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ABSTRACT

This guide is intended for those people who are concerned with the planning of computer courses for the training of teachers. It gives suggestions for the content of such courses and indicates methods by which the concepts of computer science can be explained to students. Included are the study of the computer itself and some indications of the influence of the computer within subject areas and its effect on society. The guide can also be used by informed teachers when preparing courses for secondary school children. It is expected that such teachers will equip themselves by studying the subject in depth so that they are not teaching to the limit of their knowledge. (Author)

COMPUTER EDUCATION

FOR TEACHERS IN SECONDARY SCHOOLS

AN OUTLINE GUIDE

This document has been prepared by the IFIP Working Group on Secondary School Education (WG 3.1) and invited participants. The group was set up by the IFIP Technical Committee on Education (TC 3).

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I INTRODUCTION

This guide is intended for those people who are concerned with the planning of computer courses for the training of teachers. It gives suggestions for the content of such courses and indicates methods by which the concepts of computer science can be explained to students. Included are the study of the computer itself and some indications of the influence of the computer within subject areas and its effect on society. The guide can also be used by informed teachers when preparing courses for secondary school children. It is expected that such teachers will equip themselves by studying the subject in depth so that they are not teaching to the limit of their knowledge.

It is important for all students to understand the nature and use of computers in modern society and for this reason it is essential that teachers of all subjects should have a knowledge of computing. In the near future, such a requirement can be partially satisfied by providing courses for teachers already in service but it is hoped that eventually all teachers will receive this instruction as part of their initial training.

The rapid developments in computers and in methods of information processing require both teacher and student constantly to review their knowledge of the subject. Therefore, suggestions on the content of this document will be welcomed, especially from people who have had practical experience in methods of presentation of these topics. These contributions will be incorporated in further revisions of this guide and should be sent to:

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II INFORMATION PROCESSING AND THE NATURE OF A DIGITAL COMPUTER

A computer can be described as an automatic information processor.* To understand this description, we must establish the meaning of information processing and show how this can be done by a machine which has been designed to operate without human intervention by following a set of instructions which are held within that machine.

Computer technology is in a state of continuous and rapid change and the machines which are used to process information now may be quite different from the ones that students will meet in the future. However, the concepts of information processing are fundamental and are independent of the actual machines which have been developed to apply these concepts. It follows that an introduction to the concept of a computer is an important and difficult section of any course: important because first impressions are often those which endure in a student's mind and difficult because the simplicity of the computer is often hidden behind the complexity of the equipment and the ingenuity with which man has applied his new tool.

The following section indicates an order in which topics could be introduced so that the structure and organisation of a digital computer can be illustrated against a background of understanding of the nature of information processing.

A. INFORMATION PROCESSING

(1) The development of languages and communication. Calculating and clerical aids.

Information processing has always existed and did not begin with the birth of the electronic computer. However, the needs in this area have grown to such a point today that we cannot manage now without the machines which have been developed to process information for us.

Historically, man has always been concerned with information in the form of the spoken word or the recorded message. The transmission of these messages, the recording of information on clay tablet, papyrus or book, the sifting and sorting of this information — all these activities are examples of information processing.

*In the use of technical terms throughout this document we have been primarily concerned with conveying important concepts to the teacher and the words used should not be taken as formal definitions. For more precise definitions reference should be made to 'The IFIP Guide to Concepts and Terms in Data Processing'. (ed. I. H. Gould), North-Holland Publishing Co. 1970, price U.S. $ 7.00.

(2) The organisation and presentation of information, the communication of ideas in words and diagrams. The location, manipulation and adjustment of information. The concept of a file.

When we wish to store our knowledge (for example in the form of a book), or to transmit this knowledge (for example by mail) we must use some physical representation. In most languages, with the exception of languages such as Chinese or Japanese, we use strings of letters. The fundamental point is the difference between the ideas and concepts we wish to store or transmit and the strings or characters used in practice.

By *information processing* we mean the processing (sorting, ordering, retrieving, sifting) of information in the form of character strings without reference to the meaning of these strings during the machine processing stage.

A precise method of analysis of a problem in information processing is essential because it is the only way in which we can approach a problem so that it can be processed by a machine.

