Electronic Mathematics Resources and Flexible Learning

Greig Fratus
MathGate project

G.J.Fratus@bham.ac.uk

Pam Bishop
LTSN Maths, Stats & OR Network

P.Bishop@bham.ac.uk

The following talk, presented at the Flexible Learning in Mathematics conference organised by the Mathwise User Group, illustrates good practice drawn from departmental teaching and learning pages and other interactive teaching and assessment resources in mathematics, and also looks at the important issue of locating quality resources in a reliable way. Readers wishing to follow any of the underlined links are advised to look at the electronic version in the FLIM2000 Proceedings via http://mat-nt2.bham.ac.uk/mwug/mwug2000.

Publishing Mathematics

Basic office packages – word processors, spreadsheets and databases - have limited mathematical capabilities. These can be enhanced with software such as MathType, the full-featured version of the Microsoft Word standard equation editor, for printing purposes. The current standard used by commercial publishers for mathematical typesetting is TeX or LaTeX, and programmes such as Scientific Word can be used to create output in this form. For subsequent electronic publication, Postscript (PS) or Acrobat (PDF) formats are often preferable to HTML, which has to include graphics files for the equations (GIFs).

The Internet has added a whole new area of communication to the learning process, but the ability to communicate mathematics using this tool will be limited until the mathematical mark-up language MathML is fully available. This, however, does not mean that it should be ignored. A combination of mathematical software and good practice means that learning and teaching pages for mathematics can be developed that will create a flexible learning environment and hopefully improve the learning options and experience for students.

Mathematical packages such as Maple and Mathematica can be used to produce learning and teaching materials, including interactive lab sheets, for mathematics courses. Free viewers (such as MathReader for Mathematica) are often available and give the teacher the option of producing pages that can be viewed by students at home without the need for the student to buy a personal copy of the software. However the user would need to have the full package installed if any interaction is to take place. The use of plug-ins can replace the use of graphic files to represent mathematical notation on Web pages, and some of these allow interaction as well as display.

Other examples of plug-ins

- Acrobat Reader – a free download that allows the user to view PDF files
- IBM techexplorer - a viewer for TeX, LaTeX and MathML
- LiveMath - allows the user to read and interact LiveMath Maker files

Good Practice and Related Issues

At the recent UMTC 2000 conference at Sheffield Hallam University [1] a working group identified six issues related to using the Internet as a learning and teaching resource for mathematics:

- **Infrastructure** - a sufficient number of PC's available to staff and students whose specification enables them to run a suitable web

browser efficiently; suitable embedded equation editors; email facilities that allow the interactive communication of mathematical symbols.

- **Communication technology** - electronic whiteboard facilities, and even graphics tablets, can assist in the remote interaction required to communicate mathematical ideas between teachers and learners and within groups of learners.

- **Search skills** - there is a need to cultivate in students adequate search skills to enable them to locate web resources in an efficient way.

- **Critical skills** - students often assume that materials they read are true, when in fact they may be wrong, leading to many lost hours trying to understand an erroneous statement. Students need to allow for this by developing their critical faculties together with a healthy academic scepticism, particularly for information presented to them which is unsupported by solid evidence.

- **Reliability** - important web sites should be backed up by the provision of mirror sites that may be accessed if the original site fails or is removed - the web is a dynamic series of links that work today but may not be available, or even exist, tomorrow. Addresses specified by staff for student use should exist even in cached form at least for the duration of the course being studied.

- **Standards** - the use of unusual (and not locally available) fonts in documents, the demands made by animations, video clips or different paper sizes, can mean that actually running or printing learning material may be a time consuming and frustrating experience for students.

The World Wide Web seems to have grown up in a haphazard way but lately there has been a move to standardise Web practice, often based on common sense such as maintenance and easy-to-read layouts. Some HE institutions have created guidelines for web pages that will be published on their servers - an example can be found at University College, London [2]. The Department of Mathematics at the University of Colorado at Denver take their guidelines a step further [3]. Their site is more than just a list of links as it categorises Web sites according to modules found in undergraduate and postgraduate courses in the department as well as providing some descriptions of the resources. General resources are also listed as well as tools for developing Web pages for mathematics.

Mathematics Teaching, Learning and Assessment on the Internet

Another working group from UMTC 2000 [1] attempting to find linear algebra resources was moved to comment, "it is worth making the general point that limiting searches to **.ac.uk** reduces the amount of learning material found substantially. It also seems to produce few actual on-line learning materials, apart from lecture notes." It may be that a lot of learning material in the UK is found on personal homepages. This means it could be difficult to find and may suffer from lack of maintenance. Examples of interesting material on personal homepages include Paul Flavell's design for an online power series course using Java to provide some interactivity [4], Ron Knott's pages which provide easy-to-use navigation in a comprehensive Fibonacci-themed website [5], and Stuart Price's development notes for an online ODE course [6].

