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COMPUTER SIMULATIONS

by

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CONTENTS

1. INTRODUCTION

This paper examines the various uses of simulation for education and training which involve the exploitations of the computer for the running of all or part of the simulation. The development of this form of simulation can be seen as a part of the growth in computer based training (CBT) in recent years, which has been given renewed impetus by recent advances in the micro computer field.

Over twenty years ago the mainframe computer started to be used in education to deal with complex multivariables -it was really the first time that a teaching aid could be used to dynamically demonstrate the result of many factors varying simultaneously. In the area of management and business education, the business game was rapidly developed, based upon the principles developed in war games for strategic defence purposes; but unfortunately, and for a number of reasons, its real capacity for management development purposes was not fully exploited.

The development of the use of computer based simulations went through several phases of popularity. Amongst their advantages was the fact that dynamic exercises could be tried within a life-like context of increased complexity. Disadvantages included the expense, and the dependence of teachers on computer technologists. At first, such computer based simulations had to be carried out at the computer location, although mainframe time sharing reduced this problem from the early seventies onwards, albeit with added expense.

Computer-based training thus became a monopoly of the giant mainframe computers, which have been utilised for such purposes by the educational, industrial and commercial sectors since the early seventies. Now, however, the microcomputer, like an adolescent scorning its father, has asserted itself in the CBT world, offering cheap power and the promise of greater word-processing and graphics sophistication, together with ease of programming; and the plethora of 'authoring' software packages now available means that little or no formal programming skill is required to produce competent CBT packages. Thus, whilst some of the simulation examples described in this paper were designed to run on mainframe computers, they are included as illustrations of what can now readily be achieved on micros. Indeed, the graphics facilities now available on most micros means that the visual presentation and impact of computer simulations can be greatly enhanced.

2. COMPUTER SIMULATIONS : DEFINITIONS AND EDUCATIONAL ATTRIBUTES

One commentator has pointed out how nearly all computer-based training may be seen as a form of simulation in its broadest sense, and also shows how the distinction between computer-based training and simulator training is becoming increasing blurred (1). Computers play an important part in most training simulators, whilst as noted above, much computer based training revolves around simulation techniques. One recent definition of Artificial Intelligence as 'computerised simulation of intelligent behaviour' (2) highlights the possible breadth of discussion, and matters are further confused by the overlap between simulation and modelling. Most computer simulations are organised around some form of model, whilst model building frequently involves the use of computers (3).

In this discussion, we shall consider those models which have been built into a computer program for the purpose of providing students with a substitute for part of the real world, and we shall refer to these ready-made models as computer simulations. In these simulations, students can vary or control the behaviour of key variables in a system of interest, and measure the resulting effects far more simply and with far less instrumental training than that required in a normal laboratory situation. Simulations introduce students to the logic of experimentation and enable them to undertake such experimentation in a risk-free environment. They can operate at levels of complexity to suit the age and educational level of the student user; and they can produce results in a variety of forms - numeric, textual or graphic. Moreover, they can include significant amounts of calculation and accounting, which they computer handles with ease.

This is not to suggest that computer simulations are without their problems. If trainers fail to draw student attention to the simplification involved in a simulation, and let them believe that the model is a perfect reflection of the real world, then the value of the simulation will be undermined. A further problem arises in the way students are asked to use the simulation. Goals must be set for the simulation activity, or there is a danger that students will merely go through the motions of manipulating the package without being forced to consider why they are doing so. Part of this problem can be solved by building into the simulation various 'tests' or problems which have to be solved by students before they can make further progress.

It is extremely important that trainers ensure that simulation exercises are embedded in other learning activities, and that students use their computer experience to further their understanding of the real world. An idealised view of how simulations might fit into a teaching scheme is as follows:

STUDY OF REAL WORLD OBSERVATIONS → PREPARATION FOR USE OF SIMULATION → USE SIMULATION → COMPARE SIMULATION RESULTS WITH REAL WORLD DATA

In the following discussion several inter-related uses of computer simulations will be illustrated. The first use is as a vehicle through which students can explore make-believe worlds. Such worlds may either be replicas of part of the real world, suitably simplified or reflect normative assumptions about how the world operates. Some of these simulations are presented as 'straight' simulations in which the student is meant to learn by a process of experimenting with the model. In other cases, particularly those which simulate elements of the human world, the simulation is cast in the form of a game with the student making decisions which are part of the process being modelled. In other situations, the most effective way of getting the student to invetigate elements of the real world is to provide a model that purports to explain it, but whose level of explanation is known to be out of tune with observable facts. By comparing the faulty model with empirical observations, the student is given a basis for more surely identifying, describing and explaining the elements of the real world supposedly simulated by the model. Most a priori or normative models developed in the social sciences serve this role.