If the presentation of the problem and data to the machine has been carefully prepared, the *result* of the processing will be meaningful and relevant to the user although the machine processes only strings of symbols.

(3) *Algorithms*

For a particular job to be done, be it by man or machine, we must carefully specify the finite sequence of steps which must be executed to perform the job. This sequence of successive operations or decisions which has to be followed in a particular order is called an *algorithm*. The complexity of the steps in an algorithm will depend upon the level of competence of the processor (man or machine) which has to implement this algorithm.

B. THE NATURE OF A DIGITAL COMPUTER

(1) The basic requirement of an information processor.

An information processor must be able to take in, process and give out information. For example a clerk at a desk will receive data, perform certain operations on it (in accordance with steps of a given algorithm) and then put his results in an 'out' tray.

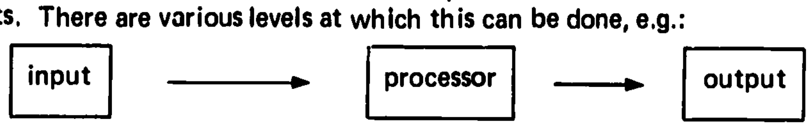
(2) The concepts of a stored program computer

An *automatic* processor stores the instructions of an algorithm as well as the relevant data and must process this data without human intervention. The electronic computer is an automatic processor which is able to perform a great number of repetitive tasks at very high speed on a large body of data. This high speed is combined with great accuracy and reliability.

The computer is therefore well suited for those routine clerical tasks which human beings find menial, time-consuming and liable to error through lack of interest or through fatigue. However, the preparation of the *program* (i.e., the list of instructions) and the organisation of the relevant data are often lengthy and time-consuming processes. When assessing the value of using a computer to perform a particular task one must consider both the human preparation and machine execution times.

(3) The components of a digital computer — input and output, storage, control and arithmetic units.

To gain a deeper understanding of the working of a digital computer it is useful to consider the machine as made up of a number of interconnected units. There are various levels at which this can be done, e.g.:



or further by splitting down the processor into components, viz: store, arithmetic and control units.

Some discussion of the role of each of these units and the flow of information between them is most important and can easily be illustrated by the use of one of the versions of the computer game designed for pupils (see Notes on Method CHAPTER VIII).

III THE NEED TO ORGANIZE INFORMATION

A. ANALYSIS AND ORGANISATION

Many human activities can be broken down into a sequence of tasks. The splitting up of a complex task into small precisely defined steps is usually called the *analysis* of the task.

However, it is not unusual to find that a job can be analysed in many different ways. Finding the best way is a matter of *organisation*, provided the meaning of 'best' can be properly defined in terms of certain criteria, such as minimising the time or cost of the operation.

Having decided upon the most appropriate organisation of the task which may involve the use of certain algorithms, then it is usually desirable to illustrate these algorithms in a *flow chart.*

If we want to use a computer to process information or to solve a problem, we must first be clear about the contribution which the computer can make. The basic tasks which the computer can be required to perform may be briefly stated as follows:

(1) Communication

This may be communication either with the user or another machine. This includes acceptance of information (input) presented on documents, cards, tapes, magnetic discs, or through teletypewriters or other input devices; production of information (output) on paper, cards, tapes, discs, displays, etc.

(2) Storage of information

Information which is to be used has to be stored so as to be efficiently identified and readily available.

(3) Processing

This is reducible to many elementary operations, such as re-arrangement of information, arithmetical and logical operations, and jumps from one operation to another which may not be in sequence.

(4) Decision-making

By this is meant the following of alternative processing operations according to criteria previously set up or determined during the execution of a program.

It is desirable to distinguish the main features of jobs which are mainly computational and those which are essentially non-numerical.

In a computational job, the main part of the analysis and organisation is normally carried out in the process of formulating a mathematical model. Thus the development of a formula is an example of analysis, and the simplification of a mathematical expression is an example of organisation.