The School of Mathematics and Statistics at the University of Birmingham has introduced a standard layout for its undergraduate course modules [7] including a drop-down list of courses and keyword search. The six standard headings for the modules are Information, Lecture Notes, Exercises & Solutions, Worksheets/ Handouts, Past Exam Papers and Reading List & Links. Whilst not all of the headings contain information at the moment the use of this template is being encouraged and its design encourages flexible learning. Each course module contains links to related modules and the Past Papers section links into The University of Birmingham's Exam Database. The ideas used here are similar to those that have been implemented by various other institutions in the UK and beyond.

Other Examples

- Sheffield Hallam University's Maths Department website includes references to jokes, tests and quizzes, dynamic geometry demos (if you can run Activex) and maths help
- Mathletics, an assessment package developed at Brunel University, is now available on the Question Mark site, the WHAM (Web Hosted Assessment for Mathematics) site at the University of Portsmouth or by contacting the author Martin Greenhow
- Software such as LiveMath has been developed for authoring mathematical teaching material, and The Geometer's Sketchpad can also be used in this way. The Interactive MathVision pages show some possibilities.
- A resource that makes use of interactivity in the PDF format to provide easily readable mathematics and a logical teaching process is the

Slide Show for Demonstrating the Tangent Line Problem developed at Akron University, Ohio

The LTSN Maths, Stats & OR Network (previously CTI Mathematics) has run several workshops related to these themes, and the following reports will give further links:

- Computer Aided Assessment in Mathematics (May 2000)
- Mathematics Resources on the Internet (April 2000)
- Putting Mathematical Notation on the Web (May and July 1999)

Locating Quality Resources

Recent research on websites for mathematics undergraduates has established that the assessment of such material is extremely rare, and quotes current literature on assessing educational websites as citing **authority** and **accuracy** as the two most important criteria [8].

Authority can be a powerful guide - information will more than likely be accurate if you can trust the publishers of the site. Generally pages mounted on institutional servers, such as universities or learned societies, will contain more reliable and accurate information. It is worth taking some time to look at the intended audience of constituent pages to decide if they are suitable for undergraduates, postgraduates, etc.

Accuracy can be difficult to assess in mathematical terms without a thorough investigation of the mathematics concerned. In more general terms, however, the accuracy of a site can be investigated by checking when it was last updated to see if it is being regularly maintained, and by looking at the links and verifying that they are not broken.

Efficiency of searching

The main search engines such as Lycos and Alta Vista depend on text searching in HTML files. It is likely that mathematics resources will not be located by these engines, because they will either be in postscript or PDF format or the mathematics itself is in graphics format. Further, the keywords used may have meanings quite outside mathematics. For example, if we search on the term "modelling" in the Google search engine, the first few results cover diverse subject areas, whereas MathGuide will give mathematical results. Not only can you search using mathematical terms but you can also browse using mathematical categories based on the Mathematics Subject Classification [9]. Examples of mathematical search engines are:

- MathGate experimental search page
- MathGuide
- MathSearch

Indexing Departmental Websites

As well as submitting sites to search engines there are other ways to get a mathematics department's website noticed in the mathematics community. Individual pages on departmental servers can be submitted to MathGate and MathGuide or the department can enter into the Math-Net Secondary Homepages Project [10].

Conclusion

Resources for the publication of mathematics in electronic form are good for static documents but have not reached a common standard for interactive ones. One can find innovative learning and teaching pages but they may be on personal rather than departmental web pages at present and it seems that assessment resources are more well developed and available. To locate quality resources in a reliable and efficient way try the newly-emerging specialist gateways and portals.

References and Notes

1. The Use of the Internet in Teaching Mathematics, in Proceedings of Undergraduate Mathematics Teaching Conference 2000 (to be published)
2. Creating WWW Home Pages, University College, London
3. Using the Web to Teach Mathematics, University of Colorado at Denver
4. An Introduction to Power Series, Paul Flavell, University of Birmingham
5. Fibonacci Numbers and the Golden Section, Ron Knott, University of Surrey
6. Web-Based ODE's Course, Stuart Price, University of Warwick
7. Course module information, School of Mathematics and Statistics, The University of Birmingham
8. A systematic evaluation of mathematical websites designed for mathematics undergraduates, Francesca Chappell, dissertation (unpublished)
9. The Mathematics Subject Classification (MSC) is used to categorise items covered by the two reviewing databases, Mathematical Reviews and Zentralblatt MATH
10. Secondary Homepages Project for UK Mathematics Departments – a MathGate and Math-Net collaboration