Computer Based Assessment (Volume I): A guide to good practice

Dan Charman and Andrew Elmes

Science Education Enhancement and Development
SEED

AN INTRODUCTION TO SEED

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SEED's overall aim is to develop, document and disseminate good practice in Science teaching and learning. The programme consists of a series of projects in areas such as lab-work, field-work, graduate teaching assistants and computer-aided learning, which are itemised inside the back cover. Most are based in the Science Faculty but some are being taken forward by staff in the University's School of Computing and in Educational Development Services (EDS). All the projects are linked to dissemination partners in other institutions who act as external advisors, ensure that SEED's outputs are capable of being used in other institutions and help to disseminate and embed SEED's end-products.

Anyone wanting further details on the SEED programme is welcome to contact Brian Chalkley or Andy Elmes at the address below. Contact details for the individual project leaders are available inside the back cover.

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Computer Based Assessment (Volume1): A guide to good practice

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Part 1: Introduction and rationale for computer based assessment (CBA)

Chapter 1: Introduction

1.1 Background

In the current climate in Higher Education in the United Kingdom and many other areas of the world, teaching staff can be forgiven for thinking they are working harder than any previous generation of University staff. If they ever existed, the heady days of a cosy staff-student relationship with intensive tutorials are gone for all but a few privileged institutions. The vast majority of degree level courses are now delivered at a fraction of the cost of a generation ago, in response to the very worthwhile objective of providing Higher Education to a far higher proportion of the population. As a result, many institutions, departments and individuals have been actively looking at ways of maintaining delivery of high quality programmes with a decreasing unit of resource. One of us (DC) was in exactly this position when faced with a new academic job and a large teaching load in the first year and this experience lead, via a series of developmental steps, to the adoption of CBA for one particular module, described in more detail as one of the case studies in volume two of this handbook. In this case, the prime motivation was to cling to sanity by not spending the entire semester in teaching and assessing a very large group of students. However, in the process of development of the CBA, there was a slow appreciation of the many other practical and pedagogic benefits of such an approach. In addition, there is now a bewildering array of strategies and experiences to draw on for the development of automated assessment in individual modules or degree programmes, as well as some misconceptions about what it can and can't deliver. CBA is much more than multiple choice questions but it can't address every assessment requirement!

Despite the wealth of excellent materials related to aspects of automated assessment, there is at present no easily available summary of the ideas, techniques and good practice currently being used. This handbook aims to fill this gap by providing advice for those contemplating using computers to assess students. There are plenty of good, and some not so good, examples in HE, but it can be a lot of work to develop materials without any prior knowledge - we hope this handbook will avoid well-worn pitfalls and reinvention of old ideas. Not all CBA is used appropriately and we do not recommend its adoption in all circumstances! The fundamental decision to proceed or not proceed with CBA rests with individual staff and particular circumstances of modules, skills, resources and infrastructure. We hope the information in the handbook will aid that decision. One thing we can be sure of is that CBA is here to stay and its potential can only grow with increasing interest in the development of new techniques, and future technological advances in computer processing power and remote communication. The 21st century holds exciting prospects for on-line assessment and computer-based learning in general.

1.2 Definitions of CBA

What do we mean by 'computer-based assessment' (CBA)?[1] Computers can help with assessment in many ways, but **this handbook is limited to consideration of the on-line assessment of students.** In other words the assessment as the interaction between the student and the computer. Computers can help assessment in many other ways, for example in the reading and compilation of marks using optical mark readers (OMR) for multiple choice tests (Chalkley, 1997; Hogg, 1997; Weaver & Chalkley, 1997),

[1] The terms computer based assessment (CBA) and computer assisted assessment (CAA) are often used interchangeably and somewhat inconsistently. CAA usually covers all use of computers in assessment including reporting and marking such as in optical mark reading. CBA is often restricted to the use of computers for the entire assessment process including delivery of the assessment and provision of feedback, for example.

although comparisons of OMR with CBA have come out in favour of CBA (King, 1994). The broader activity of computer assisted learning (CAL) where the focus is on the delivery of the materials rather than on assessment itself is also a burgeoning area within HE. Both OMR tests and CAL are excluded from the main discussion here as are the other ways in which computers can be involved in the assessment process, including the actual completion of assessments by students and the delivery of assessments from students to staff.

1.3 Who will use the handbook?

We have approached this project from a personal and practical perspective and much of the material is based on our own and others' experience of do-it-yourself CBA, backed up with educational theory and ideas where necessary. We envisage usage by:

- New users: those who wish to introduce an element of CBA into their own teaching but who have little or no experience of doing so. It's hard work finding out about what others are doing and deciding what is or is not appropriate for your own situation. We hope you will find most of the necessary information (or clear leads towards it) in these pages.

- Existing users: those with some experience in CBA or other forms of automated assessment (such as optical mark readers). Your current assessment package may suit your needs at the moment but if it needs further development then we hope you will find some new ideas here.

- Advisors and facilitators of teaching innovation and development in Higher Education. We hope you will point people who ask in the direction of this handbook or to one of the other specific sources within it. However, it's also your job to convince the sceptics of the power and potential of new approaches to assessment. We think there is some useful ammunition contained within these covers for this task!

1.4 Aims and scope of the handbook

The principal aims of this handbook are to provide:

- an up-to-date review of the principles and practice of CBA in the higher education sector

- practical information on approaches and techniques to CBA for those wishing to introduce CBA into their own teaching

- demonstration of the practical advantages and disadvantages of CBA using accounts from individual lecturers in various disciplines as case studies

The handbook is split into two separate volumes for ease of use. This volume (Volume 1) 'Computer Based Assessment: A guide to good practice' covers the first two aspects, outlined above. Volume 2, 'Computer Based Assessment: Case studies in Science and Computing' covers the third aspect. Volume 1 is not subject specific and should be of use across a wide range of disciplines, but volume 2 has a more science and computing based focus and may therefore be of most use to those within these areas, although many of the experiences and advice given are much more widely applicable. Following this introduction, chapter 2 covers the rationale for using CBA and chapter 3 discusses some of the practical obstacles which need to be considered in implementing CBA.

Contrary to belief in some quarters, CBA is not just multiple choice questions delivered on a PC! Chapter 4 reviews the wide variety of types of questions which can be delivered on-line and the on-screen feedback to the student. Constructing effective on-line assessments involves more than simply stringing together a series of questions and chapter 5 covers aspects such as question banks, randomisation of questions, managing access and file management. Finally, the range of types of software and specific products is introduced in chapter 6, with details of suppliers, costs and contacts for some commercial and non-commercial products.

Proof of the benefits of CBA is in the real world and the sister volume (Volume 2) takes examples contributed by lecturers in science and computing departments around the country and shows how particular strategies have been adopted to suit individual needs. Evaluations and key advice points should help others decide what kind of approach might suit them. Further subject specific advice is available through the Centres for Technology in Teaching (CTI centres) - full details of these and other useful organisations are also given.

CHAPTER 2

Part 1: Introduction and rationale for computer-based assessment (CBA)

Chapter 2: Why do it? The rationale for CBA in Higher Education

2.1 Functions of assessment

2.2 The practical rationale for CBA

2.3 The pedagogical rationale for CBA

Chapter 2: Why do it? The rationale for CBA in Higher Education

2.1 Functions of assessment

There are very many reasons why we assess students and it is important to consider these in the design of particular assessment strategies. Too often we are drawn into repeating assessment patterns which we have experienced ourselves or which we see in common use and assume they must therefore suit us too. The two basic types of assessment and the key functions are shown in box. 2.1.

Box 2.1: The principal functions of assessment

Formative - assessments which are part of the learning process.

- to give students feedback
- to guide student effort
- to diagnose problems in learning
- to help staff direct their teaching effort
- to encourage students
- to give students experience of assessment methods

Summative - assessments to measure performance.

- to discriminate between students
- to provide quality assurance checks both within the institution and externally
- to motivate students
- to judge student progression
- to award marks and enable a final degree classification

Formative assessments generally need to occur more frequently than summative assessments and are partly in preparation for the latter. In practice, it is common to combine formative and summative assessments with the summative element acting to assist in persuading students to participate fully in the formative element. Some useful examples of this are given in several of the case studies in volume 2. It is increasingly rare to see formative assessments applied with no summative element, primarily due to the student motivation problem and because purely formative assessment can appear to be an unnecessary workload for teaching staff. CBA offers good potential in this direction as many assessments can be run without any additional effort if they have already been developed for a dual formative-summative role.

Deciding which of these functions is most important in your assessment is critical to designing effective and efficient assessment practices. This applies to all assessment but will strongly influence the way you decide on adoption of CBA and how it will operate. Further consideration is given to the functions of individual questions in assessments in part two of this volume. It is clearly important that an individual element of assessment such as CBA should fit into an overall assessment strategy at the degree programme level. There are a large number of texts which examine the general functions and application of assessment in more detail including Brown and Knight (1994), Brown *et al.* (1994, 1996, 1997), Knight (1995) and Race (1995, 1996, 1997). Many of these texts go over the same ground but it is certainly worth going through one or two of them in some detail and perhaps flicking through several others.

2.2 The practical rationale for CBA

A much more 'hands off' approach to teaching and learning in higher education has been developing and will continue to grow in the next few years. In the UK we have been asked to teach more students with less money and even with the recent stabilisation of numbers the unit of resource is declining in real terms. The Dearing report proposed still further increases in student numbers in HE and has also suggested increased use of learning technologies partly to address the resource implications. This resource driven rationale for CBA is the most widely accepted reason for its introduction in many individual modules, degree programmes and institutions across the country and yet there are rather few hard-headed evaluations of whether this is fully justified in practice. Some of these issues are examined in detail by Stephens (1994).