In many non-numerical problems simple calculations may still occur but do not predominate. In considering, for instance, administrative or scientific data processing, we may need to identify an overall system extending beyond the computer itself and involving both people and other means of transmitting and processing information. In such a case, it is necessary to identify other tasks which must be subjected to analysis before the computer is brought into the picture. Among such tasks we should note the following:

(a) *Definition of the components of the overall system under analysis.*

This provides a basic structure within which essential data can be identified, classified and coded.

(b) *Definition of the inputs and outputs of the overall system as well as of the computer.*

As a consequence of this definition suitable algorithms may be devised to resolve each separate task within the overall system. Some of these processes such as sorting, compiling, etc. will be standard and may be relatively sophisticated; others may not have been previously prepared.

(c) *Data preparation and data flow.*

The first of these is meant to include the organisation of data collection, the specification of documents and their translation into media acceptable to the computer. A precise definition of data flow involves the organisation of the data and its destination, both in place and time.

Examples such as timetable scheduling and the construction of data banks show how complex the analysis and organisation of such systems can be. This can be fully comprehended only by the study of actual cases, where the complex structure may mean that the complete algorithm cannot yet be sufficiently formalized.

B. FLOW CHARTS

A flow chart is the pictorial representation of an algorithm. The variety of possible logical decisions within a algorithm often becomes so complex that one must find a method to comprehend the overall logical structure. Flow-charting is a method of representation which also helps to compare different algorithms.

Stress has already been placed on the complexity which may often be associated with the process of organising the solution of a problem, and which makes it difficult for a man to consider all possibilities. Flow-charts help to decide if an algorithm solves the given problem in all cases, even those which seldom occur.

The flow-chart is a device which can be used at many different levels of detail, beginning at the most general level of logical breakdown of the process. It may then be progressively amplified until it approaches in detail the elementary operations to be carried out in the computer. However, in practice the process of introducing detail will be halted at a point where it becomes more convenient to write a computer program, using the programming language selected for this purpose. This is discussed further in the next chapter.

IV. PROGRAMMING LANGUAGES

A. GENERAL

Programming a computer means that a 'programming language' is used to write down the successive actions which the computer has to execute to solve a given problem. Programming languages range from basic machine language through a hierarchy of languages, which are designed to make it easier for the human to communicate with the computer. To be processed on a computer all programs must be either written in machine language or must be translated. The extent of translation required depends on the nature of the programming language used. The more it resembles human language the greater the task of translation. The amount of translation performed by the computer determines where a given language lies in the hierarchy of programming languages. Today most programs are written in high level languages, leaving to the computer the tasks of the translation process. The language chosen depends upon the problem under consideration. All programming languages must be capable of automatic machine translation and have some common features:

- they must have a mechanism which permits us to give a name to each piece of information we have to handle (the address in an assembly language; an identifier in a high-level language);
- they must enable us to define the way in which pieces of information are to be related inside the computer due to internal structure (files, strings, lists, arrays, etc.);
- they must allow us to give a name to an instruction so as to be able to refer to it throughout the language (an address in an assembly language, a label in a high-level language);
- they must enable us to define the actions which the computer has to execute.

Once the program has been put together, it must be entered into the computer for processing. This can be accomplished in two ways:

(1) The program and the data are typed on a keyboard so that they are entered directly through a device connected on-line to the computer; this is usually associated with a *conversational mode,* which allows immediate feedback between the computer and its user.

(2) The program and data are converted into a machine readable form (punched cards, paper tape, etc) that can be read into the computer through an input device; this method is usually associated with *batch processing,* which means that programs are collected and then processed in a batch.

Writing programs in an assembly language is not absolutely essential to the success of a course in computing, but many students find that the course is enhanced by spending a relatively short time writing programs in such a language. In writing these programs the language should be simple so that students can easily write and test their programs. Many of the existing assembly languages are best used by selecting a small subset of the instruction set to achieve simplicity and ease of use.

Writing programs early in a computer course is exciting and generates interest. For this reason, many teachers introduce an assembly language within the first few weeks. Later these teachers introduce a high-level language to illustrate its ease of use. Also, the high-level language permits students to tackle problems that have much greater scope; problems that were virtually impossible to do with the low-level language.

