USING JAVA APPLETS TO DELIVER MATHEMATICS ASSESSMENT

Brian Daugherty

Using Java Applets to Deliver Mathematics Assessment

Brian Daugherty
Department of Mathematics
Portsmouth University
Portsmouth
PO1 2EG

Brian.Daugherty@port.ac.uk,

Abstract

I have used Java programs specifically to deliver Mathematics assessment via the Internet. This has primarily involved extending Question Mark Perception to introduce more flexibility - allowing full randomization of numerical values to be used into questions. As a by-product I can also produce questions involving "quasi" randomization (data being read from a finite database) and this can be also be used to produce non-mathematical questions, and to introduce several new types of question.

Introduction

Starting with the belief that traditional assessment programs tend to be too inflexible for maximal efficient use in Mathematics, I have attempted to improve the situation by inserting appropriate Java programs into Question Mark Perception.
This bypasses the need to 're-invent the wheel' by constructing the entire assessment 'framework'. Question Mark Perception provides the 'scaffolding' and allows me to concentrate purely on the mathematical aspects.

The 'first stage' has to be to produce the randomised question techniques. The 'second stage', actually using these questions in assessment, as part and parcel of developing techniques to improve Mathematics learning, has only just begun with their use on a basic Key Skills in Number unit, to be delivered by Portsmouth University over the Internet.

General Question Types

As a good example of using the "off-the-shelf" version of Perception for mathematics assessment, refer to the Mathletics program. This is a large bank of questions developed by Martin Greenhow for use at Brunel University. A large number of these questions were converted, by myself, to be delivered by Question Mark Perception, and this work has been continued by Dr. Chris Ricketts at Plymouth University (http://L62.csm.port.ac.uk/mathletics.html).

In Mathletics, each specific question has only a finite number of variants, and each variant has to be entered individually. For the sake of example, if a question bank contained the question : " What is 2 + "2 ? ", then a variant like : " What is 3 + 2 ? " would need to be set up separately, and so on.

Version 2 of Question Mark Perception introduced a refinement allowing Java programs to be introduced comparatively easily, and this has allowed me to get round the restriction mentioned in the last paragraph, by writing software that allows a question-type to be written only once, using a template. So for the question in the previous paragraph, the basic template would be

"What is a + b ?"

and then each time this question is run, “a” and “b” would be allocated different numbers, restricted only to within a range requested by the question-setter.

Initially, my work involved the emulation of several standard Question Mark types - Multiple Choice, Multiple Response and Numeric.

Question Mark Computing have supported my work in this area and have promoted its wider use by including examples on their Web Site. This site allows users to download my programs for

- Multiple Choice quesions,
- Multiple Reponse questions
- Numeric questions

and use them to produce their own questions.

To download these programs, consult the following page

http://www.qmark.com/perception/help/kbase/ques021.html

It might be expected that CAA techniques are only welcomed by staff if the time they have to expend is not too significant. Specific figures were mentioned at the 3rd. Annual CAA Conference, when the results of a pilot study suggested that most lecturers would be prepared to set a weekly CAA test if the time involved was only about 20-30 minutes (Mulligan, 1999). I hope that my applets will meet this criteria.

Dedicated Question Types

Taking things further, I have generated **dedicated** question types, derived from these **general** types.

Frequently in mathematics this has to be done because of special circumstances which can arise - for example, it would be inappropriate to use my general multiple-response type to implement a multiple response question asking for the roots of a quadratic equation, by virtue of the imaginary roots that would arise.

I get around this particular problem by writing a new applet **dedicated** to the solutions of quadratics. This was not too strenuous a task because it exploited the technique of inheritance from the program for the **general** multiple-response question type. The idea of i*nheritance* means that I was able to use most of the routines from this **genera**l program (just by calling it from within the **dedicated** program) , but was able to overwrite a few routines to customise the new **dedicated** program for my specific purposes.