The increase in student numbers means that class sizes in first year core modules can now easily reach 200-300 students. It is not possible to assess this number of students using the same methods that were in place when the same degree programmes had perhaps 50 to 80 students enrolled. A number of assessment strategies can be adopted to address this problem (see Gibbs, 1992) which may include:

- reducing the assessment loading for students
- evaluation of the function of each piece of assessment
- diversification of the assessment portfolio

The full range of implications of these possibilities is beyond the scope of this handbook but, diversification of assessments often leads to adoption of CBA as one response. However, it is vital to be sure that if resource savings are the prime rationale, then the effort invested in development of CBA will pay off in the long run. Time is precious for academic staff when they are being asked to teach more students and do more and better research. Thus one of the prime motivations for developing CBA is to save time on tutor based assessment.

How to maximise the time savings

The potential time savings are attractive but consider the following in order to maximise this benefit:

- **The timescale**

  Considerable time savings are possible with CBA but are maximised over the longer term. Anybody thinking of developing a new CBA should first sit down and carefully and realistically evaluate how much time it will take to learn the software, write the questions and feedback and sort out the practical difficulties of networking and obtaining computer time for students. On top of this the maintenance time once the system is up and running should be considered. The total time costs should be weighed up against the time saved on tutor based assessment.

- **Are there any additional resources for development?**

  Development costs can be very high for CBA. Many institutions and departments now have small funds which can be used for assistance with this. It can be especially helpful to have someone assist with putting the questions on the system and providing graphics etc. while you concentrate on actually writing the text for materials.

- **Changing course delivery and use of teaching assistants**

  Introduction of CBA may be part of a restructuring of the module delivery. It may be cost effective to employ teaching assistants (typically postgraduate students) to help in the administration of CBA and other assessments.

- **Is there a wider departmental/institutional benefit?**

  Development of materials for an individual module may not save time but if a broader departmental or even institutional strategy exists for CBA then the balance of the cost effectiveness equation may alter.

- **Are there existing assessments in the subject area?**

  The number of projects in different aspects of educational technology has grown enormously in the last five years. There are thus many existing assessments which can be of direct use. This is obviously a major potential time saver. Details of some existing projects are given in this handbook, others may be found on the world wide web and the subject CTI centres will know about most of the major initiatives (see the further information section in Volume 2).

- **Are there any question banks you could make use of?**

  National or even international question banks are currently under consideration for some subject areas. Clearly this makes sense in disciplines where there is a large amount of subject material in common and bespoke assessments could then be constructed by question selection. The terms on which such question banks would operate are likely to vary but it seems probable that they will be available on payment by non-contributors and free to those who have contributed a minimum amount of material. The Geography, Geology and Meteorology CTI centre is currently developing this idea.

Given all the above considerations, a realistic cost-benefit analysis for development of a new CBA may give a negative answer and the real time savings for an individual will only be yielded over the longer term. In the light of this it is perhaps more realistic to stress the less well advertised but far more important pedagogic rationale for using CBA in an assessment profile.

2.3 The pedagogic rationale for CBA

The focus on time savings which is often the main motivation for initial interest in CBA is sometimes an unfortunate distraction from the fundamental questions of why and what we wish to assess (see for example Parshall, 1995). Many assessment practices in Higher Education are based on sound, but to some extent outdated, principles. Degrees in the UK were until relatively recently only for a small percentage of the population and assessments were designed to test a limited range of academic skills. Modern degrees are more diverse, need to cater for a greater diversity of student ability and produce graduates with a greater range of skills. Inherent in this change in the nature of degrees is a change in what is required of assessment practices. Despite this, we take relatively little time out to re-evaluate what function we want assessment to perform. Some of the general issues have been touched upon in section 2.1, and these should guide the overall development of an assessment profile.

Clearly CBA is likely to have considerable potential as a summative assessment process. Student responses can be regarded dispassionately and marked in an entirely consistent way (see below). Assuming suitable questions can be designed, all the functions of summative assessment can be fulfilled with CBA. CBA is often perceived as only being useful for summative assessment of a wide range of low level skills in the curriculum of many degree programmes. While it is undoubtedly good at this, it is also becoming remarkably good at formative assessment, primarily due to technological advances which make assessments more interesting and interactive for students but also due to the fact that feedback is instantaneous, consistent and infinitely repeatable.

There are few teaching staff who can claim to provide that kind of service! These issues and others are discussed more widely in the sections on question design and in the case studies in volume 2, but the main advantages of CBA for formative assessment are:

- students like to get immediate feedback - it keeps the activity and the result closely connected. This contrasts with typical feedback on essays and reports which always occurs much later than the writing itself and is thus divorced from it and seen perhaps as a separate activity by students (who inevitably focus primarily on the mark obtained).

- it provides an immediate guide to student effort - lessons learned can be immediately put into action in the next piece of work.

- it diagnoses problems in learning immediately. Staff can observe these problems and adapt teaching strategies to address them.

- it is an important element in student encouragement - students like to know how they are doing as fast as possible.

Values in assessment

There is a range of ethical values guiding design of good assessment outlined by Brown *et al.* (1996) which need to be considered (Box 2.2). Computer based assessment has clear advantages over many other forms of assessment when some of these values are considered.

Many of the applications of CBA are based on objective testing of one sort or another. They thus provide a much greater degree of **reliability** and **equitability** than almost any other form of assessment. The only variation in how different students are treated is as a result of the random choice of questions contained in many CBA systems. Otherwise there is exact repeatability at any time of day, with any number of repeat sittings. Computers don't get tired and they don't see or know individuals! Computer based assessment also contributes **diversity** to an assessment profile and thus contributes further to equitability, as different students perform better on different types of assessment. The nature of CBA also means that there is usually no effect of presentation or style on judgement of quality so the **validity** is also assured. Of course this is one of the many limitations of CBA and a good reason why it is not suitable for every task but as long as it is an appropriate choice of skill to be tested and the questions are well designed, the computer will not be distracted by extraneous information. Finally, as discussed above, CBA may also be a highly **efficient** method of assessment particularly in the long term. Part of this efficiency arises from an ability to run repeated assessments at much more frequent intervals than many other forms of assessment normally allow. It thus makes **timely** assessment much easier. It contributes to many of the other values in the box but these are the principal advantages of CBA over many other forms of assessment.

Box 2.2: Values of assessment. Based on Brown *et al.* (1996). The values where CBA is especially advantageous are in capitals. CBA also plays a role in meeting the other criteria but not necessarily to any greater extent than many other forms of assessment.

Assessment should be:

VALID

It must assess what you want to measure and not depend on other qualities

RELIABLE

It should be consistent between assessors and for the same assessor on different occasions

fair

There should be equal opportunity to succeed and students should perceive the process as fair.

EQUITABLE

There should be no discrimination between students and all should be treated equally. Students with particular talents (such as good exam technique) should not be unduly favoured.

FORMATIVE

There should be ample opportunity for students to learn through assessment.

TIMELY

Assessment should occur throughout the learning programme in order to provide learning stimulus and opportunity.

incremental

A gradual process whereby students build up credit is to be preferred to reliance on performance on one occasion.

redeemable

Initial failure should not be absolute and students should have a second chance.

demanding

Assessments should not be easy and must be pitched at the right level for what is being tested.

EFFICIENT

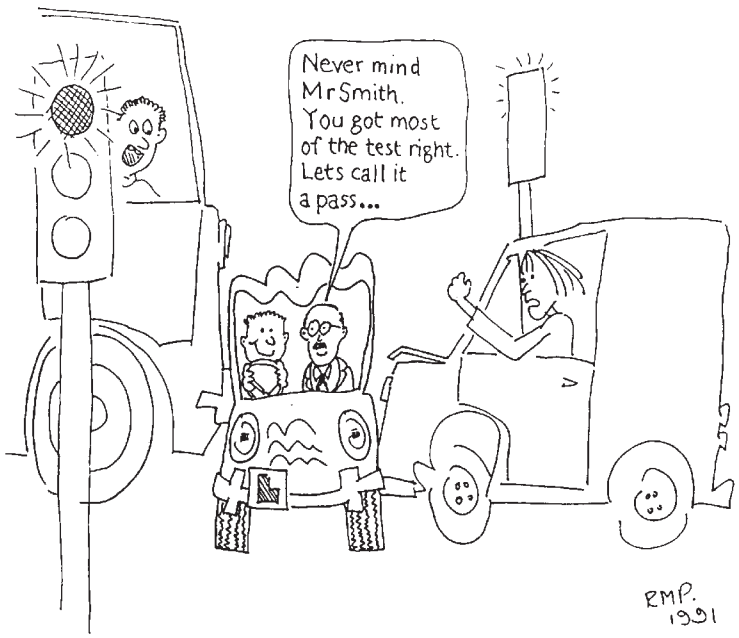
Assessment must be manageable and effective within the constraints of resources. Over-assessment wastes staff and student time.

What do we want to assess?

