USE OF QUESTIONMARK ASSESSMENT SOFTWARE TO IMPROVE LEARNING AND TEACHING

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ABSTRACT
Computer aided assessment (CAA) using Questionmark Perception software can be used to enhance learning through the regular use of formative assessment. The range of question styles available within Perception provide good interactivity and can incorporate rich feedback which is tailored to the student's response. Many refinements of fixed response questions have been devised over the past 20 years or so and while these may have not been feasible in pen and paper format they are far more achievable in practice if computerised. For example a variant of the multiple choice question where the students are required to indicate the certainty of their response, which is intended to reduce the effect of guessing, is easily computerised. The drag and drop template can be applied to a great variety of question styles which include concept maps, flow charts of practical schedules, and Venn diagrams.

KEYWORDS
Computer aided assessment, CAA, Questionmark, perception, degree of certainty, Certainty of Response Index, (CRI), concept maps, TRIADS, flow charts, laboratory schedule, Venn diagrams

INTRODUCTION

There are many advantages in using computer assisted assessment (CAA) but care needs to be exercised in its use (Bull and McKenna, 2001). We have used CAA for several years, initially on an intranet, but more recently using web-based software. Our main interest to date has been its use in formative and summative assessment of students on introductory courses in biological chemistry (Adams, Ginn and Ruddick, 1998). The aspects of CAA which appealed to us most were the ability to assess large numbers of students on a regular basis, the instant and detailed feedback which could be given to students on their answers, and lastly the availability of questions on an "anywhere at anytime" basis. Much of teaching for first year classes is built around formative assessment and the provision of questions of many different styles with rich feedback. We recently undertook a project with the LTSN Physical Sciences to provide a large bank of questions, suitable for formative assessment in introductory chemistry, biological chemistry and health and safety and environmental issues (Adams, Byers, Cole and Ruddick, 2002).

Many of our our questions fall within the early stages of intellectual development described by Perry (Finster, 1989). However we are also interested in using the computer to povide formative and summative assessment of higher order skills. The versatility of modern CAA software together with the creative use of images, allows questions and tests to be authored in ways not possible a few years ago. The purpose of this paper is to explore some of ways in which the templates in Questionmark Perception software might be fashioned to provide an even more effective instrument to assess the knowledge of students and to help them learn. There are many published articles on assessment using fixed response items but relatively few of these have been converted into automated form.

Questionmark Perception Version 3
Questionmark Perception (v3) (Questionmark homepage, 2003) is commercially available software that allows tests to be delivered over the web. It consists of question authoring software called Question Manager and Assessment Manager, which are installed on the author's PC, and server software which schedules and delivers the tests. The server software also incorporates Enterprise Reporter, which collects the results of the tests and which can be used to compile various statistical reports.

Much assessment software is based solely on multiple choice questions (MCQ's), whereas a major feature of Perception is the range of question styles which can be used. These are easily accessed by using the question templates (Table 1) provided. The writing of MCQ's can be difficult and time consuming because of the need to construct effective distractors whereas the flexibility of question design in Perception can speed up question authoring and allow a particular topic to be tested by the most appropriate question style.

Table 1. Question Templates in Questionmark Perception

Drag and drop	Macromedia Flash	Numeric
Essay	Matching	Pull down list
Explanation	Matrix	Ranking question
Fill in Blanks	Multiple Choice	Select a blank question
Java	Multiple Response	Text match

Tests or assessments are constructed using Assessment Manager. Questions are are selected from the Question Manager database and imported into question blocks. During a test the student is presented with a package of questions corresponding to a question block; when the student has answered the questions within the block the answers are submitted to the server. The next block of questions is then presented to the student. The placing of questions into blocks means that students are not confronted by a seemingly endless list of questions and also reduces the potential overload on the server when many individuals are taking the test at the same time. Another advantage of using question blocks is that a "jump block" can be inserted at the end of a block. The jump block is programmed with a condition, eg a particular score in the preceding block, which causes the test to jump to some other specified block. This permits *adaptive testing* where the test adapts itself to the performance of the student. An obvious application is where questions on a particular topic are arranged into question blocks according to the level of difficulty. If the student obtains high marks in an early block the test can be made to jump to more difficult questions.