The third use for simuations is as design or training tools. In this role, simulations provide a test-bed for the student's skill without the danger or expense of allowing him to practise on the real world. The most obvious lay example is the aircraft simulator, which is used by airline pilots prior to taking to the air.

These three roles are not mutually exclusive, and sometimes a single simulation will serve all three purposes at the same time. The distinction is made to draw attention to the different functions computer simulations can perform.

In the following three sections, a number of computer simulations are illustrated and discussed. These have been given one of three classifications, which are similarly overlapping and inter-related. First, computer simulation models are those where the simulation essentially concerns the manipulation of a pre-defined model by means of a computer program. Computer simulation games, on the other hand, go further than mere model manipulation and decision-making in a simulated environment. Finally, some examples of how computer simulations can be used for more precisely defined technical training purposes are given in the section on computer simulations as training tools.

3. COMPUTER SIMULATION MODELS

Many computer programs have been developed which provide students with replicas of the real world. Not surprisingly, a large proportion of these come from the physical sciences where the processes observable in the natural environment are often understood with a reasonable degree of certainty.

A typical example is RUNOFF, a simulation which illustrates what happens to rainfall as it enters a simple ecosystem. In order to run this simulation, students must first define various characteristics of their hypothetical ecosystem - temperature, type of vegetation, degree of vegetation cover, and lithology. They then create a storm with a given pattern of rainfall intensity, which introduces precipitation into the system. The program then models the passage of the rain through the system and displays the various 'destinations' of the rain through the system and displays the various 'destinations' of the water either graphically or numerically. An example of a run of the program is provided in Figure 1.

```
DEFINE THE ECOSYSTEM

TEMPERATURE (DEGREES C): ?15
ROCK TYPE (1=CHALK, 2=SANDSTONE, 3=CLAY): ?2
VEGETATION COVER (PERCENTAGE): ?80
VEGETATION TYPE (1=FOREST, 2=SCRUB, 3=GRASS): ?1


INPUT A STORM

DURATION OF STORM? (NO. TIME UNITS): ?6

FOR EACH TIME UNIT, ENTER AMOUNT OF PRECIPITATION (MMS):

TIME UNIT       ?5
TIME UNIT       ?7
TIME UNIT       ?10
TIME UNIT       ?10
TIME UNIT       ?6
TIME UNIT 6     ?6



--------------
SELECT DISPLAY

YOU HAVE A CHOICE OF DISPLAY:
 (1 = TABLE,  2 = GRAPH,  3 = BOTH.)
TYPE:  1, 2 OR 3: ?3


TABLE OF ECOSYSTEM OUTPUTS
(VARIABLES ACROSS, TIME DOWN)
```

TIME	P	V	E		R
	5	5	0	0	0
	7	8	0.25	1.88	1.88
	10	8	0.25	4.88	4.88
	10	8	0.25	4.88	4.88
	6	8	0.25	3.88	3.88
	6	8	0.25	2.88	2.88
7	0	4	0.25	1.88	1.88
8	0	2	0.25	0.88	0.88
9	0	1	0.25	0.38	0.38
10	0	0.5	0.25	0.13	0.13
11	0	0.25	0.25	0	0
12	0	0.13	0.13	0	0

```
YOU MAY SELECT ANY TWO OF THE FOLLOWING
VARIABLES FOR YOUR GRAPH:
   PRECIPITATION,
2. VEGETATION RETENTION,
3. EVAPO-TRANSPIRATION,
4. INFILTRATION,
5. RUNOFF.
TYPE NUMBERS ONLY...

FIRST VARIABLE: ?1
SECOND VARIABLE: ?5

GRAPH OF VARIABLES  1  AND  5
(MMS WATER ACROSS, TIME UNITS DOWN)

       0     2  3     5  6  7  8  9  10
 0     +..+..+..+..+..+..+..+..+..+..+
                      P
          R                 P
                     R                 P
     - !             R                 P
 5     >          R            P
             R         P
          R
       ! R
       !R
 10
```