The range of skills which the average graduate from higher education is expected to have has expanded enormously over the past 20 years. Graduates must not only be competent in their own subject area but also have a range of transferable and generic skills. This is partly associated with the expansion of information technology and its dominance in common activities such as information searching and retrieval, data processing and communication. As a result, all graduates are expected to have experience and knowledge of word-processing, spreadsheets and increasingly, the Internet. It also stems from the greater range of ability of those now entering higher education and a more vocational outlook for many subject areas. Graduates need to be employable and thus must be taught those skills demanded by employers as well as those traditionally imparted in degree courses. This increased remit of degree courses means that assessment now has a much greater range of functions and this has forced many teaching staff to reflect on the purpose of particular assessments. This kind of reflection is very important when deciding whether CBA is appropriate, and in question design, and can be tackled by asking the questions in Box 2.3. CBA is often seen as only suitable for superficial assessment of basic factual recall by multiple choice questions. In reality, careful design of these and other question types permits assessment of much more sophisticated skills (see case studies in volume 2) and new methods for assessing complex activities such as problem solving ability are now being developed (see for example the case study in volume 2 by Culverhouse and Burton). However, as emphasised throughout this handbook, CBA is not suitable for all assessment and the detailed purpose of an assessment needs to be carefully considered before embarking on development or conversion of assessments to computer. At present, CBA is not generally suitable for the following skills:

- oral skills
- presentational skills
- group and inter-personal skills
- complex writing skills, such as the ability to construct arguments
- non-IT practical skills (although computer simulation of some activities will probably have an increasingly important role to play here)

Assessment can have its hazards! (from Gibbs, 1991)



Box 2.3: Questions to consider when deciding whether CBA is appropriate for your needs and in assessing where and how it will be used in the assessment profile. (Based on ideas from Brown *et al*., 1996)

- **Are you assessing product or process?**

  If you want to assess the process by which an outcome is reached, you will need to think more carefully about question design and about the integration of CBA with the teaching program. Even simple multiple choice questions can provide checks at different stages in the process as well as assessment of the outcome.

- **Are you assessing knowledge or use of that knowledge?**

  Assessment of basic factual knowledge is where CBA is most frequently used and it works well because it is capable of exhaustive yet economical assessment of the full range of knowledge from a course of study. However, it can test *use* of knowledge effectively too. This is discussed further in several case studies in volume 2.

- **Are you assessing the individual or ability to work in a team?**

  Assessment of teamwork skills per se with CBA is difficult. However, open access CBA often stimulates a good deal of group co-operation and discussion. This apparent collusion should not necessarily be seen as a bad thing if the summative element of the assessment is minor.

- **Is the assessment formative or summative?**

  CBA is well suited to both types of assessment and in fact, contrary to belief by some, is often more efficient for delivery of formative assessment since students can be permitted to repeat assessments many times over if necessary, to achieve better results and greater amounts of feedback.

- **Do you want students to achieve one ('right') result or are different outcomes possible?**

  CBA is much easier if there is a single correct answer, but some types of questions such as text matching can allow for greater flexibility although they are much harder to design.

- **Is the methodology continuous or end point?**

  Assessment which depends on many separate elements is well suited to CBA, because large assessment packages are easily divided into a series of much shorter units. Frequent assessments can be difficult to arrange when they involve handing in paper-based work, but CBA allows this with little additional work.

- **Do you want the assessment to encourage deep, surface or strategic learning?**

  Over-assessment may lead to surface or strategic learning only. Are you assessing too much? Short, frequent (and therefore less stressful) assessments which are embedded in the learning process may achieve the desired result more successfully. CBA is very useful in this situation.

Part 1: Introduction and rationale for computer-based assessment (CBA)

Chapter 3: Overcoming the obstacles

3.1 Is it feasible?

3.2 Equipment for writing CBA

3.3 Equipment for delivery of CBA

3.4 Infrastructure

References for part 1

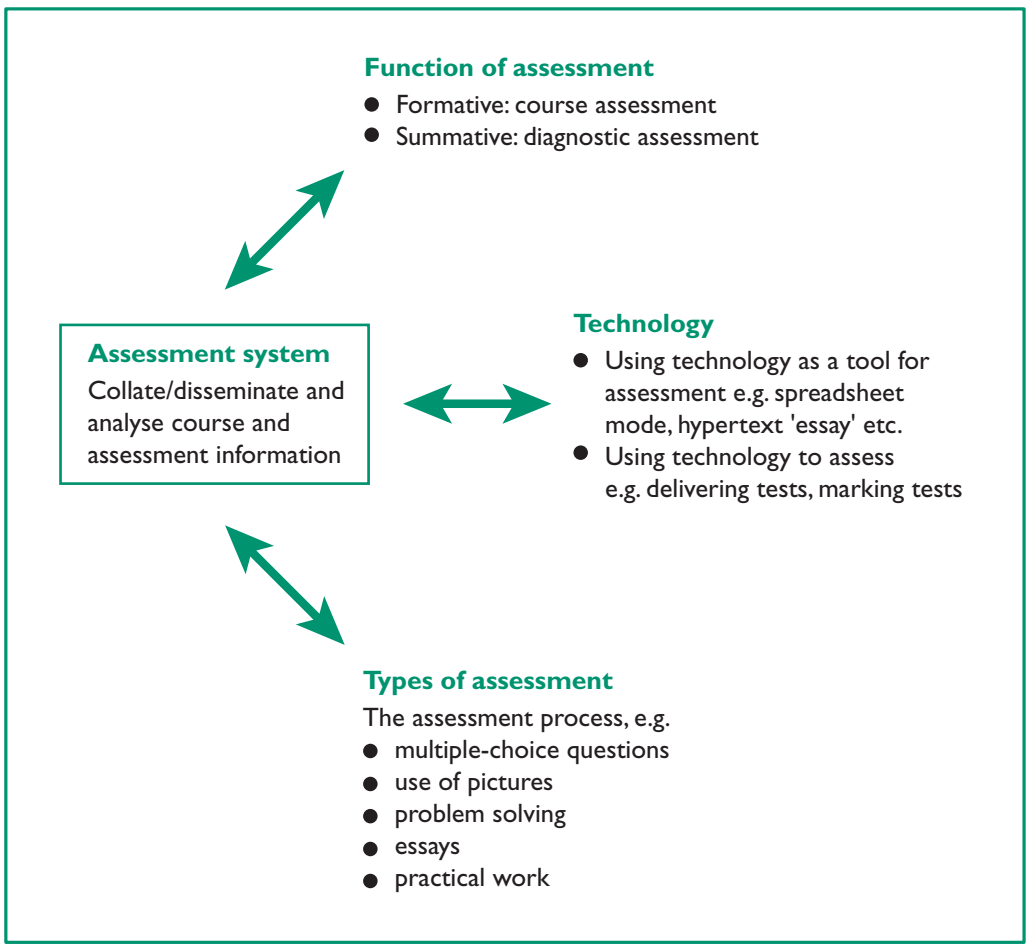
Chapter 3: Overcoming the obstacles

3.1 Is it feasible?

So far, we have explored the general pedagogical rationale and advantages of CBA. However, there are some significant limitations and drawbacks to using CBA which should be considered (e.g. Inoue, 1996) but which can be overcome or accommodated with a little forethought. These are mostly related to the provision of the infrastructure and equipment for the introduction of computers in assessment. Since these are often outside the immediate control of the individual, they will need to be resolved and acted upon at the departmental or institutional level if they are perceived to be serious enough to prevent development of computer assessments.

The key issues in assessment are highlighted in Figure 3.1, which differentiates between the assessment system, or infrastructure, and the functions, types and technology for delivery of assessment. In an individual situation, it is often the infrastructure which imposes the most significant obstacle to the introduction and development of new CBAs.

Figure 3.1: Issues in assessment. (Redrawn from Barnett *et al.*,1996)



3.2 Equipment for writing CBA

Most individuals contemplating using CBA will have access to basic computing equipment but it is important to make sure that:

- your hardware is capable of running software for designing CBA properly
- you can take full advantage of features such as the graphics facilities in order to make the assessments more attractive for students
- you have the right software for the creation and delivery of the assessments
- you are covered by the licence to develop and deliver the assessments

3.3 Equipment for delivery of CBA

Most CBA will be delivered over a local network or increasingly, the Internet. Some may be delivered locally on an individual machine but this is generally not very efficient except for small student numbers. Assuming the delivery is via a network, ask the following questions:

- How much total access time (multiply students x number of assessments x average time for each assessment) will the assessments require?
- Are there adequate computers available for this demand?
- Is all hardware comparable in performance? (in timed assessments, it can be frustrating for students to experience different run times for tests!)
- Do you have access to adequate expertise to set up the network to deliver assessments, write the student answers to a suitable location etc.?
- Do you have adequate control over the server where the assessments will be delivered? If the server is maintained by a section or service outside your immediate department, you may need to make sure they are aware of and willing to provide the level of support you require.

3.4 Infrastructure and large-scale CBA

Besides the practical constraints of equipment, the infrastructure of the department or more likely the institution may present a serious impediment to wider development of CBA (Bull, 1994). Heard *et al.* (1997a) have constructed a protocol for the implementation of large scale usage of CBA for summative assessment, and they make it clear that this is not a job to be done on a shoestring. Consideration of the facilities required for running examinations on a large scale is vital and the staff and support services must be in place and well organised for this to be successful. Good communication between academic and computing staff is essential and probably one of the weakest links in the chain in many institutions! However, the Universities of Aberdeen (Heard *et al.*, 1997a) and Luton (Zakrzewski, 1995; Zakrzewski and Bull, 1998) are good examples of institutions which run successful large scale computer examinations. It is probably not easy to implement measures such as these on an individual or departmental scale without institutional backing. All of the issues considered here could be outlined as serious obstacles, but the key principle for success is to **match your assessment design and ambitions to the resources available.**

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Zakrzewski, S. & Bull, J. (1998) The mass implementation and evaluation of computer-based assessments. Assessment and Evaluation, 23(2), 143-15.

Part 2: Materials for CBA

Chapter 4: How to write questions for CBA

Part 2: Materials for CBA

Chapter 4: How to write questions for CBA

We have already mentioned that CBA is more than just multiple choice questions delivered on computer. Although these types of question do have a very important role to play in many examples of CBA, developments in software and in the ideas behind assessments on computers, are producing a number of other approaches. This is probably one area where future advances in technology and software design will change the nature of CBA. This section explores the range of types of CBA and provides guidelines on question writing.