On the other hand many teachers prefer the reverse sequence; that is, to start students programming in a high-level language. When a student has achieved certain competency, teachers introduce the low-level language to explain 'how the computer really works'. There are arguments in favour of both approaches, and teachers of computing subjects should experiment with both methods and determine for themselves which they find most suitable.

A middle course is to start with a small subset of a high-level language using only simple instructions. From this sub-set it is possible to move easily either way to an assembly or a full high-level language.

B. ASSEMBLY LANGUAGE

Since high-level or problem oriented languages do not relate specifically to the way in which computers operate, it is desirable that teachers should have some appreciation of lower-level or assembly languages. Such languages relate to machine functions on a one-for-one basis; that is, one assembly instruction is translated (or assembled) into one machine instruction. Thus learning about assembly languages removes much of the mystery that surrounds high-level languages. However, a knowledge of *only* an assembly language would distort the view of the computer as an information processor.

Some of the assembly languages available are real languages for real machines and some are for simulated machines. Moreover, some have alphanumeric operators and operands whereas others are numeric only. Where possible, the simplest languages should be used.

A study of low-level languages will help to illustrate the following concepts:

- the relationship between the main sections of a computer; input, output, storage or memory, arithmetic unit, and control unit.
- various hardware features such as an accumulator and instruction counter;
- storage, divided into a finite number of parts, each capable of containing information referred to by an address;
- stored information as either data or an instruction;
- the idea that instructions are usually executed sequentially, unless interrupted by a branch or a halt.

C. PROBLEM–ORIENTED LANGUAGES

Problem-oriented languages, also referred to as high-level languages, are designed to facilitate the communication of the problem itself to the computer. The tedious coding of the assembly-level languages is avoided by powerful statements that are ultimately translated into many lower-level instructions but this translation process is of little concern to the problem-solver. What is of concern is the ease with which he can express his problem; in other words he needs a computer language similar to the one he speaks and he needs symbols, operators and subroutines which are very similar to those he uses when solving a problem with pencil and paper.

The program written by a programmer in the high-level language is called the 'source program' and is entered on punched cards or in some other machine readable form. The 'source program' is then made available as data to be operated upon by a special program called a *'compiler'* (usually supplied by the computer manufacturer). The compiler is readily available for entry into the computer from magnetic tape or disc. It examines each source program instruction and interprets this into the necessary sequence of machine instructions.

The final sequence of machine instructions to be obeyed is called the 'object program' and is output from the end of the compilation process. The object program can be permanently available for repeated use of processing the problem data to obtain the desired results. The compiler program for a high-level language carries out many of the functions which the assembler carried out for assembly level programs, e.g., assigning instruction locations, computing absolute addresses. One of the greatest advantages of high-level languages is that a single instruction in one of these languages may generate many machine code instructions. Thus one key word can initiate a whole set of procedural steps within a program.

Several high-level languages exist, the most common of which are FORTRAN, ALGOL, BASIC, PL/1, COBOL and APL. Often the choice of which language to use is dictated by the processing facility available. Sometimes the facility can handle various languages; the choice is usually the one with which the teacher is most familiar. If there are multiple languages available at a particular facility and the teacher knows all or several of them, the choice becomes somewhat more difficult but the teacher can then make the decision based on what he feels would be best suited to the particular problem to be solved.

The conversational use of a language via a remote computer terminal has educational advantages. An interactive terminal provides diagnostic aid and allows immediate error correction. Time-sharing use of computers allows a single computer to handle the problems of a number of users simultaneously. The speed of the central processing unit is vastly greater than that of the input-output devices, and the central processing unit can work in turn for each user for a small slice of time so that each gets the impression of having the computer to himself. A computer can also be organized so that a number of programs appear to run simultaneously. This is known as multi-programming.

V. SOME NOTES ON APPLICATIONS

A. COMPUTERS IN INDUSTRY AND COMMERCE

The complexity of society today confronts us with an ever growing amount of information. This information is generally inter-related, but the volume of data and the intricacy of relationships is such that it exceeds a human's capacity to consider and relate the many factors that are needed to make decisions. Due to the practically unlimited capacity of a computer's store and its speed of operation the handling of an extensive amount of information to extract desired facts or relationships becomes possible. Applications of computers in commerce, industry, public administration and scientific areas have evolved in the search for greater efficiency. Today this is the only way to handle large information systems bringing the results in a suitable form at a level usable for operating and decision-making.