Figure 1 shows an example of the modules that could be used to deliver a **general question type**. A **specialised question-type** could specify that it is inheriting these modules, but also overwriting any modules at will – for example, it might be possible to set up a specialised question-type just by over-writing "Set up original question".

As long as the **general** types have been coded appropriately in the first place, the method of inheritance is an efficient way to produce applets delivering specialized questions.

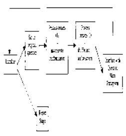

Fig 1. Program procedures used to generate a general question-type

Carrying this idea yet further, I have written dedicated programs designed to test skills in a specific area, written purely because it makes an easy-to-use question. In other words, these are questions that could be delivered using my **general** types, but I have attempted to save potential users the work involved in setting up the questions - they are "self-standing" - the only thing a question-setter has to do is invoke the relevant applet - there are no parameters to be entered into the program. If the time required to write the dedicated-question program is not too great, then this process is worthwhile and the end-result is the production of a whole suite of specialised questions, e.g.

- What is the scalar product of two randomly-generated vectors
- What is the value of <*randomly-generated number*> to <*n*> significant figures
- What is the type of a <*randomly-generated*> partial differential equation (i.e. is it hyperbolic, parabolic or elliptic)

The range of any randomized numbers is set within the program itself – it is not necessary for a question-setter to define the range, because the pre-set range is sufficient to provide an adequate test of the skill(s) which are required to be tested.

The use of "quasi-randomization" to develop new questions

By "quasi-randomization" , I refer to a situation where the values are read from a file, and the values are therefore obviously finite in number. If this data is used in a very simple way, I could produce what I refer to as “Trivial Pursuit” randomisation. But in practise, most of my question-types operate at a more sophisticated level.

To start off by summarising how the datafile is set up (refer to figure 2) : imagine the original datafile to be composed of lines, each line corresponding to a question. The first entry in each line would be used to generate the question stem, with following entries on the same line corresponding to correct answers, i.e. potential keys.