Figure 1. An example of a run of the RUNOFF computer simulation

A moderately intense three hour storm contributes water to an ecosystem with 80% forest cover, on a sandstone lithology, with atmospheric temperature of 15°C. The delayed response of the system in producing runoff is clearly demonstrated on graph, reflecting the influence of the forest canopy in intercepting much of the early rainfall during the storm.
Source: Shepherd, Cooper and Walker (1980)

RUNOFF is an interesting case study, because it can be used to demonstrate to students that all simulations, however realistic their behaviour might seem, are only embodiments of theory. RUNOFF - like many other educational computer simulations - is a highly simplified model.

This point is worth emphasising in the classroom, because students are always too ready to accept the results of a computer simulation as 'the truth'. Follow-up sessions could attempt to take students a step or two beyond the 'clean' output of the simulation to confront the 'dirtier' patterns observable in the real world. As long as teachers continually bring students back to an examination of the real world, they need have few fears about the over-simplification represented by the simulation models they might consider using. Indeed, simplified models are often preferable to ultra-sophisticated ones. Not only do simpler models allow students to see more clearly the effect of experimenting with inputs to the model, but they also allow students to discover for themselves the degree of simplification involved, and to accept this as a challenge to identify the complexities of the real-world system in complementary activities.

Such simulations are particularly valuable in helping students to examine processes that occur through both space and time. One such example is SPREAD, a simulation program which illustrates some of the factors involved in the spread of a contagious disease. SPREAD is based on the diffusion of Dutch elm disease in Britain during the 1970s, and demonstrates the importance of spacing in affecting the speed at which the disease spreads. Students set up a pattern of healthy and immune trees in a regular grid, and the program then simulates the diffusion of the disease on a year-by-year basis. Trees that become diseased are marked with a 'D', those that survive are indicated by an 'I' and those that die are marked with an'X'. Most elements of the hypothetical treescape are modifiable by the student user (for example the distribution pattern of the trees can be adjusted in various ways), but the disease always spreads from four initially diseased trees in the top left hand corner of the study area.

These simulations illustrate very clearly how the computer undertakes tediously repetitive calculations on behalf of students giving them more time to question the assumptions of the models being used, and providing them with plenty of evidence with which to evaluate the appropriateness of the simple diffusion analogy for describing time-space processes in the real world.

4. COMPUTER SIMULATION GAMES

Games are a type of simulation which can be used to illustrate the processes of decision-making which lead to the creation of the man-made environment. (Taylor & Walford, 1978; Wynn, 1985). Frequently games provide insights for students which are difficult to achieve by other, more traditional teaching methods. In a role-playing game, students act out singly or in groups the attitudes and decisions of target individuals, groups of institutions, and discover the significance of social rules by immersing themselves temporarily in the appointed role. In a computerised game, students may play with or against the computer, and the exercise benefits from the greater realism which is made possible by using the computer to calculate the outcomes of the students' decisions.

SLICK! is an interactive computer simulation designed for the 10-16 age range. It focuses on a case study of oil pollution around the UK coast, and has been designed to run on a number of popular micros (BBC, Apple II and RML 380-2 micros). In addition to the program itself, the user is supplied with:-

A data sheet describing the various methods of pollution control and their benefits and disadvantages.

A map of the coastline to be protected during the game which is near a busy tanker route and contains many environmentally sensitive features.

A briefing sheet which informs the student that he or she has just been appointed Local Pollution Officer for the area and has a budget of £5000 for anti-pollution materials.

- Illustrations of the various methods of pollution control.

- Program notes.

- Four Briefing Papers with background on the oil company's environmental activities and further information on the problems of dealing with oil spillages.

At the start of the program a replica of the map appears on the screen, in full colour. This is followed by an order form on which materials up to the value of £5000 are ordered. If desired, the program will automatically allocate this figure to help younger students. An emergency is then announced. A tanker is leaking oil at a specified grid reference on the map. The screen shows information on wind speed and direction and the student must predict where the slick will move in a certain time period and type in the appropriate grid reference. The game is controlled by a time base and students have less and less time to make predictions and take action as the game progresses.