ADAPTING THE QUESTION TEMPLATES

The question templates in Perception are easily modified and adapted to make questions which are not available in the question wizards. The software allows questions to be edited in QML, a variant of HTML and it is therefore relatively easy to incorporate the less common characters and symbols as well as links to other documents. The drag and drop template is the most versatile since it allows the use of diagrams, pictures and markers in a multitude of different ways. Over the last twenty years or so many different styles of fixed response questions have been proposed, but the inability to automate their marking and to make them interactive has meant that they have found little practical application. Given the wide range of potential question styles and the interactivity that is inherent within Perception, it is worth re-examining some of these ideas which were originally proposed for pen and paper tests.

Multiple Choice Questions – degree of certainty test
MCQ's normally consist of a question stem followed by a number of choices, one of which is the correct answer. Conventionally a mark is awarded if the correct answer is chosen and no marks if the incorrect answer is selected. However it is possible for a student to obtain the correct answer by guessing and earn the same merit as a student who truly knew the answer. For a test consisting of many questions however the effect of guessing on performance is substantially diminished In order to deter

guessing, negative marks can be awarded for incorrect answers, though this goes against the grain for most teachers who tend to approach assessment in a positive rather than negative manner.

Drussel and Schmid (Drussel and Schmid, 1953) have experimented with the "degree of certainty test" where the student has to indicate how certain he/she is in selecting the particular choice. Marks are then awarded using a scale which reflects the certainty with which a response is made. For example if an incorrect response is made, the student is strongly penalised if the degree of certainty is high and only slightly penalised if the degree of certainty is low. Conversely if a correct response is made, the student is highly rewarded if the certainty is high but only slightly rewarded if the certainty is low. The authors suggested a scale of marking indicated in Table 2. This makes the range of scores far greater than for regular MCQ's. The study also showed that the time taken to answer questions is about the same as for conventional MCQ's.

Table 2

Degree of certainty	**Score if correct item marked**	**Score if correct item marked**
Positive	4	-4
Fairly certain	3	-3
Rational guess	2	-2
No defensible reason for choice	1	-1
Omission	0	0

Hasan *et al* (Hasan, Bagayoko and Kelley, 1999) in a similar approach formulated a *certainty of response index* (CRI). Questions were posed in the conventional manner but a supplementary question asked the student to indicate their certainty of response on a scale of 0 – 5 (5 = certain, 0 = totally guessed answer). The authors proposed that a class of students which had a low average CRI for a wrong answer, had a lack of knowledge whereas a high average CRI for a wrong answer indicated a misconception. Other conclusions could be drawn from a detailed analysis of the CRI data. Thus it might be possible to assess the effectiveness of delivery of parts of the instruction and where more emphasis might be placed. From an individual student's perspective careful analysis of his or her CRI's might lead to a questioning of perceived understanding of a particular topic and where the intervention of the tutor might be sought. The analysis of CRI data might therefore yield much useful information, particularly where questions are examining higher order skills. The use of computer assisted assessment, with sophisticated statistical analysis of responses, could prove very effective in this respect.

Although Perception does not supply a CRI question template, the *pull down list* (Fig 1) and *matrix* (Fig 2) templates can be modified to accommodate this type of question. The scoring of