Early applications were the automation of the repetitive work of clerks, so that the production of business records, papers and data was more efficient. Applications such as payroll, accounting, inventory control, invoicing, financial control, planning etc. were first done by the punched card processing of individual files. Unit record equipment is now being replaced by the computer. This enables the absorption of individual files into an integrated system. Within such systems it is possible today to record a customer's order, to schedule a shipment, to instruct the factory, to update inventory records, to prepare the salesman's commission statement, and to use the collective information of the files for future planning.

The concept of total business systems applies in many other areas. Two such areas are library processing and ticket reservation systems.

Library processing grew out of the processing of individual data files such as circulation and utilization records, book ordering, indexing, classification and information retrieval files. Current systems integrate these files into a single total library system. Ticket reservation systems started as real-time inventory control activities. In addition to the more effective selling of tickets, the airline uses the system to increase efficiency and to assist in short and long range planning. As in the previous examples, the processing of individual files evolved into a total system.

Process control systems carry the idea of business systems one step further. Consider the thermostat in a room. It controls the temperature in one operation. The control of many independent monitoring devices by a computer is an effective computer application. Among the common uses today are steel manufacture, electric power production, petroleum cracking and bakery production.

Similar to these process control system are systems of traffic control and the monitoring of patients in hospitals.

B. COMPUTERS IN EDUCATION

Today, in the field of education, many teachers, administrators and others can use the computer to lighten their tasks and to improve their efficiency. Teachers, both in training and in service need to be made aware that opportunities exist for them to become more effective through the use of this development of modern technology.

Among the many ways in which computers are used in education are the following:

(1) In organizing instruction, whether individual or in classes, it is desirable for teachers to match the individual student with the learning materials, resources and activities which fit his requirements as closely as possible. The computer can be used, on-line or off-line to assist in this. It can keep:

   (a) material and resource files which would include course packages and inventories of availability of people and materials;

   (b) student profiles containing their achievement records and personal details.

   This is commonly called Computer Managed Instruction

(2) The computer may be used by individuals or by groups, on-line or off-line, for learning in a variety of modes. Drill and practice, simulation and gaming fall in this category.
This is commonly called Computer Assisted Instruction (or Learning).

(3) The computer may be used by teachers and administrators in the following areas of educational administration: planning, finance, organisation and management.

   This is usually referred to as Educational Administrative Data Processing.

Students especially in the later stages of their school careers, will be able to organise their own learning using a computer in the first two above ways. They will also be able to use computers in the increasing part they are taking in the organisation of school affairs.

To introduce the teacher to these computer applications a course should include:

(a) The emerging role of the computer in the management of instruction and as an aid to learning. This is built on the concept of the individualisation of instruction which may be included in other education courses.

(b) Computer equipment and techniques available and criteria for its selection; also for the selection of instructional materials in this context.

(c) Understanding, but not in depth, of programming in languages suitable for computer assisted learning.

(d) Consideration of those subject areas where computers can be most helpful and of the limitations of this usefulness in other areas.

VI THE IMPORTANCE OF COMPUTERS AND COMPUTER METHODS WITHIN SCHOOL SUBJECTS

In some subjects, such as mathematics, the influence of the computer at the secondary level is already well advanced. In others, the impact is at an early stage of development but it is clear from the use of the computer in research in many disciplines that it is rapidly bringing about an enrichment of knowledge and indeed a new way of thinking.

We may take geography as an example:

Questions posed by geographers tend to be spatial ones and so answers in spatial terms are likely to be the most satisfactory. In the past, the map has tended to be the show piece of a geography project. The computer can produce maps quickly and cheaply, and different sets of data can be displayed easily. Thus, maps may be used to formulate further questions or to rephrase the original question to obtain a more meaningful answer. This interactive use of mapping is likely to revolutionize geographical thought in giving wider dimensions to thematic mapping.

