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Computerised education for health professionals

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As a result of the use of computers and information technology to support the management of health care information, it is essential that all health care professionals have a solid grounding in health informatics or information technology (IT). IT education is more than computer literacy, it also includes the concepts of information science and how it can be best used by health providers and consumers. IT education can be learnt via Computer Based Education (CBE), but equally CBE offers learning opportunities provided by no other teaching medium. Therefore, it is critical to identify, develop, implement and evaluate educationally sound computer based education programs that support and enhance education and practice. These programs must reflect educational theories and instructional design principles and be applicable to current practice.

This chapter will outline basic principles, concepts and importance of computer based education and the tools that are available to support it. The content includes a review of learning theories, instructional design principles and concepts and application of these in computer based education, principles and concepts related to implementation of computer based education and the types and uses of computer based education eg: drill and practice question and answer, simulation. Also included is an overview of the types and uses of tools available for use in computer based education eg: authoring software and multimedia, evaluation of computer based education and a glossary of terms.

Why is computer based education important?

Research into how students learn, the consequence of different styles of learning, and the effect of instruction on the learner has lead many researchers to seek a innovative solutions to education and training. Educators in many fields have, and are, exploring alternative teaching strategies to obtain prescribed learning goals, and an increase in student performance outcomes. Among the educators who have recognised the need to examine alternatives to traditional teaching methods, are the health professionals. These educators believe the challenges of the future in health will not be served by rigidly structured, group based education (Jacobs 1976), but rather individualised modes of instruction accommodating students of different academic background and learning styles (Conklin 1983). Some ‘researchers believe that technology has provided such a panacea (Mouton 1990). Following technology advances and a decrease in the cost of computers, educators have begun to

examine computer based approaches to education more closely (Hamby 1986, Butcher & Greenberg 1992).

Over ten years ago educators advocated instructional computing, citing the benefits of individualised, self directed learning, the inexhaustive nature of computers, the capacity of expanding students participation in the learning process, and the availability of immediate feedback (Thomas 1986). The name given to this type of instruction is known as Computer Aided Instruction (CAI) or Computer Based Education (CBE), and the learning process as Computer Assisted Learning (CAL) (du'Jardin 1992). CBE was developed over twenty years ago using time sharing computers, mainframe or minicomputers. However, the disadvantages of transportability and costs of the programs prevented the spread of CBE until the availability of microcomputers (Ball et al 1988).

Emerging multimedia technologies such as video images, CD-ROM, advanced graphics, sound and animation programs and the use of the telecommunications network (Kidd et al 1992, Procter 1991, Wager 1992), have made available interactive media driven by computer technology (Zelmer 1992). The transfer of 'educational and professional knowledge can also be enhanced through other computer mediated communication technologies like bulletin boards, electronic mail, computer conferencing, online systems, imaging and Hypertext (Taylor 1992).

The principle of student interaction is a basic component in any CBE program. The types of CBE used include: drill and practice, tutorials, problem solving, gaming, testing and simulation. In 1970 De Tornyay indicated the distinctive capabilities of computers for health stimulations, pointing to the variety of experiences provided in a given time and the safety aspect of not practising on real patients. Students can therefore make mistakes and receive immediate feedback on the consequences of their decisions. Programs can be repeated, providing opportunity for revision and assistance in retaining information (Kidd et al 1992).

CBE can be used by all disciplines within the health care sector. Distance education, hospital orientation, continuing education or professional development are all areas where computer technology can be used to strengthen knowledge and skills (Spector 1986, Shehee 1989, Arnold & Baker 1988). The establishment of computer networks to provide instruction for health care providers and patients is another example of the use of CBE. This is of particular significance in rural and 'remote geographic areas, where health care providers are unable to be given educational leave to attend seminars and conferences (Marten & Conover 1990).

CBE, particularly in the simulation mode offers tremendous potential for Health education. Decreasing length of stay, bed closers and increasing competition for clinical places has meant the total opportunities afforded students in the clinical environment is decreasing. Computer simulation provides one avenue for students to gain insights into problems posed by real clinical practice without having to directly access clinical agencies. Computer simulation also enables students to experiment with care options. Within the clinical environment any inappropriate decisions exposes the patient to possible detrimental outcomes. Computer simulation encourages students to experiment safe in the knowledge that no real risk exists. Equally drill and practice packages provide health educators with immediate assessment of rudimentary competencies (eg drug calculations) prior to clinical placement. Such tests could be provided by the computer, randomly assigning questions, with

results being presented immediately to the student, and potentially, the educator at his/her desk.

