system which became known as the Certificate of Secondary Education examination, was to be based on individual subjects. As GCE was aimed at the top 20% of the ability range, the proposals suggested that the target group for the CSE be the next 40%, of whom the best 20% were expected to enter for at least four subjects. A rigid pass/fail structure was unnecessary since the examination was purely a qualifying one which would not be used for selective purposes, and a system of grading such that the majority of candidates would achieve success was recommended. The SSEC laid down conditions under which examining boards could become CSE boards (52), and these proposals were accepted by the Minister of Education in 1961.

The CSE examination began to function four years later, under the control of fourteen regional boards. The governing council of each board had no representatives from the universities, but included a large proportion of teachers. It was hoped, therefore, that the CSE would develop a character of its own, making it particularly suited to the needs of its target group, but in fact, in many cases, the examination and

syllabus made it merely a simplified version of the GCE 0-level.

The certificates would provide information useful to local employers, technical colleges and colleges of further education in that they offered a means of comparing one candidate's level of attainment with another. A grading system had advantages over a pass/fail system which might imply some candidates were suited for particular kinds of employment and others not. Grades were awarded on a five-point scale, but only Grades 1 and 4 were defined:

(Candidates failing to attain even a Grade 5 were considered to have been unsuitably entered in the first place).

<u>Grade 4</u> was to be the "standard of performance expected from a sixteen year old of average ability who has applied himself to a course appropriate to his age, ability and aptitude". This was a deliberately vague definition which allowed the standard to set itself and avoided the two pitfalls of firstly, a standard set too high and therefore excluding some of the intended target group, and secondly, a standard set so low that the target group would not be entered.

<u>Grade 1</u> was defined more specifically, and with very careful wording: it was to be an indication that the calibre of the pupil was such that "he might reasonably have secured a pass in the Ordinary leveloof the GCE examination, had he applied himself to a course of study leading to that examination...". This definition, therefore, implies an overlap between 0-level standards and those of CSE, which was intended to help teachers with decisions concerning borderline 0-level candidates.

The many different CSE Examining Boards introduced syllabuses with varying emphases. These syllabuses did not have to be approved by the SSEC or subsequent bodies. Provision was also made for three different modes of examining. In Mode 1, the external examinations were set on syllabuses provided by the board's subject panels. In Mode 2, these external examinations were set on syllabuses provided by the school and approved by the

boards' subject panels. In Mode 3, examinations were set and marked internally but moderated by the regional board.

The great diversity of syllabuses and examinations which resulted, made comparability of standards between boards, between subjects, and especially between CSE and GCE, a wellnigh impossible achievement. One of the functions of the Schools Council for Curriculum and Examinations established in 1964, was to try to establish an equivalence between the two sets of examination results. However, initially the examination timetables were such that "double-entering" for CSE and GCE was possible. Results often showed that these borderline candidates could fail at O-level but still obtain a Grade 1 CSE. The correlation of the standards of the two systems was in question.

Many parents pressurised teachers to allow their children to follow O-level rather than CSE courses, as GCE qualifications were regarded as superior. The problem which existed in the days of the School Certificate and the Matriculation Certificate had returned, with candidates striving to obtain the best qualification available, namely, the Ordinary level pass of the General Certificate of Education.

This dual examining system, currently in existence, is elitist and divisive. Many people feel that, with the increase in the numbers of comprehensive schools throughout the country, a comprehensive examining system would be more appropriate. In addition, despite at least twenty years' existence, the CSE qualification is neither well understood nor well accepted in industry or commerce. Early in the 1970's, the Schools Council suggested that the feasibility of a single examining system at 16+ be investigated.

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# Chapter 2

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# The Role of Examinations

2.1 The purpose of examining

James M. Thyne classifies the purposes of examining into two categories (a) content purposes

(b) criterion purposes.

Content purposes include testing a candidate's ability to understand, comprehend, recall, recognise, apply, organise, analyse, synthesise and evaluate (47). Not all examinations test all of these, and the emphasis placed on these areas can vary considerably from one type of examination to another. However, it would be pointless to assess a candidate's performance in any of these areas if that measurement were not put to some kind of use. Therefore, if there are content purposes for examining there must be some criterion purposes also, and criterion purposes themselves assume that content purposes have been fulfilled.

Examinations can be used for the following criterion purposes:

- (a) as a means of maintaining standards
- (b) as a stimulus to both pupil and teacher
- (c) as a qualification
- (d) as a means of selection
- (e) as a prognosis
- (f) as a social control

## 2.2 The uses of examinations.

## a) as a means of maintaining standards

Oxford and Cambridge Universities were originally able to raise the standards achieved by their abler undergraduates by using competitive entrance examinations, and the same means may also be used to maintain standards. The quality of students depends largely on their attainments at school, and as most candidates will work to achieve whatever level is demanded by the examination for which they are entering, universities have found entrance examinations an effective way of ensuring that a candidate acquires an adequate academic background.

b) as a stimulus to pupil and teacher

Examinations provide an incentive to pupils by giving them a goal towards which to work (43). The pupil knows that in a given time he must achieve certain targets, he must assimilate a specified body of knowledge and he must be able to reproduce it, or any part of it, precisely and specifically, in different forms and in varying situations. He must focus his mind; to be certain of doing well, he must work as hard at those parts of the syllabus he finds uninteresting as at those parts he favours. To achieve success it is usually necessary for the pupil to work steadily over a protracted period of time, and so examinations also encourage persistence. An examination gives a student feedback about his progress and provides him with a means of measuring his attainments against his own previous performances, against the achievements of his peers, and against national standards. However, external examinations which are known to have a high failure rate may leave candidates with no incentive to attempt them.

A parallel case can be drawn for teachers. Examinations also give the teacher a goal with a specified syallabus to be covered within a given time. They ensure that the teacher will do his best to cover all aspects of the work which may be tested, and prevent the teacher from concentrating solely on topics which are neither his forte nor his partiality. They encourage him not to digress too far from the central core of knowledge to be imparted and also not to favour the better pupils at the expense of the less able. The teacher also receives feedback as regards his own efficiency compared with other schools and other teachers within the same school.

Examinations influence what is taught in schools, but may not be too oppressive a constraint on teaching. Channels are open for teachers to criticise examinations should they wish, and the provision is made, although comparatively rarely used, for teachers to write their own syllabuses and submit them for approval.

#### c) as a qualification

The certificates which are awarded on the basis of public examination results, furnish the candidate with a testimony to his skills and proficiency in different subjects. These give evidence of his abilities and perseverance which will be valued by prospective employers, by those responsible for allocating university or college places, by his parents and by himself. The Norwood Committee, in their assessment of the School Certificate Examination, pointed out that this evidence was particularly valuable for pupils in schools not normally, or not as yet, regarded academically.

Certificates can indicate whether a candidate is likely to be competent to undertake the next stage of training or study. The national standing of the current external examination system means that the same set of examination results can be used for matriculation requirements, for entrance to professional bodies, and for the use of employers.

It is not always necessary for a pupil to remember at a later stage what he has learnt for an examination. Preparation of this kind furnishes a pupil with the ability to learn up a subject long enough to apply it to a specific purpose; to be able to do this is useful in many professions such as that of a lawyer, journalist, administrator etc.

# d) as a means of selection

Examination results are often used as an administrative device for purposes of selection. In the past, they were used to determine which schools would receive government grants and how much would be awarded. Nowadays, they are often used as a basis for awarding scholarships or bursaries. In this case, and also in the fields of industry and commerce, the number of qualified people frequently exceeds the number of places available and so a selection has to be made. This may be by use of external

examination results, but sometimes there is little to choose between a field of applicants, and then a more specific type of examination is necessary. Such an examination must put top candidates into rank order and avoid 'bunching' at the top end of the scale.

e) as a prognosis

Examinations which are used for selection purposes are assumed to have a predictive value, proficiency at a given level being taken to indicate probable success later. As regards university places, matriculation results (0-level and A-level) are assumed to give a good indication of what will be accomplished in finals. However, in the past, success in the 11+ examination which selected pupils for the more academic courses of the grammar schools, did not correlate so well with 0-level passes, and a significant number of 11+ 'failures', who were directed towards the more practical courses of the secondary modern schools, achieved noteworthy academic qualifications later. This non-agreement of these two sets of results was one reason for the abolition of the selection examination at 10-11 years.

## f) as a means of social control

The national recognition of external examinations allows selection processes to appear to be fair. Qualifications obtained in this way provide the opportunity for children from poor backgrounds to move up the social ladder. All social systems have their disadvantages; in some the poor are discriminated against, whereas in a system which encourages promotion by merit, it is the unqualified who feel frustrated. External examinations have only appeared to be a fair means of selection because it is possible, by restricting the number and type of schools available, and by manipulation of the curriculum, to ensure that only a limited number will learn what is necessary to achieve success in this way.

## 2.3 The disadvantages of examinations

The case against examinations was expressed clearly and concisely in the Report of the Norwood Committee in 1941 ( ). Since then any criticism of the examination system has tended to be only a reiteration of points made at that time. The most common objection is that examinations and their syllabuses not only influence the curriculum but dominate and restrict it. Teachers are not encouraged to follow up lines of thought as they occur and they become reluctant to experiment with new ideas, preferring to stay with methods which are known to produce good results. The prospect of increasing examination passes provides the temptation to concentrate on examinable techniques, ignoring the importance of other attributes.

The Norwood Committee also felt that the goal of working for an examination was an undesirable one, and that schools should find more appropriate ways of motivating their pupils. They commented on the unsuitability of the current examination system for the vast majority of pupils, but acknowledged the very real danger of children being pressurised into such examinations by their parents' wishes that they hold a meritorious certificate, by the need for qualifications for job prospects or college entrance, and by schools pitting themselves in unofficial competition with other schools (43). Most of these criticisms could still be levied at the current dual O-level/CSE system.

Increasingly, there is concern that many examinations are little better than a test of a good memory, emphasising as they do recall of knowledge in a fairly stereotyped form. They encourage a passive type of mind and do not encourage pupils to think for themselves. This situation is improving as different examining techniques are developed, but it is still true that current examination procedures rarely allow room for creativity or initiative (53).

# 2.4 Why not abolish 16+ examinations altogether?

Examinations form an essential constituent of our educational

system. Fraser and Gillan state that "for education to be effective, teaching objectives must be defined. Learning experiences must be provided to achieve these objectives, and examinations are part of the process that determines the extent to which the objectives are being attained". (15).

Also, our society is supposed to be based on promotion according to merit. It requires that people provide some indication of their ability to do a given job or to follow a specified course. If the public examination system were abolished, there would undoubtedly be a return to the situation where each profession held its own qualifying examinations, and each firm, college and university set its own selection examinations. The advantages of a commonly recognised and nationally valid system are apparent as it avoids this multiplicity of testing and reduces the time that any one candidate is involved in sitting papers.

# 2.5 Success and failure

Apart from reflecting the background knowledge of a candidate, examination qualifications provide an indication of the type of personality who works well under pressure. This is not necessarily an indication of consistent effort, and sometimes stress times are the only times when certain people will work. When once the threat of examinations or other types of deadline is removed, those people may be comparatively unproductive workers ( 6). Conscientious people with a steady outflow of work have a valuable contribution to make, but these are not always successful examinees. Nervous candidates are often poor examinees but may be fruitful and diligent workers.

A poor examination result does not provide a distinction between candidates who fail to find a solution to a problem in a given time, and so abandon the task altogether, and those who would persist until an answer was found. Obviously, the latter type of person would be preferred in almost any employment. The limited time available in an examination can also work to a

candidate's advantage, as it necessarily restricts the length of answer, discourages repetition and encourages succinctness and a careful marshalling of facts; this might not occur in other circumstances.

Success tends to be more acceptable when only relatively few candidates have been entered, for example, in Associated Board music examinations or in University scholarship examinations. Where there is a sizeable entry, the disappointment of the large numbers who fail tarnishes the pleasure of success for those who pass. This mass failure was the strongest reason for the abolition of the 11+ examination. It has been argued that if 80% of the population had 'passed' and proceded to grammar schools, then comprehensive schools would never have been introduced, but the given situation where between 12% to 25% only of the 10 year-old population passed, the majority being labelled 'failures', was found to be increasingly unacceptable.

Similarly, in the GCE Ordinary level examinations, attempted by approximately half the population, the large numbers of failures (about 40% of candidates for each subject), led to the abolition of the pass/fail system and its replacement with a grading system where the top three of the six grades correspond to the previous concept of pass.

Obviously, failure destroys morale, and repeated failure can have devastating effects, causing loss of self-confidence and dulling a candidate's appetite for both the subject concerned and any other subject or course of training culminating in an examination. Most teachers try to prevent a candidate from being repeatedly disappointed, and many of the legislations governing the eligibility of entry to examinations are designed to protect candidates from this kind of discouragement.

In the past, 60% of schoolchildren were rejected three times over; they 'failed' the ll+, they failed to be entered for O-levels or a comprehensive spread of CSE subjects, and consequently, they failed to be selected for the top professions and better paid jobs. Repeated rejection results in behaviour problems and a feeling of worthlessness. The ending of 11+ examinations removed the

first rejection, and it is one of the aims of the new 16+ examination to remove the second.

## 2.6 The determination of standards

Basically, there are two ways of establishing the standards of an examination:

- (a) norm-referencing where standards are fixed in terms of relative standing
- (b) criterion-referencing where standards are fixed in terms of performance.

Which is most appropriate depends on the purpose for which the examination is to be used. The differences between these two systems have been examined in some detail in recent years as a result of the concern about labelling large numbers of the population as 'failures' (47).

## Norm-referencing:

When norm-referencing is used as the basis for establishing standards, each candidate's performance is assessed relative to the others in his group. The emphasis is placed on whether this candidate shows more skill or greater depth of understanding than the others, and because it is the difference between candidates which is important in this system, norm-referenced examinations are designed to maximise the differences (32). It is assumed that the distribution of scores obtained by candidates entered for any given examination is a normal one with the greatest number of scores falling around the centre and spreading to either side. The group as a whole is assessed relative to external groups, usually previous years entrants, as it is taken that there will be little variation from year to year. Any variation is regarded as an indication that the papers were either too hard or too easy and appropriate adjustments are made. This means that in any group there will be approximately the same proportion of failures, irrespective of whether it is a particularly good or a particularly bad group (18).

Thyne (47) justifies this method of establishing standards as follows: a mark on its own is meaningless. In order to give any indication of its value some kind of comparison must be For example, the mark could be compared with the possible made. total, say 60 out of 100 or 60 out of 150. In this case, the first mark would seem to be better than the second. However, this again is meaningless if the degree of difficulty of the paper is not known. A score of 60% is more creditable on a more difficult paper. Also, as the difficulty of an examination increases, the marks as a whole go down. Therefore, on a more difficult examination, 60% would appear in a higher position in an ordered list. This indicates that it is the standing of a particular mark which reflects its merit.

Ranking is one possible way of showing the relative merit of a mark, but there are two major problems associated with this The first is that entry numbers vary, so how could a method. distinction be made between the candidate who is nineteenth out of twenty candidates, and the one who is nineteenth out of ninety candidates. The second problem occurs with tied marks. For example, where a candidate obtains the second highest mark but has four candidates tied above him on the highest mark, is that candidate to be regarded as second or fifth? There are other disadvantages also. The ranking procedure takes time particularly where large numbers of candidates are involved; it does not differentiate between candidates who are only just first, for example, and those who are first by a large margin; it does not provide an easy way of comparing a particular candidate's performance in different subjects where the entry numbers vary greatly. (Is 14th out of 51 a better achievement than 34th out of 85?)

A more meaningful picture of any one candidate's performance can be obtained if, instead of considering ranks, comparison is made with the medians and quartiles of the distribution. However, this provides only three reference points and so is considered to be a rather coarse measure. A more precise positioning of a

candidate's mark can be made if percentiles are used and the distribution is divided into hundredths. Thus the 10th percentile is ten hundredths up the distribution, and the 25th percentile corresponds to the lower quartile etc. Quotation of five particular percentiles, say the 90th, 75th, 50th, 25th and 10th percentiles is equivalent to giving results on a six grade system. These representative percentiles are then scaled so that they have the same numerical value in each distribution. This allows direct comparison to be made between subjects. It is true that this method assumes that a group performs equally well in all subjects, but on the other hand, there is no justification for assuming that the group will do better in some subjects than in others.

Once the percentiles have been scaled, the pass mark is set at a particular percentile, often about the fourtieth. This gives rise to one of the major criticisms of this system, which is that there will necessarily be a large proportion of failures (40% in this case). It also introduces the difficulty of drawing a pass/fail line just where candidates are very thickly clustered. A second criticism of this system is that it takes no account of how good the group is, and so the system is open to abuse. Schools have been known to enter large numbers of candidates in order to boost up the chances of their better pupils.

Finally, a candidate's position in a group does not give any indication about what he can do, or at what level he is performing in absolute terms (47).

#### Criterion-referencing:

In this system of establishing standards, a candidate is measured against the level of his own performance, and there is no inter-candidate competition. Essentially, a criterion-referenced examination is a test of mastery of skills. Candidates are required to perform a given task or tasks at a specified minimum level of proficiency as, for example, in music examinations and driving tests (32). It is theoretically possible for everyone to pass

this type of examination as their performance is in no way affected by any other candidate. Equally, all candidates might fail if even the top candidate did not reach a level deemed to be satisfactory. However, such a system does provide every candidate with the chance of success, and it also has the advantage of telling more precisely users of the system, such as employers, what level of performance they can expect from the holders of such a qualification. "Tests are intended to provide information about specific knowledge and skills of examinees and yield scores interpretable in terms of tasks or performances". (32). However, a candidate who only just passes a criterion-referenced examination is not distinguished in any way from one who had a much higher standard. This type of comparison is norm-referencing, not criterion-referencing.