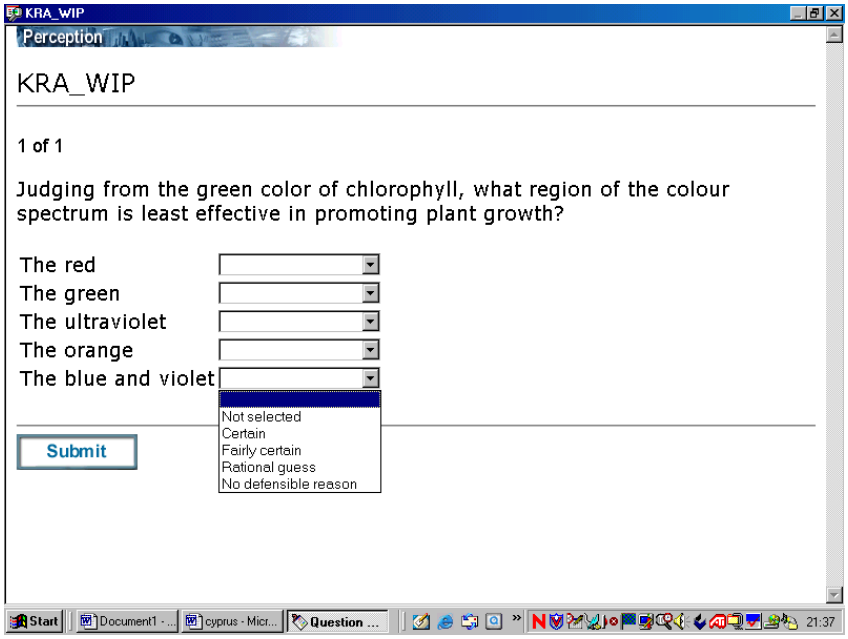

Figure 1

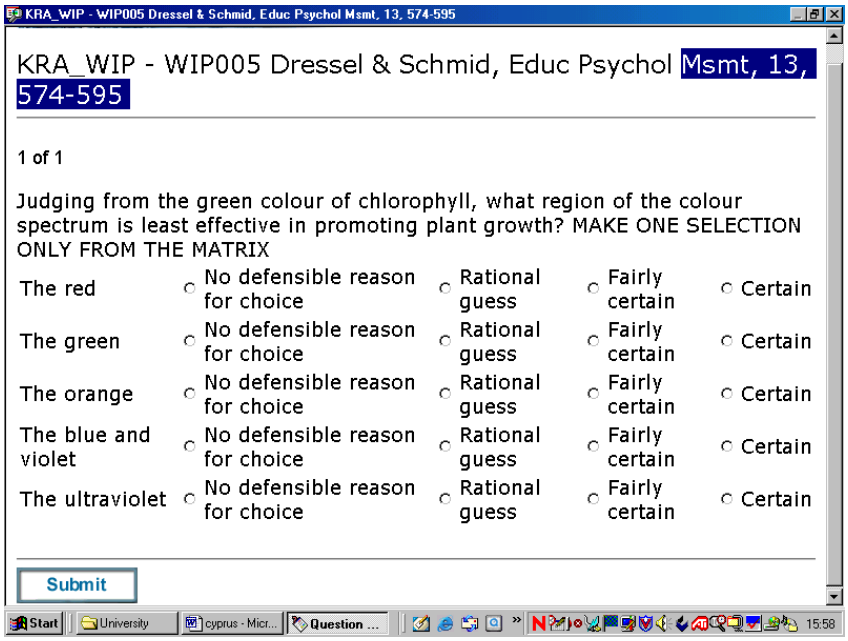

Figure 2

the outcomes is straightforward. As the authors of the above papers point out, clear instructions to the student in presenting this type of question are crucial. The format of the pull down list is less cluttered and perhaps easier to follow than the *matrix* presentation.

Concept Maps

The use of concept maps originated from research carried out by Novak (referred to by Novak, 1990). They are visual representations of concepts and the linkages between them. They are a metacognitive tool which allows students to construct relationships and connections between concepts and importantly

with knowledge they already possess, therebye faciltating learning. Concept mapping is based on the constructivist approach to learning where knowledge is constructed in the mind of the learner by him or herself. There have been many papers published on the use of concept mapping. These include their application in the improvement of teaching (Novak, 1984), in assessing learning (Pendley, Bretz and Novak, 1994; Nicoll, Francisco and Nakhleh, 2001), in laboratory activities (Stensvold and Wilson, 1992), in secondary school chemical education (Regis, Albertazzi and Roletto, 1996). Indeed a whole issue (volume 27, number 10) of the Journal of Research in Science Education published in 1990 was devoted to concept mapping.