It is essential that teachers of all disciplines should now prepare for such developments as this so that secondary school education can keep abreast of the changes which will take place in the near future.

It is possible to identify a number of themes which are emerging in the various disciplines and which can be grouped together under the following headings:

A. THE VALUE OF AN ALGORITHMIC BASIS FOR A DISCIPLINE

In many disciplines, the traditional way of teaching is no longer necessarily the most efficient.

The representation of algorithms as flow-charts is a powerful method which shows the logical structure of the topic under consideration. It should be stressed that although the value of flow-charting became generally appreciated through its use in computer science, it is in fact quite independent of this subject.

The same can be said of the ability to create models which is an essential method in research. Often in the past this activity has been confined to a small number of researchers whose results have later been presented as established facts. It should be our concern to give pupils actual experience of the creation of models.

In this respect, computer science helps in two valuable ways: firstly, by the actual use of the computer to simulate the operation of a model and secondly, and more generally, by its study of algorithms and logical processes.

It should be stressed that the formulation and development of a model is specific creative work within a discipline. This model making does not always lead to the formulation of an algorithm. One value of the study of computer science is that it helps to identify those areas in which the algorithmic approach is possible.

In biology, for example, pupils are usually required to accept passively a specified classification of plants or animals. It is preferable that they should instead be guided to understand the principal methods needed to construct a general model, called in the present instance a classification of certain living things. Application of some of the methods of computer science can lead to more rigorous ordering of the various properties, to the systematic use of the logical connections of the properties as "and", "or" and "not", and thus to the generation of useful models of the system which is to be classified in terms of words and symbols.

B. THE AVAILABILITY OF MORE DATA

The amount of raw data is increasing very rapidly. To extract significant information from this demands a sophisticated treatment which cannot easily be done without the computer. The use of involved analyses is now much easier: what used to be practically impossible is now commonplace.

The use of processed data gives an enrichment of knowledge in many disciplines which in its turn will cause changes in the curriculum at secondary school level.

In the subject of linguistics revision of the classification of words and parts of sentences may result from various statistical evaluations of long texts by a computer. This revision can form the preparation for research into translation from one language into another and even though the translation should fail, can give knowledge about the weakness of existing grammatical systems, and help the search for improved versions.

C. CHANGES IN THE RELATIVE IMPORTANCE OF VARIOUS TOPICS IN THE SYLLABUS

Some topics have not found a place in the curriculum because they would demand a large amount of calculation and therefore take up more time than they are worth. The computer has made the calculation easier and shorter so that these topics can now be included in the curriculum. It will happen therefore that the curriculum will change: some topics will come in and, since the curriculum would otherwise be overcrowded, others will go out. The exchanges will not be decided by computer scientists but by the subject specialists themselves when they realise the advantages which the computer can give them.

The recent development of numerical methods in mathematics means that it is no longer necessary for work in the evaluation of integrals to be confined to a few fundamental functions. Such methods of numerical integration, with associated work in the estimation of errors and how they are propagated, are examples of the topics mentioned above.

In addition, the computer science approach, in particular its interdisciplinary nature, can generate some entirely new topics which may be found sufficiently important to deserve a place in the curriculum.

D. REMOVAL OF DRUDGERY FROM A TOPIC

Many people have limited patience with data manipulation. Once a necessary method has been mastered its repetition may be regarded as an unwanted drudgery. This has then led to the obscuring of the beauty and value of a topic beneath a mass of routine calculation. Alternatively, teachers have been forced to ignore or play down the topic to keep their pupils happy. With computer solutions available to remove this drudgery the teaching and enjoyment of the topic can be transformed.

In economics the importance and meaning of such statistics as mean, variance and correlation cannot be fully understood unless their values have been developed within suitable examples. The tedium of the extensive calculation often interferes with the students' insight into the theories under consideration. When a computer is used the drudgery is dissipated and the teacher will be free to direct his pupil's attention to the fundamental points at issue.

E. ILLUMINATION AND UNDERSTANDING OF A TOPIC

It is unfortunate when pupils are asked to accept facts without any demonstration, proof or possibility of experimentation.

The computer can remedy this situation through its power of simulation which although far from fully developed is already making an important contribution to teaching.