Criterion-referencing necessitates the predetermination of standards. It is essential that the level of performance which is deemed to be satisfactory must be clearly defined. The specifications should state exactly what any pupil is expected to do, in what circumstances (oral, practical, open book examinations etc.) and at what level of proficiency he is expected to perform. What level this is depends on the purpose of the examination, and also on the consequences for not reaching the required standard. For example, if a standard were set such that any candidate failing to attain it would be prohibited from proceding to a course at a higher level, the underlying reason for this should be that such a candidate would not gain any benefit from study of a more advanced nature. Exactly how many criteria are defined depends on the number of uses to which the results are going to be put and on the number of crucial levels of performance (47).

Criterion tests are particularly useful in subjects with a hierarchical structure, for example mathematics and foreign languages, in order to ensure readiness for the next stage. They are essential tests of competence in certain areas of study, e.g. surgery, aviation, motoring skills. They also provide valuable feedbacks about the level of proficiency of a student. However, norm-referenced tests are more useful for purposes of discrimination e.g. awards and scholarships, university entrance.

No criterion-referenced examination can be better than the specification of the criteria and therefore these need to be well planned and carefully thought out. Also, no examination of any kind is perfectly valid as regards consistency of marking, and since there is no scaling in a criterion-referenced examination it is imperative that every possible action be taken to ensure that the examination is as valid as possible. Where differences in scores are significant then the exact nature of these differences should have been explicitly stated at the beginning.

With criterion-referenced examinations there is little that can be said about a candidate's relative performance in different subjects, whereas with norm-referenced examinations, a system can be devised to scale percentiles and hence achieve a satisfactory method of comparison of standards between subjects. In a criterion-referenced system, a candidate entered for two subjects would either succeed in satisfying the criteria in both subjects, or fail in both, or pass in one and not the other. In the case of two passes it is not really feasible to say which performance was the better one. To attempt to do so would be a return to norm-referencing.

It is proposed that the new 16+ examination be criterionreferenced whereas the present dual GCE and CSE system is normreferenced. However, it remains to be seen to what extent normreferencing may be implicitly or explicitly applied by readjustment of criteria.

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The need for a unified system

# 3.1 The call for a single system of examining

As early as 1964, the SSEC constituted a Committee the terms of reference of which were: "To consider the future relationship between the examinations for the Ordinary level of the GCE and for the CSE and to make recommendations..." (37). When the Schools Council was established, taking over the work of the SSEC, it authorised the Committee to continue its investigation. As a result, Schools Council Examinations Bulletin No. 23 was published in 1971; it recommended that a variety of feasibility and development studies be carried out before any far-reaching changes were introduced.

Consortia of joint GCE/CSE boards were formed, and developed syllabuses and examinations deemed to be suitable for the top 60% of the ability range i.e. all those normally entered for GCE and CSE. Not all subjects were considered, but those that were covered, were very diverse. They included essential subjects such as English Language and Mathematics, both of which are normally taken by a larger percentage of the population, but the consortia's studies excluded minority subjects such as physical science, taken mainly by abler candidates.

Experimental examinations continued from 1972 to 1977, with the separate consortia working along very different lines. These years produced a wealth of evidence for the Waddell Committee, whose report in July 1978 stated that a common system of examining was both "feasible and desirable" on educational and administrative grounds (49).

# 3.2 The disadvantages of a dual system

A dual system of examinations is divisive, and whilst it might have been more justifiable when grammar schools and secondary modern schools were in operation, it cannot be justified in a system of comprehensive education. The 1966 Joint GCE/CSE Committee commented, "There are now two separate

systems of examining the educational attainment of pupils aged about 16. Yet the distribution of attainment is continuous..." (37). There is no natural division in a continuous distribution so the problem of selecting a CSE or GCE course for a pupil is often a difficult one. Because the GCE examination caters for the top 20% of the ability range, CSE qualifications are regarded as inferior, and for this reason, even when CSE is clearly the most appropriate course for a pupil, teachers can meet with opposition from both the pupil and his/her parents.

The role of examinations has changed since the CSE system was devised. The raising of the school-leaving age to sixteen years means that almost all pupils stay at school until the summer term of the fifth year when they take what has become, for the majority, a school-leaving certificate. In view of this change in function, the Governing Council of the Schools Council suggested the time was right for a complete reappraisal (35). There are now eight O-level examining boards and a further fourteen regional CSE Boards, each providing their own choice of syllabuses and papers, in addition to a choice of mode. Many very different syllabuses exist under the same title, and conversely, some virtually identical courses have dissimilar titles. The wide choice causes confusion, particularly among infrequent users of examination qualifications.

In many cases, O-level and CSE courses for the same subject are widely divergent, and where schools offer both courses, a choice has to be made usually at the end of the third year of secondary education, too early to predict accurately the development of some pupils. In areas where middle schools operate, this choice comes almost immediately after transfer to the secondary school, and at a time when staff have had little opportunity to become cognizant of their pupils' abilities. Once committed to a particular type of course a pupil cannot easily transfer to the other type should he later seem more suited. This divergence also means that groups usually have to be taught separately, and with falling rolls in schools, this can be very uneconomic, wasteful of both teachers and resources, and resulting in small

numbers in each group. It also forces schools which might prefer to implement a mixed-ability policy, into a setting or streaming situation (35).

Entering pupils for two types of examination involves schools with at least two examining boards, and doubles the entry fee for candidates taking some O-level and some CSE examinations. Borderline candidates are sometimes entered for both types of examination which places a heavy burden of work on them and puts them through the stress of sitting many papers. This practice is less frequent now that a five-scale grading system is in operation for O-level certificates. The top three of these are deemed to be a pass, leaving two grades indicating the level of achievement of candidates who fail. Previously, a candidate who attempted O-level but failed was worse off than a candidate who had followed a CSE course.

With two totally different examination systems in existence, there is the problem of comparability of standards. Results have to be measured on the same scale both because the two populations overlap in ability, and because the definition of a Grade 1 CSE qualification equates it to a pass at Ordinary level. This in itself makes a Grade 1 more desirable, increases pressure on staff and pupils, and makes candidates attaining Grades 2-5 feel that they have failed.

The disruption to the normal timetable in the summer term goes on for an extended period with the non-simultaneous operation of a dual system, and as CSE candidates are usually examined before GCE candidates in comparison they have lost about four to five weeks' teaching time (29).

3.3 The benefits of a common system

The Waddell report emphasised that a common system of examining does not imply a common examination. It defined a common system of examining to be:

(i) common papers taken by all candidates;

- (ii) common papers taken by all candidates, but containing questions designed to present different degrees of difficulty (for example, structured questions which all candidates are expected to attempt and which have a built-in "incline of difficulty");
- (iii) common papers taken by all candidates, but containing questions/part-questions with stated different mark weightings (tariff questions) which involve choice of question on the part of the candidate;
- (iv) a common paper taken by all candidates, plus alternative papers reflecting different approaches to the subject and/or different forms of assessment, but which are not intended to be at varying levels of difficulty. Candidates can attain the highest grades whichever papers they choose;
- (v): a common paper taken by all candidates, plus alternative papers which are intended to be at varying levels of difficulty. If the candidate chooses an easier alternative paper he cannot normally attain the highest grades."

The Committee emphasised that, in many subjects, alternative papers would be needed to cover the whole ability range. It recommended that a central coordinating body be set up to oversee the writing of national criteria for syllabuses, examinations and assessment in order to ensure comparability of standards between boards. This would both remove the multiplicity of examinations, titles and syllabuses, and therefore remove much of the confusion that exists amongst users, and also increase the confidence of the public in the system.(35).

The common system would be a more acceptable means of recording achievement as it is in accordance with comprehensive educational principles, and it would remove the inferior status of CSE. It would eliminate all the other disadvantages mentioned above, and it would provide an opportunity for a re-think about assessment practices, and a chance to eliminate any undesirable

characteristics of the present system (29).

The Waddell Committee anticipated no opposition from CSE Boards who would lose their second-rate status, but expected a certain amount of protest from the GCE Boards. However, the University of Cambridge Local Examinations Syndicate, a GCE examining board, expressed the view that GCE examinations had too much prestige and their abolition would "reduce the importance of examinations in the public eye" (48). The Syndicate was not without reservations, however, and expressed concern about the operation of different modes and the difficulties of ensuring comparability between modes. The Waddell Report expressed the view that "Public confidence in comparability and standards will be reinforced by the knowledge that all groups of boards are applying the same criteria, agreed with a central coordinating body, to all their syllabuses and assessment and moderation procedures" (17).

# 3.4 Feasibility studies in Mathematics

The Waddell Committee reported on the feasibility studies conducted between 1972 and 1977, and their findings are summarised in this section. The range of ability for a common system of examining is greater in mathematics than in most other subjects; because of the importance of the subject and the frequency with which employers ask for a qualification in the subject, 72% of the population enter for mathematics examinations. A particularly wide syllabus and varied methods of assessment were found to be needed to cope with this extended ability range.

Eight consortia offered feasibility studies in Mathematics as shown in the table overleaf.

Schemes 6 and 8 were non-operational, and scheme 7 offered only a Mode II examination. Details of the other schemes are included in Appendix A (50).

(a) Introductory comment:

The syllabuses provided for these studies mostly lacked

			Numb	per of o	candidat	tes	
Сот	nsortium	1972	1973	1974	1975	1976	1977
1.	WJEC Scheme I) Scheme II	-	789	869	1182	4509	9120
2.	London/SEREB	-	-	1127	1182	-	-
3.	JMB/ALSEB/NWREB						
	later						
	JMB/ALSEB/YREB/ TWYLREB	-	-	3213	3053	6052	8643
4.	AEB/Middlesex	-	-	2234	2809	2930	3167
5.	Cambridge/EAEB	-	1023	1691	2431	2366	6166
6.	Oxford and						
	Cambridge/SREB	-	-	514	276	-	-
7.	SWEB/Cambridge	-	-	304	308	286	345
8.	EMREB )	155	-	311	-	-	-
	)	252	-	235	-	-	-

detail. All included a general statement of aims and a list of material to be covered. However, the depth to which topics were to be studied could only be ascertained by reference to specimen papers initially, together with past papers in the later years of the study. None of the syllabuses particularly encouraged investigational work.

#### (b) Ability:

Candidates entered for the experimental examinations were checked for ability by using the NFER scholastic aptitude tests, and they were found, in some cases, to be a poor representation of the required ability range. Schemes 3 and 4 had many candidates below the 40th percentile, whereas scheme 6 did not have enough less able candidates. Only borderline candidates had been entered for scheme 5.

(c) Syllabuses:

Syllabuses 1 and 3 were basically traditional whereas

syllabus 5 was fundamentally modern in its content, and none of these schemes attracted a wide enough cross-section of schools. Scheme 5 was also criticised as being an inadequate preparation for A-level, the syllabus lacking depth and the examination questions being undemanding.

The syllabus offered in scheme 2 was found to be a good blend of traditional and modern concepts, providing an improved basis for A-level work. The Committee also felt that schemes 1, 3 and 4 were a good foundation for further study. ³Of these, schemes 1 and 4 required that all pupils cover the whole syllabus. This was considered to be unsatisfactory in the case of less able candidates as it placed a heavy work load on them and forced them to study topics the underlying concepts of which were beyond their grasp.

(d) Examinations:

Those schemes which offered only a common paper were found to be totally unsatisfactory. It is very discouraging, and educationally undesirable, for less able candidates to be faced with large numbers of questions they cannot attempt. Equally, it is tedious for an able candidate to work through a mass of easy questions before reaching more demanding ones. No common paper was found to be fair to the extreme ends of the ability range.

The three schemes which worked well enough to be considered as a basis for a possible solution were:

- (i) three papers of increasing difficulty with candidates taking any consecutive two papers
- (ii) two compulsory papers with an optional harder third paper and compulsory coursework assessment for all
- (iii) two compulsory papers, with a choice between a more demanding third paper or internal assessment of coursework.

Scheme 3 issued formulae sheets which the Committee considered to be helpful, and schemes 2 and 4 quoted formulae in the questions

where they were required.

Objective tests were used in schemes 2, 3 and 4. The Committee felt that these not only gave good syllabus coverage but also provided less able candidates who experience reading and writing difficulties, with a fairer chance to show what they could do. Short answer questions were also considered to have the same advantage.

## (e) Comparability:

Where candidates were assessed by different means, either coursework as opposed to a written paper, or where two papers from three were taken, problems arose as to how to equate standards of grades. In the latter case, the two populations were graded independently and then compared by means of the common paper.

# (f) Coursework:

Topic work was included in schemes 6 and 7, and coursework was compulsory in scheme 2 but an optional alternative to a third paper in scheme 3. This scheme was commended for the provision of detailed guidance to teachers as regards possible study topics, supervision of pupils, time allocation, presentation of work, records and assessment.

Despite a number of criticisms, the Waddell Committee felt that the studies had demonstrated the feasibility of a common examining system for mathematics. Common papers were not regarded as satisfactory. The most appropriate scheme seemed to be one of differentiated papers which include a more difficult paper based on an extended syllabus for the most able (50).

#### 3.5 Conclusion

Similar feasibility studies were conducted for other subjects with the result that in its Report dated July 1978, the Waddell Committee recommended the introduction of a common examining system for all subjects. It advocated that the new system be

introduced without delay to bring to an end the years of speculation and uncertainty. There followed a Government White Paper (17) accepting the recommendations of the Committee, and in October 1978, it was announced that a single system of examining to be known as the General Certificate of Secondary Education (GCSE) would be introduced with effect in 1988.



#### 4.1 General outline

Courses leading to the GCSE are expected to be introduced into schools in September 1986, with the first examinations being held in the summer of 1988. O-level and CSE examinations will be held for the last time in 1987. The GCSE is to be a single-subject examination operated by five examining groups in England and Wales, and schools will be free to choose to enter candidates with any of the groups. (See Appendix G). Each group is required to offer a full range of subjects.

> All syllabuses, assessment and grading procedures are to be based upon nationally agreed criteria, which will ensure that syllabuses with the same title have sufficient core content in common to justify identical nomenclature, and that all groups award the same grade for the same level of performance. Syllabuses may be offered in three different modes:

- Mode 1 Syllabuses set and examinations conducted by the Examining Boards, except for assessment of coursework and practical and oral examinations.
- Mode 2 Syllabuses designed by the school and assessed by the Boards.
- Mode 3 Syllabuses designed and assessed by schools and moderated by the Boards.

Certificates recording grades will be of a common form and issued by each examining group rather than by individual boards. Initially, grades will be norm-referenced on a seven-point scale equivalent to Grades A, B, C of GCE and Grades 2-5 of CSE, as shown below:

2 C		
GCE O-level	GCSE	CSE
А	A	Π
В	В	1
С	С	
D	D	2
Е	E.	3
	F	. 4
	G	5

The system has no pass/fail grades, but any candidate failing to produce sufficient evidence to be assessed will be ungraded and this subject will not be recorded on a certificate. This is different for candidates who previously would have been deemed to fail but yet whose performance may have been classifiable.

Grade descriptions for grades C and F are currently available and these give an indication of the skills that are likely to have been attained by a candidate with this qualification. Eventually, criteria will be clearly defined and agreed as a basis for awarding grades, after which grades will indicate with certainty what level of skills has been achieved. The top grades of GCSE will require a performance not less exacting than O-level. However, in some ways, this may be more demanding, as previously a poor performance in one area could be compensated for, to a certain extent, by an excellent performance in another area. With criterion-referencing a candidates grade is determined by the simplest task at which he fails irrespective of success at a more complex level.

There is to be no minimum or maximum age of entry, but the GCSE is aimed primarily at those who are completing the fifth year of their secondary education. Whilst norm-referencing is still in operation, the target group for the examination is to be the top 60% of the ability range, i.e. those pupils currently catered for by the GCE/CSE system. Once the examinations are criterion-referenced, it is envisaged that this will allow the target group to cover a greater ability range, as any candidate who feels they have reached the required standard for a given subject may enter.

The national criteria will provide a basis for continuous checks in whether the examination system is promoting or distorting its own aims, and these should also make easier the work of the SEC in monitoring standards between groups. It is believed that public confidence in the system will be maintained by the inclusion of at least one GCE and CSE board in each examining group and by
the fact that all groups will be operating in accordance with the national criteria. (9)(11).

#### 4.2 Aims and objectives

By introducing the GCSE, the Government aims "to improve the quality of education and to raise standards of attainment by stretching and stimulating pupils throughout the ability range." (Reference 9 page 2 para 5). It is hoped that ultimately at least 80-90% of the population will attain a level equivalent to the current grade 4 CSE, which is held to be the standard of an average pupil. The emphasis for each subject criteria has been 'fitness for purpose'. This is felt to be the key to increased motivation in schools, and the introduction of graderelated criteria and the abolition of norm-referencing is expected to provide further stimulus. However, it is debatable whether improved motivation and/or more highly trained teachers could raise such a proportion of candidates to a level previously considered to be average; attainment is also limited by intelligence and aptitude. There may be exceptional cases where pupils from the 10th-20th percentiles reach the specified standard, as for instance in art, where the degree of success bears little or no correlation to general academic achievement, but it seems unlikely that such an extraordinary improvement would become the general rule.

## 4.3 Differentiation of assessment and syllabuses

In many subjects, differentiated syllabuses to cater for the spread of the ability range are thought to be advisable in order to offer pupils the chance to demonstrate their potential ability in that field. Too restricted a curriculum would be boring, unchallenging and lack interest for an able student; too demanding a syllabus would discourage less able candidates. Some subjects such as English lend themselves to treatment of the same topic at different depths, but other subjects, particularly those with a

linear development such as Mathematics, would offer more to all candidates by including an extended syllabus of greater size and complexity. In fact, such a syllabus has been stipulated for Mathematics, with the lower levels constrained in terms of syllabus content and complexity. The differing syllabus content overcomes some problems as regards the varying abilities of candidates, but both re-introduces a dilemma for schools who do not wish to pursue a streaming or setting policy, and for those who do, increases the difficulties associated with movement of pupils between sets or streams.