Evaluation of any software should be seen as an integral part of the development and implementation of CBE. An awareness of the effectiveness of CBE is best ‘obtained through the evaluation process. Evaluation includes the assessment of students learning style preferences, attitudes towards CBE, the value of CBE for individual disciplines and the recognition of skills required to develop and implement CBE (Billings & Cobb 1992, Ward 1992, Franco et al 1991, McCormac & Jones 1992, Kock 1990, Byrum 1992). The evaluation process is applicable to both commercially produced or self developed CBE packages. One of the first questions to ask is how has educational theory been applied in the development of the CBE package.

Applying educational theory to CBE

Techniques proposed by theory and supported by research form the foundation for effective CBE. Most techniques applied to computerised education have their foundations either in behaviourism, systems theory or cognitive educational theory.

Behaviourism

Behaviourism, Thorndike’s connectionism, Pavlov’s classical conditioning and Skinner’s operant conditioning (Skinner, 1954; Thorndike, 1969) were the theoretical underpinings used by the early researchers examining the impact of CBE on behaviour Behaviourism is based on the principle that instruction should be designed to produce observable and quantifiable behaviours and behavioural change in the learner. So when using CBE, behaviourists would expect to change the student in some obvious and measurable way. However, Pavlov’s work on the “psychic stimulus” led to the realisation that higher order conditioning was the result of building complex chains of stimuli that control behaviour. This promoted the belief that when designing educational instruction the process should be organised from the simple to complex.

Skinner’s work expanded on this, he espoused the use of reinforcers following a response or reinforcers produced by a response. He regarded the reinforcer as ‘responsible for behavioural change. Behaviourism also uses the strategy of breaking the content into chunks (chunking), the use of frequent practice activities and provision of immediate feedback. Positive reinforcement is also used as is the practice of keeping the learner informed of progress and success in a lesson (Dreber and Caputi 1992). This theory was the design basis for many CBE packages.

Systems theory

The systems theory conceptualises the organisation and structure of a whole organism. Measurement and identification of the relationships of factors and events, that effect the organism’s stability is an essential component of the systems theory. The application of the systems theory in education and particularly to instructional development of CBE, is in the approach taken to design the learning activities. The systems approach consists of a series of steps that guide the developer through systems definition, systems design/ development systems evaluation (Simonson and Thompson 1990).

Cognitive theory

Cognitive theory moves from behaviourist theory to the internal processes which influence learning. Cognitive psychologists focus mainly on the way in which learners receive, organise, retain and use the information. They emphasise the more complex intellectual process such as thinking, language and problem solving; these they feel are important aspects of the learning process (Snelbecker 1985) and needed for the performance of actual tasks (Montague 1988).

According to Simonson and Thompson (1990) Cognitive Theory has many guidelines for the development of CBE programs:

- Instruction needs something to get it started, to keep it going and to keep it from being random
- Before learners can understand abstract experiences, they require a sufficient depth and breadth of more realistic experiences (Dale 1946)
- Sequencing instructional material is important.
- The form and pacing of reinforcement must be considered.
- Discovery learning is an important technique when using cognitive theory.