After each successful prediction of the slick's movement (there are 28 to make in each game) students can try to deal with the threat. This can include loading a tug with dispersant or absorbent materials, de spatching the tug to the slick and unloading the materials, placing booms at sensitive points, and deploying skimmers to mop up any oil the booms collect. Feedback is given, such as the remaining weight of their slick. At the end of the game, the student is given a score reflecting the quality of their decisions and the accuracy of their predictions. The slick can take 50 routes, so the game can be played many times by the same student or group of students. This program has several benefits; it teaches about pollution control whilst still requiring a range of numerical and other skills, such as map interpretation, and also illustrates the sophistication of graphics now available on most micros.

POVERTY is representative of a large numbe of computer games which put students in charge of a hypothetical land use system and challenges them to optimise the use of available resources. POVERTY represents a hypothetical group of villages in a marginal farming area of West Africa. Most of the events which affect the farming cycle in this area - weather, disease, war etc - are included within the game. The program introduces events at random, though the frequency with which they occur is kept within realistic limits. The game may be played by a single student managing the affairs of a single village, or by two or more students (sharing the same terminal), each in charge of a different village in the study area. The object of the game is not winning, but using the resources available to escape the downward spiral of poverty. Students representing separate villages can play against each other. They take decisions about which crops are to be grown for each year of the simulation, and the computer takes on the dual role of game accountant and provider of certain random 'Acts of God'.

One of the features shared by such games as POVERTY is the large amount of calculation required to keep the players informed of the outcomes of their decisions. It is this calculation burden that led to the creation of computer versions of games such as POVERTY. In these games, the main role of the computer is to relieve the players from keeping track of the scores at each stage of play. This has the advantage of allowing students to concentrate on the concepts conveyed by the game.

Not all games demand the full computer treatment. Indeed, the designer of a game should be wary of transferring a complete game on to the computer if one of its main aims is to provide students with first-hand experience of social interaction. With mixed-ability groups of students at middle-school level, for example, the less able student often benefits from role-playing interchanges and subsequent discussions with the more able students in the group. In such cases, teachers may wish to use the computer only in an ancillary role, perhaps to keep scores between rounds, or to provide students with access to game information.

An example of this can be found in the use of the Hackney Partnership Game, which addresses the problems of co-operation and collaboration between public and private agencies in the redevelopment of inner city sites in a London municipality. This is one of a series of case study simulations developed by Wynn and others, all of which lend themselves to micro-computerisation (See Wynn, 1985).

The simulation is designed for 15 to 20 participants, and is based on the search for consensus within and between four role playing teams - Local Community Group, Local Private Sector, Local Authority and Developers and Investors. The focus of debate is the potential use of twenty derelict sites chosen from the inner city borough of Hackney. Twelve possible projects, each with different costings, employment creation factors and other requirements and attributes, may be implemented on any of the twenty sites, and a fluctuating overall budgetary allowance makes several such projects feasible on any one site. The game is more of an argumentative rather than design process and the micro is thus used to store the succession of recommendations for site-use produced by different role playing groups in four separate rounds; and the distribution of these recommendations within the Matrix Board of Sites and Projects is displayed on peripheral VDUs. This not only provides role playing teams with a continually updated impression of the most favoured project/site combinations but also allows them to recall any of the previously entered solutions (special 'Solution Forms' are given out to all participants) for reference and consultation. Without the micro, the participants' instant access to this wide range of data would be impossible and the simulation itself extremely difficult to manage.

The program is written in Basic and runs on the North Star Horizon, with printer keyboard and two Visual Display Units. On one, 'feasible solutions' for project implementation on particular sites are shown as they are keyed in, whilst on the other, a matrix of sites versus projects shows the distribution of feasible solutions giving participants a continually updated impression of the most popular site and project combinations. Any feasible solution can then be retrieved, viewed and printed out if required for further examination and discussion. This is of particular value when groups are asked to compare and choose between different 'feasible solutions' for land use on the different sites.