In "A General Introduction' (Reference 9 Page 1) it states that "differentiated assessment techniques would be used in all subjects so as to enable all candidates to demonstrate what they know, understand and can do". Two difficulties arise in assessment. If the problems posed are too easy, the outcome is not valued, the assessment is unsatisfying and candidates may be distinguished one from another by careless mistakes. If the problems posed are too hard, the candidates may be overwhelmed by the amount they are unable to do, the assessment becomes a depressing experience which might encourage wild guessing and perhaps result in the bunching together of candidates at the bottom end.

Differentiated assessment alleviates these problems and may be achieved in a number of ways:

(a) Differentiated by outcome (41)

In subjects such as English, a well thought-out stimulus can result in creative writing whatever level of ability the candidate possesses.

(b) Structured questions (41)

The question is usually divided into sections and each part is written in such a way as to guide the candidate through the question. The main criticism is that this discourages alternative approaches and stereotypes the answers. Abler candidates can feel frustrated by their lack of freedom to choose an appropriate method, and are also denied the opportunity of demonstrating their powers of analysis. It is usually intended that the parts of the question

be arranged in order of increasing difficulty. Experience suggests that the candidate's notion of order of difficulty can vary considerably from the examiner's view.

(c) Stepped papers (41)

In this case, the questions are intended to be arranged in order of difficulty throughout the paper, and frequently use is made of tariff questions, in which the marks allotted to the question are printed alongside it. Candidates are free to make their own choice of questions, the idea being that less able candidates will select the easy questions, average candidates those of greater difficulty, and able candidates the most demanding ones. However, limited candidates frequently over-reach themselves by attempting questions which are beyond them, whilst able candidates sometimes play safe in an examination situation and select easier questions which do not truly reflect the extent of either their knowledge or aptitude.

## (d) Differentiated papers (41)

Here papers are arranged in an incline of increasing difficulty; the differentiation between the papers includes not only content and the structure of the question, but language, pace and complexity (14).

Such a scheme has been stipulated for Mathematics and no common paper may be set covering the whole of the ability range. It has also been specified that at least three levels of assessment must be provided in mathematics. Candidates taking the easier papers will not be able to attain the highest grades which will only be available to those candidates who tackled the most demanding papers. This scheme leads to problems of comparison of standards. A candidate who takes the highest papers may do badly, and the question then arises of how to compare a poor performance on a demanding paper with a better performance on an easier paper.

#### 4.4. Grade descriptions

The national criteria include in each of the twenty subjectspecific criteria, grade descriptions of the level of attainment

that it would be reasonable to expect from a candidate achieving grade C or grade F. These grades have been selected because they are intended to be equivalent to the current 0-level pass and CSE grade 4 respectively. A grade description differs from grade-related criteria in that it is indicative of the likely level of attainment of the candidates as opposed to an absolute specification of mastery of minimum skills and knowledge. The joint Council formed by the JMB and Schools Council, and aided by other agencies, found that their attempts to elicit, from existing joint 16+ papers, identifying factors upon which to base grade descriptions lacked clear definition by being both uninformative and imprecise; they also tended to be couched in negative terms, and contrasted with total mastery of concepts. This latter difficulty seems to have been overcome, and the descriptions included in the national criteria are expressed in positive terms of increased attainment in progressing from lower to higher grades. However, some subjects are undoubtedly more nebulous and less informative than others, but obviously it is more difficult to describe clearly certain attributes such as creativity, imagination or powers of analysis.

The problem of merging existing O-level and CSE grades into a single system has been overcome to a certain extent by the inclusion of the descriptions in the national criteria, and this also goes part-way towards solving the problem of maintenance of standards. However, it could be argued that a new system of examining would have benefited from a new grading structure rather than a perpetuity of the old, and any existing disparity as regards comparability of standards between subjects will have been maintained rather than eradicated.

The grade descriptions obviously cannot have been based on a system which has yet to come into existence, and therefore experience of consideration of borderline candidates in the current system has been combined with an idealisation of what the standard ought to be. Grade descriptions were hoped to be a stepping-stone towards the publication of grade-related criteria which would incorporate absolute definitions of the performance required in

terms of skills and knowledge for attainment of each of the seven grades. It is clear that the current descriptions are far from this objective, and it may be that a restructuring of the entire assessment system will be needed ultimately. It is perhaps for this reason that publication of such criteria has been postponed to an undisclosed date.

4.5 Comparability

The School Council's first occasional paper produced by the Forum of Comparability says on page 17 'if it were possible to create nationally agreed grade definitions in terms of standards of work this would, while involving very considerable difficulty, be likely to illuminate the problems of comparability'. This is what the eventual introduction of grade-related criteria will hope to do.

Emphasis is placed on comparability in an attempt to be fair to all candidates, especially when such candidates may ultimately be in competition. Comparability problems occur in four main areas:

- (a) comparability between examining boards
- (b) comparability between alternative syllabuses for the same subject (or Modes 1 and 11)
- (c) comparability from year to year
- (d) comparability between subjects

The latter instance is of little importance as there is evidence to show that candidates with qualifications in different subjects are rarely in competition with one another; those who compete are likely to have followed very similar courses. The equivalence of grades in different subjects is only important when subjects are taken as a general level of academic attainment, and this is comparatively rare. For similar reasons, disparity of standards between years ceases to matter the further apart those years are, and is only of significance when the years are close together; in



this case, standards are likely to be maintained by the presence of experienced examiners.

The existence of national criteria will help to eradicate problems of comparability between boards and alternative forms of the same subject, by restricting the curriculum by stipulating the possession of certain skills for the attainment of grades, by itemizing common aims and objectives, and by the imposition of specified assessment procedures. Moderators at present experience great difficulty in making consistent decisions about relative performances of candidates who have followed alternative syllabuses supposedly to the same level. The national criteria should greatly ease the problems concerning comparability.

# 4.6 Distinction and Merit Certificates (10)

Distinction and Merit certificates have been proposed for candidates who have high levels of attainment in a range of subjects within a specified framework. The demand for such certificates increases once again the pressure for comparability between subjects, since the basis for awarding such certificates will be that any particular grade will indicate the same level of performance in any subject. Forrest and Shoesmith (14) came to the conclusion that cross-moderation procedures would seem to provide the solution, and they saw no difficulty in adapting existing procedures to the GCSE.

The aim of Distinction and Merit certificates will be to encourage the ablest pupils to achieve their best grades, and to induce them to undertake to study a wide and well-balanced combination of subjects. This has the added advantage of discouraging premature specialisation.

It is expected that subjects will be arranged in groups, rather similar to the days of the School Certificate, but in a less rigid system. However, the publication of the precise details of such groupings has been indefinitely postponed.

The proposal most likely to be adopted for the Distinction

Certificate groups the subjects as follows:

- 1. Mathematics
- 2. English
- 3. A science
- 4. A modern language
- 5. One from (a) History
  - (b) Geography
- 6. One from (a) CDT (Craft, Design and Technology)
  - (b) Home Economics
  - (c) Art and Design
  - (d) Music
- 7. One from (a) another science
  - (b) another modern language
  - (c) the other subject in group 5
  - (d) another subject in group 6
  - (e) English Literature
  - (f) Welsh (first language)
  - (g) Religious Studies
  - (h) Classical subjects
  - (i) Additional Mathematics
  - (j) Economics or Business Studies or Social Studies
  - (k) Computer Studies

It is likely that the requirements for the certificate will be:

- (a) that a candidate studies a subject from each of the seven groups listed, and attains a minimum of grade C in all seven subject areas.
- (b) that the grades of the candidate include at least two grades A.
- (c) that there is not more than one grade C in the set of seven results.

There are, in addition, certain alternatives offered for candidates with Welsh as their first language. This also applies to the Merit Certificate. The Merit Certificate is also intended to be a stimulus to able candidates, but will be less demanding. At present there are two equally favoured proposals for this award. Scheme A:

The subjects are grouped into only six categories as in the preceding grouping except for the omission of group 4, and of Additional Mathematics in group 7. A candidate will be required to study a subject from each of the six groups, and to attain a minimum of grade C in all six subject areas. Scheme B:

The subjects are grouped in the same seven categories as for the Distinction Certificate, but the grade requirements are less demanding.

Since candidates may be entered through different examining groups, application for a Distinction or Merit certificate probably will have to be made by the candidate, or on the candidate's behalf, to the group through which he has taken most subjects, and such an application would have to be accompanied by evidence of successes with other groups.

There is no suggestion that all grades which would aggregate to either of these certificates, need be gained at one sitting, unlike the days of the School Certificate, so an able candidate may still take some subjects early, or alternatively, have a second attempt to attain a required grade in a weaker subject.

It is expected that these Certificates, when introduced, will have a significant effect on the present curriculum in schools, as few pupils presently qualifying would meet these requirements. A survey was conducted in 1982, and the results were analysed, firstly imposing the structure of the subject areas, and secondly, without this restriction, because candidates in 1982 had not been influenced in their choices by the existence of such a scheme. The results are shown in the table below:

·	Imposing subject area requirements	Ignoring subject area requirements
Distinction Certificate	17	3%
Merit Certificate (6 subjects)	7%	22%
Merit Certificate (7 subjects)	4%	20%

The survey also found that candidates who are likely to attain Distinction or Merit certificates at present opt to follow at least eight different courses of study. The Secretary of the State for Education and Science and the Secretary of State for Wales do not wish to discourage this, particularly as, for example, extra sciences or modern languages are often taken as a preparation for A-level, and so it is unlikely that an upper limit on subject entries will be imposed. However, it is generally agreed that there is no point in encouraging pupils to undertake an excessive number of subjects, and so it is expected that no more than seven will be required.

When subject grouping existed in the days of the School Certificate, about one-third of candidates failing to gain the Certificate, did so by falling below standard in only one subject. This could well be repeated in the GCSE. The main difficulty for schools could prove to be the provision of adequate materials and facilities for students to study the practical subjects in group 6 of the Distinction Certificate (Group 5 of the Merit Certificate). As CDT is an area of teacher-shortage, and Music and Art and Design demand high levels of inherent talent, this group could well be the downfall of many aspiring high-flyers. Music syllabuses have been drastically altered in order to bring the subject within the grasp of the less scholastic and less talented, but this has caused a furore and there is strong opposition from more academic musicians.

There is quite strong opposition to the general principle of introducing Distinction and Merit certificates on the grounds that they are elitist and divisive, and against the general philosophy of the GCSE.

4.7 Mature Students

There is to be no upper age limit for candidates wishing to enter the GCSE, but in view of the difficulties which will arise with part-time students and the production of coursework, it is intended that special syllabuses will be written in certain subjects,

including Mathematics. Almost certainly these will not be ready in 1988, but should be introduced soon after.

# 4.8 <u>Subject - specific criteria for Mathematics: Aims and</u> <u>Objectives</u>

The educational aims of the GCSE examination in Mathematics are set out in Appendix B. It is a comprehensive list although most of the aims state explicitly the skills which it is hoped a candidate will acquire. There are only two references to any of the pleasure to be derived from the subject. It is not explicitly stated, although it may be implied in 2.12, that part of the function of a mathematics course is to arouse intellectual curiosity. As far as the most able candidates are concerned this must surely be the most important aim of all, and certainly one which ought to be fostered in any budding mathematician. There is no mention either of an appreciation of the power of Mathematics, but perhaps it is only the more advanced school topics such as calculus, vector geometry and sumbolic notation which begin to convey this notion, and these topics would not be studied by most pupils. A number of earlier syllabuses which included statements of aims would concur with the view of the ATM whose first aim is: "to encourage students to enjoy mathematics and to develop positive attitudes towards it.", (4 para 1.1) and the list of aims could be improved, perhaps, by the inclusion of some reference to enjoyment.

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The aims which are listed will ensure that varied techniques of assessment are used; that inter-disciplinary studies are encouraged; and that time will be spend developing practical skills and an aesthetic appreciation of the subject. I believe that the essential structure of the discipline will have been conveyed if all the aims are met, and it will no longer be sufficient to teach only techniques which can be tested in a formal written examination.

The assessment objectives listed in Appendix C, can be seen to be a very comprehensive list. The use of different types of

assessment is ensured. Objective 3.16 makes specific reference to oral tests and mental calculations, and 3.17 refers to coursework of a practical and investigational nature. Objective 3.5 encourages all candidates to become familiar with a calculator and 3.7 encourages the necessary skills for its proper use. The full breadth of skills which individualise mathematics from other subjects seem to be covered in the assessment objectives, but it remains to be seen what weightings are attached to the different objectives by the various examining groups.

# 4.9 Subject - specific criteria for Mathematics: Content

It has been stipulated in the national criteria that there must be a differentiated scheme for mathematics which involves at least three different levels of assessment. Each level will have its own content which must include the 'core' items set out in Lists 1 and 2 of the subject-specific criteria (see Appendix D). Items on List 1 are to be included in all mathematics syllabuses, and are intended to be virtually the whole of the syllabus aimed at candidates who are expected to attain grades E, F or G. List 2 contains additional core items to be included in the syllabus for candidates assessed at the middle level, and with the expectation of achieving grades C, D or E. In my opinion, there are a number of omissions in List 2 which would need to be remedied by the examining groups or the teacher in order to maintain a balanced mathematical curriculum for these candidates.

If a comparison is drawn with a typical O-level syllabus, then Lists 1 and 2 combined are sadly lacking in algebra. There is no mention of simultaneous equations and no suggestion that these could be solved graphically even though the lists include straight line graphs. Inequalities are not mentioned; these are easily understood by grade C candidates if they are developed alongside equations. Difficulties only seem to arise when inequalities are treated as a separate topic at a later date.

Only common factors are mentioned and no other. Whilst quadratic functions are to be studied graphically, and therefore

approximate solutions of quadratic equations could be found by this method, the list lacks sufficient algebra for quadratic equations to be solved by factors. Substitution into formulae and use of square roots are included so that the formula method could be used, but as in many cases, this is a long and inappropriate method, it would seem pointless to study this technique in isolation. The content seems to offer only half of this topic and to have omitted a large portion which would develop manipulative skill and understanding of algebraic techniques.

There is no mention of set theory, although this was included at the basic level in the draft criteria. One can only conclude that teachers themselves have requested its removal as did sixty-eight centres out of nine hundred and eighty corresponding with the Southern Examining Group. Yet set notation and set language provide the basis of expression of all modern mathematics and is fundamental to the development of probability, so its omission must be seen as working against aims 2.2 (the ability to write about mathematics in various ways), 2.8 (the use of mathematics as a means of communication) and 2.15 (the acquisition of a foundation appropriate to further study of mathematics). The use of Venn diagrams to solve problems concerning the relationship of sets, has been found enjoyable by many children. In the absence of the formal proofs of traditional Euclidean geometry, this was also a means of developing logical reasoning, and provided a suitable test of logical development at quite an early age. It seems to be both a retrograde step to remove it and deliberate omission of material which would provide evidence for objective 3.14. One wonders what the ultimate effect on primary schools will These schools now develop most early mathematical concepts in be. terms of sets, viz. the property of membership of a set, relationship between sets, and partitioning. Will primary schools feel that they have developed these early ideas only for them to be abandoned at a later stage?

The geometry content has also been reduced. Formal geometric proofs and straight edge and compass constructions were invariably enjoyed by girls, even by some who did not like any other aspect of

the subject. To a large degree these topics have been deleted from most current O-level syllabuses, but there is a certain amount of compensation there by the inclusion of transformation geometry. This is not so with the GCSE content lists which make no mention of transformation geometry. In the case of this topic, one hundred centres out of nine hundred and eighty responding to a questionnaire sent out by the Southern Examining Group, particularly requested its inclusion, so these requests have been ignored (44).

Also surprising, is the fact that symmetry has not been included. This can provide an interesting and visually attractive topic with relevant applications to everyday life. Even the least able children can, with the aid of tracing paper, produce fascinating patterns and aesthetically pleasing designs once they have understood the concept of symmetry, and have acquired knowledge of reflections, rotations and translations in particular. Would this topic not have been in line with aims 2.11 (appreciation of patterns), and 2.12 (production and appreciation of imaginative and creative work arising from mathematical ideas)? Is there then enough content to allow for objective 3.11 (recognition and use of spatial relationships in two and three dimensions) and 3.8 (use of mathematical instruments and ability to draw accurately)? Use of drawing instruments is included in List 1, but surely this cannot be interpreted as a return to ruler and compass constructions, or can it? Also, in accordance with aim 2.15 (the acquisition of a foundation appropriate to further study of mathematics), work on symmetry should be included as it is essential to the later development of group theory and therefore provides necessary mathematical background for an able child.

There are two curious omissions within the mensuration aspect of the content list. The area of a trapezium is not included. This can be useful when dealing with travel graphs which are included in List 1; it would be needed to find an approximation of the area under a curve, not a concept included in the lists, but surely this comes under the umbrella of providing a foundation for further study; and as the formula is more complex than those for

the area of other shapes mentioned, it would provide practice in more difficult algebraic substitution and manipulation, and in use of brackets. Personally, I would not like to think of a candidate supposedly of O-level grade C standard being unable to use such a simple formula; and one which I am in the habit of encouraging able 12 year-olds to discover.

The second point regarding mensuration, is that all volumes that are required to be studied, are in fact, volumes of prisms. A grade C candidate is able to understand, and should know, that not all solids come into the category of having volumes calculated by the product of the area of cross-section and the height. Again, by including pyramids in List 2, greater opportunity for practice in differentiating between different types of solids would be provided, and there would be more material for testing objective 3.11. Of course, teachers will include opportunities for this work to be developed, but will it be recognised that this all takes time; and that this time has not been spent with only the examination in mind, but with a view to adding breadth to the candidate's understanding of mathematics?