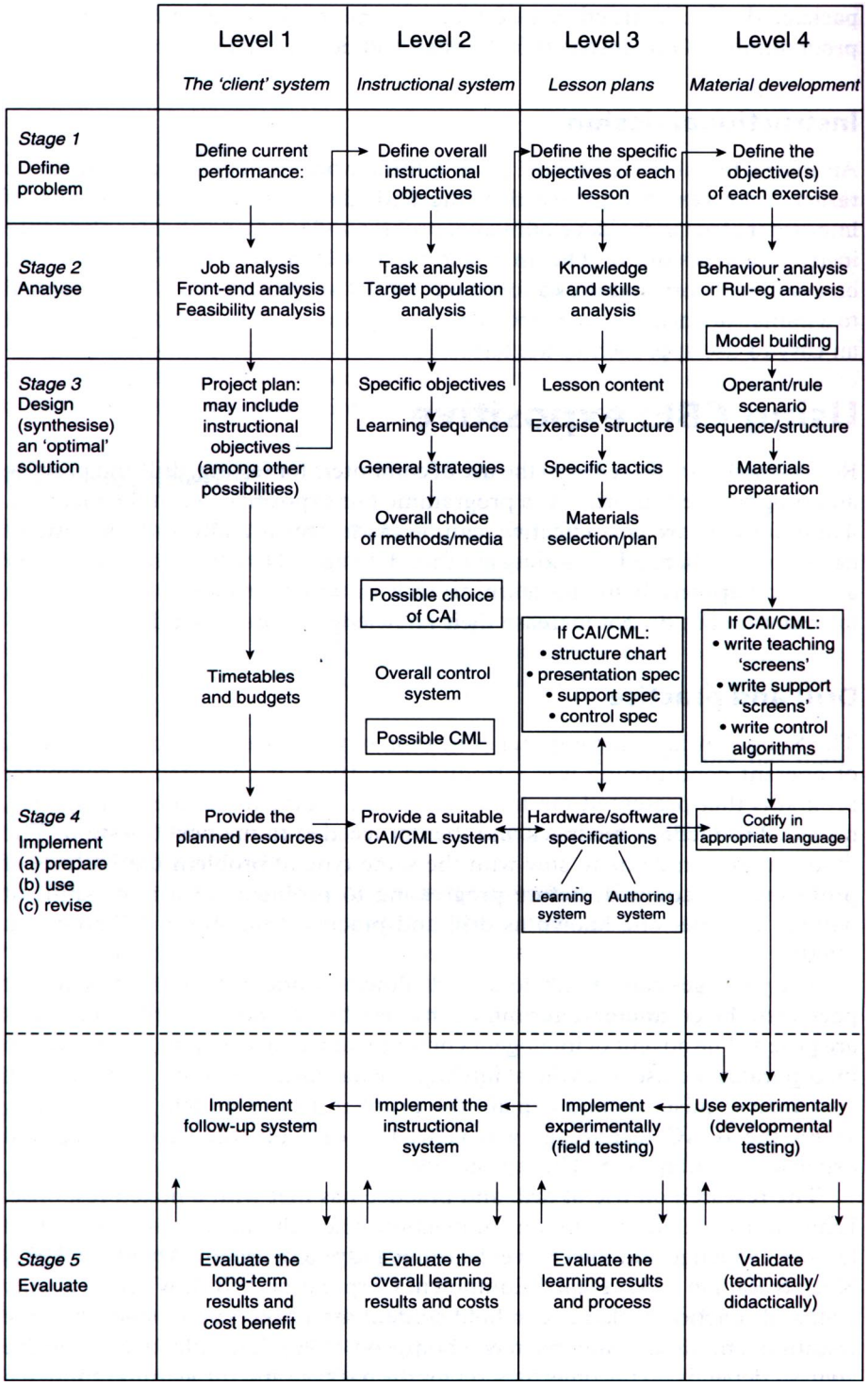
However, the three theories considered above do have some commonality in that all advocate feedback and all look at sequencing instruction. But that is where ‘common features end, as the behaviourists consider student outcomes, the advocates of systems theory look at entire systems, while cognitive theory centres on the learner.

CBE package design

In any educational program, planning the environment in which the learning takes place is almost as important as the content itself. In CBE the screen is the primary interface between the user and computer, producing and setting the learning environment. Four specialised areas are readily identified in CBE package design: instructional design, content specialist, graphic design and programming. Only instructional design will be considered here.

Instructional design

An instructional design model gives a framework to help designers keep on target, it serves to organise thinking and ideas, ensures the inclusion of important steps in the developmental process and ultimately helps to produce instructional products. The approach used by Romiszowski (1986) is based on systems theory and uses a four level model of instructional design applied to a framework of a five-stage problem solving process (figure 19.1). This provides an easy to use approach to the task.