The Hackney Partnership Game illustrates one way in which the traditional role playing game can be provided with computer support. It also illustrates the positive contribution that can be made by computer graphics in providing a visual reminder of the current state of the game. Another example of this role is to be seen in PORTS, in which students build up a map of a hypothetical coastal region within which the growth of competing ports is to be simulated. The 'gameboard map' is presented on the screen of a graphical VDU during the simulation and serves to remind students of the spatial arrangement of their simulated world. Where the game is set in a real location, the presence of a visual display may help students playing the game to learn something about the geography of the area in question.

One final point needs to be underlined. The use of such games, computer or otherwise, must be carefully organised and handled by trainers, or their surface entertainment component may over-ride their educational intent. Not that teachers should oversee student participation in a game in an authoritarian manner, as this would plainly conflict with some of the educational benefits of this form of exercise. Rather, teachers need to set the game experience within a clearly defined educational framework. In practice, this may be achieved in several ways, either by briefing the students carefully before the game or by providing them with documentation which clearly outlines the educational and geographical implications of the exercise. Careful debriefing is essential after the game if these lessons are not to be lost (Walford, 1969). Wynn (1985) provides useful examples of ways in which games can be 'embedded' in complementary educational activities to maximise the learning benefits.

5. COMPUTER SIMULATIONS AS TRAINING TOOLS

The final type of computer simulation to consider is that meant to be used as a design, management or training tool. In several disciplines, particularly those with a strong vocational orientation, the computer is frequently called upon to act as a training device. For example, engineers, highway designers, architects and environmentalists commonly use the computer to implement design decisions or to practise a skill without having to consider the consequences of doing it 'for real'. In these circumstances, the computer models used in the simulations have to be as realistic as possible, and therefore contrast with most of the educational simulations discussed so far in which simplification is a desirable characteristic. In some cases, trainees will already have mastered the appropriate theory; in other cases they may need no theoretical understanding of the system they are being trained to manipulate. In either case, trainees use the simulation for the practical experience it provides.

An example of such a computer simulation is ROUTE, a program which simulates the decision to build a motorway through a large English town. It was designed to introduce students to cross-disciplinary approaches to solving environmental problems but ROUTE may also be used as an introduction to the techniques of environmental impact analysis. Under program control, the computer displays a map of the town, which is subdivided into three types of land use; rural, low-density housing, and high-density housing. The student then types in an 'environmental impact matrix' which summarises the importance he attaches to the impact of the proposed motorway on up to seven factors; noise, vibration, atmospheric pollution, social severance, land take, visual intrusion and danger. He then enters a proposed route for the motorway, distinguishing those parts which are to be built on the surface, in cuttings or in tunnels. The computer is then set the task of producing a scored environmental impact matrix for this route, given the student's stated set of importance values. The program can inject further realism into the exercise by calculating the financial cost of building the proposed motorway.

The bulk of experience of this form of computer simulation, however, is found in the industrial and commercial sectors and detailed examples from two major chemical and pharmaceutical firms are included here. Mobil Chemical's Films Division produces biaxially orientated polypropylene film (BOPP) which is extensively used in the packaging industry. It is necessary to produce BOPP to very close tolerances and uniformity of thickness, and it was thought that CBT might be chosen as a means of training plant operatives to master the various operations in BOPP manufacture. The aim of the CBT package was to reduce the times required to train new operators and to standardise on operating procedures. The foremost reason for selecting CBT as a training medium was the desire to teach every operator the same things without the subtle differences that can be imparted by some teachers. A CBT package should produce uniformly trained operatives.

The computer used was a Regency Systems RC-1 Microcomputer, and the package consisted of three major parts. The first part was a set of tutorial lessons using text and animated graphics which covered the basics of fluid flow of molten material and the fundamentals of the equipment and the second part was a test concerning the sorts of problems that crop up on the plant.

The final part is the most interesting, since it uses a process simulator program with which the operator is put in charge of a simulated film manufacturing plant and is required to produce film to given standards. Whilst using the simulator, any one of nine problems can be chosen. These are the ones that most commonly arise in the operation of the real plant. In each case, the situation is that the plant is producing unacceptable film; time is passing and the operator must try to correct the faults that arise. As time progresses,a simulated roll of film is being produced and the operator can get cumulative gauge uniformity profiles. The various indicators and control settings are reproduced realistically on the screen even down to random 'blips' in the gauge measurements which, whilst having nothing to do with any real variation in thickness, also arise in real life.