Matrices is another topic the inclusion of which was requested by many centres involved in the Southern Examining Group's survey. However, there seems little point in including matrix algebra purely as a manipulative exercise, when the previous main areas of applications, solution of simultaneous equations, and transformation geometry have been excluded.

Lastly, apart from the inclusion of statistics and probability, the content seems to be extremely 'traditional', with almost all accepted 'modern' topics being dropped. One had hoped that the GCSE would bring an end to the unnatural separation of these two areas of mathematics, but again, unless examining groups, or the teacher acting on his own initiative, undertakes to offset the imbalance, children will be studying a very old curriculum, and will have lost the opportunity for learning something of newer developments in mathematics, developments which can provide some <u>very</u> interesting study.

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On the positive side, the inclusion of content lists in the

national criteria provides a common framework as a basis for standardisation of syllabuses throughout the country. This will be of great benefit to users of examination results who will understand better what is meant by a qualification. Also, and perhaps more importantly, a child who has to move from one part of the country to another, may find the resulting change in curriculum less traumatic when it is nationally restricted in this way, and particularly in a subject such as mathematics, where its linear structure determines to a certain extent the order in which topics must be studied.

Perhaps the content lists have been deliberately restricted at the middle level in order to form only a common core and to allow the examining groups freedom to extend the syllabus in whichever way they wish. This provision would also allow quick and easy alteration and up-dating of syllabuses, as it would avoid the need for the subject - specific criteria to be re-written.

# 4.10 Subject - specific criteria in Mathematics: Differentiated papers

Differentiated papers in Mathematics were advocated by the Cockroft report (7), which commented that in the dual GCE/CSE system, candidates were obtaining grades for as little as 30% (grade 4) or 20% (grade 5). The problem arose particularly in the CSE papers which were trying to cater for the Grade 1 to Grade 5 range, with the result that most of the questions were beyond the reach of the less able. The Report felt that this was educationally undesirable because lower grade students were aware of how little they had achieved, and this knowledge undermined their confidence in their ability as adults to cope with the mathematics of life. The Report recommended that papers more suited to the ability range should be introduced in order that low grade pupils could attain higher marks and so be assessed in terms of positive achievement. It would also seem to imply that no paper should attempt to cover a spread of five grades.

The GCSE subject - specific criteria has stipulated a minimum of three levels of assessment for mathematics, in accordance with

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the Cockroft report. Two possible arrangements for such a scheme are:



The probable grade bands are:

Level	Grades
upper	A', B`, C
middle	C,D,E
lower	E,F,G

The intention is that, provided a candidate is entered at the correct level, most of the questions set will fall within the candidate's reach. This will help to ensure that the candidate is occupied throughout the duration of the paper, and will also give the candidate a sense of achievement. However, some overlap is allowed to ease the pressure of selecting the appropriate level for a pupil.

There is still some problem with a wide ability range if the four-in-line scheme is adopted. Because there are comparatively few high-grade pupils, the second paper will be taken by approximately two-thirds of all candidates entered for mathematics. In order to satisfy the requirement of assessment by positive achievement, papers will probably need to be stepped in incline of difficulty, and possible use made of structured questions. The problems arising from this approach have been discussed in an earlier section, and it therefore seems likely that paired papers might be seen to provide a more satisfactory solution (40).

There is an additional difficulty with timetabling four-in-line papers. They could be set on four different dates, but this would extend the already long examination period still further. Alternatively, papers 1 and 3 could be synchronised and so could papers 2 and 4, as no candidate would enter for both of either pairs of papers. However, for a large number of pupils entered at the middle level this would mean taking the more demanding paper first a daunting prospect for all but the most confident. Rearrangement would merely shift the problem to the lower and upper ability groups.

There is some evidence to show that teachers favour the differentiated scheme. During their feasibility studies, the WJEC operated two schemes, one with two common papers and the o'ther using differentiated papers (50). In the early days of the study, candidates were allowed to enter both schemes, and their results have provided useful evidence as regards comparability of the two schemes. Latterly, the numbers entering for the common papers decreased whilst the differentiated papers became increasingly popular. It would seem therefore, that this scheme is likely to gain the support and approval of teachers and pupils.

The danger to be avoided in the introduction of the GCSE examination at different levels, is that the old GCE, CSE and elementary CSE could become the levels in the new scheme, and this would avoid the issue of the fundamental reappraisal which it is hoped and desired that the GCSE will encourage.

#### 4.11 Subject - specific criteria in Mathematics: Coursework

One of the most revolutionary aspects of the new GCSE criteria, is that by 1991 it will be compulsory to include a coursework component in the assessment of each candidate. This component will account for between 20% and 50% of the total assessment. The term 'coursework' does not imply the aggregation of marks obtained for pieces of preparation, or for written exercises, or for tests based on these exercises.

Objectives 3.16 and 3.17 outline the elements to be covered

- by coursework:-
  - (a) oral response to questions about mathematics
  - (b) discussion of mathematical ideas
  - (c) mental calculations
  - (d) practical and investigational work
  - (e) extended pieces of work (projects)

The work included in these projects is to be separate from, and not a duplication of, work assessed in written examinations. Since grades will eventually be awarded to individuals, candidates may only produce projects in groups if each individual's contribution can be identified and assessed independent of the work of other members of the group. This is sometimes difficult to put into practice, particularly where a number of groups are working simultaneously, and it may be difficult to elicit from the group exactly who was responsible for what, especially where a more timorous candidate may be overwhelmed by a more egotistical character. The marking and recording scheme currently in operation for the Midland Examining Group is included in Appendix E, and it can be seen that no credit is given for ability to work with others. Ιt is not expected that the GCSE will acclaim this attribute by the award of marks either, which is a pity as it is a valuable quality in most forms of employment.

There are many benefits to be gained from the inclusion of coursework in an assessment. Many attributes such as practical skills, interactive skills, and the ability to organise material, cannot be assessed on a written paper. Conscientious candidates who, because of poor recall or high anxiety, fail to perform in examinations at the level of their attainment throughout the course, will benefit enormously and receive a fairer assessment of their true mathematical knowledge and ability, and it is probable that knowing this system is in operation will increase their motivation.

The assessment of a candidate over a period of time may give a truer and more reliable reflection of his potential than work produced in only two examination sessions. Introduction of a coursework component allows time-consuming investigations to be

assessed where the inclusion of such in a written examination with an imposed time limit would cause undue stress.

Since there are many advantages to including coursework in a candidate's appraisal, why is there so much opposition to its introduction? There is always some reluctance to changes of any kind, and especially to quite radical innovations. Much of this stems from anxiety on the part of teachers about their capacity to cope with a new system. There has been assurance from Examining Groups that they will provide in-service training, but some teachers wonder whether this training will be adequate.

This training and assessment of coursework itself is timeconsuming, and teaching is already a hard-pressed profession. Many teachers work in stressful situations and do not want the additional strain of an increased workload. It is on these grounds rather than academic objections that the opposition to coursework is based.

#### (i) Oral work:

If oral work is to be included in the coursework section, this will test the ability of candidates to think "on one's feet" and give an immediate response. This is impossible to examine in a written paper where a candidate can leave a question and return to it later after having had time to think. Also, in an increasingly multicultural society, oral discussion will help those who experience difficulty with reading or writing in English. Rephrasing of a question which has not been understood initially, would help to eliminate problems of language with both immigrant and English children, and would also help to ascertain the level of the child's thinking.

#### (ii) Mental calculations:

Mental mathematics, and particularly mental arithmetic once was fashionable, but is rarely emphasised nowadays. Regular practice of this type would provide pupils with skills which would be useful in everyday life, and which would facilitate (and therefore encourage) making rough estimates of an answer found with the aid of a calculator. If mental arithmetic questions are put into context situations e.g. How many 12p stamps can I buy for f1?, then pupils

also learn to associate appropriate units and to make unit conversions, and they learn to extract the relevant mathematical data from the language which surrounds it (40).

(iii) Investigational work:

Investigational work, as opposed to any other kind of project work, rarely has a practical application, but it is intended to convey something of the fascination of mathematics in its own right. It encourages understanding and develops awareness of mathematical patterns and relationships, and provides the opportunity to generalise, and to form hypotheses and test them. The ability to design, conduct and evaluate a simple investigation or survey is difficult to test in a written examination. Also, candidates develop investigations in their own direction, so this type of work cannot be assessed on a written paper because of the danger of going outside the knowledge and experience of other candidates.

It is the intention of the GCSE, by inclusion of these types of coursework to improve the examination's validity by giving a truer assessment of the candidate's skill, knowledge and ability.

## 4.12 Subject - specific criteria in Mathematics: Grade descriptions

The criteria include grade descriptions for grades C and F. These are not meant to be grade definitions, only including examples of the likely level of attainment of candidates achieving this standard, and therefore they cannot be criticised on grounds of omission. It is clearly stated that candidates should expect to have a <u>good</u> knowledge of the subject content contained in the lists, which is in line with the philosophy of grades given for positive achievement as opposed to the current system of rewarding attainments as low as 20%. It is perhaps because the emphasis has been placed on mastery of the subject content that the lists contain less material than would normally be covered in a syllabus intended for candidates expected to achieve these grades.

As far as the examples for grade C are concerned, it would certainly be in keeping with current O-level standards for such

candidates to have mastery of these topics. Most of these areas are studied before the end of the third-year in secondary school, leaving plenty of time for a candidate to totally assimilate the underlying concepts. It is to be hoped that grade descriptions are not mistaken for a description of the candidate's total knowledge, as in order to be in keeping with O-level standard, their knowledge would extend far beyond these examples, not only in breadth, but in depth also. However, that is not to say that there would be total mastery of all the more advanced techniques and concepts.

It is also clearly stated in the grade descriptions that examination papers will not include hurdles in order to ascertain grade levels, and that a compensation system, whereby a poor performance in one area can be offset against an excellent performance in another area, will be in operation, presumably until such time as criterion-referencing is introduced.

#### 4.13 Conclusion

The introduction of GCSE examinations in mathematics would seem to offer an opportunity for developing an interesting and varied course in secondary schools, particularly for the middle and lower ability levels. The inclusion of coursework will motivate those who are prepared to work as they see this as a means of compensating for poor written examinations. Several different assessment techniques have been incorporated and made compulsory, so that the examination's validity should increase, and the curriculum will automatically become more varied in more traditional schools, in order to prepare for the different types of assessment.

The core syllabus is very traditional, but inclusion of coursework does allow the teacher to compensate for this to a certain extent. However, a true evaluation cannot be made without examination of the extended syllabuses proposed for the most able, and without some indication of the weightings which will be given to the different assessment objectives. These will be considered in the next chapter.

Chapter 5

A comparison of the draft GCSE mathematics schemes

offered by the examining groups

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In this chapter a comparison is made of the draft syllabuses in Mathematics for the 1988 GCSE examination. Approved syllabuses are not yet available and the publication date for many of these has been postponed.

#### 5.1 Levels of assessment:

The National Criteria stipulated that syllabuses and assessment schemes should be produced for three different levels of achievement. All examining groups have been obliged to fulfil this, but no group has extended the scheme for further levels of differentiation.

# 5.2 Aims and Objectives:

Each mathematics syllabus reiterates exactly as stated in the subject-specific criteria, the educational aims for those following GCSE courses, and the assessment objectives as far as 3.15 inclusive. Objectives 3.16 and 3.17 are usually included where a coursework component is offered i.e. the Welsh Joint Education Committee, the London and East Anglian Group and the Southern Examining Group. The Midland Examining Group does offer this alternative, but has not included these objectives because their syllabus is still being developed in order to fulfil them. The Northern Examining Association is the only group not as yet offering a coursework component.

## 5.3 The differentiated assessment schemes and grades available:

The Midland Examining Group has developed a scheme of six written papers, with one pair corresponding to each level of assessment. The first paper consists of short-answer questions which include, for purposes of comparability, some common questions between papers for adjacent levels, but no questions common to all three levels.

The other groups have all opted for the four-in-line approach as follows:

Gr	oup	<u>Level</u>	Pap	ers	
1.	Northern Examining Association	1	la	nd	2
2.	London and East Anglian Group	2	2 a	nd	3
3.	Southern Examining Group	3	3 a	nd	4
4.	Welsh Joint Education Committee	)			

This offers a whole paper for purposes of comparability but poses the candidates with the problem of facing a second written paper which is considerable more demanding than the first.

The assessment levels are targetted as follows:

Level	Target		Gr			
	Grade	Northern	Midland	London and East Angl <b>ia</b> n	Southern	Welsh
1	F	EFG	EFG	EFGU	EFG	EFG
· 2	D	CDE	CDE	CDEFU	CDEF	CDEF
3	В	ABC	ABC	ABCDU	ABCD	ABCDE

Both the Midland Examining Group and the Northern Examining Association may award grades below the levels shown, and in the case of the Northern Examining Association, an outstanding performance may result in the award of a higher grade. The remaining three groups seem to be going against the philosophy of a common examination by stating categorically that candidates who achieve a standard below that of the lowest specified grade will be totally ungraded, which implies that the subject would not be recorded on a certificate. This would be a return to the idea of a pass/fail examination and would not be in accordance with the GCSE's acknowledgement of a continuous distribution of attainment. It will increase greatly the pressure on teachers to gauge correctly and precisely the performance of each candidate in the examination. Finally, it may also be at cross-purposes with the concept of criterion-referencing, as such candidates may be capable of attaining lower grades but may not have been given the opportunity to demonstrate this. Perhaps the system will be modified when criterion-referencing is introduced.

Several examining groups state that to achieve the target grade, a candidate would be expected to attain  $\frac{2}{3}$  of the total marks, whilst candidates attaining only half marks would be awarded the grade below. One can presume, therefore, that to attain a grade C on the Intermediate level papers would require a mark of possibly 80%, but probably 90%. This is difficult to achieve in the stress of an examination, especially if time is a factor against the candidate. It seems a pity in view of associations with an O-level pass of grade C and an O-level fail of grade D, that the middle level papers have been targetted at grade D rather than grade C. Early candidates in particular will still compare their results with 0-level, and yet it seems that a borderline pass will be more difficult to achieve in the GCSE system; it will require either a near perfect performance at the middle level, or tackling papers where most questions are aimed at candidates whose ability is above grade C. However, the philosophy of the GCSE emphasises positive achievement, and grades C and above are intended to cover only the top 20% of the ability range.

#### 5.4 School-assessed component:

The current provision and demands of the coursework component vary considerably. Only one of the groups, the Southern Examining Group, has stipulated the inclusion of internal assessment for the 1988 examination. The Northern Examining Association does not offer a coursework component at all, and the other groups have made it an optional undertaking. The Welsh Joint Education Committee requires the completion of two tasks to each of which should be devoted two lessons a week for a period of four weeks, totally sixteen lessons, or approximately three weeks' work. At the other extreme is MEG, with a demand for five mini-projects, each of two

to three weeks' duration, totalling ten to fifteen weeks or approximately one term's work. Yet both of these coursework components carry approximately 25% of the total marks available. However, it should also be borne in mind that the coursework of the Welsh group is an optional <u>addition</u> to the written papers and this group also offers the advantage of grading certificates a second time on the written papers alone and awarding them the highest of the two grades, whereas the MEG allows the coursework component to be offered as an <u>alternative</u> to Section B (the more difficult questions) of the second paper.

The table below compares the demands of the different groups:

Group	No. of assignments	Duration	Mental tests	Oral tests	Aural tests	% of total marks
Northern	1 <b>-</b> '	-	-	-	-	-
Midland	5	10-15 weeks	-	-	-	25%
London	5	not specified	l test 5%	-	-	30%
Southern	n 3	not specified	-	included in each assignmen	2 tests 10% t	50%
Welsh	2	16 lessons	-	-	included in one task	26%

Groups also vary tremendously in the amount of advice and assistance they have prepared for teachers embarking on this type of work.

It would seem that, for true comparability, this element of the assessment will need to be further discussed and standardised.

## 5.5 Differentiated syllabuses

(i) Lower level

All examining groups are required to include in their

syllabuses for this level, the entire contents of List 1 of the National Criteria. Most groups have extended this slightly, but the Northern Examining Association have added many topics. (see the comparison table on the next page). The criteria state clearly on page 3, that it is expected that List 1 'will constitute almost the whole of the syllabus content for any examination on the results of which the great majority of candidates is expected to be awarded grades E, F or G'. It seems likely, therefore, that the Northern Examining Association will be asked to revise and reduce their syllabuses for this level.

All groups have included work on number patterns and geometric patterns. To facilitate drawing the latter, they have mostly included accurate construction of triangles and quadrilaterals. The geometry section has been increased still further; most groups have added nets of solids, and the relationship of vertices, faces and edges, which is an interesting topic and encourages still further the idea of pattern occurring in mathematics.

Simple transformations also make the graphical section larger and therefore these syllabuses are more balanced than the Lists.

Three of the groups have included simple linear equations. There is no reason why grade E, F and G candidates should not be able to cope with this topic, and its inclusion gives them the added satisfaction of being like other candidates in having studied equations also.