Robinson (Robinson, 1999) defines a concept map as "…a diagram consisting of nodes that represent concepts and labeled lines that indicate the relationship between those concepts." The nodes are usually shapes, such as circles or rectangles, which contain the names of the concepts. If there is a relationship between two nodes or concepts, a line is drawn which join them. The nature of this connection is written as a label across the line (example Figure 4). This is called a *proposition*. Concept maps are usually constructed in freehand by the student but there is no reason why they could not be constructed on the computer using one of the many available drawing software applications.

The drag and drop question template of Perception can be used to familiarise the student with the process of constructing a concept map and reveal its potential as an heuristic device. For example an outline map of concepts might be be provided together with a list of proposition labels. The student is then challenged with the task of dragging the proposition labels to positions linking the appropriate concepts (Figure 3). Conversely a diagram with propositions arranged on it might be presented together with a set of concept labels; the student is then required to drag the concept labels to positions which are linked by appropriate propositions. In both cases it is easy to score range of outcomes using Perception. Marks can be awarded for a unique "correct" answer or partial credit can be given for placing some of the labels in logical positions.

Other Applications of the drag and drop template

There are many other applications of the drag and drop template which can be used for a variety of purposes and to examine higher order skills. Many of the novel templates devised in the TRIADS project (Ciad homepage, 2003) can be emulated in Perception. The use of flowcharts as a device for preparing students for practical classes is a further potential application. It is well known that many students enter the laboratory with little understanding of the procedures that they are about to carry out (Johnstone and Wham, 1982). They simply follow the instructions in the laboratory schedule on a line by line basis without an underlying understanding of the process, ie so called *recipe working*. By constructing a flowchart from a practical schedule the student is forced to take a holistic view of the procedures and therebye a better appreciation of the overall process. An illustration of how Perception can be used in this context is given in Figure 5 .