At the heart of the process simulator is a set of complicated mathematical equations which describe how the process reacts to the various settings available to the operator. Changes in the setting are all time dependent.

For example, a change in temperature of the molten polypropylene may be selected, but the change will occur slowly, just as in the real case. The equations used in the simulator cause the process to respond in just the same time-scales as the real film making plant. Similarly, simulated mechanical adjustments can be made but, like temperature changes, they are not instantaneous in their effects. So, as the operator uses the simulator he learns that it is often necessary to wait, to see the cumulative effect of any changes made. Sometimes, the simulator is programmed with random and transient effects in film thickness which the experienced operator would ignore in real life. So, on the simulator, these transients are programmed to disappear after a time.

A thorough evaluation was made of this project. The results showed that the development costs of the CBT program were recovered in one year taking into account savings on normal training costs alone. There were also similar savings in terms of reduced wastage of scrap polymer and increased productivity.

Rather different uses of computer simulations as training tools have been made at Glaxo Pharmaceuticals UK. Here a range of CBT packages have been made available on the distributed network of Hewlett-Packard mini-computers, which are linked to over 1,000 computer terminals on four separate sites. These interactive packages have, in the first instance, been used to train staff in the use of key programs in the Stock Control, Stores Recording, Quality Assurance and Production systems. Within each package, the use of on-line programs is simulated using mock data which has no effect on the live databases (Figure 2). These packages are entirely self-contained and require minimal resources in terms of disc space and processing power. They can be used on an ad hoc basis by any of the company's staff and also under supervision on site with a subject expert on hand to answer any questions that may arise. They have contributed significantly to computer end-user training and have in part replaced formal courses previously held at the company's Greenford (London) site, saving considerably in human, financial and technical resources. The range of packages is now being extended to cover other subject material such as office systems and the use of database enquiry languages.

```
V805                DISPLAY PLANNED ISSUES AND RECEIPTS              S/CPIR

ITEM               [LIMESTONE FLOUR        ] STORE NO [00] MAIN UNIT [KG] <
ITEM      "BHOO" OPENING STOCK   PASSED [        0] UNDER TEST [        0]
 DATE        REFERENCE      ISSUES   TOT-ISS  RECEIPTS   PROJ.STOCK

          --------> OPEN STOCK          0                0            0
  >30-AUG-86 S000020901          0             2000         2000 <
```

The second screen of ?S/CPIR now shows us the following:
* a delivery of 2000 kgs of limestone flour is expected on 30th Aug 1986 and the Planned Receipt no. for the delivery is S000020901.
* there is no 'opening stock'(i.e. no stock of limestone flour currently in store 00).
* the Item Class is ABHOOB (this tells us it's a raw material).
* once the Planned Receipt has been booked in, there will be 2000 kgs in store.(This is called the Projected Stock).
* the Main Unit is Kilograms.(Indexes to Item Classes and Units are included in the MENTOR User Manual).

Note that the Planned Receipt no. begins with an S which tells us we are operating at Speke.At Ware such Planned Receipts begin with a W, at Barnard Castle they begin with a B, and at Greenford with a G. Once you have studied this, press ENTER to continue.

```
V805            DISPLAY PLANNED ISSUES AND RECEIPTS                  S/CPIR

ITEM [16090          ] [MAGNESIUM STEARATE BP          ] STORE NO [00] MAIN UNIT [KG]
ITEM CLASS [ABGOOB] OPENING STOCK   PASSED [        0]  UNDER TEST [        0]
 DATE       REFERENCE     ISSUES   TOT-ISS  RECEIPTS   PROJ.STOCK

        OPEN STOCK          0                0             0
 3-APR-86 S000020801          0             1000          1000
```

Try answering the following questions.[Press ENTER after typing in each answer]
1.What is the Main Unit for magnesium stearate? [ ]
2.How much stock is there currently in store? [ ]
3.How much magnesium stearate should be delivered on Apr 3rd 86? [ ] [ ]
4.What is the Planned Receipt reference no. for this delivery? [ ]
5.How much magnesium stearate will there be in Store 00 once this delivery arrives and is booked in? [ ] [ ]

Let us now imagine that today is April 3rd 1986 and the delivery of 1000 kgs of magnesium stearate arrives at Store 00. You now wish to book this delivery into the store, which you can do with the option +GRN. First make a note of the Planned Receipt no and delivery quantity, because you'll need these details later. Now type in +GRN in the NEXT SELECTION box below and press ENTER.