Figire 19.1 Matrix for the overall instructional design process. *Source: Romiszowski 1986 pp.272*

Using CBE: expositive

Romiszowski (1988) refers to the use of computers for testing, drill and practice and programmed tutorials as a programmed or expositive use of the medium. These formats are cost effective, can be made user friendly and the content can be easily changed by adding

another database. However, they also foster a surface approach to the learning task in which students are rich with information but do not increase their knowledge or understanding.

Drill and Practice

The Suppes-Atkinson computer education model, based on Skinner's theory of Operant Conditioning was introduced in 1963. It consisted of computer programs that presented randomly generated problems, elicited a response, provided immediate feedback and then proceeded to the next question. The model allows students to stay with the same type of problem until a level of proficiency is 'attained, before progressing to problems of a more difficult nature. This became known as drill and practice (Simonson and Thompson 1990).

The packages can be individualised allowing students to work at their own pace with the computer determining mastery before more complex questions are posed. The advent of intelligent computer aided instruction (ICAC) which incorporates the use of artificial intelligence has meant that the computer can also analyse mistakes and explain the problem to the student. By the early 1990's the ICAC technology was viewed as difficult, time consuming and expensive (Simonson and Thompson, 1990).

The research on use of drill and practice has met with a mixed response. Limitations include the loss of motivation when the novelty is lost, lack of learner challenge and lower level learning and rote learning. (Koch and Rankin 1987; Digital Equipment Corporation 1983; Meadows 1977). Whereas quality drill and practice packages can hold student attention much longer than the traditional methods. (Simonson and Thompson, 1990). The effectiveness in the analysis depends on the objectives set for the package and the learning approach taken.

Tutorials

Self teaching programs abound, these give a short passage of information then question the user. As with the drill and practice programs the quality is variable. Some of these programs can adjust the level of knowledge exhibited by the student and therefore give a degree of individualised teaching (Koch and Rankin 1987). Other programs are simply electronic page turners which are repetitive by nature and also become boring (Simonson and Thompson, 1990). These also reward surface approaches to learning.

However, well designed tutorial programs can offer one-to-one, individualised instruction which is impossible in the large classroom. The program can adjust the level of and complexity of the tutorial to suit the level of knowledge displayed by a student as the tutorial progresses. The student, by having to drive the package, becomes an active participant with some control over the rate of advancement and of their own learning. The introduction of ICAC has the potential to expand the tutorial and to take the learning from the surface approach to a greater depth.

Using CBE: adaptive

Simulation, dialogue tutorials, and inquiry type database searches are referred to as adaptive or experiential uses of the computer in education (Romiszowski 1988). These have encouraged an increased shift to a theoretical base in computer educational package design which will foster deeper approaches to learning.

Simulation

Simulation is described as a representation or model of an event, an object or some phenomenon. In clinical nursing terms, it refers to the verbal or pictorial description of a real-life patient care situation but, in reality it is generally an incomplete model that contains only the essential elements of what is being simulated. Nevertheless, simulation is recognised as one of the more effective methods of managing clinical teaching. Simulation encourages the student to become an active participant, to think more deeply and to become part of the educational environment (Conrick 1993).

In nursing, clinical simulations have developed around patient management problems and have been described by many writers (Dincher and Stridger 1976; Holzemer, Schleutermann, Farrand and Miller, 1981; Holzemer, Reskin and Slichter, 1986). Although most reports in the literature are subjective and anecdotal, they catalogue a variety of advantages for using simulations in 'teaching clinical nursing. "A serendipities advantage of using simulations to teach clinical nursing is that simulations tend to simultaneously teach in two or more domains, such as psychomotor and cognitive or cognitive and affective" (Hanna 1991 p 29). de Jong and Njoo (1992 pp 412, 413) also regard simulation as having much to offer and they explain three reasons for the popularity of simulations using computer technology.

- Computers used for skills or procedures have very practical advantages for example being able to introduce catastrophes: reducing stress in treating patients and cost effectiveness for example flight simulators or laboratory experiments.
- Simulation about dynamic models allowing natural time scales to be altered so that processes may be sped up or slowed down to make them more visible to the learner
- Used to simplify models from the real world in order to have them match the prior knowledge and level of cognitive development of the learner.

There are disadvantages of simulation not the least of which is the considerable time and effort needed for design and the cost in dollar terms. There is also little 'evidence supporting the relationship between clinical simulation performance and the clinical setting (Henry and Holzemer 1993).