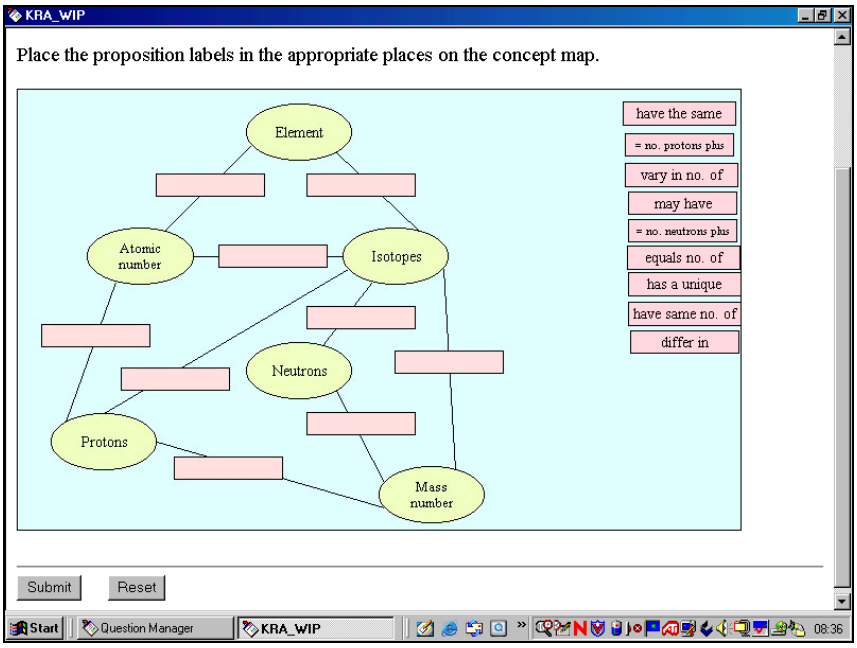

Figure 3

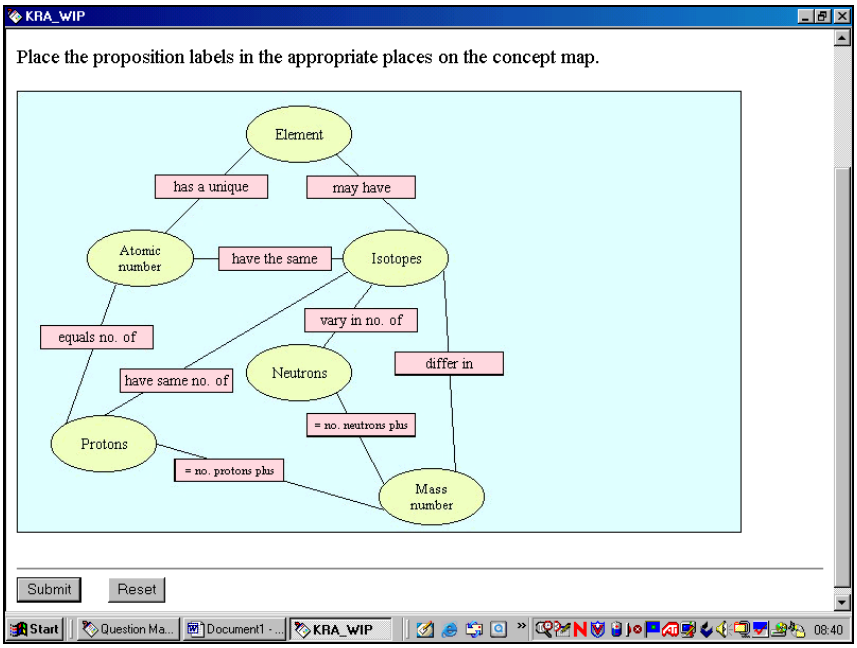

Figure 4

Figure 6 illustrates the use of the Venn diagram to describe the properties of chemical species. In this case various acids and bases are placed into appropriate places on trisecting circles (Johnstone, 1998)

All of the diagrams presented here were constructed using the simple and inexpensive drawing package called Smartdraw v5 (Smartdraw homepage, 2003). It is highly intuitive software, with an integral tutorial, and should require no more than an hour for an average person to become proficient in its use. It allows a variety of shapes to be created and colour-filled. Importantly it allows files to be saved in JPEG and GIF format which is essential for the drag and drop template. Work is currently continuing on increasing the variety of templates with a view to testing higher order skills.