NEXT SELECTION [   ] NEXT KEY [   ]

Figure 2. Simulating the Use of a Computer System within a CBT package

Above, the key information on the main stock control program is explained. Below the user is questioned on his understanding. Depending on user responses the program branches to recap or progress to the next stage in the instruction package.

A further development at Glaxo in the CBT field has been the design of an interactive 'Expert System' to aid the diagnosis of bronchial hyper-activity. The system, called ADEPT, has broken new ground in several areas, notably in medical teaching and video-disc application.

ADEPT contains both knowledge about the subject area of asthma and the methodology for comparing information from a particular patient with this knowledge base. This information is collected as responses from the user to a series of questions presented in sequence. These questions are designed to explore various areas relevant to establishing a diagnosis and assessing the severity of the condition.

This information is quantified and then adjusted by data relating to symptom frequency and severity. This leads to an overall assessment of the condition of the patient at the time of presentation. For patients who are receiving therapy which might influence the overall symptom pattern, an appropriate correction is applied to the assessment and this leads to a prediction concerning the underlying severity of the disease being treated. Once a conclusion has been reched about the underlying (untreated) disease severity, it selects a suitable treatment or treatment combination from a list of possible therapies. Age and other factors are taken into account in reaching this therapeutic proposal. When appropriate, non-therapeutic measures are also indicated.

From the practical point of view, the ADEPT system incorporates a touch screen which obviates the need for a keyboard, therefore making data entry really rapid. From a user's point of view, this means no fumbling with keyboads and no looking alternately between the screen and keyboard. It also incorporates a video disc to support the computer software. At any stage in a consultation the user can call for an explanation, which is normally a short video sequence, illustrating and explaining the point being made.

So, in summary, ADEPT has brought together three disciplines, each with different skills and objectives, but with a common purpose. It is bringing advanced technology, advanced medical thinking and advanced computing to the practising doctor. Use of the system potentially leads to:

- The diagnosis of hyper-reactivity and assessment of severity.
- A highlighting of associated supportive information.
- A proposed treatment regimen.
- A prognostic summary.

The system is currently being used in training hospitals in different parts of the country, and it is expected that further packages will be produced in due course which similarly incorporate the use of video clips.

6. CONCLUDING REMARKS

The number of educational and training packages now being written for micro-computer delivery is huge and it is one of the fastest growing industries in the world. Soon, micro-computers will be powerful enough to duplicate most of today's mainframe systems capabilities and we may well see a move away from mainframe delivered courseware. In spite of the proliferation of micro-computers for business, IBM is capturing the micro market like it captured the mainframe market, whilst many manufacturers are seeing rapidly declining sales. It may be wise to consider the likely life expectancy of your proposed micro, before considering a move towards micro supported CBT. Many major computer companies are now producing a new range of micros on which IBM compatible software will run.

Some of the better systems for micro-computers have produced excellent results and success stories can be found all over the world. Many made-to-measure packages are now available, but the increased 'user friendliness' of higher level languages and authoring software is making it ever easier for trainers to design their own courseware and build customised applications to meet their own needs.

The need for training of trainers in this area of micro courseware development is clear enough, increasingly so because improved technology allows ever better graphics, sound, animation and video clips to be incorporated into computer simulations. At the same time, there is a parallel need for wide ranging reviews of the technical and financial feasibility of introducing micro-based education in both the developed and developing worlds. It was H G Wells who commented that "human history becomes more and more a race between education and catastrophe" and we would be wise to harness as fully and rapidly the educational potential now offered by the micro-computer.

NOTES

1. R. B. Stammers 'The computer terminal as a simulator' Journal of European Industrial Training, Vol 5, No 7, 1981, pp 27-29.

2. D. Catton, quoted in C Guilfoyle, 'Artificial Intelligence crosses the bridge to see the light of day', Datalink, June 24, 1985, p8.

3. For a discussion of the distinction between modelling and simulation, see W. S. Dorn, 'Simulation versus models : which one and when?'. Journal of Research in Science Teaching, 12 (4) 1975, pp 371-377.

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