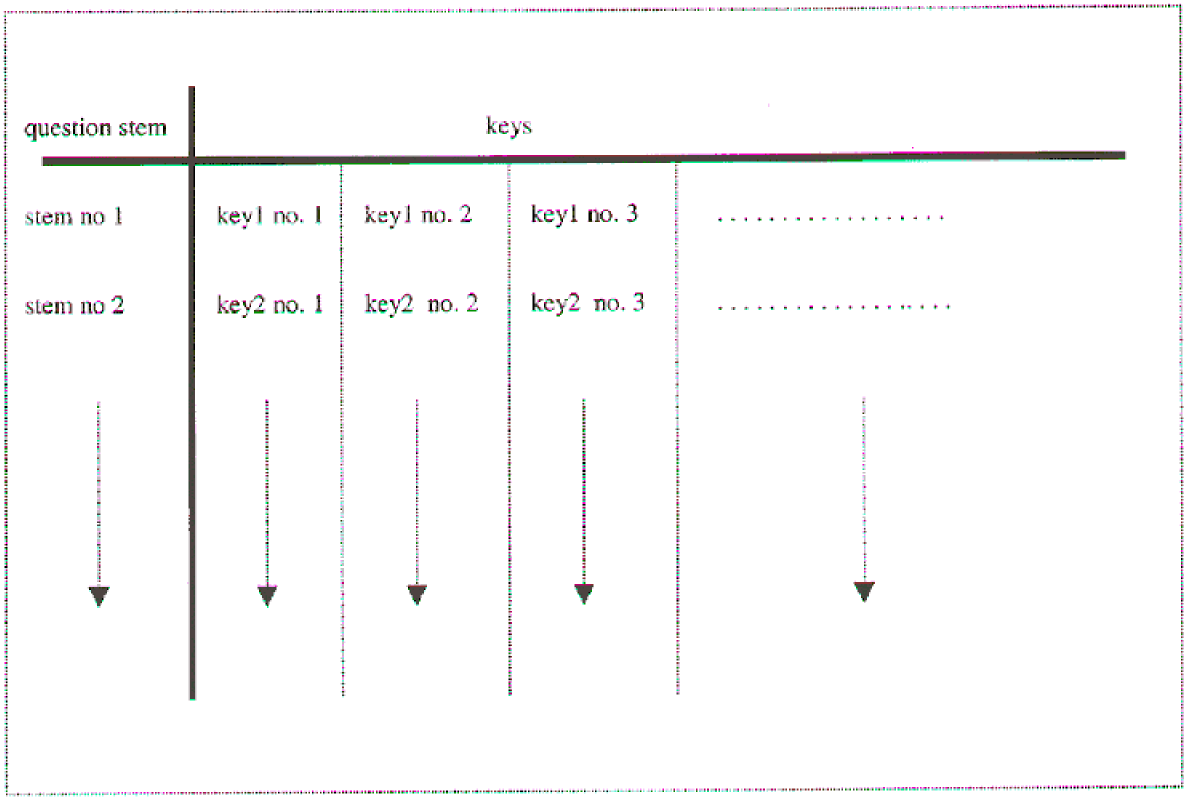

Fig 2. Schematic view of the layout of a datafile described in this section

In general, when the question template is run:

1. The question is chosen at random, i.e. the relevant line in the datafile is chosen at random, and the stem is read.
2. The relevant number of correct answers are read at random from all the keys on the same "line" (this procedure will need to modified very slightly when specific wrong answers, i.e distracters, need to be chosen)
3. The required no. of incorrect answers, i.e. distracters, will be read off at random from the rest of the file, i.e. from the keys on the other lines. It is important that checking techniques are incorporated to a) stop duplication of options and b) to stop an option being chosen as a distractor when it is actually a correct key (but was not actually chosen as a key for this specific question being generated)

Each question obviously takes time to set up in the first place, but can then, to quote a few examples, be used for the following question types

- Which of the following items are members of <*group*> ?
- Which of the following items are in both <*group 1*> and < *group 2* > ? (This would search for keys that are common to two "lines" in the file. If no keys are common to both lines, then two other lines are chosen, and so on until a match is found)
- Multiple choice / multiple response questions involving the display of images
- Questions where one or more specific distracters are required to be displayed in company with a specific question, e.g. a foreign language vocabulary test where a specific wrong answer can always accompany a specific word, with the full range of distracters being filled out at random from the rest of the file.
- "Standard" multiple choice / response questions, which would duplicate the operation of the original unmodified assessment package, but with the advantage that the questions are more accessible, in just one single file, and therefore easier to modify.

The randomization can be taken to its limit in a multiple response question. Here **the number of correct options (keys)** can be itself be randomly generated each time, and students can, if required by the marker, receive marks only if they have chosen **all the correct options (and no incorrect ones**).

Some Future Aims in Developing Questions Further

- **Incorporation of Computer Algebra Systems** I have already written successful, but quite basic, Java programs capable of producing questions by accessing Maple. However, I cannot, at the moment, display these questions over the Internet because of security features built into current browsers, features which I hope will be relaxed in the future. (we could employ a plugin to allow delivery of these questions, but this would be an ad hoc method which would reduce the elegance and flexibility of the question delivery) .

  - **Partial Credit and Branching** Branching questions have proved problematic. The difficulty is that when the program branches, it will lose knowledge of the randomly-generated variables it was working with. Because of the importance of branching, e.g. allowing review of work or allowing the award of partial credit, it would be extremely useful if we could produce a workable solution.

  - **Graphical Questions**. I have written a routine allowing graphs to be drawn at random, i.e. the relevant equation is entered with "constants" to be generated at random. This is an improvement on many, if not most, current CAA applications, which

- whilst claiming to be displaying randomized graph questions, are actually using pre-drawn images, rather than using "proper" randomization.

- lean heavily on questions to do with straight lines, while I can use the same applet to display any function (excluding "ill-behaved" ones).

The "Second Stage"

The next task will be to actually use these applets in genuine packages. This has initially started with their use in a Key Skills unit to be delivered by Portsmouth University.