This is not intended to be a manual on the detailed construction of CBA questions and there are a number of other sources of useful information on guidelines for writing objective questions (e.g. Lee & Mamone, 1995; Partington & Peel, 1993a, 1993b; Jones, 1997) or for specific pieces of software (Heard *et al*., 1997b). However, it is probably useful to highlight some of the key considerations here. In fact, although much can be learned from reading about the basic principles and from looking at other people's examples, perhaps the only successful way to develop question writing skills is to try it out. Only you can decide what to ask questions about and exactly how to ask them, although of course some trials with students and colleagues can be very worthwhile for guiding changes and additions once they are written.

4.1 Bloom's taxonomy and question writing

There is a common misconception that objective assessment is good at testing simple factual recall but not much else and many lecturers are indeed using it in this way. However, well designed questions can do much more than this. Heard *et al.* (1997b) have based consideration of question design around Bloom's taxonomy which identifies six types of learning:

- knowledge
- comprehension
- application
- analysis
- synthesis
- evaluation

Objective tests are good at testing at least the first four of these and may exceptionally be used for testing of synthesis and for evaluation too, although this can probably be done more effectively with other subjective assessments. It is vital to consider which of these skills you wish to test before deciding on an assessment strategy and certainly before writing the questions. There is a danger of encouraging surface learning strategies if a large proportion of the questions are simply testing factual recall (Scouller & Prosser, 1994).

4.2 Multiple choice

Multiple choice questions are the simplest and best known types of objective assessment. The structure consists of a stem (question or incomplete statement) and a series of options, only one of which is correct. The other options are distracters, designed to provide a range of plausible but incorrect alternatives.

Up to five options are commonly offered and this is often a limitation on OMR based tests but with CBA, you can provide as many options as you like. Equally, there is no reason why there shouldn't be fewer options - true/false questions are the extreme of this. However, the marking scheme needs to take into account that with true/false questions guesses have a 50% probability of being correct: negative marking for incorrect responses is normally the best solution.

More complex question structures can be developed around multiple choice questions, although it may be better to use multiple response for these (see section 4.4). If you are limited to a multiple choice structure, you can have a two tier arrangement (see Box 4.1) where the student selects a correct combination of options.

Assertion-reason questions can also be constructed and answered with a multiple choice structure. These types of question tend to force greater thought and if well written can test much higher level skills than a basic multiple choice question. The normal phraseology of these questions gives five options:

A *The assertion and reason are correct statements and the reason correctly explains the assertion*

B *The assertion and reason are correct statements but the reason does not correctly explain the assertion*

C *The assertion is correct but the reason is incorrect*

D *The assertion is incorrect but the reason is correct*

E *Both the assertion and the reason are incorrect*

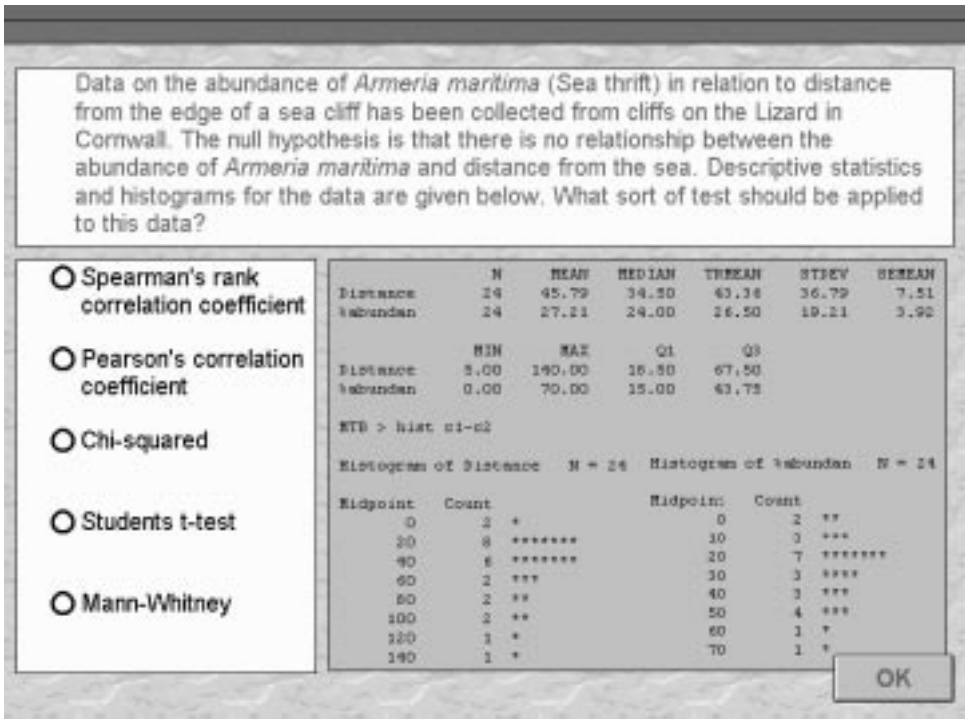
In the simple example below, both assertion and reason are correct but the reason does not explain the assertion.

Assertion: Children need calcium to grow bones

Reason: Milk is rich in calcium

Of course, in CBA, graphics can be incorporated into these types of question to test interpretation or identification skills (see Figure 4.1).

Figure 4.1: An example of a multiple choice question. Testing the ability to interpret summary statistics and choice of an appropriate statistical test. There is only one correct answer.



Box 4.1: Example of two-tier structure in a multiple choice question. (In this case two of the options from i to v are correct (ii and iii) so the student would select C for the final answer.) This type of question structure is much better phrased as a multiple response question (see section 4.4).

Question: Which of the following periods are full glacials?

i Ipswichian

ii Devensian

iii Wolstonian

iv Chelford

v Hoxnian

Possible answers:

A i & ii

B i, ii & iii

C ii & iii

D ii, iii & iv

E ii, iii & v

4.3 Push button

Push button questions are in effect a variant of multiple choice questions, which computers make much easier to deliver than paper based assessments. Instead of selecting an option by checking a box, the student actually clicks the answer itself (as in Fig. 4.2). In principle, this could be a graphical representation as well as text but most software is limited to the use of text.

Figure 4.2: An example of a push button question. The student simply selects one of a series of options. In this case, all the buttons contain graphics but they can also contain text or numbers too (Courtesy of Question Mark Ltd).

4.4 Multiple response

Multiple response questions have a similar structure to multiple choice questions with a stem and a range of options but the student can select one or more responses (see Fig. 4.3). There are parallels with the two tier multiple choice question but multiple response questions have the advantage that they can allocate marks for individual answers. For example, if there are three out of seven correct answers, then there is a possible mark of 3 maximum, but students may score 0, 1 or 2. With the two-tier multiple choice structure, students can only be right or wrong even though they may have only part of the answer incorrect. Most software will permit either unlimited or limited numbers of choices. If unlimited choices are permitted then obviously, there needs to be a penalty for incorrect answers. Likewise students may or may not be told how many correct responses there are.

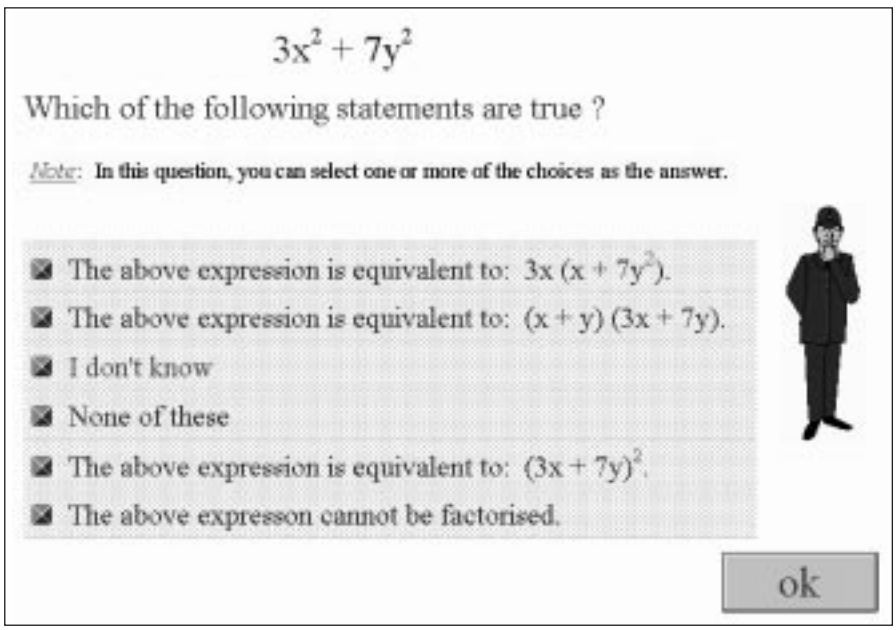
4.5 Hotspot graphical

Graphical interaction is where CBA really has major advantages over other forms of assessment. The simplest approach is to have a graphic (which could actually be text as a graphic if necessary) where the student has to select an area or item in response to a question (see Fig. 4.4). The correct response area is defined by the question designer in advance but its definitions are hidden from the student. This often incorporates a moveable pointer which is picked up and placed by movement of the mouse.

4.6 Text matching

Questions involve completing a sentence or free entry in response to a question (see Fig. 4.5). The response is marked using pre-defined search strings. For example, if a question asked, 'Who is the president of the United States?', the answers Bill Clinton, Clinton and William Clinton might all be acceptable so the string to search on would be 'Clinton'. You might even consider it acceptable to have 'clinton' in which case the answer could be made case insensitive. These question types need very careful design and testing if they are to be extensively used in summative assessments.

Figure 4.3: Typical screen of multiple response question. (from Mathletics, a CBA for diagnosing mathematical ability of science students - see Case Study 5 in Volume 2)



4.7 Numeric

Numeric questions ask the student to enter a digital response to a question. They are often useful for assessment of end results or stages in a previously carried out calculation series. Again they need fairly careful design to ensure rounding errors or precision do not affect the results. If in doubt, the precision required should be specified. Most software will accommodate ± ranges in recognition of these difficulties.

