MathinSite: Maths Insight from a Maths Website

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Abstract

During the early 1990s, mathematics software was written using Visual Basic for students at Bournemouth University. With the advent of the Java programming language, this software was translated and extended into MathinSite, a website containing mathematics applets (small programs that can be run through a web browser). The primary aim of these applets is to help deepen mathematical insight through dynamic, interactive visualisations. Use of the Internet not only ensures that the content can be delivered within a student's own educational surroundings, but also that any user can access the content any time of day or night from any computer in the world with an Internet connection.

The Execution

In the early 1980s, the author, armed with a BBC Model B computer, wrote some BBC Basic software presenting graphical visualisations of Mass/Spring/Damper Systems, Projectiles and a CNC Lathe Cutting Simulation. These visualisations all proved popular with students; the latter, in particular, proved popular with UK Local Education Authorities since the software allowed students to use a computer visualisation to validate their CNC lathe programs before committing them to expensive CNC machinery! The arrival of event-driven programming languages, Visual Basic in particular, allowed the author to enhance this graphical approach to include the use of scrollbars to change system parameters, obviating the need for textual input. To see, for example, how a Mass/Spring/Damper System's response changed in real-time as the system's parameters changed fascinated students and encouraged inquisitiveness and a willingness to learn. When using the Exponential Equation program, for example, written to investigate $y = A + Be^{kt}$, students could be heard exclaiming, "Oh, is that what k does!", as they changed the value of k using a scrollbar. At the time, the author had problems delivering such software over his university's network. The advent of the Java programming language, however, opened up the possibility of Internet delivery so, with the award of one of Bournemouth University's Learning and Teaching Initiative bursaries and the help of a Computer Studies placement student, MathinSite was begun.

To date, a variety of Java applets have been written. The applets' topics have, necessarily, been restricted to mathematical applications that

- can be visualised,
- depend upon the variation of parameter values, or similar, to enhance the visualisation and hence deepen the user's understanding and
- are relevant to the author and his own Design and Engineering undergraduates.

Applets included so far range from simple mathematical functions up to complicated engineering applications of mathematics, such as dynamically illustrating how the stability of a second-order system is governed by the position of the system's poles in the complex *s*-plane.

Considering MathinSite's applets in isolation should be avoided. For example, the 'Differentiation 1' applet consists only of the well-used – possibly over used – graph of $y = x^2$ and two movable points on the curve together with their associated 'rise' and 'run' lines. Just using the applet, users will not necessarily understand anything. However, when used with the associated worksheet it is possible to take users through the meaning of chords and tangents. It would be superfluous to force this applet to do the same with the graph of any other function. The separate 'Differentiation 2' applet, however, does show the graphs (and first- and second-derivative graphs) of other functions. However, the main thrust of 'Differentiation 2' is to use the applet's graphics and worksheets this time to promote a good understanding of the concepts of gradient, curvature and stationary points.

What Support Was Needed?

The applets are simple to use since the only user-interaction is via scrollbars or by 'dragging' with the mouse in the graphics area. Any student who is familiar with the 'Windows' environment will be able to operate the applets within seconds. Unlike graphical calculators and computer algebra packages, MathinSite's mathematics is readily accessible and does not necessitate a serious learning curve just to reach the usable content. When using the applets on their own, it is not always possible for students to make the connection between the on-screen movements and the underlying mathematics. In order to make these connections, students are encouraged to use, at least initially, the worksheets that accompany each applet. These take students 'by the hand' and help them to discover aspects of mathematical understanding that are not easy to grasp from a static diagram in a book. Since the amount of on-screen text is kept to an absolute minimum, students cannot be distracted by unnecessary tutorial type screed whilst interacting with the applet – any tutorial text is on the separate, paper copy, tutorial and theory sheets. Armed with the worksheets, students do not need the help of any tutor to engage with MathinSite's content – MathinSite is self-supporting.

The Barriers

Some students do not buy textbooks. Some students miss lectures. Some do not read course notes. And some students don't like interacting with computers. It appears as though whatever students are given to help them learn and understand course material, some of the help will not work for some of the students. So it is with MathinSite. Students are told of the availability of this resource, but some avoid its use – often because other factors are deemed more important, such as assignment work (although there will be occasions where the applets will help corroborate answers to assignment questions undertaken manually).