CAL and CAA are very much in the mode of education known as the constructivist view – a view which opposes the reliance purely on 'passive' learning based on lectures, and proposes a much more interactive role for the student, interacting with information so as to make it meaningful. The best way of achieving these constructivist aims would be an ongoing process for any particular subject area, subject to the usual trial and error methods, and reflection on practices. I list here a few aspects of the constructivist approach which I consider to be especially important for mathematics, along with some extra comments (although I have not attempted to give comprehensive comments – various advantages of computer-orientated techniques are left implicit)

- **In general, collaboration and cooperation are considered to have important benefits in developing critical skills in a subject, as well as social skills and self-confidence**. It can often lead to students "teaching each other". This aspect has not normally been developed as much in Mathematics because of the obvious effects of plagiarism. Introducing features such as randomization should enable the full potential of this aspect to be achieved in mathematics. It is worth noting that although my work concentrates on computer-delivery of questions, the computer could very easily be used to produce paper-based randomized questions.
- **Students' prior knowledge should be adequate to allow efficient learning of new ideas**. This is especially important in Mathematics – the 'pyramid' structure (with each topic tending to require knowledge of topics at a lower level) can lead to students becoming disillusioned with maths, if they miss a topic for any reason. Links with prior knowledge and with other topics being studied simultaneously should be emphasised
- **Students should be able to develop skills that allows them to reason and solve problems in new contexts** – which are skills that cannot be developed if the reliance is purely on memorizing and accurate reproduction. This is particularly important in Mathematics – being able to understand the meaning behind mathematical ideas such that the student would be able to use them in new areas away from their use in "standard textbook" questions.
- **The scenario of "not being able to see the wood for the trees" should be actively avoided** (I, like most people I suspect, can certainly remember

this problem as a student). In maths, this situation could be exasperated by different books approaching the same subject in different manners.

- **There should be recognition that students are likely to be individually different**.
- **Motivation should be improved by emphasising, as much as is possible, the relevance or value of what the student is being asked to do.**
- **Any tasks should be as authentic as possible**
- **Cues should be provided that make any progress explicit**

Key Skills in Number

The first use of my applets, in earnest, are to be found on the nascent Key Skills in Number units, being developed by Portsmouth University for delivery over the Internet. Although the Mathematics is considerably lower than University standard, the techniques developed for these packages and the experience of how well they are received will be of use at a higher standard.

The pedagogical aspect, e.g. the effectiveness of the material presented, will be a major factor to be considered in setting-up these units. At the End of Program Conference for the TLTP's Capability project (*Developing Key Skills using Online Learning*), it was announced by the Program Director, Barbara Page, that this aspect had required much more attention than had originally been anticipated.

At the same conference, Tom Boyle, Director of the Learning Technology Research Institute, University of North London, reinforced this announcement, by pointing out that "it was all very well to have all these grand ideas, but if the students don't like them, they won't work".

Current development is available for viewing on the WebCT package at Portsmouth University. For those who are unable to access this package, a (fairly current) copy is available for viewing on

http://bdaugherty.tripod.com/keyskills.html
http://www.daithagoras.co.uk

Some other important features of CAA in Mathematics

- Allows regular assessment, at a frequency that would not be possible using the traditional methods. Producing benefits :-
    - Students could be hopefully inspired to work more diligently throughout the entire year
    - a larger number of assessments could, by itself, improve the quality of assessment - in contrast to a situation where a poor assessment technique could unfairly dominate a small number of exams.
    - Allows “rehearsal” techniques to be inserted into lectures. Bligh (1998) contains several references to the success of this technique in terms of subject retention (the word ‘rehearsal’ refers to some active involvement with the subject matter of a lecture, as distinct from the traditional way that a lecture is the process by which the speaker's notes become the listener's notes - without passing through the head of either). An example of such a technique is described in another paper presented at this conference
      (McCabe, Heal and White, 2001)
- Allows the assessment process to be spread more evenly, such that students cannot omit “harder” topics and have to study the entire course.
- Could increase the retention rate (producing cost gains to the institution)
- Could allow students without the full, usual entry qualifications to “catch-up” and integrate into the course (if the intake is intended to be wide-ranging, across age ranges and / or international borders, it is inevitable that students will have a shortfall in a few “basic” areas).