LOW	ER LEVEL		All syllabuses Additional item	conta s are	ain the conte e listed belo	ents of List ow Underli	1 o: ned	f the National Cri items appear in L	teria ist 2		
NOR	THERN EXAMINING ASSOCIATION	MID	LAND EXAMINING GROUP	LON	DON AND EAST GROUP	ANGLIAN	SOU	THERN EXAMINING GROUP	WEL	SH JOINT EDUCAT COMMITTEE	ION
	(proposed)				(proof)			(draft)			
1.	SETS										
( <u>a</u> )	Definition of sets by listing or description, using the notation <b>{}</b> where appropriate.										
( <u>þ</u> )	Representation and interpretation of sets on a Venn diagram.										
(c)	Use of Venn diagrams to solve problems.										
2.	NUMBER										
,		(a)	Number patterns and sequences	(a)	Number patte	erns	( <u>a</u> )	Simple number patterns	(a)	Simple number ; and sequences	patterns
		(b)	Cubes	(b)	Cubes						
3.	COMPUTATION										
	(a) Calculation of a given fraction or percentage of a quantity.	n									

NORTHERN EXAMINING	MIDLAND EXAMINING	LONDON AND EAST ANGLIAN	SOUTHERN EXAMINING	WELSH JOINT EDUCATION
ASSOCIATION	GROUP	GROUP	GROUP	COMMITTEE

- (b) <u>Conversion</u> <u>between vulgar</u>, <u>decimal fractions</u> <u>and percentages</u>.
- (c) One quantity as a percentage of another.
- (d) <u>Multiplication of</u> <u>vulgar fractions</u> by a whole number

 (e) Simple inequalities (e) The idea of the inequality of numbers
(f) Increase or decrease

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(f) Increase or decrease of a sum of money by a given percentage

# 4. APPROXIMATION

(a) Rounding off to a given accuracy

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NOR	THERN EXAMINING ASSOCIATION	MIDLAND EXAMINING GROUP	LONDON AND EAST ANGLIAN GROUP	SOUTHERN EXAMINING GROUP	WELSH JOINT EDUCATION COMMITTEE
5.	APPLICATIONS				
<u>(a</u> )	date, calendar				
(b)	temperature				
( <u>c)</u>	simple business transactions				
			(d) Routes on a map		
			(e) arithmetic examples of pricing e.g. postage, telephone fares, price per given weight or area		
					(f) Profit and loss
					(g) Timetables
					(h) Savings
					(i) Local rates
					(j) Expense of running a car or motor bike
(k)	Execution of a num algorithm	nérical		(k) Interpretation of flow charts	

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NOR	THERN EXAMINING ASSOCIATION	MID	LAND EXAMINING GROUP	LONDON	AND EAST ANGLIAN GROUP	SOU	THERN EXAMINING GROUP	WELS	SH JOINT EDUCATION COMMITTEE	
(b)	Angles on a straight line									
		(c)	Tessellations			(c)	Tessellations	(c)	Geometric patterns in	2 <b>-</b> đ
						(d)	Irregular polygons			
 ( <u>e</u> )	Solid figures	( <u>e</u> )	Symmetric properties of solid figures			(e)	Vocabulary of solids, faces, edges and vertices	(e)	Simple solid figures, edges, faces and vertices	
(f)	Nets	( <u>f)</u>	Nets of cube, cuboid and prism	(f) Ne	ts of simple solids	(f)	Nets of cuboids	( <u>f</u> )	Nets	75
11.	MENSURATION									
(a)	Estimating lengths									
(b)	Measurement and estimation of areas by counting squares									
(c)	Multiple shapes									
(d)	<u>Area of</u> parallelogram									

NOR	THERN EXAMINING ASSOCIATION	MIDLAND EXAMINING GROUP	LON	DON AND EAST GROUP	ANGLIAN	SOUTHER	N EXAMINING GROUP	WEL	SH JOINT EDUCATION COMMITTEE	
(e)	Area of circle									
(f)	Surface area of rectangular block									
(g)	Estimation of volumes									
(h)	Measurements necessary to calculate volumes	•								76
(i)	Use of Pythagoras' theorem in right- angled triangles									
12.	SCALE DRAWING									
(a)	8-point compass									
(b)	Construction of a triangle, rectangl and a circle	(b) Construction of e simple figures	(b)	Use of drawi instruments construct pl	ng to ane			(b)	Construction of tria and quadrilaterals f given data	ngles rom
13.	SIMILARITY AND CONGRUENCE			TIGULES						
(a)	Concept of congruence						•			

14. TRIGONOMETRY

NOR	THERN EXAMINING ASSOCIATION	MID	LAND EXAMINING GROUP	LONI	DON AND EAST ANGLIAN GROUP	SOUT	THERN EXAMINING GROUP	WELSH JOINT EDUCATION COMMITTEE
15.	TRANSFORMATIONS							
( <u>a</u> )	Enlargements with scale factor 2			(a)	Enlargements with a positive integral scale factor	(a)	Enlargements	
(b)	One way stretch parallel to one of the axes							
		( <u>c</u> )	Transformation of simple plane figures					
		(d)	Reflections in horizontal or vertical lines	(ð)	Reflections	(d)	Reflections	
		( <u>e</u> )	Rotations about origin through multiples of 90 ⁰			( <u>e</u> )	Rotations	
(f)	Rotational and line symmetry	( <u>f</u> )	Rotational and line symmetry	(f)	Line symmetry and rotational symmetry			
				(g)	Translations	(g)	Translations	
16.	VECTORS			•				

NOF	THERN EXAMINING ASSOCIATION	MIDLAND EXAMINING GROUP	LONDON AND EAST ANGLIAN GROUP	SOUTHERN EXAMINING GROUP	WELSH JOINT EDUCATION COMMITTEE	
17.	MATRICES					
18.	STATISTICS					
				(a) Dispersion Range as a measure of dispersion		
10						

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19. PROBABILITY

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(ii) <u>Middle level</u>

At the middle level the whole of the contents of Lists 1 and 2 of the subject-specific criteria must be included, but again these lists are considered to constitute 'almost the whole' of these syllabuses for this level. The Northern Examining Association have extended the lists also at this level, by so much that it is difficult to imagine that it will be acceptable bearing in mind the desire to establish a unified system.

Most groups have taken the opportunity to extend considerably the algebraic demands of the syllabus so that they are more in line with the routine algebraic skills of an O-level candidate, and all but the Welsh group have included work on transformations.

A detailed comparison of the addition to the syllabuses follows:
MID	DLE LEVEL A A	ll syllabuses contain dditional items are li	the contents of Lists 1 and sted below Underlined it	2 of the National Crite tems are included in the	eria e Lower level	
NOR	THERN EXAMINING ASSOCIATION	MIDLAND EXAMINING GROUP	LONDON AND EAST ANGLIAN GROUP	SOUTHERN EXAMINING GROUP	WELSH JOINT EDUCATION COMMITTEE	
1.	SETS					
(a)	Definition of sets by listing or description, using the notation <b>1</b> where appropriate		(a) Set language and notation			
(b)	Representation and interpretation of sets on a Venn diagram		(b) Representation of sets and statements			80
( <u>c</u> )	Use of Venn diagrams to solve problems	5	(c) The use of sets in solving problems. Venn diagrams for not more than 2 subsets			
(d)	Use of symbols		(d) Use of symbols			
2.	NUMBER					
		(a) <u>Number patterns</u> and sequences	(a) <u>Number patterns</u>	(a) <u>Simple number</u> patterns	(a) <u>Simple number</u> patterns and sequence	es
(Ъ)	The real number line				(b) Real numbers	

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NORTHERN EXAMINING ASSOCIATION	MIDLAND EXAMINING GROUP	LONDON AND EAST ANGLIAN GROUP	SOUTHERN EXAMINING GROUP	WELSH JOINT EDUCATION COMMITTEE
(c) Prime factors				
	(d) Ideas of ordering	g	(d) <u>Simple inequalit</u>	ies (d) Inequality of numbers
3. <u>COMPUTATION</u>				
(a) <u>Calculation of a</u> <u>given fraction on</u> <u>percentage of a</u> <u>quantity</u>	<u>r</u>			
(b) Recurring decimal	ls			Ş
4. <u>APPROXIMATION</u>				
(a) <u>Rounding off to</u> <u>a given accuracy</u>				
5. <u>APPLICATIONS</u>				
(a) <u>Dates, calendar</u>				
(b) <u>Temperature</u>				
(c) <u>Simple business</u> <u>transactions</u>		-		
(d) Simple interest				

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NORTHERN EXAMINING ASSOCIATION	MIDLAND EXAMINING GROUP	LONDON AND EAST ANGLIAN GROUP	SOUTHERN EXAMINING GROUP	WELSH JOINT EDUCATION COMMITTEE
			(e) <u>Increase or</u> <u>decrease of a</u> <u>sum of money by</u> <u>a given percentage</u>	<u>.</u>
(f) Compound Interest				(f) Compound Interest
(g) Appreciation and depreciation				
				(h) <u>Savings</u>
				(i) Local rates
				(j) Expense of running a car or a motor bike
			(k) <u>Interpretation of</u> <u>flow charts</u>	
		(1) Routes on a map		
		(m) Arithmetic egs of pricing, postage, telephone, fares, price per given weight or area		



NORTHERN EXAMINING ASSOCIATION		MIDLAND EXAMINING GROUP		LONDON AND EAST ANGLIAN GROUP		SOUTHERN EXAMINING GROUP		WELSH JOINT EDUCATION COMMITTEE		
								( <u>f</u> )	Linear equations involving brackets and fractions	
(g)	Factorisation of difference of two squares	(g)	Factorisation of $x^2$ – $a^2$						· -	
( <u>h</u> )	Factorisation of a quadratic expression with integer coefficients	( <u>h</u> )	Expression of the form x ² + bx + c							
(i)	Linear equations in two unknowns with integral solutions	( <u>i)</u>	Simultaneous linear equations in two unknowns with integral solutions	( <u>i)</u>	Solution of pairs of simultaneous linear equations in two unknowns with integer coefficients			<u>(i)</u>	Simultaneous equations of the first degree in two unknowns	
(j)	Solution of $x^2 + bx + c = 0$ with integral solutions	( <u>j)</u>	Quadratic equation of the form $x^2 + bx + c = 0$	15					·	
(k)	Solution set for a linear inequality in one variable									

NOR	THERN EXAMINING ASSOCIATION	MIDLAND EXAMINING GROUP	LONDON AND EAST ANGLIAN GROUP	SOUTHERN EXAMINING GROUP	WELSH JOINT EDUCATION COMMITTEE
8.	RELATIONS AND FUNCTIONS				
( <u>a</u> )	General notion of a relation between the elements of a set or the elements of two sets; represent- ation by arrow diagrams, ordered pairs or Cartesian graphs			(a) Different ways of representing functions	· · · · · · · · · · · · · · · · · · ·
(b)	Notation f(x) for the image of x unde the function f. Definition of f(x) by means of an alge formula. Evaluation for given x	er ebraic	·		
9.	CARTESIAN COORDINAT	TES			
(a)	Sketching of a graph representing				

graph representi some practical situation

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NOR	THERN EXAMINING ASSOCIATION	MID	LAND EXAMINING GROUP	LOI	NDON AND EAST ANGLIAN GROUP	SOUTHERN EXAMINING GROUP	WE:	LSH JOINT EDUCATION COMMITTEE
(b)	Solution of an equation, or a pair of linear simultaneous equations	(b)	Solution of an equation using a graph	(b)	Solution of two simultaneous linear equations by graphical methods			
(c)	Interpretation of y = mx + c						( <u>c</u>	) Interpretation of y = mx + c
(b)	Linear inequalities (boundaries limited to axes and one other line)							
		(e)	Estimates of gradients by drawing					
10.	GEOMETRICAL TERMS							
( <u>a)</u>	Angles on a straight line							
(b)	Vertical, horizontal							

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NOR	THERN EXAMINING ASSOCIATION	MID	LAND EXAMINING GROUP	LONDO	ON AND EAST ANGLIAN GROUP	SOUT	THERN EXAMINING GROUP	WELS	SH JOINT EDUCATION COMMITTEE
(c)	Reflex angles								
(d)	Adjacent and vertically opposit angles	e	<b>.</b> .		<i>.</i> .				. ·
(e)	Interior and exterior angles								
(f)	Trapezium	(f)	Trapezium						
(g)	Major and minor arcs								
( <u>h)</u>	Line symmetry and rotational symmetry Order of rotational symmetry	(ħ) y 1	Rotational and line symmetry	(h) <u>1</u>	ine and rotational symmetry			(h)	Symmetry about a line or a point
(i)	Solids, verticės; edges, faces Making solids from nets	(i)	Solid figures Nets of cube, cuboid, prism	(i) <u>1</u>	lets of simple solids	(i)	Vocabulary of solids, faces edges, vertices. Nets of cuboids and other prisms	(i)	Edges, faces and vertices. Nets.

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(j) Rotational
 symmetry of
 parallogram

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NOR	THERN EXAMINING ASSOCIATION	MIDLAND EXAMINING GROUP	LONDON AND EAST ANGLIAN GROUP	SOUTHERN EXAMINING GROUP	WELSH JOINT EDUCATION COMMITTEE
(k)	Prism. Line and rotational symmetry, plane symmetry				
(1)	Interpretation of plans and elevations				
				(m) Irregular polygons	5
		(n) Tessellations		(n) Tessellations	(n) <u>Geometric patterns</u> <u>in 2-D</u>
11.	MENSURATION				
(a)	Length of arc of circle				
(b)	Mensuration and estimation of area by counting squares				(b) Estimation of area by counting squares
(c)	<u>Area of</u> parallelogram				

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NORT	THERN EXAMINING ASSOCIATION	MIDLAND EXAMINING GROUP	LONDON AND EAST ANGLIAN GROUP	SOUTHERN EXAMINING GROUP	WELSH JOINT EDUCATION COMMITTEE
(c) (i)	Use of ruler and compass to: Bisect a line segment				(c) Ruler and compass constructions
(i:	i) Bisect an angle				
(11	ii) Draw an angle of 60 ⁰ and related angles				
(d)	Use of set squar and ruler to dra parallel lines	e w			
(e)	Angles of elevat and depression	ion			
13.	SIMILARITY AND CONGRUENCE				
( <u>a</u> )	Ratios of length areas and volume of similar figur	s, s es			
14.	TRIGONOMETRY				
15.	TRANSFORMATIONS				
( <u>a</u> )	Translation	(a) Translations	(a) <u>Translations</u>	(a) Translations	

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NOR	THERN EXAMINING ASSOCIATION	MIDLAND EXAMINING GROUP	LONDON AND EAST ANGLIAN GROUP	SOUTHERN EXAMINING GROUP	WELSH JOINT EDUCATION COMMITTEE
(Ъ)	Enlargements with scale factors $\pm \frac{1}{2}$ , $\pm 1$ , $\pm 2$				
(c)	One-way stretch parallel to one of the axes		· · ·		
(d)	Reflections in axes, $y = x$ , y = -x, $y = cand x = c$	(d) <u>Reflections in</u> <u>horizontal or</u> <u>vertical lines</u>	(d) <u>Reflections</u>	(d) Reflections	
( <u>e</u> )	Rotations about the origin through multiples of 90 ⁰	(e) Rotations about multiples of 90 ⁰ about origin or midpoint of side	(e) <u>Rotations through</u> <u>multiples of 90</u> 0	(e) Rotations	
16.	VECTORS				
( <u>a</u> )	Vectors represented graphically in two dimensions				

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NOR	THERN EXAMINING ASSOCIATION	MIDLAND EXAMINING GROUP	LONDON AND EAST AN GROUP	GLIAN SOUTHERN EXAMINING GROUP	G WELSH JOINT EDUCATION COMMITTEE
(b)	Representation graphically of addition and subtraction of $\therefore$ vectors and multiplication of vectors by scalars	-			
(c)	Vectors in column form; column vectors to represent a translation; addition and subtraction of vectors and multiplication of vectors by scalar for vectors in column form	- S		ж <b>и</b>	
17.	MATRICES				
(a)	Order of a matrix				
( <u>b</u> )	Addition, subtraction, multiplication of matrices				

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NOR	THERN EXAMINING ASSOCIATION	MIDLAND EXAMINING GROUP	LONDON AND EAST ANGLIAN GROUP	SOUTHERN EXAMINING GROUP	WELSH JOINT EDUCATION COMMITTEE	
(c)	Use of matrices such as in shopping lists and sporting competitions					
(d)	Route matrices					
18.	STATISTICS					
(a)	Interpretation of data represented by straight line	f s				
( <u>b</u> )	Grouped data					
(c)	Cumulative frequency diagram		,		<u>-</u> ·	
( <u>d)</u>	The mode and modal class and identification of the median					
( <u>e)</u>	Estimation of the median from a cumulative frequency diagra from grouped dat	m a			-	

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NORTHERN EXAMINING ASSOCIATION	MIDLAND EXAMINING GROUP	L'ONDON AND EAST ANGLIAN GROUP	SOUTHERN EXAMINING GROUP	WELSH JOINT EDUCATION COMMITTEE
(f) Scatter diagrams				
			(g) Range as a measure of dispersion	

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(iii) Higher level

It is interesting to notice that, at the Higher level, there is general agreement between the groups as to what should form the core knowledge of a candidate who hopes to attain a higher grade. At this level, the Northern Examining Association which had much larger syllabuses at the two lower levels, have come into line with the other groups. The Welsh Joint Education Committee seem to have the smallest syllabus and do not include any work on transformation geometry or on matrix algebra; all the other groups have included these topics to a generally uniform depth of study.

The extension by all groups of the algebraic content of the syllabus is considerable. There is universal inclusion of the solution of pairs of simultaneous linear equations, factorisation and the solution of quadratic equations. Simultaneous equations are also expected to be solved graphically and, with the exception of the Welsh Joint Education Committee, all groups have added the graphical solution of linear inequalities.

The London and East Anglian group is alone in its omission of the manipulation of algebraic fractions and of equations involving fractions. There is general agreement too, as to the depth to which functions and their graphical representation should be studied. All groups include the concept of gradient and its application to estimating velocity and acceleration from distancetime graphs and speed-time graphs respectively.

The mensuration content is virtually identical including prisms, pyramids and spheres and all but the Welsh group include length of arc and area of a sector of a circle. The ratio of areas and volumes of similar shapes has found a place in all syllabuses as has the extension to 3-dimensions of Pythagoras' theorem and the trigonometry of right-angled triangles.

Only the Midland Examining Group excludes set theory and will not set questions expressly to test this topic, but they state that 'words such as "set", "subset", "intersection", ... may be used in examination questions at any level where it is thought it would clarify the meaning for the candidates' (Page 10 of the Syllabus

and Scheme of Examination for GCSE Mathematics); all the other groups concur as regards coverage of this topic. Vectors are introduced by all groups and applied to simple geometrical problems involving equivalence, parallelism and incidence in rectilinear figures.