Dialogue CBE

Dialogue CBE is the "intelligent" use of CBE in which the student may either ask or respond to questions. These programs have a common element of adaptation to the individual learner and they actually "learn about the learner". As explained previously, because of difficult programming, time constraints and cost there are few dialogue CBE programs available.

Some dialogue packages however, are built on deep questioning techniques and multi-faceted analysis of the responses given by the student. These packages have the potential to take student learning from the surface approach to the deeper learning approaches (Conrick 1993).

Implementation of computer based education

Implementation is equal in time and energy requirements as the development process and lays the groundwork for a smooth efficient transition from a developed concept to a working productive tool (Smaldone & Greenberg, 1992).

Developments in computer and information technology during the late 1980s and early 1990s have enabled greater power and ease of use (Alessi & Trollip, 1991). This extends to networking, multimedia and virtual reality and their application to education. Mikan (1992) states there are twelve (12) components to the implementation process and they are:

- Establish need
- Organise early adopters
- Survey and utilise local resources
- Establish computer support groups
- Conduct faculty development sessions
- Determine administrative and faculty commitment and support
- Prioritise computer applications
- Select hardware and software
- Plan for computer user interface
- Provide computer support services
- Evaluate benefits and effectiveness
- Expand computer applications

These components form the framework of a process which is useful, flexible, relevant and applicable in establishing or enhancing computer based education.

Types and uses of tools available for use in CBE

Contemporary educators have skills in the use of blackboards, white boards, overhead projectors, slide projectors and video players. Likewise, CBE demands a rudimentary understanding and skill in the use of computer devices and the software that makes them work. Both elements fall into one of two major categories development requirements and implementation requirements. Before describing the various tools used for CBE production, it is pertinent here to examine the task at hand and to offer a few words of warning on costs.

While, it is true that some types of CBE can be produced using modest resources, the quality of the final product must be acceptable to the user. This may not be as simplistic as it sounds. It must be remembered that the users of CBE are sophisticated audiovisual consumers having spent their lifetime being exposed to broadcast quality television productions and in some cases complex computer games, so in order to engage this audience in educational tasks using a computer, similar high quality production is necessary.

This quality does not always come cheaply and may require the services of video production personnel, script writers, graphic artists and instructional designers. The initial outlay for the necessary hardware and software for development and production of CBE can also be quite high as is the time needed for development. The latter is mooted as approximately one hundred hours of production time to one hour of delivery. An alternative to in-house development is to contract a software design house but once again the costs can be very high. With these issues in mind, it can be argued that the choice to develop CBE should only be made once an exhaustive search of the available software has been found wanting.

On the positive side however, there are a number of educational institutions which have and are continuing to develop the resources necessary for CBE production. Most of these institutions are willing to negotiate the use of these resources by other individuals and institutions. This can reduce the costs of equipment and the educator's time while creating potentially fruitful networking.

Tools to develop CBE

Before beginning the foray into the tools required to develop CBE it is important to note that the specific brand names mentioned here are current at the time of press, are examples of the packages available and are not specifically recommended by the authors. The tools and packages selected will depend on the institutional 'needs, developers need, personal preference and budget. These should be discussed and packages trialed before purchase.

The following is offered as a guide to requirements only and not as a panacea for CBE production.

A workstation equipped with:

- A computer with substantial memory and speed capacities; able to accept sound and video cards, and peripheral devices such as scanners. This will vary depending on the nature of the package developed and the technology of the day. At the time of press, 16-20 megabytes (Mb) of RAM and hard disc capacity or 600 Mb - 1 Gb is not an unreasonable request.
- The graphic software comes in one of two major groups; image creation or image editing. The first group facilitates the creation of images by providing drawing and painting tools (eg Adobe Illustrator, Corel Draw, Aldus Freehand). Drawing packages allow the user to add text and draw a variety of shapes (eg squares, circles, polygons and curves). Once the image has been created individual objects within the image can be manipulated (eg changing position, size or shape). Painting packages 'provide similar features as drawing packages but include tools that simulate painting and the ability to edit individual pixels. This enables minor changes to be made to the shading or lines of an image. The second group of graphic software, image editor, (eg Adobe Photoshop) enables these images to be manipulated. Still Images can be captured by scanning photographs or line drawings, or direct from video tape, or disc, via video capture cards.. Changes can be made to colour hues, brightness, or size of the image. These packages also enable visual effects to be added to the image. "Filters" provide a variety of visual effects such as blurring, sunglare, diffusion, solarisation, or sharpening. A number of image editing software programs allow editing of video motion (eg Adobe Premiere, Video for windows). Small clips of video can be captured then edited into one sequence of video display much the same as video productions are edited. It should be noted here that video motion requires large amounts of memory storage and are therefore limited to short clips (15 seconds up to 2 or 3 minutes).
- Animation software, as the name suggests, enables a number of images to be integrated into an animation sequence (eg Macro Mind Director). This is particularly useful for health education. Simulating physiology, 'demonstrating procedures, or describing the function of equipment can all be enhanced with animation.
- A colour scanner enables images to be stored digitally for use in the production. They are available as both black and white or colour and in a range of sizes from hand held devices

to A3 size models. Slide scanners are also available. However before beginning scanning check copyright issues. To some extent scanners are being superseded by digital cameras or photo CD. These devices allow images to be captured as digital images direct circumventing the need to scan them in.

- Colour and movement are enhanced by the inclusion of sound in multi media productions. Sound recording devices and software that facilitates the manipulation of the sound are therefore essential inclusions in any development work station (eg Sound Wave). Sound recorders provide the interface between the sound and the computer. They may be as simple as a microphone or as sophisticated as a sound studio. Audio editing software allows alteration to pitch and tone, as well as joining a number of sounds 'into one sequence. The sound is usually represented graphically on screen to facilitate subtle editing.
- Authoring software facilitates the development of resources for CBE and provides the means of combining these resources into an educational package (eg Authorware Professional, Tool Book, Macro Mind Director, Hypercard). Screens can be designed, interactions with the user created, and navigational attributes developed in the authoring environment. Some authoring systems enable a "run time" to be attached to the final version or provide a "player" that can be distributed with the final version. Both enable the user to access the educational package without having a copy of the authoring software that developed it.

Authoring systems reduce the programming skills needed to develop and educational package. The author simply directs the computer, (eg put text here, link this button to this screen) and the software performs the necessary programming to create the package. While authoring systems are capable of performing many detailed tasks and can be used by the novice to produce basic packages, to achieve more complex interactions requires advanced understanding 'of the package's capabilities. In some cases it may be advisable to have some understanding of basic computer programming and /or access to a programmer.

Resources additional to the work station would include:

- Video production facilities. A multi-media production will require some video motion. This will need to be scripted, shot, edited, and compressed before integration into the computer package.
- Facilities to master a laser or compact disc. Computer packages that include still and motion graphics, plus sound can require a large storage capacity. Large hard discs are one option (600mb to 1gb) but increasingly optical storage devices such as laser or compact discs are being used. Commercial companies will press, or master, final versions of a package to both media.

Delivery needs

When selecting delivery hardware the rule of thumb is to buy the fastest machine the budget will support and ensure that it is equipped for multi media packages. The latter will include sound and video cards, facilities to accept an internal or 'external CD player, and stereo speakers. Monitors should be colour and as large as the budget will support. The larger the screen the more features/ options that can be included in each screen. Attached to each machine should be a CD or laser disc player, amplified speakers or two sets of quality head

phones. The CD player should be multi-session and triple speed. These need not be included in the original purchase but the option to add to the basic machine should be available.

The number of machines, their location and laboratory configurations will depend on the intended use, number of students and budget. Laboratories can be arranged with the computers in rows or around the walls. Rows enable more machines to be placed in the same area while the wall configuration allows the teacher to visualise the computer screens. When performing "follow along" teaching this is useful to ensure all students are keeping up.

Ergonomics also needs to be considered. Appropriate work station desks, seating, lighting that does not reflect on the monitor screens, and security for the hardware need to be considered and incorporated into the budget. The budget should also cover maintenance and replacement of the equipment. Accidental damage and the inevitable updating of equipment and software is a reality for any institution involved in the ongoing development of CBE.