4.8 Other question types

The types of question discussed so far are standard approaches for CBA but there are a number of other more unusual techniques which have shown their worth in some circumstances. The best of these represent fruitful experimentation in new methods of CBA. Some further details on these are mentioned elsewhere but it is worth outlining some possibilities here to illustrate the broad potential of CBA.

- **Qualitative responses and self assessment**

  This approach relies on qualitative input from the user and then uses that to decide on an overall grade.

- **Problem solving**

  Problem solving is a difficult skill to assess automatically. It involves incremental steps and a consideration of the efficiency of a solution. The Mastertutor approach (see Case Study 5, Volume 2) is a good example of how CBA can help with such complex assessments. Hughes (1996) also describes an assessment package which incorporates elements of problem solving and Leddo (1996) has developed a computer-based game for teaching scientific reasoning, although this involves no major elements of assessment.

- **Assessment of long text answers**

  Text and numeric response questions can be longer than a few words but they will rarely go beyond a sentence. Marking computer programming is an example where much longer text responses can be assessed automatically. A good example of this is in Case Study 7, (Volume 2) by Joy and Luck. Another approach is computerised long-menu questions (Schuwirth *et al*., 1996a).

- **Clinical decision making**

  Computer simulation in teaching of clinical skills often requires use of multimedia. Testing of case-based clinical decision making has also been implemented by Schuwirth *et al*. (1996b).

Figure 4.4: An example of a hotspot question. The student has to move the marker to the correct part of the computer output. In this case, the photograph is purely illustrative.

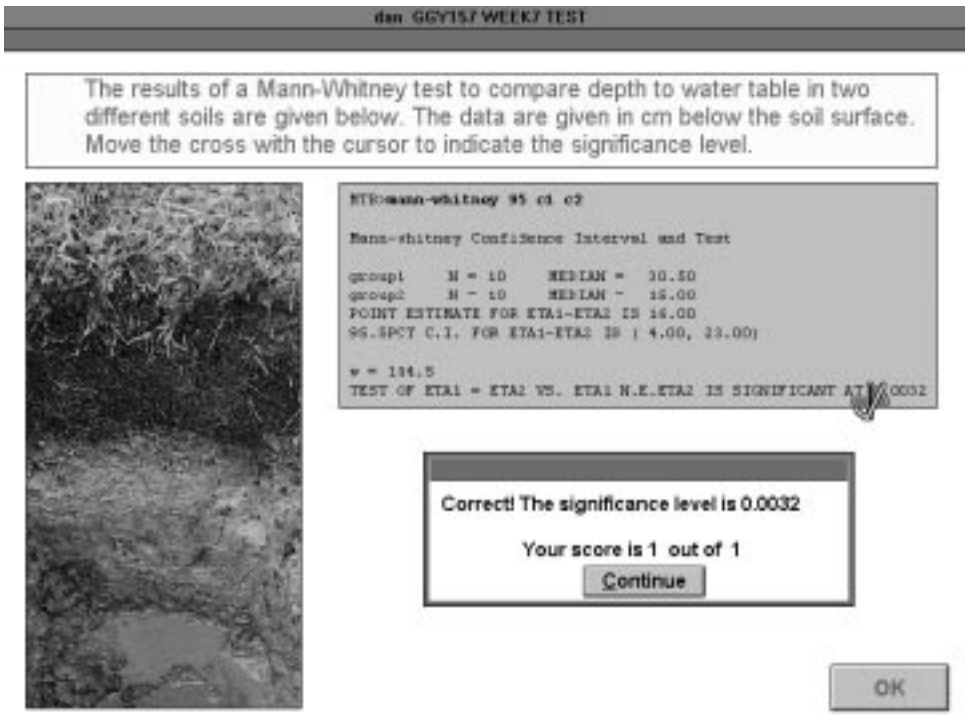


Figure 4.5: An example of a text matching question where the student can type in any response. In this case the correct answer is 'stratified random' although this is not case sensitive. The scoring on the question has allowed one mark out of two for any answer including the word 'random' so the response 'simple random' received one mark, as explained in the feedback box.

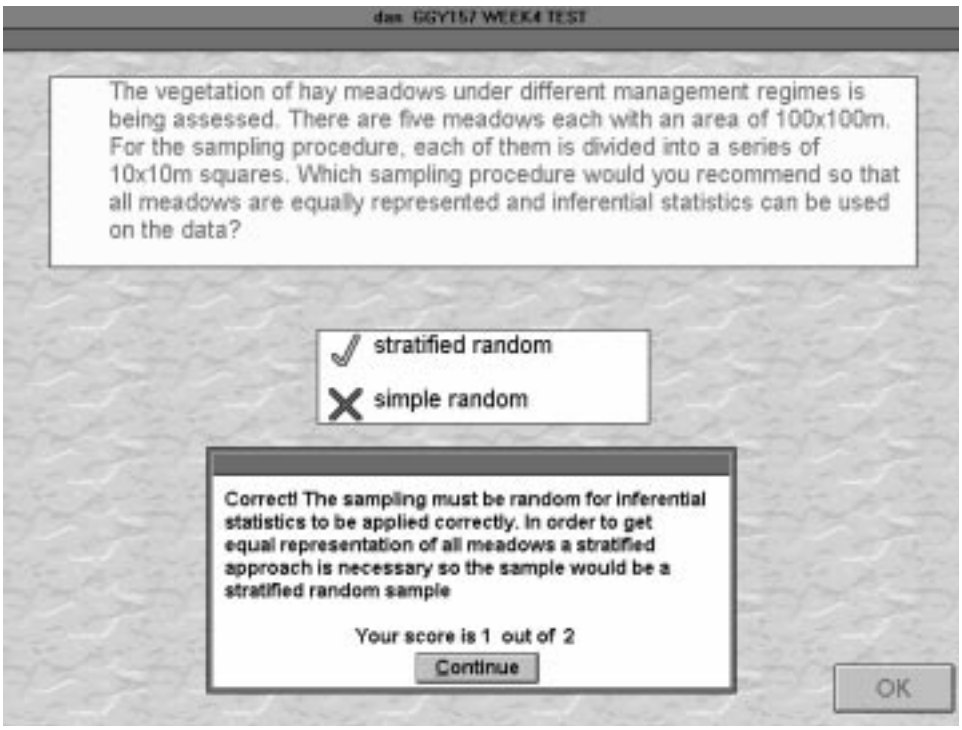
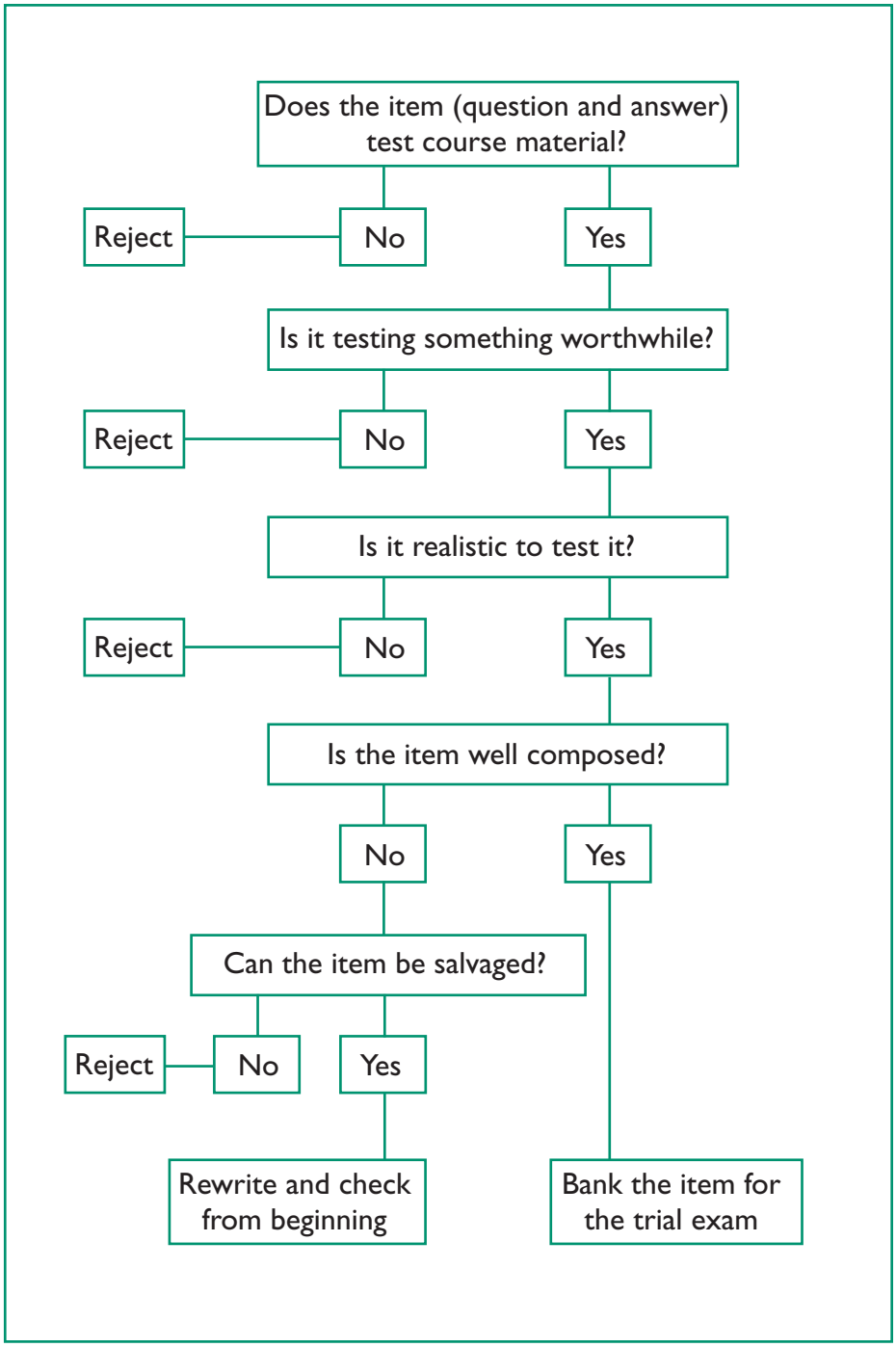


Figure 4.6: Decision tree to aid evaluation of objective questions. (Redrawn from Heard *et al.*, 1997b).