There are in addition, many topics such as circle theorems, which three of the five groups include, so the overall picture is one of a consistent demand being made of higher grade candidates by all the examining groups. The only possible exception is the Welsh Joint Education Committee who might, therefore, be asked to extend their syllabus at this level.

A detailed comparison of the syllabuses follows:

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HIGHER LEVEL * indicates that the topic has already been included at either the Lower or Intermediate levels										
NORTHERN EXAMINING ASSOCIATION	MIDLAND EXAMINING LON GROUP	DON AND EAST ANGLIAN GROUP	SOUT	THERN EXAMINING GROUP	WELS	TH JOINT EDUCATION COMMITTEE				
1. <u>SETS</u>										
(a) *	(a)	*	(a)	Sets; language and notation	(a)	Idea of a set, set language and notation				
(b) *	(b)	*	(Ъ)	Universal set, unions, intersectio complement, subset, empty set, number of elements in a set. Disjoint sets	(b) n	Union, intersection complement, subset, empty set, Universal set, number of elements in a set				
(c) *	(c)	Venn diagrams involving not more than three sets	( <u>c</u> )	Venn diagrams	(c)	Venn diagrams				
( <u>d</u> ) *	(d)	and their use in simple logical problems	( <u>d</u> )	The use of sets in solving problems involving not more than three subsets of the Universal set	(b)	Use for solving problems				
2. <u>NUMBER</u>										
(a) *			(a)	Expression of a number as a product of its prime factor including the index notation	S					

NORTHERN EXAMINING ASSOCIATION	MIDLAND EXAMINING GROUP	LONDON AND EAST ANGLIAN GROUP	SOUTHERN EXAMINING GROUP	WELSH JOINT EDUCATION COMMITTEE
	(b) *		(b) Inequalities >, <, ≥, ≤	(b) *
(c) *	( <u>c</u> ) *		( <u>c</u> ) Powers, roots reciprocals	
(d) Manipulation of surds			(d) Irrationals	
(e) Fractional indices	(e) Fractional indices		(e) Law of indices, positive, negative and fractional	(e) Use of indices
(f) Modulus of a number				
3. COMPUTATION				
	<ul> <li>(a) Reverse %s i.e.</li> <li>find cost price</li> <li>given selling</li> <li>price and</li> <li>percentage profit</li> </ul>	- t		
	( <u>b</u> ) % error			
4. APPLICATIONS				
(a) *	(a) Compound Interest	t		(a) *

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NOR	THERN EXAMINING ASSOCIATION	MIDL	AND EXAMINING GROUP	LONI	DON AND EAST ANGLIAN GROUP	SOU	THERN EXAMINING GROUP	WEL	SH JOINT EDUCATION COMMITTEE
5.	RATIO								
(a)	$y \ll x^2$ $y \ll \frac{1}{x^2}$			(a)	Direct and inverse variation, square and inverse square law	(a)	Direct and inverse variation	( <u>a</u> )	Direct and inverse variation
6.	ALGEBRA								
(a)	Fractional indices	(a)	Positive, negative and fractional indices	(a)	Positive and negative integral indices	(a)	Laws of indices which may be fractional	( <u>a</u> )	Use of indices including fractional zero or negative
<b>(</b> Ъ)	Expansion of expressions such as (ax + b)(cx + d)	<b>(Ъ)</b>	Expansion of (ax+by)(cx+dy)		· · ·	<b>(b)</b>	Expansion of (ax + by)(cx + dy) or (ax + by) ²		
(c)	*	(c)	Factorisation of $ax^2 + bx + c;$ $a^2x - b^2y^2;$ ax + bx + ay + by	(c)	Factors	(c)	Factorisation of ax ² + bx + c (a = 1, 2 or 3) Difference of 2 squares	( <u>c</u> )	Factorisation difference of 2 squares; trinomials of the form $ax^2 \pm bx \pm c$
(d)	Quadratic equations ax ² + bx + c = 0 rational or irrational solutions	(d)	Extension to ax ² + bx + c = 0 including irrational solutions	(d)	Quadratic equations	(d)	Quadratic equations by factorisation or formula	s (d)	Solution of quadratic equations by factorisation and by the formula

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NOR	NORTHERN EXAMINING ASSOCIATION		MIDLAND EXAMINING GROUP		AINING LONDON AND EAST ANGLIAN S GROUP		SOUTHERN EXAMINING GROUP		H JOINT EDUCATION COMMITTEE	
								(e)	Remainder theorem and its use in the factorisation of cubics	
(f)	Manipulation of algebraic fractions	(f)	Manipulation of fractions with numerical and linear algebraic denominators			(f)	Manipulation of fractions with numerical denominators	(f)	Simple fractions with linear denominators	
(g)	Equations involving algebraic fractions	(g)	) Fractional equations with numerical and linear algebraic denominators and non-integral solutions			(g)	Fractional equations with numerical or algebraic denominators	(g)	*	
( <u>h</u> )	Transformation of a formula	(h)	Change of subject where subject may appear more than once	(h)	Further transform of formulae	ation (h)	Change of subject where subject may appear more than once	( <u>h</u> )	*	
(i)	Simultaneous linear equations with rational solutions: solution of a pair of simul- taneous equations one of which is linear	(i) ;	*	(i)	Solution of equat by the intersecti of two graphs	ions (i) on	Simultaneous linea equations by graphical method	r(i)	Simultaneous equations in two variables (one linear, one quadratic)	

NOR	NORTHERN EXAMINING ASSOCIATION		MIDLAND EXAMINING L GROUP		LONDON AND EAST ANGLIAN GROUP		THERN EXAMINING GROUP	WEL	SH JOINT EDUCATION COMMITTEE
								(j)	Applications of algebra in problem- solving
( <u>k</u> )	*					(k)	Inequalities in one unknown	(k)	*
(1)	Solution set for linear inequalities in two variables	(1)	Formation, graphical representation and solution of linear inequalitie	(1) es	Solution of linear inequalities and the representation of solutions on the number line and in 2-D space	(1)	Solution of inequalities by graphical method		
7.	RELATIONS AND FUNCTIONS; GRAPHS								
( <u>a</u> )	Function as a relation for which each element the domain has a unique image	( <u>a</u> )	*	( <u>a)</u>	The idea of function of a variable	( <u>a)</u>	*	(a)	Idea of function as a mapping
(b)	Range of function	ı		(b)	Domain and range	(b)	Domain and range	<b>(</b> b)	Domain and range

NOR	THERN EXAMINING N ASSOCIATION	IIDLAND EXAMINING GROUP	LONDON AND EAST ANGLIAN GROUP	SOUTHERN EXAMINING GROUP	WEL	SH JOINT EDUCATION COMMITTEE	
(c)	Simple combinat- ions of functions; composite functions	5	(c) Composite functions		(c)	Composition of two functions	
(d)	Inverse functions		(d) Inverse functions				
(e)	*	<pre>(e) Interpretation     of the constants     m and c in the     expression     y = mx + c</pre>		(e) Interpretation of graphs includin m and c from y = mx + c	(e) ^{Ig}	*	201
(f)	Particular functions $f(x)=ax^2 + bx + c$ $f(x)=x^3 + bx + cx$	(f) Plotting and skétching graphs of +d $y=ax^3 + bx^2 + cx + y^2 = \frac{k}{x^2} (x \neq 0)$	(f) Graphs of functions restricted to $Ax^2 + Bx + C + D/x$ d	(f) Functions of the form ax ² + bx + c	( <u>f</u> )	Graphs of the function $Ax^3 + Bx^2 + Cx + D + Ex^3$	ι <b>s</b>
(g)	$f(x) = \sin x^{0}$ $f(x) = \cos x^{0}$ $f(x) = \tan x^{0}$ for 0 x 360 $f(x) = \frac{a}{x}$ f(x) = /x/	(g) Sines and cosines of angles in the interval 0 <b>≪9</b> ≮180 and appropriate graphs	ο				

NOR	THERN EXAMINING ASSOCIATION	MIDI	LAND EXAMINING GROUP	LON	DON AND EAST ANGLIAN GROUP	SOU	THERN EXAMINING GROUP	WELS	SH JOINT EDUCATION COMMITTEE
(h)	Sketching a graph of f(x)	(h)	Sketching graphs						
(i)	*					(i)	Different ways of representing functions		
				(j)	Maxima and minima			(j)	Maximum and minimum values
(k)	Gradient of tangent by drawing	(k)	*	(k)	Graphical estimation of gradient and application to rates of change	(k)	Gradient of curve by drawing, line of best fit	<u>(k</u> )	Gradient of tangent by drawing
(1)	*	(1)	*					(1)	Distance-time graphs and speed-time graphs
(m)	*	(m)	*	(m)	Velocity and acceler- ation in simple kine- matic examples	(m)	Interpretation of gradient of distance-time graph	(m)	Interpretation of gradients
(n)	Interpretation and estimation of area under a graph	(n)	Calculation of area under a straight line graph	( <u>n</u> )	Trapezium rule for area under a graph and application to speed- time graphs	(n)	Area under a straight line for speed-time graph	(n)	Area under speed- time graph

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NOR	THERN EXAMINING ASSOCIATION	MID	LAND EXAMINING GROUP	LON	DON AND EAST GROUP	ANGLIAN	SOUT	THERN EXAMINING GROUP	WELS	SH JOINT EDUCATION COMMITTEE
8.	MENSURATION									
(a)	Surface area of cone, sphere, prism	(a)	Surface area of cuboid, cylinder, prism, pyramid, cone and sphere	(a)	Surface area cylinder and	a of 1 sphere	(a)	Mensuration of prism, sphere, pyramid and cone	(a)	Mensuration of pyramid, cone, sphere
(b)	Volume of cone, sphere, prism, pyramid	<u>(</u> b)	Volume of pyramid cone and sphere	(b)	Volume of py cone and sph	vramid, nere				
( <u>c</u> )	*	(c)	*				(c)	Nets of prisms and pyramids	(c)	*
(d)	*	(d)	*				<u>(d)</u>	Mensuration of trapezium	(d)	*
(e)	*	(e)	Effect of enlargement on area and volume	(e)	Ratio of are volumes of s figures and	eas and similar solids	( <u>e</u> )	Effect of enlarge- ments on area and volume. Ratio of areas and volumes of similar shapes	<u>(</u> e)	Relation between ratios of lengths, areas, and volumes of similar figures
( <u>f</u> )	3-d application of Pythagoras' theorem	( <u>f</u> )	Pythagoras' theorem extended to 3-d	(f)	Problems sol applying Pyt theorem to 2 angled trian ively, inclu	lved by hagoras' ? right- ngles success uding 3-d	(f) -	Application of Pythagoras' theorem to 3-d	(f) 1	Application of Pythagoras' theorem to simple problems in 3-d

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NOR	THERN EXAMINING	MID	LAND EXAMINING GROUP	LONDO	N AND EAS GROUP	T ANGLIAN	I SOU	THERN EXAMINING GROUP	WELSH JOINT EDUCATION COMMITTEE
(g)	*	(g)	Length of arc, area of sector	(g) L o	ength of f sector	arc, area	u (g)	Length of arc, area of sector and segment	
9.	SCALE DRAWING AND GEOMETRY								
(a)	×						<u>(a</u> )	Reflex angle	
(b)	*	(b) (c)	* Sum of angles of irregular polygon				(b) (c)	Idea of axes and planes of symmetry *	(b) *
( <u>d</u> )	Ruler and compass construction: drawing a perpendicular to a straight lin from a point outside	ne .							
( <u>e)</u>	Locus as a set of points, sketches and accurate construction	( <u>e)</u>	Intersecting loci and simple loci in 3-d				<u>(e)</u>	Intersecting loci in 2-d	

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NORTHERN EXAMINING ASSOCIATION	MID	MIDLAND EXAMINING L GROUP	LONDON AND EAST ANGLIAN GROUP			SOUTHERN EXAMINING GROUP		SH JOINT EDUCATION COMMITTEE
							(f)	Geometric theorems: proportional division, internal bisector
<pre>(g) Circle theorems: angles in the same segment, angle at centre is twice angle at circumference cyclic quad</pre>			(g) (h)	Circle theorems: angle at centre and circum- ference, angles in same segment, cýclic quad, angle between tangent and chord Intersecting chord properties	(g)	Circle theorems: angles in the same segment, angle at the centre is twice the angle at the circumference, cycl quad, equality of tangents from a point	(g) e .ic	*
10. TRIGONOMETRY								
(a) Sine rule	( <u>a</u> )	Sine rule					(a)	Sine rule
(b) Cosine rule	<u>(Ъ</u> )	Cosine rule					<u>(</u> b)	Cosine rule
	( <u>c</u> )	Area of triangle = ½ absinC					(c)	Area of triangle = ½ absinC

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NOR	RTHERN EXAMINING MIDLAND EXAMINING ASSOCIATION GROUP		LAND EXAMINING GROUP	LONI	DON AND EAST ANGLIAN GROUP	SOUTHERN EXAMINING GROUP			WELSH JOINT EDUCATION COMMITTEE	
<u>(</u> d)	Trigonometry applied to 3-d	(d)	Problems extended to 3-d	( <u>d</u> )	Problems solved by applying trigono- metrical methods in two right-angled triangles success- ively, including 3-d	(d)	Trigonometry of right-angled triangles applied to isoscales triangles and to problems in 3-d	(d)	Application of trigonometry of right-angled triangles to simple problems in 3-d	
11.	TRANSFORMATIONS									
( <u>a</u> )	*	(a)	Translations described by column vectors	(a)	Translations	(a)	Translations using column vectors $\begin{pmatrix} x \\ y \end{pmatrix}$			
(b)	Reflection in any line	( <u></u> )	Reflections in lines parallel to or at 45° to the axes	(b)	Reflections	(b)	*			
(c)	Rotation through any angle	(̈בַ)	Rotations about any point through multiples of 90 ⁰	( <u>c)</u>	Rotations of multiples of 90 ⁰	(c)	Rotations using positive angles to represent anti- clockwise. Determ- ination of centre a angle of rotation	nd		

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NOR	THERN EXAMINING ASSOCIATION	MID	LAND EXAMINING GROUP	LON	DON AND EAST ANGLIAN GROUP	SOUT	THERN EXAMINING GROUP	WELSH	JOINT EDUCATION COMMITTEE
(d)	Enlargement by any scale factor	(ð)	Enlargements, scaling up or down, origin as centre, positive or negative scale factor	(đ)	Enlargements with positive, negative or fractional scale factors	(d)	Enlargements with positive and negative scale factors		
(e)	Combination of transformations, inverse transformations	( <u>e</u> )	Combinations of transformations	(e)	Combination of transformations	<u>(</u> e)	Combined transforma in the plane	ations	
(f)	Use of 2 x 2 transformation matrices perform transformations in a plane	(f)	Representation of transformations of the plane given the matrix and finding the matrix given the transformation	(f) 1 5	Transformation of the plane associated with 2 x 2 matrices	(f)	Matrices applied to transformation geometry	D	
12.	VECTORS								
(a)	Position vectors especially of the midpoint of a line segment	( <u>a</u> )	Position vectors the represent- ation of vectors by directed line segments	( <u>a</u> )	Scalar and vector quantities Representation of a vector by a directed line segment	( <u>a</u> )	Position vectors	( <u>a</u> ) V	ectors

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NORTHERN EXAMINING ASSOCIATION	MIDLAND EXAMINING GROUP	LONDON AND EAST ANGLIAN GROUP	SOUTHERN EXAMINING GROUP	WELSH JOINT EDUCATION COMMITTEE
(b) *	(b) Base vectors	(b) Unit base vectors	(b) Base vectors and their use in determining a matrix for a given transformation or the nature of a transformation for a given matrix	
(c) Triangle rule for addition and subtraction	<pre>(c) The sum and difference of vectors and their use in expressing the vectors in terms of two coplanar vectors</pre>	(c) Sum and difference	(c) Vector addition	(c) Sum and difference; commutative and associative laws
(d) *	(d) Multiplication by a scalar	(d) Multiplication of a vector by a scalar Multiplication of a vector by a matrix		(d) Multiplication of a vector by a scalar
	(e) Magnitude of a vector $\begin{pmatrix} x \\ y \end{pmatrix}$ as $\sqrt{x^2 + y^2}$	(e) Modulus of a vector	(e) Magnitude	
	(f) Use of the result $a = b \Rightarrow /a = /b$ and a parallel to	/ ъ		

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NOR	THERN EXAMINING ASSOCIATION	MI	DLAND EXAMINING GROUP	LON	DON AND EAST ANGLIAN GROUP	SOU.	THERN EXAMINING GROUP	WELS	H.JOINT EDUCATION COMMITTEE
(g)	Relationship between and then	(g)	$ \begin{array}{l} \mathbf{A} = k\mathbf{b} \\ \Rightarrow \mathbf{a} \text{ parallel} \\ \mathbf{to} \mathbf{b} \text{ or } \mathbf{h} = \mathbf{o}, \\ \mathbf{k} = \mathbf{o} \end{array} $		,				
(h)	The use of vectors to investigate simple geo- metrical properties of plane shapes	(ħ)	Deducing properties of equivalence, parallelism and incidence in rectilinear figures			(h)	Simple examples of vector geometry	(h)	Simple applications to geometry
13.	MATRICES								
(a)	*	<u>(a)</u>	Matrices			<u>(a)</u>	Matrices		
(b)	*	(b)	Practical applications, order	(b)	Representation of data by a matrix				
(c)	*	(c)	Addition, subtraction	(c)	Addition and subtraction of matrices				
(d)	*	( <u>d</u> )	Multiplication of one matrix by a scalar and a compatible pair of matrices	( <u>d</u> )	Multiplication of a matrix by a scalar	(d)	Multiplication by a scalar Matrix multiplicati	on	

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NORTHERN EXAMI ASSOCIATIO	NING MIDLAND EXAMINI DN GROUP	NG LONDON AND EAST ANGLL GROUP	AN SOUTHERN EXAMINING GROUP	WELSH JOINT EDUCATION COMMITTEE
(e) Determinan a matrix	it of	(e) Determinants: singular matrices		
	(f) Algebra of 2 x 2 matri	ces		
	(g) Zero matrix	(g) Null matrix		
(h) Identity f addition a multiplica	or (h) Identity Ind Ition	(h) Unit matrix	(h) Identity matrix	
(i) Inverse fo addition a multiplica	or (i) Inverse of and non-singula ation matrices	r 2 x 2		
14. STATISTICS	5			
	( <u>a)</u> Criticism of statistical and results	data		
(b) Calculatic the mean f grouped da	on of (b) Averages: m from mode, media ata continuous grouped dat	ean, n of and a		

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NOR	THERN EXAMINING ASSOCIATION	MIDI	LAND EXAMINING GROUP	LONI	OON AND EAST ANG GROUP	LIAN S	SOUT	HERN EXAMINING GROUP	WELSH	JOINT	EDUCATION
(c)	Range	(c)	Range								
(d)	*	(ð)	Cumulative frequency diagrams								
(e)	Quartile and interquartile range as a measure of dispersion	(e)	Estimation of quartile and interquartile range								
( <u>f)</u>	Unequal internal histograms										
15.	PROBABILITY										
(a)	The use of Venn diagrams and set notation to illustrate and calculate prob- abilities assoc- iated with AND and OR			<u>(a)</u>	P(A) + P(B) = P(A) for exclusive ex P(A) P(B) = P(A) for independent	(AuB) vents; nB) events	(b)	: Dependent events			
(c)	×	(c)	) *				(c)	Tree diagrams		-	

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As List 1 constitutes almost the whole of the syllabus for the Lower Level, the content to be covered by candidates for these papers is virtually fixed. The groups themselves have defined a syllabus with a largely common content for candidates at the top end of the scale who will be attempting the Higher Level papers. It is the syllabus which is aimed at the group with target grade D which seems to vary most from group to group in both breadth and depth of study of the subject matter. It may be that the groups will have to cooperate to reach syllabuses which make more consistant demands of a candidate. It will be interesting to see whether the groups will individually move towards syllabuses which reflect a general consensus of opinion or whether the SEC will initiate moves to bring about a It seems unlikely that the consultation between the groups. present disparity between these syllabuses will be allowed to remain in a system which is intended to represent a single common examination with comparable standards throughout the country.