This power of simulation can, for example, develop the understanding of pupils by showing dynamic processes in action. It can also be used to provide exciting glimpses of the topics which lie ahead, thus motiviating the student in his work and encouraging him also to seek ways of employing the computer.

In physics, the concept of the instantaneous velocity of an accelerating body at a certain moment in time, can be developed by the use of examples showing the convergence of the average velocities as the time interval is progressively reduced towards zero. Examples of this kind can easily be prepared on a computer and their discussion and solution will increase the pupils' understanding of these physical processes, leading them smoothly towards the concepts of differentiation and integration.

F. CHANGES IN THE STRUCTURE OF CAREERS

The computer is already causing deep and rapidly accelerating changes in society and therefore in the spectrum of jobs available.

The computer industry itself offers a wide choice of new careers, ranging from systems analysts to programmers and operators, and is also opening up many new opportunities in engineering. On the other hand, the computer is rapidly reducing the chances of employment in routine clerical jobs. It should be noted that ability in the rational use of computer science will be demanded in the future of those wishing to enter such professions as geographer, biologist, physician, to mention but a few.

The teacher must be aware how these changes will affect the structure of the teaching of his subject and that they will do so, not merely during the last years of secondary education, but throughout.

VII COMPUTERS AND SOCIETY

Computer systems have been introduced into business, commerce and government administration to increase efficiency and to facilitate the processing of information. A modern system consists of people, information and machines which interact. It is extremely important to realise that *people* are the most important components of a system and not the machines.

It is essential therefore to include a discussion about the impact of computers on society in any course of computer studies so that students are able to assess the increasing use of these machines and to consider their effect on everyday life. The growth of automation may result in societies which fail fully to utilise the potential of the individual. It is the duty of teachers to develop fully this potential within their students so that they can lead satisfying lives against a background of continuous change and development.

The effect of the computer on the individual can be discussed in relationship to his employment and to his private life. The introduction of a computer system in his place of work can have far reaching effects not only on the job that he is asked to do but also on his position within the total business structure.

Among the problems to be faced is the effect of the increasing use of automation on unemployment. If the amount of available employment should fall significantly then the length of the working week is also likely to shrink. The consequent increase in unemployment and enforced leisure might have a serious effect on people's self respect and consequently lead to a less happy society.

For a full life people need to be involved in creative activity; careful planning will be necessary to make sure that satisfying occupations are available to the whole population and not just to an intellectual or technocratic elite.

Within ones private life the computer's effect can be highly individual or generally part of the environment. The maintenance of privacy is a major concern today. The growing use of data-banks and their possible misuse has become a problem of both national and international alarm. Questions which should be asked are:

Is it right that information about an individual should be centralised and readily available?

Who should have access to such information?

Should the individual have access to his own file?
Would he have the right to appeal against information which he felt to be inaccurate or unjustifiably detrimental to his character?

Is it possible to guarantee that information will not be accessed by accident or intent by unauthorised persons?

In many cases, fears are justified and benefits and disadvantages have to be weighed against each other. In other cases, fears are largely imagined – would the individual be willing to accept a computer diagnosis of ailments rather than to rely on the more personal but more fallible diagnosis of a doctor?

The efficiency which computers bring to methods of achieving goals makes the choice of these goals a vital matter. Short-sighted aims will lead more quickly and certainly to disaster. A need to think over the basic aims of life becomes even more important for all who, in a democracy, have the power of choice. It is easy but dangerous to let financial profitability be the main variable to be maximised. The cost of technological developments tends to accentuate the differences between those nations which can afford them and those which cannot. Continuing action needs to be taken in international co-operation to see that the gap is narrowed rather than widened.

In any attempt to influence the pattern of future society it is necessary to be aware of certain basic problems. Man is frequently reluctant to accept change even though those changes may be for his ultimate benefit and well being. The changes which are being wrought by the introduction of computer systems are more rapid and far reaching than man can easily comprehend.

Teachers must prepare to encounter unreasoned opposition to these changes. It should be borne in mind that such resistance is unlikely to come from those who have been educated to appreciate the advantages which computer science will bring to them.