Several of these latter ideas were put forward in a paper presented at the Fourth International CAA Conference in 2000 (Pollock, Whittington and Doughty (2000)).

National Mathematical Issues

We further need to bear other ideas in mind.

- At large there is perception among many people that Mathematics is a 'hard' subject,

- Mathematics can require greater concentration than other subjects, and again present-day resources are not well-placed to tackle this. This feature has become even more important with strains on student finance in Britain – this does create conditions where it becomes harder to study generally, but Mathematics probably suffers more than most (if not all) other subjects in this respect. **Stated baldly, If you are going to fail because of a lack of finance, then Mathematics is the subject where you are most likely to fail.**

If the reaction of the government is used as a yardstick, in Britain these problems could be said to be openly manifesting themselves - for example, a shortage of teachers has resulted in the government offering a bounty of 4,000 pounds to all new Mathematics teachers, and in February 2001 serious proposals were put forward to additionally cancel all student debts incurred by people who subsequently became mathematics teachers.

End Comments

There are a few “problem areas” which are worrying me at the moment

- There is the oft-stated concern about “dumbing-down” of standards in Mathematics
- Related to this, I am not certain that there is enough incentive as there could be in the British University system to actually increase standards in Mathematics.
- There is a more direct worry that producing different randomized versions of the “same” question could lead some people to believe that totally different questions are being produced. My experience so far in related areas, leads me to believe that refuting any claims like this are likely to be harder than might be expected.

Web Site - Mathematics Education Group, Portsmouth University

The formal address is

http://L62.csm.port.ac.uk

and can also be accessed at

http://www.up-pompey.co.uk
http://www.pompeyuniversity.co.uk/

A menu bar offers the following options :-

- Randomized Question Types
- Full list of Question Mark Perception tests available for public use
- Key Skills in Number,
- Astronomy and University Mathematics sections
- Mathletics
- Astronomy and Mathematics links
- Question Mark Perception links

References

Bligh, Donald, Whats the Use of Lectures ?’**,** intellect

McCabe and Daugherty (1999), ‘*Extra sensory perception – extending the power of QM Perception*’, Proceedings of the Third International Computer Assisted Assessment Conference 1999, 127-136

McCabe, Daugherty, Manns, White (2000a), '*Transcendental Testing : Innovative Development of Question Banks and Question Templates*', Proceedings of the Fourth Annual Computer Assisted Assessment Conference, 2000 (issued separately) – also available on http://info.lboro.ac.uk/service/fli/flicaa/conf2000/mccabe.pdf

McCabe and Daugherty (2000b), '*An Integrated System for Web-Based Assessment in Mathematics*', Exam Questions and Basic Skills in Technology-Supported Mathematics Teaching – Proceedings of the 6th. ACDCA Summer Academy 2000, 145-148

McCabe, Heal and White (2001), '*Integration of Group Response Systems into Teaching and LOLA, the Missing Link in Computer Assisted Assessment'*, Paper to be presented at the Fifth International Computer Assisted Assessment Conference 2001

Mulligan (1999), '*Pilot Study on the Impact of Frequent Computerised Assessment on Student Work Rates*', Proceedings of the Third International Computer Assisted Assessment Conference 1999, 137-150

Pollock, Whittington and Doughty (2000), '*Evaluating the Costs and Benefits of changing to CAA*', Proceedings of the Fourth International Computer Assisted Assessment Conference 2000, 59-70

Thelwall (1998), '*Advantages of Randomly-Generated Computer Assisted Assessment*', Proceedings of the Second International Computer Assisted Assessment Conference 1998, 111-116