4.9 Question review

It is essential to review the questions after they have been written and during their use by students. The decision tree (Figure 4.6) is a useful initial way to review questions and decide whether they need changing. Equally, writing feedback to questions often points up problems with the question design itself. Some tips on review of questions:

- Ask colleagues to try the questions to discover any initial errors or misleading questions.
- Check that distracters in MCQs are plausible.
- Try the test out on a group of students where the summative element is small or zero.

- Encourage students to respond to you on questions and feedback. If the CBA is networked, students can email responses directly to you while they are actually doing an assessment. Contrary to the above, an element of summative assessment encourages a better student response on the problems with the assessment, as they have an incentive for telling you if they think a question is wrong or misleading.

- After running an assessment, do at least some question analysis. Are there any questions which every student gets wrong? Are there particular distracters which almost all the students are choosing?

4.10 Writing feedback

Provision of feedback is one the biggest advantages of CBA over paper based objective tests. However, it has to be well thought out and useful without being long-winded. Similar considerations apply to any feedback to students but the following are useful things to bear in mind with CBA feedback:

- Make it clear whether the response is correct or not.

- Keep it as positive as possible - even if an answer is not correct, give credit for being nearly right and don't give the impression that the response given was completely idiotic. On the other hand, you don't need to be excessively effusive for correct answers unless they are the really difficult questions.

- Give feedback on correct responses too. Some answers may have been arrived at by the wrong reasoning or even by chance - even if the reasoning and answer were both correct, feedback can reinforce this.

- Make sure there is adequate time for reading of feedback. Formative assessments should not be strictly time limited if you are expecting students to make good use of feedback.

- Consider using graphics in feedback to make them more interesting

- Explain why a wrong answer is not correct. Give the correct answer and explain how to derive it. If the response was only slightly wrong, try to suggest where the student could have gone wrong.

- Avoid over-jovial responses but do keep it reasonably simple and friendly.

- Use feedback to adjust the possible responses. You may need to change the question once you come to write the feedback!

- Consider the timing of feedback - will it be given after each question or at the end of the assessment? This may affect the detail and form of feedback. Instant feedback on each question can be very effective but you need to bear in mind the time it takes for students to read and digest this.

- Give pointers to further learning opportunities and information such as page references in textbooks, course materials and journal literature.

Part 2: Materials for CBA

Chapter 5: How to construct the assessment

5.1 The random element and question banks

5.2 Libraries and structuring assessments

5.3 Managing access time and people

5.4 File management and control

5.5 Assessments as learning resources

5.6 Marking schemes

Chapter 5: How to construct the assessment

In this chapter we move from writing questions on to considering the issues involved in putting the questions together to form an assessment. In some ways the overall design of CBA can be more complex than that for other assessments such as paper based objective tests, simply because the range of options is very much larger. Computers are capable of selecting questions, managing student access times and gathering and storing the information in many different ways. The widespread use of local networks and the world wide web (see chapter 6) means that this potential is now much greater than it ever has been, and there are therefore some fundamental aspects of assessment design which should be considered before writing and implementing a test.

5.1 The random element and question banks

Paper based assessments are fixed in advance, although it is possible to generate several different versions of an assessment either manually or in a semi-automated OMR system. Computers, however, can generate and deliver different sets of questions to different students, or to the same student on different occasions. The variety of combinations depends on the size of the question bank from which the questions are drawn. Even a relatively small (say 2-3 times the number of questions delivered in any one test) question bank gives a good degree of variability. Randomisation of question order and of possible responses within multiple choice and multiple response questions gives a further degree of variability so that this is a very worthwhile feature even if the assessment delivers a fixed set of questions. The random element:

- forces students to read each question carefully and evaluate each response even if they have come across a similar question previously
- enables repeat sittings of assessments on the same topics without the need to generate new sets of questions. This aids student learning and can be used to provide a revision resource or it can be used to provide resit examinations in summative assessments.
- means that every student can get a unique assessment - in open access assessments where students are permitted to work in groups, different questions will be asked. This can help stimulate group discussion and 'self-help' groups forming (see case studies in volume 2).
- avoids copying in summative assessments - students adjacent to one another are very unlikely to encounter exactly the same question. Even if they do, this will almost certainly not occur at the same time since only one question is displayed at any one time.

5.2 Libraries and structuring assessments

Randomisation of questions and answers is a tremendous advantage of CBA but it can lead to problems, since, if the question bank is large, there may be students who by chance who only get assessed on a restricted part of the syllabus if the question bank is too broad. One way to avoid this is to use libraries of questions within an assessment. Libraries are subsets of the full question bank, each of which contains a group of related questions. An assessment of 20 questions may be structured to take five questions randomly from within each of four libraries instead of taking all the questions randomly from the entire undivided question bank. More complex structures can be produced with some compulsory sets of questions and some randomly chosen questions. Here are some tips on structuring assessments and use of libraries:

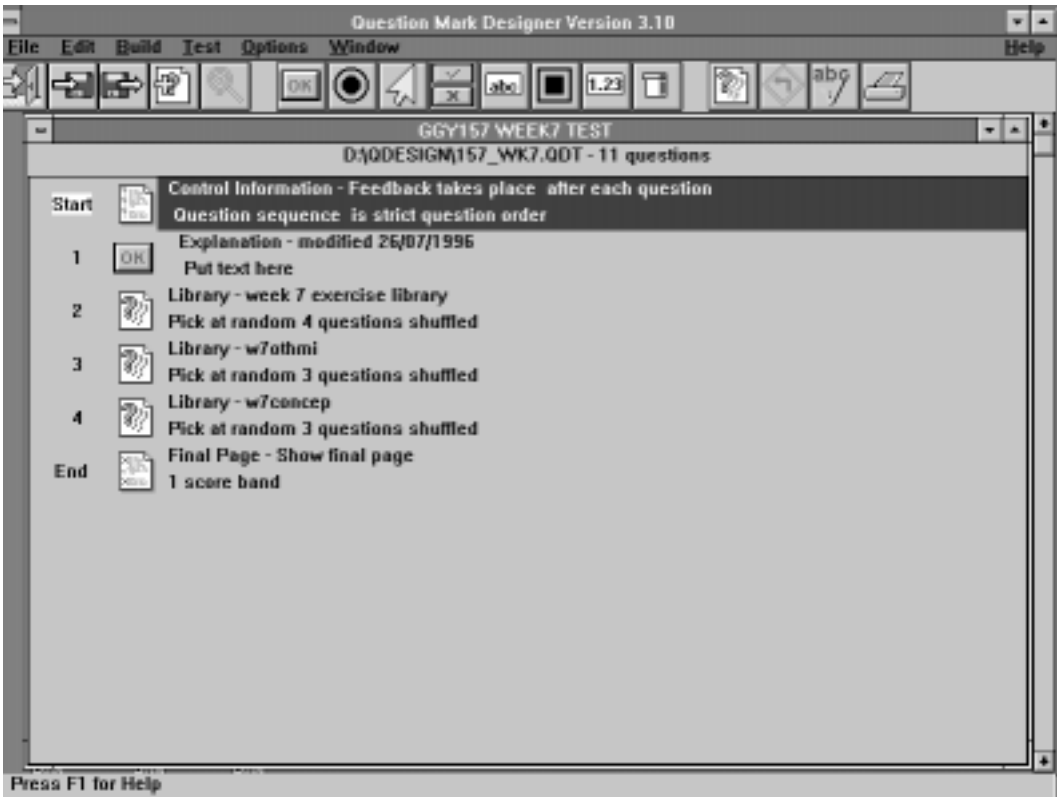
- Think about what you would ideally like to do and then find out whether the software will allow this structure or a modification of it. Many poor CBAs are the result of restrictive thinking at the basic design stage.

- Build up question banks slowly. It is difficult to generate large numbers of good questions in one sitting. As the question banks grow, they can be sub-divided into libraries.

- Think about the balance of the assessments. Are you assessing the full range of material? Are there areas which it is more important to assess than others? Do you need to ask all students one or two very important questions? Make sure your structure meets the needs of the curriculum and the intended learning outcomes.

- Have a look at other assessment structures. It helps to see how other people have approached this aspect. Beware though - not all assessments make use of these facilities as much as they might so think about how they could be changed as well!

Figure 5.1 An example of a an assessment structure designed using Question Mark (see Chapter 6). This incorporates control information, an introductory screen of information which the user will see (the 'explanation'), and calls on three separate libraries of questions. Four questions are chosen at random from the first library and shuffled into a random order and three question are chosen from each of the other two libraries, making a ten question assessment. In this case the control information indicates that the student will receive feedback after each question and the final page item shows that the score is given at the end of the assessment.