VIII SOME NOTES ON METHOD

The above outline describes a list of topics, some or all of which could be incorporated in a course for pupils. There are many different ways in which these topics could be combined to constitute such a course. The depth to which each topic is treated can, of course, be varied.

The teacher can determine reasonable educational objectives for each group of pupils, depending on their age and ability, in a particular environment. For all courses it is highly desirable that full use is made of teaching aids and that pupil participation is an important part of each lesson. The topics in any course will lend themselves to working in small groups and to the use of assignment cards and projects. The teacher can provide a wide variety of assignments at various levels, so that each student or group can find a problem or project which is of interest and of the right ability level. Success is important to the individual.

The following notes come from the contributions of many teachers on successful ways of presenting the topics in the Guide to pupils of various ages and abilities. It is hoped that these suggestions may be helpful to others teaching in this field.

CONCEPT	PUPIL PARTICIPATION/METHOD
Recording information	Various coding methods including needle-sort punched cards.
Retrieving information	Using a needle with punched cards to extract the desired information.
Management of information	Using a simple language, as near as possible to English itself, to build, store and manipulate simply structured files in a computer. Emphasis should be placed on the need for validation, on the danger of persistence of errors, as well as on the ease of retrieving information and organizing it through sorting and the automatic generation of reports. Simple examples can be taken from vital statistics, class library or any set of homogenous elements with which the students are familiar.
A sequence of events and decisions — the flowchart	To find the most efficient way of performing a task. The logical structure of everyday occurrences. Flowcharts for nursery games; e.g., musical chairs, hopscotch.

The automatic execution of an algorithm	Investigation of the operation of a washing machine, a lift, traffic lights.
The information processor Input — process — output	Scoring at a football or tennis match.
Algorithms for information processing	Looking up a word in a dictionary; selecting a team; school rules; the average age in a class.
The requirements of a processing machine	The computer game — there are many versions of this game and descriptions have appeared in various books. The important point is to have a simple device which the pupils can make to act as a store. A stack of numbered/ lettered matchboxes is perfectly satisfactory. In the store is placed the program which is executed instruction by instruction, data being moved about and operated on via other stores. If it is possible there are advantages here in using a subset of a computing language which can be run on a real computer; e.g., a subset of BASIC could consist of the following eight instructions: INPUT A PRINT A A = B + C A = B – C A = B * C A = C / C GO TO 50 IF A>B THEN 50 If it is felt desirable to process words rather than numbers, a language which handles words should be used.
Problem solving	For the flowcharts and algorithms some problems are bound to be mathematical. There are others which are not; e.g., sorting, merging and updating. One or two simple programs can be run on the matchbox computer and may be tested on a real computer. The use of mark-sensed cards may be possible here and will eliminate a program or data preparation bottleneck.

Machine functions	After initial exposure to problem solving it is useful to look at the way the central processor works. This can be done by introducing three special registers: 1) the instruction address register 2) the instruction register and 3) the accumulator. The matchbox computer which includes these registers can be used to process an assembly code program. Again, the code should be simple. For an initial demonstration of the running of an assembly level program the pattern of stores can be projected by an overhead projector on to a magnetic board; instructions, instruction labels and the data (on magnetic cards) can be moved about as the program is being run step by step.
Computer electronics and binary operations	Many logic kits are now available with a variety of modules. Building up and combining the basic circuits of computers can be very exciting but technical problems may cause great demands on time.
Real applications	An expansion of simple data processing programs into suites of programs, for example, inventory control and payroll. Mathematics students will want to develop numerical and statistical methods. Pupils may gain an insight into the application of computers in non-numerical fields by using 'package' programs which have been prepared by computer specialists, e.g., PERT. These programs can be used as working models to simulate the action of economic, business, scientific or other systems. Visits to computer installations, films. Projects from which pupils give short lectures.
Social implications	Depending on the maturity of the pupils; discussion or short lecture sessions are important.

SOURCES OF FURTHER INFORMATION

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(2) *Association for Educational Data Systems*
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(4) *National Computer Centre*
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(5) *National Council of Teachers of Mathematics*
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(6) *Netherlands Research Centre for Informatics*
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