#### 5.6 Written papers:

At present the groups will be making very different demands on their GCSE candidates as regards the time which they will be expected to spend in written examinations. In addition, the percentage of marks available does not vary as the time allowed. For example, a Southern Examining Group candidate will have to work for 1¹/₂ hours on Paper 3 with 25% of the total marks available to him, whereas at the same level, a Northern candidate will only have to work another 30 minutes to have the possibility of gaining 55% of the total if he is an Intermediate level candidate or 45% of the total if he is entering at the Higher level. Both the London and East Anglian Group and the Welsh Joint Education Committee offer approximately 35% of the total marks for Paper 1 which will last for  $1\frac{1}{4}$  hours in the first case, but 2 hours in the latter. Every comparison shows considerable disparity between the dictates of the different groups.

		Northern Examining Group	London and East Anglian Group	Southern Examining Group	Welsh Joint Education Committee
Paper	1	11	$1\frac{1}{4}$	1	2
Paper	2	$1\frac{1}{2}$	$1\frac{1}{4}$	1	2
Paper	3	2	2	11	2 <u>1</u>
Paper	4	21/2	2	11	$2\frac{1}{2}$
		Northern Examining Group	London and East Anglian Group	Southern Examining Group	Welsh Joint Education Committee
Paper	1	50% <b>?</b>	35%	25% -	37%
Paper	2	50% 45%	35%	25%	37%
Paper	3	55% \$45% 7	35%	25%	37%
Paper	4	55% 🕽	35%	25%	37%
Course work	e-		30%	50%	26%

Details of the duration of the papers in hours and the marks available are shown in the tables below:

The Midland examining Group has not been included because they alone have opted for a scheme of two papers designed specifically for each level as opposed to the chained system of four papers gradually increasing in difficulty. On Paper 1 (MEG), however, there is some overlap of questions between two adjacent levels, but no question appears at all three levels. This group also has prohibited the use of calculators on Paper 1 at each level, whereas all other groups will allow their use on both of the candidates' written papers. It should be noted, however, that some groups are including as part of their coursework assessment, mental arithmetic and aural tests without calculating aids, to examine the arithmetic competence of their candidates.

Details of the proposed format of the examination papers are only available for the Southern Examining Group and the London and East Anglian Group, but a comparison can be made with the other groups based on the specimen papers they have supplied. None of the groups include a paper which is entirely multiple choice, and only the London and East Anglian group have specificially stated that they will use this method of testing thorough coverage of the syllabus. Short-answer questions provide another reliable means of testing syllabus coverage and all the groups for which details are available have used questions of this type. Most have included some longer structured questions also, and in this section of their papers, the Midland Examining Group offer candidates a choice, and the London and East Anglian group offer the possibility of gaining full marks by answering correctly all but one of the longer questions. The Northern Examining Association does include longer questions but the paper is arranged in order of increasing difficulty and complexity rather than being split into two distinct sections.

Details of the numbers of questions on each paper are shown in the table on the next page.

For the Midland Examining Group, the numbers of questions on the specimen papers are as follows:

Paper 1

Lower level	30 short answer	A: 6 long questions
		B: 4 long questions
Intermediate level	26 short answer	A: 6 long questions B: 4 from 5 questions
Higher level	25 short answer	A: 6 long questions B: 4 from 6 questions

Paper 2

In each case the school-assessed component is an alternative to section B of paper 2.

5.7 Written papers and the assessment objectives of the national criteria:

This section discusses the content of the written papers in a

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* details not supplied but obtained from specimen papers

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	Northern Examining	Southern Examining	London and East	Welsh Joint
	Association*	Group	Anglian Group	Education Committee*
Paper 1	27 questions	20 short answer;	15 short answer;	37 short answer;
	increasing in	2 long questions;	3 long questions;	6 long questions;
	length	No choice	No choice	No choice
Paper 2	25 questions	15 short answer;	13 short answer;	28 short answer;
	increasing in	3 long questions;	3 long questions;	9 long questions;
	length	No choice	No choice	No choice
Paper 3	30 questions increasing in length	10 short answer; Not more than 5 longer questions; No choice	25 multiple choice; 4 long questions (full marks on 3)	15 longer questions; No choice
Paper 4	20 questions increasing in length	10 short answer; Not more than 5 longer questions; No choice	4 or 5 short answer 5 long questions (full marks on 4)	10 longer questions; No choice

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general way, and is intended to give an indication of the extent to which the assessment objectives of the national criteria have been met by the written papers of the different groups. As mentioned previously, the Midland Examining Group sets two papers specifically for each level, whilst candidates from other groups take two adjacent papers in a chain of four. Specimen papers are available for all but the London and East Anglian group.

For Paper 1 (Lower level), all groups have produced a predominantly arithmetic paper with most of these questions being met in realistic everyday situations, e.g. railway timetables, holiday prices, cookery recipes. Diagrams have been used effectively by each group to assist candidates with their interpretation of the question, and in addition, the Southern Examining group has used non-essential illustrations to enhance the appearance of the paper. These extra diagrams also have the effect of spacing out the printed text of the question and this seems to make questions look less daunting to a candidate.

The papers display a general consensus of opinion as to how many questions should be asked on certain topics. All groups have set two or three statistics and probability questions, and one or two questions requiring a graphical solution or an appreciation of Cartesian coordinates. All but the Welsh group have included a question involving appreciation of pattern, but no group except the Welsh has tested any algebra at all. The number of geometry questions varies from three to seven, and mensuration questions from one to six. However, the papers themselves do not include the same total number of questions, and are not of the same duration, so there could not be an exact correspondence anyway.

Paper 2 (Lower and Intermediate levels) is again predominantly arithmetic in each case. One of two further graphical questions have been set, all groups have tested algebra, and one further statistics/probability question has been included by all except the Welsh group which has set a further three questions on this topic. The Welsh group also has nine questions on geometry whereas

the other groups have only two or three. Again, there is extensive use of diagrams, illustrations, tables and charts, and on each double page of each examination paper there is at least one form of pictorial display.

It is debatable whether most of the groups' papers at the Lower level would satisfy assessment objective 3.2 of testing the candidate's ability to "set out mathematical work, including the solution of problems, in a logical and clear form using appropriate symbols and terminology". The majority of shortanswer questions require only one line of working, and with the aid of a calculator, candidates could obtain the answer directly and fail to show any working at all. The Welsh Joint Education Committee acknowledge this by setting 'answer-only' questions for the first part of their papers with longer questions requiring working to be shown in the second part of the papers. On their paper 2 particularly, these longer questions are less structured and would, therefore, force candidates to show some stages of working. Paper 2 of the Southern Examining Group includes some questions where a number of steps are necessary in the calculation and presumably this would encourage the candidate to set down a solution in a reasonably ordered way, but the Northern Examining Association papers do this to a lesser extent, and the Midland Examining Group's questions are so structured that virtually all questions are reduced to answer-only or one-line solutions. However, as the written papers will not stand alone eventually, but will be taken in conjunction with an assessment of coursework, it can be presumed that the school-component will provide evidence that the candidate has the ability to produce a well-ordered and structured solution to a problem.

Assessment objective 3.6 expects a candidate to be able to "understand systems of measurement in everyday use and make use of them in problems". The Midland Examining Group have satisfied this criterion by setting two questions specifically on conversion of units. No other questions require measurement conversion, and all answers have the units printed in the answer space, so this seems a rather artificial way of testing this objective, and also

seems to avoid that part which states "... and make use of them (units) in problems". The Southern Examining group only requires conversion of minutes to hours and pence (p) to pounds (£), but they do not provide units in their answers, and the onus is on the candidate to do this. The Welsh and Northern groups provide the most thorough testing of this area of understanding.

The groups provide little opportunity for numerical approximations or for candidates at this level to work to appropriate degrees of accuracy in calculations. All calculations result in an integral answer or an easy fraction. The Welsh group have set two questions requiring numerical approximations to be made, but no other group tests this, although this ability forms part of assessment objective 3.7. All groups have required the use of instruments so that measurement can be taken to appropriate degrees of accuracy, and graphs have been included also, which entail either taking approximate readings, or plotting approximate points. Apart from this, only the Northern Examining Association has set a question which involves estimation.

There might be grounds for criticism, also, as regards the extent to which assessment objective 3.9 of testing the candidate's ability to "recognise patterns and structures in a variety of situations, and form generalisations", has been met. All groups have included questions on pattern, but the Northern Examining Association has included only one at this level, and therefore, have not tested this ability in a variety of situations. The Southern group would seem to have covered this topic best, including questions on numerical and geometrical patterns, and a numerical sequence arising from a realistic physical situation.

Finally, in several cases the schemes of assessment test particular objectives in only one question of two papers. Question 16 of Paper 1 of the Southern group is the only time that candidates need to use any type of mathematical instrument; however, this question is a fairly lengthy one and provides quite a thorough test, but it is also the last question of the paper, and may never be reached by slower candidates. Of course, whatever

the position of a question on a paper, if a candidate has an aversion to that topic, he may simply omit the question, so inclusion of a particular test in a scheme of assessment does not necessarily imply that a candidate has been tested in that area, and since only the aggregate mark is considered, in the absence of criterion-referencing, it does not necessarily imply that he has been successful in that area either.

Intermediate level candidates take Papers 2 and 3, and Paper 2 has already been discussed. With the exception of the Welsh group, Paper 3 is still mainly arithmetic, but there is an increase in the number of questions involving geometry, Cartesian graphs, and algebraic notation and manipulation. On the Welsh paper, the arithmetic and algebraic content are fairly evenly balanced.

Candidates taking Papers 2 and 3 will have been tested by between six to twelve geometry questions, three to seven questions involving algebra, two to five statistics and probability questions, and one or two questions requiring the recognition of pattern. This combination seems to provide a more exact correspondence with the list of assessment objectives set out in the national criteria. Certainly the groups' Paper 3 provides a better opportunity for testing objective 3.2, the setting out of mathematical work, and objective 3.15, the ability to respond to a relatively unstructured problem.

Greater use is made of algebraic notation and symbols (objective 3.10), and a more thorough assessment of estimation, approximation and working to degrees of accuracy is provided, (objective 3.7), partly facilitated by the introduction of trigonometry and the necessity to approximate answers obtained by this method. The situations in which understanding of systems of measurement is tested (objective 3.6) are more realistic at the Intermediate level, so the only remaining criticism is ( ) whether assessment objective 3.9, the recognition of pattern in a variety of situations, has been examined thoroughly. Both the Northern and Welsh groups include only one question of this

type and this is on number patterns, whereas the Midland group includes two questions, one on each paper, but these are also both numerical, and the question on the second paper is optional anyway. Again, the Southern group seem to have tested this topic better than any other, including two questions arising from physical situations, one of which leads to a numerical sequence, and the other to a geomatric pattern which can be reduced to two algebraic expressions.

On Paper 4, the algebraic content exceeds the arithmetic content for all but the Southern Group's paper, and with the exception of this group, candidates taking the Higher level examination would have to answer ten questions on algebraic methods alone, in addition to which there are further questions involving algebra which lead to Cartesian graphs. Bearing in mind the needs of a candidate proposing to study mathematics further, it is pleasing to see the emphasis the groups are placing on this branch of the subject, but one could wish that the Southern Examining group had tested this area of skills and understanding more thoroughly.

Candidates at this level will have been set between two to four questions on statistics and probability and from five to ten questions on geometry. The widest discrepancy occurs in the number of questions requiring graphical treatment, which ranges from two on the Southern group's papers to nine on the Northern papers.

Again, there could be criticism as to whether assessment objective 3.9 has been tested. On the Welsh group's paper 4, there is no question on pattern in the sense that it has been tested on other papers. However, a part of one question does require an algebraic formula to be constructed and since this is then a generalised statement, the criterion could be said to have been met as far as the wording "... and form generalisations" is concerned. The Southern and Northern groups set only one question on pattern, but whilst the Southern group's question involves both geometric and algebraic pattern, the Northern group's question is

entirely numerical, and again the criterion for assessment objective 3.9 includes "... in a variety of situations", and this does not seem to have been met. The Midland group have allowed their only question assessing this objective to be optional, and therefore it could be avoided by candidates if they wished. However, there are underlying patterns and structures throughout mathematics, and, if the word is taken in a wider sense, then many questions test structure, for example of algebra or of vector geometry, in the sense of the framework upon which these branches of mathematics are built.

In all other respects the criteria for assessment seem to have been met by papers at this level. Objectives 3.13, the application of combinations of mathematical skills and techniques in problem-solving, and objective 3.15, the ability to respond to a problem in a relatively unstructured situation, have been tested.to a greater extent than at any other level, but clearly, it is easier to do this with more able candidates.

It can be concluded, therefore, that apart from a few minor areas of criticism, the examining groups have borne the national criteria in mind quite carefully, and that they have tailored their written papers to meet the requirements laid down in these criteria.

It can be expected that, initially at least, explicit or implicit norm-referencing may be used to obviate any apparent discrepancies between the groups.

<u>Chapter 6</u>

Current and Future developments

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### 6.1 The current situation

The education system is now faced with the reality of having to prepare itself for the introduction of courses leading to the GCSE examinations in September of this year, 1986. This is an extremely short time for such preparation to take place. Syllabuses have not yet been finalised and in some subjects even draft syllabuses are not available. The teachers' strike action in 1985 and 1986 has caused disruption not only in schools, but also in GCSE training programmes arranged by the examining groups. The Times Educational Supplement dated January 24th 1986, reports on its front page that "Patchy attendance at Phase 1 training courses may force most authorities in the London areas to withdraw from Phase 2 training", and adds later that, for example, there has been only a 40%-60% turnout for Phase 2 training arranged by the Midland Examining Group. The lack of attendance at these training sessions is giving cause for concern, especially as there is so little time to remedy the situation. Teachers in many schools do not have anynexperience of the joint GCE/CSE dual-certificated examinations which have been the forerunners of the GCSE, and similarly, many teachers do not have experience of organising investigational work or the kind of projects which will be required for course-work assessment. There is also lack of expertise in moderation procedures, and the moderation arrangements for some groups are unclear and therefore unsatisfactory.

Devonshire County Council has already contacted other South-Western local education authorities and examination boards to see whether they would cooperate in setting up a new examination because they feel the time is too short to be ready for the GCSE examination. But if there is too little time to be ready for a system which is already in the pipe-line then surely, there is far too little time to set up an alternative system from scratch, and realistically, the Devonshire County Council can only be asking for a modified version of the current dual GCE and CSE systems.

The introduction of the GCSE and simultaneous abandonment of any other type of examination are the root-cause of many of the problems currently facing teachers. In the past, when any new syllabuses have been introduced or any radical changes made, they have always run, alongside the old syllabuses for a while and then the older ones have been phased out after a period of time, usually two years. This allows teachers time for adequate and thorough preparation for the new courses, whilst still teaching courses with which they feel familiar.

A call for the postponement for two years of the introduction of the new system is reported on the front page of the Times Educational Supplement, dated February 7th, 1986. Teaching unions have pledged to continue their policy of noncooperation with the new examination, and if, in the face of this, the Government insists that courses be introduced in September, the result could be total chaos in schools. In addition, local education authorities are also beginning to realise the cost of implementing a predominantly resource-based system of assessment, and they are concerned about their ability to finance such a scheme, especially as these expenses will not be spread over a period of time, but will have to be met immediately.