The Enablers

Tutorials are a valuable way of introducing students to MathinSite. Once students have seen MathinSite in action and realise how valuable it can be, they are quite willing to investigate further applets on their own. However, it is not always possible to book computer rooms for a one-off MathinSite tutorial so, for some student groups, this introduction is not possible. Instead, using it at relevant junctures during lectures becomes highly appropriate – not just for demonstrating a mathematical point, but also to remind students of its existence. Obviously if MathinSite's use were to be assessed and marked, this would force students to use this resource, but there are no immediate plans to do this. MathinSite is not specifically intended to help directly with assignments; its main success to date has been in deepening understanding, giving students a feel for mathematics and helping students to engage with mathematics.

Evidence of Success

That many students do use MathinSite is evidenced by subsequent comments on what they have learned and by asking the question, "When are you going to write an applet on…?". Particularly gratifying are oft-heard comments of the type, "I never realised, before using the applet, that changing that parameter had that effect". In terms of national and international usage, MathinSite's hit-rate soared when the website was placed on an American Java Resource site. A web search for MathinSite on a variety of Internet search engines reveals that it is now listed on mathematics resource web pages in many countries. One email to MathinSite, from the Assistant Director of a Mathematics Education Centre at an American university, mentioned "Wonderful stuff!" and was recommending its use to all his students.

How Can Other Academics Reproduce This?

Other academics need not reproduce this particular resource since it is freely available for all to use. However, the approach adopted here could easily be applied to other disciplines where a graphical interpretation can enhance learning and understanding. The drawback is that the production of Java applets needs programming skills and can be very time-consuming, as can the production of the accompanying worksheets. Certainly, without the funding from Bournemouth University's Learning & Teaching Initiative and further funding from the UK National Teaching Fellowship Scheme (NTFS), MathinSite would still be at the design phase.

Quality Assurance

At the time of writing (March, 2002), most of the work on MathinSite has involved writing and releasing as many applets as possible. Because of this, the production of worksheets has had to take second place. Each applet as it comes on-stream is tested with a not-inconsequential group of critics – students! As well as local face-to-face discussion with end-users, MathinSite facilitates basic feedback from its own web pages. Up to the present, there have been no adverse comments. Any 'negative' feedback has been to correct minor errors or to suggest ways of enhancing individual applets. The NTFS funding for the project will allow continued production of material to 2003, in particular to write the outstanding worksheets. Also during the 2002 – 2003 academic session, it is proposed to incorporate a web-based feedback form on MathinSite and to visit a variety of UK educational establishments to explain and promote its use.

Other Recommendations

MathinSite started out nearly 20 years ago as a hobby – a mathematics lecturer wanting both to improve his programming skills and to help his students to visualise mathematics. It had to wait most of the 20 years for the right technology, and funding, to come along to turn it into a worldwide resource. Without 'enthusiastic amateur' beginnings, such projects rarely come to fruition. Once a concept has been proven, however, it becomes easier to attract funding, which then facilitates buying out one's time, or buying in the services of others. So far during the production of MathinSite, the author has been most fortunate to employ two excellent Computer Studies students, out on their placement year, who have been used to very good effect in writing applets. Along the way the author has also bought time out to produce some applets himself, and to endeavour to write up the backlog of tutorial sheets.

Anyone starting such a project should therefore consider the following:

- Don't wait for someone to provide funding. If you have a good idea, try to develop it in any time you have available.

- Sell the idea to your own university or college. Your institution's Learning and Teaching Resources Centre, in particular, may know of, or may help you to attract, available funding.

- Funding, if you can get hold of it, gives you greater flexibility in deciding how your project's development should proceed.

- Make sure you have a realistic project plan – particularly, what you want to achieve and by when.

- (The right) Industrial placement students can be a very valuable resource.

- Dissemination is vital. The use of MathinSite blossomed once information about it was placed strategically on Java and Mathematics resources websites. Publications and conferences are also invaluable for maximising your project's coverage within your own academic community.

- Try to draw in your own colleagues for help, support and feedback – and as a valuable quality assurance resource.

- Don't forget to involve your students. Students are not shy when they want to tell you something is good – or not!

Reference

MathinSite: Web-Based Material for Deepening the Mathematical Insight of Engineering Undergraduates. Paper presented at the ASEE/SEFI/TUB Colloquium, Berlin, Germany, Edwards, P., (2001), http://www.asee.org/conferences/international/proceedings/Edwards.pdf

MathinSite; http://mathinsite.bmth.ac.uk/; (12-09-02).