5.3 Managing access: time and people

The widespread networking of computer systems in education has resulted in an additional level in the application of CBA. Stand-alone workstations can be a worthwhile way of delivering CBA to small numbers of students in closely controlled environments. Indeed, psychometric tests (where many CBA ideas initially sprang from) are still often delivered this way. However, networking allows close control of student access time and place automatically, as well as making it much easier to manage results and the assessments themselves. Using the network to manage access can be especially useful for:

- controlling open access assessments which are essentially formative. Students can be limited to access times of a week or so on a series of sequential assessments, to help nudge them towards a balanced pattern of working. This is well illustrated by the case study on data analysis in geography (see Case Study 3 in Volume two).
- overcoming limitations on workstation availability, by scheduling different sets of students at different times.
- allowing different kinds of access to students at different times. For example, assessments may be made available on a restrictive one-off basis for summative assessment, followed by open unrestricted access later in the module for revision purposes.

Security is a potential problem in allowing open and/or remote access to assessments. How can you be sure that students are not sitting the assessment for one another, even with password protection? If this is a major concern then supervised access is the only option (as in formal examinations). Clearly it may be a difficulty, but it is certainly no more of a problem than dishonesty in conventional coursework assessments.

5.4 File management and control

Good control systems for access to question files are obviously important for ease of use as well as security. Perhaps, however, more important is the careful management of answer files generated by students as these form a resource not only for the summative scores but also for potential feedback to students themselves should they have difficulty in understanding where they have gone wrong from on-screen feedback or if they want to query results. Again the network facilitates all these activities by:

- allowing students read access to question files when they need it but not to be able to corrupt or misuse these files.
- directing the 'traffic' of incoming information to students from question banks and the outgoing answers from students to different locations if necessary.
- subsequent compilation of results and generation of data on student performance and use of questions provided as revision resources.

5.5 Assessments as learning resources

CBA has often been seen as an effective mechanism for large scale summative assessment of students - for example the development of CBA examinations at Luton and Aberdeen (Heard *et al.*, 1997a; Zakrzewski and Bull, 1998). It can undoubtedly be effective used in this way, but it has even greater potential for use as a learning resource, perhaps used for mixed formative/summative assessment or simply as formative assessment. However, if there is no summative element it may be difficult to achieve high usage by students! This has been partly covered by earlier sections, but this is an important consideration when designing assessment structures.

Even if your main aim is to develop summative assessment, consider using CBA to help prepare the students for the assessments. A large enough question bank on which a purely summative assessment is based could even be made open access for revision!

5.6 Marking schemes

Any summative objective test must have a marking scheme which ultimately yields scores on a comparable scale to those being used by the institution to grade students. Objective tests frequently lead to a greater range of marks and since conventional marking schemes in the UK tend to bunch between <40% (fail) to >70% (first class) this can lead to problems. It is not such a contentious issue for pass/fail modules but it may still be difficult to design a marking scheme which yields appropriate final results. Things to consider are:

- Variable scores for questions of different difficulty/complexity. CBA software will frequently allow this and if final scores are calculated as a percentage, it does not matter that different students may have different absolute numbers of marks available to them.

- Negative marking strategies. Opinions differ on whether these are appropriate or necessary. As usual it's down to individuals and specific circumstances. They are probably most appropriate for true/false questions. However, students need to be given the option of not responding (zero marks).

- If variable or negative marking schemes are used, students need to be clearly informed of this in the on-screen information.

- Use a pre-test to determine the likely range of scores and adapt the marking strategy from this.

- Scale the marks after all results are available. Again, if you use this method, then the students should be informed in advance. However, we think this should be avoided wherever possible and it is preferable to adapt the marking scheme within the test so that students do not gain a false impression of their running summative performance.

Part 2: Materials for CBA

Chapter 6: Delivery of CBA - choosing the software

Chapter 6: Delivery of CBA - choosing the software

This chapter introduces the main types of software for CBA and provides some costs and contact details for major suppliers and educational projects. It should be borne in mind that software is developing quite rapidly and further innovations are likely in the future which will considerably expand the capabilities of CBA. The Internet is increasingly successfully used for delivery of assessments (Taylor, 1995; Dickinson, 1997) and offers great future potential as do other developments such as videodisc technologies (Mansen and Haak, 1996). However, although the web is gaining in popularity as a mode of delivery for CBA, it is not always appropriate (see Box 6.1).

Box 6.1: Principal advantages and disadvantages of CBA delivered via the Internet (principally the WWW). It is likely that the disadvantages will decrease as time goes on.

ADVANTAGES

- Access time: can be accessed at any time so students are not dependent on University timetables or opening hours.
- Access location: can be accessed from any location with an Internet connection. It is therefore especially useful for distance learning. It could also be seen as a means of reducing pressure on University resources.
- Flexibility: the web is platform independent. The same CBA can be accessed using PCs, Macintosh or other types of computer

DISADVANTAGES

- Dependent on external connections and networks/hardware. Local Networks may be more stable than external connections and networks.
- Access control: it is potentially harder to control access.
- Security: Due to potential access, security may be harder to ensure.
- Assessment types: many web based CBAs are more limited in terms of the range of question types than their Windows based counterparts

6.1 How to select appropriate software for your needs

There is an increasingly wide range of software options which are available for developing CBA. Making a decision as to which to use will probably depend on issues such as:

- **What is to be assessed?** Decide whether the assessment should be formative or summative or both and what the feedback requirements should be.
- **Group size** How many students will there be and does this affect how/when the CBA will run?
- **Mode of delivery** e.g. CD-ROM, floppy disk, Web etc. Thought needs to be given as to how and when the assessment is to be undertaken. For example, it may be that you want the test to run at a prescribed time or for it to be available during a flexible time-slot.
- **Security** Decide on the level of security. For example, you may want password protection. Additionally, you will probably need to store question and answers files at differing places on the file server or drive directory.

- **Question style:** multi-choice/response, numeric, text, hot-spot, graphics or mixture of these etc.
- **Available expertise:** what particular areas of expertise are already available (computer programming, networking skills etc.) for developing and supporting the CBA?
- **Resources and facilities:** rooms, networked PCs, Web access, program software etc.
- **Time:** developing a CBA can take time; ensure there is enough available for development and pre-testing.
- **Cost:** you will no doubt be working to a budget!

Having a good idea of what is already available will shape what can or cannot be done within the time and budget that has been allocated for developing the CBA. Contacting the appropriate departmental/institutional computing service providers as well as programme co-ordinators and timetable administrators will often prove a good place to start (the latter being important if you are planning to test large groups with limited room sizes). You can discuss your plans and take on any advice on implementation, as well as learning what resources can be called upon. These early discussions are important: it is crucial to have the support of key players (i.e. those that have the day to day responsibility of running and maintaining computer networks and systems and programme time-tabling) in order to have a well-managed CBA.

It is also worthwhile spending some time talking to other colleagues from both within and outside your institution who have used or are interested in using CBA. Learn from their experiences and take on any advice or ideas on what software and approach may be appropriate for developing your particular CBA. You never know, they may already have something that exactly suits your needs!

Having completed an audit there are a variety of pathways you can undertake to develop your CBA; we have divided them into generic, authoring shells, commercial and non-commercial CBA software.

6. 2 Generic Software

If you have the services of an experienced programmer (this could be expensive if you have to recruit or buy in someone to program for you) you could use a generic program language such as 'C', 'C++', 'FORTRAN', 'COBOL' or 'Basic' to develop your CBA. However, in most cases this would be rather like hitting a small pin with a sledge hammer! Microsoft's 'Visual Basic' is useful for less experienced programmers, of which the latest releases could arguably be considered authoring software.

6.3 Authoring packages

An approach that many developers of CBA have chosen is to make use of authoring software (often used for creating multi-media applications). Most of these programs enable you to build your applications in an environment where text, graphics, audio and video can be placed into an interface whose properties can be set by program coding. Manufacturers often claim that their authoring software products are easy to use and that 'virtually' no training is required; applications are relatively quickly created by clicking icons and/or by cutting and pasting from 'script libraries'.

Creating a CBA application using an authoring software program usually follows a similar process:

- design and create the interface using a toolbox provided (usually a set of icons which enable the user to draw, add boxes, push buttons, images, text etc.)
- set properties of the interface (e.g. give a value to a checkbox, provide a name to a box that may be used to enter text etc.)

- write the code to respond to the user's action (e.g. when the user clicks the mouse over a checkbox etc.). As mentioned earlier, these program codes are often already written or can be assembled by clicking icons. However, regardless of what the manufacturers say about the need for virtually no training, some understanding of the principles of computer programming is an advantage especially if you are considering developing a sophisticated CBA, for example, opening-up other external applications, or playing video or audio etc.

Many authoring software programs are able to produce applications which can be used on the Web (mostly by the use of 'plug-ins' - a program usually available by downloading from the Web which allows Web browsers to run certain applications). Not only does the web provide a wide delivery system but it also has the advantage that end-users do not have to use the same computer system platform (in other words a CBA developed on a PC version of the authoring software can often be used on a Mac or UNIX system over the Web).

There are a growing number of authoring software tools on the market, many of which have an educational version (and usually a reduced price for educational users). Probably the most familiar are Asymetrix's 'IconAuthor' and 'Toolbook' along with Macromedia's 'Authorware'. These programs are expensive (c. £1000), but the manufacturers claim that the pay-off comes in the time saved by easy development for non-experienced users. Asymetrix also market 'CBT Express', which is a considerably cheaper product (c. £300) and is aimed specifically for training and educational institutions. This application has no programming or scripting language to worry about; applications are developed from template libraries or by the use of 'Wizards', for example to create exercises or build tests.