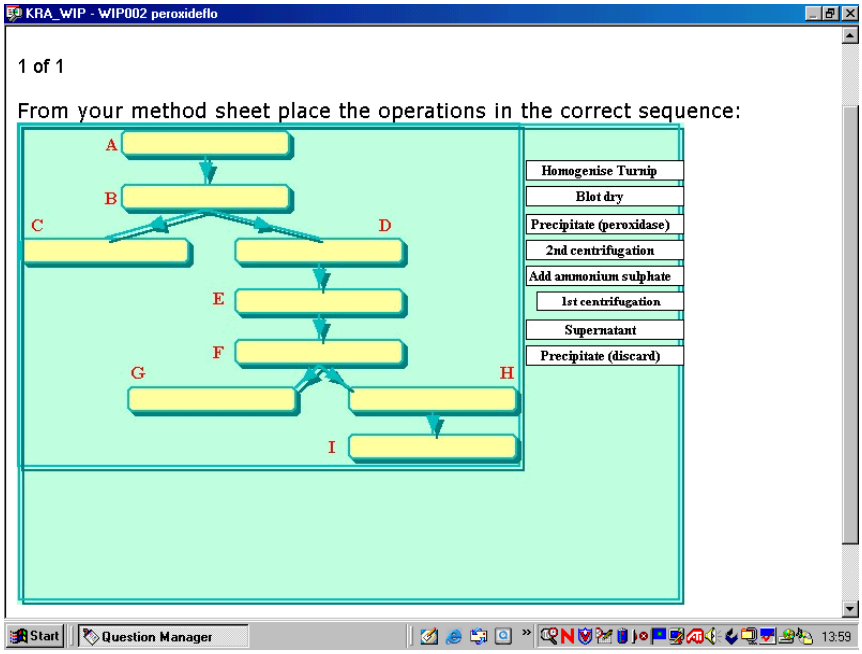

Figure 5

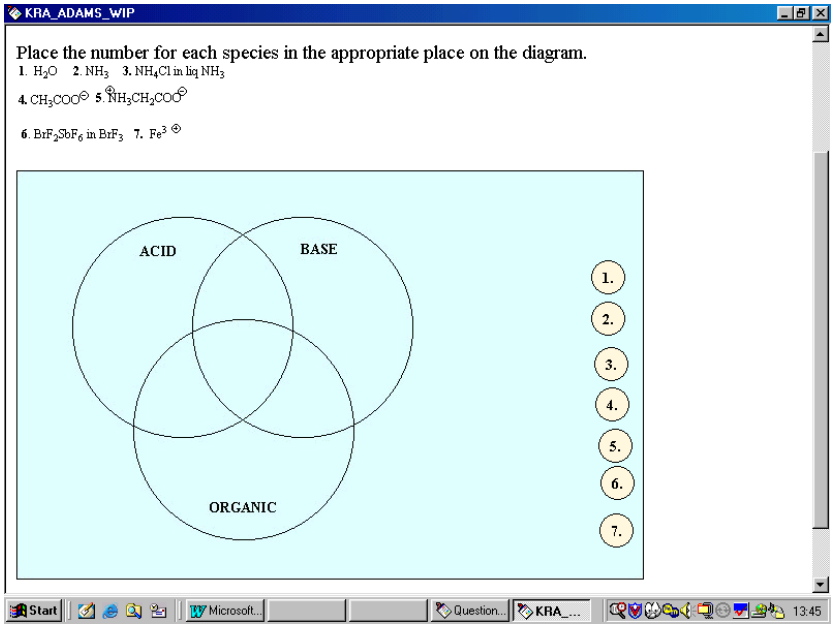

Figure 6

CONCLUSIONS AND FUTURE WORK

There is a stereotypical view amongst many academics that CAA is synonymous with MCQ's. However not only does modern CAA software provide a range of question types which are distinctly different from MCQ's, but as has been demonstrated here, it can be extended to give a rich variety of question types. This should remove some of the objections that critics have levelled in particular at MCQ's *eg* the abilty to get correct answers by guessing and the difficulty of producing distractors which are effective. It can also be very difficult to examine some topics using the rigid framework of the MCQ but the greater selection of question styles now available allows a choice of question type

which is more appropriate to a particular topic. It is also important to take acount of the student's engagement with the different visual formats of questions. This is likely to be a factor of some significance in formative assessment where 'attractive' question design might have a greater impact on the student's desire to practise answering questions.

What all CAA questions share in their design the pre-programmed nature of the response to the student's input *ie* they are *fixed response questions*. Experienced teachers can often predict the range of answers that students might give in response to a particular question and it is important to programme these responses, together with appropriate feedback, into the question. Perception also allows students to make there own 'free response' in the essay question template. Although this cannot be marked automatically it can provide information on the issues which need to be addressed when setting questions on a particular topic.

Further work will include the development of new question templates, especially those based on the drag and drop template. Also because questions can be edited in the mark-up language QML (which is very similar to HTML) there is ample opportunity to incorporate additional features into questions. As indicated in this paper the literature contains many creative proposals for fixed response questions, which, if incorporated in CAA software such as Perception, can greatly enhance the effectiveness of CAA.

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