As more information becomes available and as teachers themselves become more familiar with the demands of the new system, it will be the teachers' responsibility to communicate details of the GCSE to parents. It can be expected, therefore, that as more and more people consider the implications of the introduction of the scheme, that there will be increased criticism and comment.

### 6.2 Possible objections to the GCSE

(a) It is probable that the system will be accepted by all as a fairer means of assessment than a scheme which only involves written papers and examines a pupil on his performance on two or three days alone. The introduction of coursework allows the poor examinee who may be a conscientious pupil to show what he can do in less stressful situations. However, it has been assumed that teachers will undertake the moderation and assessment of this work,

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conduct oral examinations, and hold discussions with individual pupils, certainly at great cost to the teachers in terms of time, and perhaps without further payment. Anyway, there comes a point beyond which further financial remuneration does not compensate for either the stress of an increased workload or the loss of the time involved.

(5) The philosophy of the GCSE recognises that there are no natural divisions in the attainment of pupils and that this distribution is a continuous one, therefore, a seven-grade system has been proposed, and only candidates failing to provide sufficient evidence of work will be ungraded; there will be an end to the pass/fail system. This is the theory, but in practice, with the introduction of differentiated papers and the linkage of only specified grades to these papers, several groups have stated categorically that failure to reach the minimum standard required for the lowest specified grade will result in a candidate being unclassified. This, surely, is a return to the pass/fail system. In future a candidate attempting the Higher level papers in Mathematics may gain grades A,B,C or U, whereas a current O-level candidate may be awarded grades A,B, C,D,E or U.

(c) The main criticism of the dual GCE/CSE system is that it is elitist and divisive. This same criticism has caused the postponement of the introduction of the Distinction and Merit certificates which were intended to act as incentives for the most able to encourage them to follow a wider range of subjects.

Figures based on a 10% sample of all school-leavers and published by the Department of Education are quoted in the table below, and show that there is a definite need to broaden the curriculum as only one in five pupils with one or more GCS grades A-C or CSE grade 1 attains "that level in all four basic subject areas of English, Mathematics, Science and a foreign language". (Times Educational Supplement 22.11.85, page 14).

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% of those with O-level	Boys	Girls
grades A-C or CSE grade	1983-84	1983-84
1 who passed in:		
English	66%	78%
Mathematics	63%	48%
English and Mathematics	50%	44%
English, Mathematics,		
Science and a modern	19%	22%
language		

The idea of the Certificates is reminiscent of the School Certificate and Higher Certificate, and can be criticised on the same grounds that they will attract many unsuitable candidates. However, unlike the School Certificate, subjects may be 'collected' over several attempts and then the aggregate submitted for the award of a Merit or Distinction Certificate.

From the other point of view, Sir David Hancock, DES Permanent Secretary, is reported in the Times Educational Supplement dated 22.11.85 (page 10) as telling a Girls' School Association conference in Stratford-upon-Avon that school inspectors had detected a narrowing of the curriculum in independent schools, caused by the pressure to attain good examination results. A reply commented that the proposed Distinction and Merit Certificates would narrow the curriculum still further, and curriculum restraints are indeed a worrying implication of the introduction of the GCSE.

(d) Finally, the inclusion of projects as part of the assessment for many subjects may favour the "haves' and disadvantage the 'have-nots'. Children from home backgrounds where a positive interest in their educational achievement is taken, may be provided with more resources and materials than a poorer or less interested background could supply.

### 6.3 Criterion-referencing and grade-related criteria

Since the national criteria Lists 1 and 2 provide virtually

the whole content of the syllabuses for the Lower and Intermediate examinations it can be seen that it will be at least a simpler problem to define grade-related criteria for grades G to C. At the Higher level, however, the extension of the Lists has been left to the discretion of the examining groups, and in this situation, it will be extremely difficult to define nationally acceptable criteria for the highest grades. However, it has already been pointed out that in practice there is general agreement between the groups as the the depth of study required of candidates at this level. By the time criterionreferencing is introduced, the groups may well have reached total agreement. But this in itself is restrictive and will mean that the country is moving towards a national centrally-controlled cirriculum and if this is so, there will certainly be strong opposition on grounds of loss of freedom of choice.

# 6.4 <u>Sixth-form courses</u>

Sixth-form courses will undoubtedly be affected by the introduction of the GCSE examinations. There will probably be increased demand from candidates who have taken the examinations at the Lower and Intermediate levels for courses which afford them the opportunity of gaining a higher grade and this will be further intensified if and when the Distinction and Merit certificates are introduced. Problems will arise as to what extent earlier coursework should be carried forward, both in the cases of resits and of candidates aiming for a higher level. Reassessment of previous work at another level places further demands on teachers' time and so does the stress of fitting alternative coursework into sixth-form lessons which are usually fewer per week than in the comparable fourth and fifth year courses. It is unclear whether the proposed but as yet unpublished syllabus for mature students which will probably not include such heavy coursework demands, will or will not be available to sixthform pupils.

There will be an effect on A-level courses too. There is no provision in the 16 plus syllabuses for the study of calculus, which will therefore need to be studied from scratch in the sixthform, and the algebraic background of pupils will be weaker than at present, in spite of the fact that better provision is made at the higher level than at the other two. The time spent on projects and school-based assessment will be time away from practice of routine skills and it is possible that candidates may lack dexterity and facility in basic manipulative techniques simply through lack of experience. However, they will have gained other valuable attributes such as the ability to organise data and to work independently, and they will have developed both practical and interactive skills.

## 6.5 Possible future trends.

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The deliberate division of the GCSE assessment procedures of a candidate's education into

(a) that which is taught and learnt in the more traditional wayand (b) that which is learnt by means of a candidate following

hiw own line of research and developing his own ideas, could be seen as a move towards deschooling. Deschooling recognises the fact that schools are not the only organisations which have valuable educational experiences to offer the pupil and that teachers are not necessarily the best people to provide an optimum learning environment. Advocates of deschooling propose that only clearly-defined teachable skills should be imparted by teachers in schools, perhaps for only part of the day, and thereafter the children should be free to follow whatever programme of activities interests them, provided it has an educational content and provided there is some supervisory care. It has long been recognised that this would necessitate the provision of large supplies of resources and reference materials, but such facilities will need to be begun to be provided in order to meet the requirements of the GCSE.

Deschooling also implies that teachers would have to monitor

a pupil's progress and growth in subtle and previously unspecified ways. It has been argued that teachers are not qualified to do this and also that few are sufficiently talented to do so, even if training were provided. The compulsory introduction of profiling in 1990, will force teachers to undertake precisely this kind of assessment, and its introduction could facilitate an eventual move towards deschooling.

Lastly, supporters of a deschooling scheme suggest that society should provide an open market in which proponents of various activities compete to attract children to share their interest and experiences. It could be argued that many of the Youth Opportunity courses have attempted to do exactly this, thereby completing another requirement for the provision of a deschooled system of education.

In conclusion, therefore, the introduction of the GCSE will bring far-reaching changes which will profoundly affect the school curriculum, and totally alter traditional ideas of assessment. It will also affect the organisation of the school day and of individual lessons, and it will cause to be accumulated, large and numerous resource banks of reference material. It should increase the motivation of pupils by providing for each one an opportunity to show "what they know and can do rather than what they do not know and cannot do" (page 1: The National Criteria for Mathematics). Although affecting extensive changes itself, it is possible that there will be a 'ripple' effect, and that the decade which follows will see a succession of changes and a complete break-away from the provision of educational instruction in its present form.

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#### APPENDIX A

SUMMARY OF INFORMATION ABOUT THE JOINT EXAMINATION AS DETAILED IN THE WADDELL REPORT PART II (50)

In the first two years each examination was a feasibility study, but thereafter the consortia of the examining boards were free to decide whether to continue to offer the examinations.

The following feasibility studies in Mathematics were non-operational and details are not, therefore, included:

6. Oxford and Cambridge/SREB

8. EMREB

Mode II examinations were operated by the Cambridge/SWEB Barnstaple local consortium and details of this joint examination are not given. MATHEMATICS (Chapter 3)

#### I. WJEC Scheme I WJEC Scheme II

Years of operation	1973	1974	1975	1976	1977
Number of candidates	789	869	868	4,509	9,120
Grades awarded GCE A grades and B CSE 1 C CSE 2 3 4 5 U	% 84 10.6 138 17.5 187 23.7 106 13.4 81 10.3 77 9.7 30 3.8 86 10.9	%   89 10.2   143 16.4   199 22.9   77 8.9   63 7.2   93 10.7   88 10.1   117 13.5	69 7.9 130 15.0 202 23.3 91 10.5 121 13.9 118 13.6 62 7.1 75 8.6	97 2.1 404 8.9 760 16.8 659 14.6 727 16.1 717 15.9 516 11.4 629 13.9	265 2.9 595 6.5 1,362 14.9 1,510 16.5 1,569 17.2 1,509 16.5 993 10.9 1,317 14.4

### Aims, Objectives, Syllabus

No new syllabus was provided but both schemes were based on the GCE O-level II syllabus and the CSE general syllabus.

#### Schemes of Assessment

#### Scheme I

Paper 1 Section A 25 short questions Section B 8 long questions	50 %	All to be attempted Candidates required to answer as many as possible	Incline of difficulty in the questions
Paper 2 SectionA 25 short questions Section B 8 long questions	50%	As for Paper I	As for Paper 1

### Scheme II

Three question papers, candidates being required to take papers 1 and 2 or papers 2 and 3.

Paper I 50% 28 short answer questions 5 structured questions		Papers 1 and 2 designed to allow award of CSE grades and GCE grade C (exceptionally B)	Incline of difficulty		
Paper 2 50% 21 structured questions and problem solving		Papers 2 and 3 designed to allow	questions in paper 1 through each paper to end of paper 3 No choice of		
Paper 3 13 structured questions and problem solving	50 %	award of OCE grades A and B	question		

#### Modifications

1975 new syllabus constructed.

1978 Scheme I discontinued. Scheme II requires candidates to choose either

### MATHEMATICS

# 2. LONDON/SEREB

Years of operation -	******* *		1974	·· 1975
Number of candidates			1,127	1 182
Grades awarded	•		•/	
GCE and CSE grade 1	••	{ A B	85 7.5 143 / 12.7	66 5.6 141 119
CSE		2 2 3	.251 222.3 96 8.5 130 11.5	241 20.4 106 9.0 96 8.1
	. ·	- 4 - 5 U	225 + 20.0 131 11.6 66 - 58	293 24.8 145 12.13

### Aims, Objectives, Syllabus

Initial discussion produced a set of aims which it was felt could best be met by a blend of traditional and modern approaches. The ability range was to be covered by a common core syllabus rather less extensive than a conventional CSE syllabus, with a further optional section. Work involving more advanced application of the core and work from (at least 4 of) the further sections was to be covered in an optional third paper which contributed to the higher grades.

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### Scheme of Assessment

Paper 1 Multiple choice 1 hour Both papers set on common core syllabus 17% All questions to be attempted and designed to allow award of CSE grades and GCE grade C 17%n About 10 structured questions 1 hour 40 mins Paper 2 Paper 3 A conventional 2 hour paper with choice; 33% Designed to contribute 7 sections 2 questions in each, candidates to to higher GCE grades . . ..... answer 6 questions Optional paper Course Work 1.1 33% Teacher assessment. Criteria set by consortium  $k^* k$ . . . . apa 1 ..... 63 6.2.2 ÷ 6 10(110 B. St. S. Sec. 11°, 11 ~ *** • •

### 3. JMB/ALSEB/NWREB (1976 JMB/ALSEB/TWYLREB/YREB)

Years of Operation Number of candidates		1974 3,213		1975 3,053		1976 6,052		1977 8,643	

### Aims, Objectives, Syllabus

The aims of the examination were listed as:

- (a) Knowledge and information: recall of definitions, notations, concepts.
- (b) Techniques and skills: computation and manipulation of symbols and use of mathematical instruments.
- (c) Comprehension: the capacity to understand problems, to translate symbolic forms, to follow and extend reasoning.
- (d) Application: of appropriate concepts in both familiar and unfamiliar mathematical situations.

On this basis a syllabus was developed consisting of:

- (a) A common core "traditional in content".
- (b) Two optional topic syllabuses:
  - I. Algebra, Trigonometry, and Calculus.
  - 2. Choice, Chance and Statistics.

### Scheme of Assessment

Paper 1, 1½ hours 33.3% All objective questions	No choice	Objective questions regarded as effective discriminators, to have high reliability and to allow wide syllabus coverage
Paper 2, 2 hours 33.3 % Various types of questions to test common core, particularly abilities which cannot be tested by objective questions	No choice	Paper used to test abilities difficult to test by objective questions
Paper 3, 11 hours + 33.3% 2 hour reading time. Section A 6 straightforward questions, each counting 1 unit. Section B. 6 more difficult questions each counting 2 units. Questions on both topic options in each section	Choice of questions with mark weighting of each indicated. Students to choose questions to make up a total of 12 units	Questions deliberately set at different levels of difficulty

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4. AEB/MIDDLESEX

Years of Operation • Number of candidates		1974	1975	1976	1977
		2,234	2,809		3,167
Grades awarded GCE and CSE grade I CSE	A B C 2 3 4 5 U	57 2.5 93 4.2 237. 10.6 381 17.0 293 13.1 483 21.6 372 16.6 318 14.2	51 1.8 124 4.4 169 6.0 680 24.2 649 23.1 516 18.4 275 9.8 345 12.3	2,59 2,0 1,152 85 5,2 0,24612∂ 8,4 4,489,616,7 1,484 / 116,5 1,621 7,21,2 2,255,24 8,7 1,624 7,21,3 5,2 3,151	**************************************

### Aims, Objectives, Syllabus

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A common core of work was identified. A simplified set of objectives was given involving knowledge, skills, understanding, application and inventiveness. The core was based on a pruning of the AEB O-level common core with the addition of statistics. Both traditional and modern elements were included. Outside the common core some choice was necessary to conform with the policies of both boards. Initially three alternatives At traditional, B. traditional/ modern and C. modern were provided.

### Scheme of Assessment

Paper I, I hour Objective questions on any part of the common core syllabus Sections A, B and C	25%	
Paper 2, 11 hours A combination of structured response and open-ende questions on any part of the common core syllabus Sections A and B	35% d	All questions compulsory
ນໄດ້	· ku	Papers 1 and 2 were used as a reference in determining the weighting of paper 3A, B or C.
Paper 3, 21 to 3 hours Three alternative papers All candidates offer one only from Mode I A. General maths (traditional) ¹ B. General maths (traditional and modern) C. General maths (modern) Mode III alternative	40%	Each paper to contain questions for the whole ability range and also questions to allow able candidates to give extra evidence of their abilities dive ferre.
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Modifications

1975 Paper 3 included alternative D, commercial mathematics and statistics. 1978 Paper 3 made optional; all CSE grades may be awarded on papers 1 and

### MATHEMATICS

### 5. CAMBRIDGE/EAEB

Years of Operation	1973	1974	1975	1976	1977
Number of candidates	1,203	1,691	2,431	2,366	6,166
Grades awarded GCE and A CSE B Grade i C CSE 2 3 4 5 U	98 8.1 265 22.0 246 20.4 141 11.7 137 11.4 148 12.3 97 8.1 71 5.9	%   127 7.5   327 19.3   272 16.1   203 12.0   216 12.8   206 12.2   166 9.8   174 10.3	%   184 7.6   394 16.2   372 15.3   328 13.5   292 12.0   341 14.0   204 8.4   339 13.9	%   187 7.9   404 17.1   399 16.8   299 12.7   280 11.8   295 12.5   210 8.9   292 12.3	308 5.0 672 10.9 894 14.5 894 14.5 974 15.8 845 13.7 623 10.1 956 15.5

### Aims, Objectives, Syllabus

The pilot scheme in 1973 was based on material common to EAEB and CAMBRIDGE syllabuses and was thus shorter than either of these. There were small additions in 1974.

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#### Scheme of Assessment

Paper 1, 21 hours 2 sections A, B	(50%)	A large number of short questions to cover the whole syllabus, section B more demanding than section A
Paper 2, 21 hours 2 sections A, B	(50 %)	No choice of questions on paper 1 or paper 2. Each paper to include sufficient questions suitable for all candidates within the specified ability range.

### Modifications

1975 - A four paper (0, (1, 2,) 3) scheme was tried. In addition to papers 1 and 2, 243 candidates of low ability (according to teacher assessment) took an additional paper 0 and 280 high ability candidates took an additional paper 3. There was no special syllabus work associated with this first experiment. Candidates were then assessed on the results of the various combinations of 2 consecutive papers.

1977-A modified scheme involving papers 1, 2, 2a, (high ability) and 2c (low ability) was tried.

#### APPENDIX G

16-PLUS EXAMINATIONS FOR THE GCSE: GROUPS OF BOARDS IN ENGLAND AND WALES

### 1. Northern Examining Association

- GCE: Joint Matriculation Board
- CSE: Associated Lancashire Schools Examining Board North Regional Examinations Board North West Regional Examinations Board The Yorkshire and Humberside Regional Examinations Board
- 2. Midland Examining Group
  - GCE: Cambridge University Local Examinations Syndicate Oxford and Cambridge Schools Examinations Board Southern Universities' Joint Board for Schools Examinations
  - CSE: East Midland Regional Examinations Board The West Midlands Examinations Board
- 3. London and East Anglian Group
  - GCE: London University Entrance and School Examinations Council
  - CSE: East Anglian Examinations Board London Regional Examining Board

#### 4. Southern Examining Group

- GCE: Oxford Delegacy of Local Examinations Associated Examining Board
- CSE: Southern Regional Examinations Board South East Regional Examinations Board South Western Examinations Board

# APPENDIX G continued

5. Welsh Joint Education Committee

GCE and

Welsh Joint Education Committee

CSE

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