Contact details:

Asymetrix: 0171 454 1061 or at http://www.asymetrix.com

Macromedia: 0181 2008282 (through Computers Unlimited) or at http://www.macromedia.com

Some other authoring software suppliers/producers:

Digital Workshop 'Illuminatus': 01295 258335 or at http://www.digitalworkshop.co.uk

Linotype-Hell 'Dazzler': 0124 222333 or at http://www.linotype.co.uk

Matchware 'Mediator': 0181 940 9700 or at http://www.mwin.com

A more comprehensive listing of authoring software can be found at:

http://www.mcli.dist.maricopa.edu/authoring/

Hardware Requirements

Depending on the intensity of the multi-media materials (graphics, video, audio etc.) that you intend to use, for the development of CBA using authoring software you will probably need at least 16Mb of RAM, a Pentium processor, a 2Mb graphics card and a fast hard disk of at least 1Gb capacity. For delivery of CBA the requirements may not need to be so high. However, conflicts can often occur especially when using a variety of differing specification end-user machines. The best advice here would be to exhaustively test out the CBA on all computers and networks (if appropriate and where practical) that are intended for use in delivery before final release of the application.

6.4 Commercial CBA products

There are a few commercially available software programs (we are not intending to list them all) designed specifically for computerised assessment , of which Question Mark's 'Designer' claims to be the world's leader. The popularity of these packages suggests that they strike the right balance for many users since they offer considerable flexibility of assessment design and delivery, and because they are specifically for CBA, they are easy to use and require no specialist programming knowledge.

Question Mark

Question Mark produce packages for assessments to be created on either DOS, Windows and Mac platforms and there is also 'Perception' - a package for Web based assessment. There are a wide variety of question types to choose from, and you are free to design your own presentation layout which is supported by an extensive selection of fonts, text colours and appearances. Pictures can be added to the tests to illustrate questions with maps, graphs etc. The program is also capable of opening other applications during an assessment (for example, you may want students to review data in a spreadsheet and then answer a question). Once the questions and feedback text have been designed, they are then stored into libraries. Assessments are created by setting key parameters such as password protection, time limits, date and time of test, number of attempts etc.; the question libraries are then assigned to the assessment. Question Mark say that assessments can be developed with just within just a few hours of using the software. Assessments can be delivered via single machines, local networks and the Web. Reports and analyses can be quickly undertaken from the answer files generated by the assessment and there is both a powerful analysis tool and export utility (e.g. to MS Excel, SPSS etc.).

Costs: Single 'Designer' licence £499 + VAT. (Presenting and reporting software included)

Contact details: 0171 263 7575 or at http://www.qmark.com. The Web site contains a lot of information and advice and Question Mark also have an E-mail discussion group.

Interactive Assessor

A competitor to Question Mark's 'Designer' is EQL's 'Interactive Assessor'. This is very similar in approach offering a powerful but easy to use system for creating question banks, generating customised tests, running tests and providing automatic results analysis.

Users are given a free hand to design the layout of their questions. Drop down menus and a toolbar make the editing facilities easy to access and operate. Text tools allow a variety of fonts and styles and there are also drawing tools to allow for the construction of objects. Once the questions have been designed, the test characteristics are then set, for example the number of marks, level of difficulty etc.: they are then stored in question banks. Tests are then created by selecting questions from these banks. Paper based tests can also be undertaken with the 'Assessor' software, as an OMR (optical mark reader) can be linked into the results reporting and analyses part of the program. EQL will soon be releasing a Web-publishing version of 'Assessor'.

Costs: Single user licence is £695 +VAT.

Contact details: EQL International Ltd telephone 01506 472255 or by E-mail to Graham Divers (Graham@eql.co.uk) or at: htttp://www.eql.co.uk/assessor.htm

LXR*TEST

As an alternative to both Question Mark's 'Designer' and EQL's 'Interactive Assessor', there is Logic Extension Resources 'LXR*TEST', where once again the approach is very similar. Both Mac and Windows versions are available and a demo version can be downloaded from their Web-site.

Costs: Educational site licence for the 'Scoring Edition' is US $1199.

Contact details: Logic Extension Resources, E-mail: info@lxrtest.com or through their Web-site http://www.lxrtest.com/

6.5 Non-commercial CBA Software

There are a vast number of 'off the shelf' assessment packages, many of which have been developed not only as part of national programmes such as the 'Teaching and Learning Technology Programme' (TLTP) but also by individuals or groups which have decided to create their own to meet the needs of their modules or courses. It is worthwhile spending some time looking at these products as there may already be an application that comes close to meeting your requirements, and of course many are available at a much lower cost when compared to developing in-house or buying from commercial sources.

An increasingly large number of these assessment applications have been specifically developed so they can be used on the Web. Below is a selection of those available and currently being developed. Further specific projects are detailed in Volume 2.

The CASTLE project at the University of Leicester

The University of Leicester's Castle Project, funded by the Joint Information System Committee (JISC) and JISC Technology Applications Programme (JTAP), is developing an authoring shell so that tutors and course managers can create on-line interactive assessment tools quickly and easily without any prior knowledge of Web scripting languages such HTML, Java, cgi etc. The program presently available from this project includes a 'create tool', 'modify tool', 'mark engine' and 'create 2-frame quiz; these tools are freely available for use.

Contact details: http://www.le.ac.uk/cc/ltg/castle/ or by E-mail to Helen Pownall: hrp3@le.ac.uk.

NetQuest at the University of Bristol

The University of Bristol's NetQuest project is developing TML (Tutorial Markup Language). This is a superset of HTML (Hyper Text Markup Language)to enable tutors and students to create sets of questions for self or course assessment. It has automatic marking and user authentication can be set by password if required. The project aims to provide a large question set which will act as a central resource, accessible over networks including the World Wide Web, marked up so that the user can request a set of questions on any given topic.

Funded by the University of Bristol's Continuing Professional Development Fund and the charity Baby Lifeline, NetQuest is compiling indexed and searchable question banks in the subject areas (initially) of geoscience, chemistry, medicine, veterinary science and engineering. These will be complemented by "assessmentware", software which will allow students (for self-assessment) and tutors to grade automatically the tests they have requested.

Contact details: http://www.ilrt.bris.ac.uk/mru/netquest/tml/ including downloadable software and tutorials.

MarkThis at the University College of St. Mark & St. John, Plymouth

An unusual approach is the 'MarkThis' software which has been developed at the University College of St. Mark & St. John, Plymouth. The aims of this program are to provide better student feedback, make explicit the criteria by which marks are allocated, stimulate discussion related to the monitoring of marking standards and reduce the effort involved in marking. The program requires the setting up of lists of student names, marking criteria (these can be obtained from a default list or you can create your own) and marking weights. Once these have been created, the marking process can begin. The name of the student is selected from the list, the software then displays a list of comments from which you select one which best describes the student's work. Each comment has a weighted mark and personalised comments can also be added in a text field. Once all the marks and comments have been allocated then an output report can be generated. 'MarkThis' is freeware and runs in an environment created by Toolbook 3.0 which in turn runs under Windows 3.1 (or later).

Contact details: Dr. Peter Smee, 01752 777188 or E-mail: stapes@lib.marjon.ac.uk.

TRIADS at the Universities of Derby & Liverpool and the Open University

The 'TRIADS' (Tripartite Assessment Delivery System) project which is at present still under development aims to improve the quality of learning by developing a CBA system. The project will try to identify which learning outcomes can be best assessed using computing technology. Once these have been ascertained, it is proposed to develop user-friendly templates of differing question styles on which users can base their own questions. 'TRIADS' is a collaborative project between the University of Liverpool, the University of Derby and the Open University. It is funded by HEFCE's Fund for the Development of Teaching and Learning (FDTL).

Contact details: Prof Chris Paul, E-mail: crcp@liv.ac.uk, Dr. Don Mackenzie E-mail: d.mackenzie@derby.ac.uk or Dr. Dee Edwards E-mail: d.j.edwards@open.ac.uk.
Web-site: http://www.pcweb.liv.ac.uk/apboyle/triads/index.html.

University of Sunderland Pharmaceutical Sciences assessments

The University of Sunderland's School of Health Sciences is developing its own chemistry tests for Web delivery using Question Mark Web. Many of these tests use Pharmaceutical examples and will be suitable for students studying Chemical and Pharmaceutical Sciences, Pharmacy, and Pharmacology as well as Chemistry. Most of the tests will give feedback (either on all questions or those which were wrong or unanswered) when you submit your answer.

The tests were produced using QM Web to convert Question Mark for Windows tests into HTML for delivery on the Web. The feedback at the end of the test is provided by the QM Web On-line Scorer which also takes care of recording submitted answers and of keeping a log of the test usage. The answer file produced can subsequently be processed by Reporter in Question Mark for Windows. The tests can be tried out from the web site below.

Contact details: Dr. David Adams, E-mail: David.Adams@sunderland.ac.uk.
Web site: http://www.sunderland.ac.uk/~hs0dad/student.htm

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THE SEED PROJECTS AND THEIR CONTACT DETAILS

Project 1: A web based bibliographic database on Science teaching and learning, designed to support the information requirements of the SEED Projects.
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Project 2: An investigation of the potential development of Curriculum Support Teams.
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Project 3a: A handbook on field teaching in the Sciences.
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Project 5: A handbook on laboratory teaching.
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Project 6: Peer assisted learning strategies (Supplemental Instruction) (P.A.L.S (S.I.).
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Project 7: Development of a framework for the training and management of graduate teaching assistants.
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Project 8: Development of a computer-aided learning package for environmental organic chemistry.
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Project 9: Environmental issues in the Mediterranean: a case study of the Maltese Islands.
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Project 10: Computer based assessment in science: a review of good practice.
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Project 11: CAL and basic Science.
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Project 12: A handbook on employer-links in Science.
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Project 13: Using multimedia for providing feedback to students undertaking concurrent project-based practicals.
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Project 14: An environmental data base for projects in environmental impact assessment (EIA) and conservation.
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Project 15: Webkit - a toolkit to produce interactive web pages in support of CAL.
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Project 16: Qualifications update in applied Science for industry.
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Project 17: Baseline assessment of competencies and skills for Science and Computing.
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