Evaluation of computer based education

The increasing use of computer and information technology in health care is creating a greater demand on educators to utilise the technology in education. Evaluation is the critical step in the process to ensure high quality computer based education.

Effective evaluation incorporates evaluating the development tool, content, lesson, delivery systems and learning outcomes. Theoretical aspects of cognitive psychology can guide the process of evaluation and design of computer based education. There are eight major aspects which can be applied and these are summarised below:

1 Perception and attention

Effective computer based education is dependent on presentations that are designed for easy and accurate perception. For perception to occur student attention must be gained and maintained. This can be affected by factors such as past experience, level of student involvement, personal interests, difficulty of lessons, novelty format, timing and variety.

2 Memory

Efficient storage and retrieval of information is a critical element

3 Comprehension

Information must be perceived, interpreted and integrated into current knowledge not just stored and retrieved.

4 Active Learning

Learning is achieved by observing and by doing.

5 Motivation

Motivation is critical to learning.

6 Locus of Control

Refers to whether the control of the content, methodology and any other instructional factors are determined by the teacher via the lesson, student or a combination. The success of the

lesson depends on which aspects are controlled by the student and which aspects are controlled by the teacher via the lesson.

7 Transfer of Learning

This refers to the extent to which student performance has improved from the lesson and the application to real situations. Transfer of learning is the critical outcome of computer based education.

8 Individual differences

Students do not all learn alike and therefore some methods of instruction are better for some students than for others. One advantage of computer based education is that instruction can be individualised by utilising appropriate methodologies and lessons. (Alessi & Trollip, 1991).

Evaluation of the lesson incorporates the above aspects but has three distinct phases and these are:

Quality review

- Language and grammar
- Surface features of the displays (eg displays, presentation, text quality, input devices)
- Questions and menus
- Other issues of pedagogy (motivation, locus of control, interactivity, animation and graphics)
- Invisible functions of the lesson (records and data, security, accessibility)
- Subject matter
- Off line materials (manuals, auxiliary materials, other resources)

Pilot testing

Is a process of testing the lesson by utilising representatives of the target population for use. It has seven steps:

- Select the helpers
- Explanation of the procedure
- Find out how much of the content they already know
- Observe them go through the lesson
- Interview them afterward
- Assess their learning
- Revise the lesson

Validation

This phase is the process for checking of the lesson for authenticity in real situations. It is sometimes referred to as field testing. There are two reasons for this process. Firstly, the real situation for the lesson can be quite different from the pilot test. Secondly, the helpers utilised in the pilot testing may not have covered all ranges of abilities from the target population (Alessi & Trollip, 1991).

This process of evaluation is summative, very comprehensive and can be adapted to suit many varied situations in health care education. There are many guidelines and checklists available in the literature but individuals can develop 'specific tools to meet specific needs (Alessi & Trollip, 1991, Discenza, 1993, Posel, 1993, Smaldone & Greenberg, 1992).

Evaluation is probably the most important step in the process of computer based education as it ensures successful effective outcomes of the development process. It is critical to apply and evaluate the theoretical underpinings of cognitive psychology, teaching and learning, computer and information technology and instructional design to computer based education. This brief summary of the process of evaluation will give the reader some basic guidelines. The area of evaluation of computer based education in health care is limited and is an area that must be expanded to ensure high quality educational outcomes and ultimately patient care.

The reader may contact the authors for details about specific educational packages developed in Australia.

Glossary

Courseware	are the actual materials that students use.
Hypercard	is an authoring tool for the Macintosh computer
Hypermedia	links between different types of media, eg sound, graphics and text
Hypertext	words linked by key words, eg text on a screen, click on a word which will then be linked to a variety of interrelating functions.
Interactivity	is the relationship between the stimulus of the presentation, and the response of the user. There are five levels of interactivity which reflect the success of interactive projects. Level 1 (passive) is a forward-backward, predetermined and linear sequenced instruction; level 2 (hierarchal) is a predefined set of options, much like a menu; level 3 (update) relates to computer generated problems and update and feedback on user responses; level 4 (construct) is an extension on update interactivity, where the learner has to manipulate components to reach a goal; level 5 (simulation) provides the learner with more control over the instructional sequences.
Multimedia	any combination of two or more different types of media, usually made interactive through computer controlled technology

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