Maths-CAA Series
August 2004

Web Based LATEX/PDF Support Materials for Learning Mathematics

Contents

Web Based LaTeX/PDF Support Materials for Learning Mathematics

Dr Robin Horan and Dr Martin Lavelle
School of Mathematics and Statistics, The University of Plymouth, Plymouth, PL4 8AA
Email: rhoran@plymouth.ac.uk and mlavelle@plymouth.ac.uk

Abstract: This article describes a method of producing PDF packages to support the teaching of mathematics. The packages contain a variety of different teaching approaches, including worked examples, exercises and quizzes, with instant feedback and solutions. The packages are constructed using software that is either free or extremely cheap. The output is extremely attractive, with perfect mathematical typesetting. The packages themselves are simple to use, freely available [1] and may be used on any platform.

1. Introduction

For many years it has been apparent that there is an increasing gap between the mathematical skills of students on science and engineering based courses and the numeracy requirements of the courses they study. Many of these students will have done little or no mathematics after the age of 16 and, when they first attend university, they are often extremely anxious about the prospect of continuing with mathematics. This is all too familiar to lecturers across the engineering and physical sciences disciplines, who frequently encounter the difficulties caused by their students' lack of competence in basic mathematics. With this in mind, a library of portable, interactive packages is being constructed that students can use to improve their command of these crucial skills. They have been designed specifically to be easily disseminated over the web. The majority of the packages currently available are for basic mathematical skills but some higher level material is also available and more is under development. All of this software is intended to be a flexible tool to help support students' learning of mathematics. It is important to realise that this is not intended to replace conventional teaching methods. Similarly, it is not claimed that using the web is the only way to support this teaching but it is one of many possibilities, none of which alone can 'solve' the mathematics problem.

2. Existing On-Line Provision

There are many different software systems that have been designed to support mathematics teaching. The majority of these are aimed at undergraduates in numerate disciplines who already have at least A-level mathematics. There

are, though, fewer such packages available for science and engineering students entering university armed solely with GCSE mathematics, and even amongst those with A-level mathematics, there will be many whose basic skills will benefit from more practice. In addition to the question of the level of the material, there are a number of other disadvantages associated with the construction of much of the existing software. The mathematical typesetting is often very poor, which is an unnecessary distraction for weaker students who are easily intimidated by formulae. Many systems are constructed rather like books on the screen and do not make full use of the facilities available for computer-based learning. The density of material visible on the screen is often confusing. Finally, many of the systems are limited by site licences to use on a campus, which means that student access is severely restricted. The aim of this project is to produce packages at a level appropriate for the large proportion of students who do not have a good mathematics A-level. The material produced should also have book quality mathematical typesetting and be attractively presented, in an uncluttered yet colourful manner. Additionally, the packages should have the following properties:

- ease of navigation (little time needed to master the software);
- a variety of teaching tools (worked examples, exercises, tests);
- immediate feedback with detailed solutions to the questions;
- portability and ease of access;
- no requirement for special software;
- rapid linking within the document;
- a final test, providing the student with an instant assessment of the skills gained by working through the package.

The last property is particularly important since it enables a student to gauge the level of understanding attained after a package has been attempted. This self-assessment aspect was seen as a critical part of the formative learning process. To meet these aims, it was decided to use a combination of LaTeX and Portable Document Format (PDF) software. Before outlining the methods used, it is worth explaining why HTML was not chosen.

3. The Disadvantages of HTML

Curiously, although HTML, the language of the web, was developed for use by physicists at Europe's premier particle physics laboratory, CERN, it is not well suited to displaying mathematical formulae. Generally such formulae must be imported in the form of graphics files (such as PNG or JPEG format images) and these are often ugly and generally use different fonts to those in the text. This can obscure the mathematical content of the formula. This well known shortcoming is being addressed and an extension of HTML, called MathML [2], is under development. When the project began this facility was not available, and even now MathML is still under development and it may be some time before it is completely compatible with most systems. In addition, even if MathML were fully available, it would still not fulfil the list of requirements mentioned above. Linking in HTML generally means opening new pages and doing this over the web can be slow, especially for students working from home with a modem. These difficulties led to the adoption of the methods described below.

4. Constructing the Packages

The packages are constructed using LaTeX, a document preparation system based on Donald Knuth's TeX typesetting program. This is not a WYSIWYG (What You See Is What You Get) approach but uses macros to generate the mathematical text and other features of the document. While it is true that this procedure requires some practise, nowadays, with specialist editors such as WinEdt, the hurdles are not very high. Figure 1 shows a screen capture of the editor, WinEdt, which was used to generate the packages.

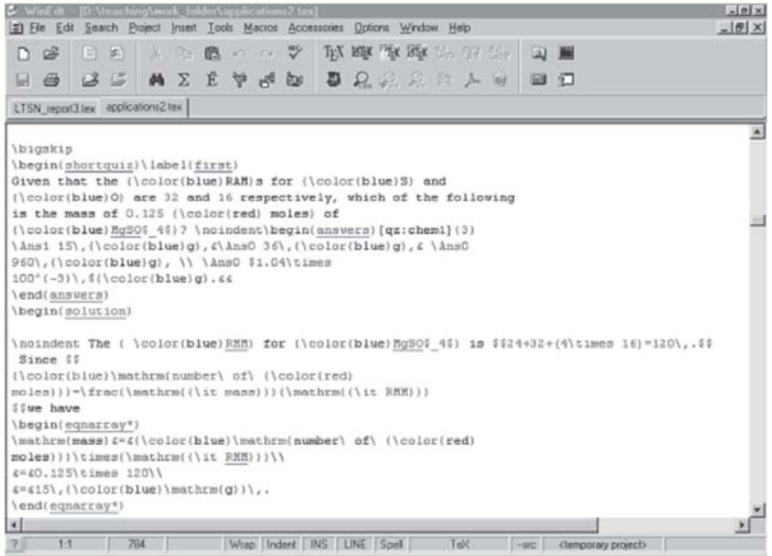

Figure 1: Screen capture of WinEdt, the editor used to generate the packages

The screen display shows some LaTeX coding for part of a quiz from the Functions package and gives some idea of how LaTeX files are written. The LaTeX file may be converted into a PDF output by simply clicking on the button on the toolbar marked 'PDF LATEX'. Various other buttons and drop down menus at the top of the picture make production of a LaTeX file much easier than it was even a few years ago. Help on entering the world of TeX can be found on the web [3]. Many of the particular LaTeX macros used were developed by Prof. D. Story [4] in Akron, Ohio. These macros featured in a previous article in this series [5]. In that article " a heavily customised version" of the exerquiz macro was used. A web page with further details of Story's work is available [6]. This is required reading for anyone wishing to generate similar packages. The LaTeX file is compiled by a programme that produces a new file and this may be viewed on screen or printed out. Of the various kinds of output file available (postscript, dvi, PDF), PDF was chosen since it supports the interactive features desired and this format can be read using the easily obtainable and freely available Adobe Acrobat Reader [7].

5. Features of the Packages

All of the packages that have been generated include worked examples, a screen capture of one being shown in Figure 2.

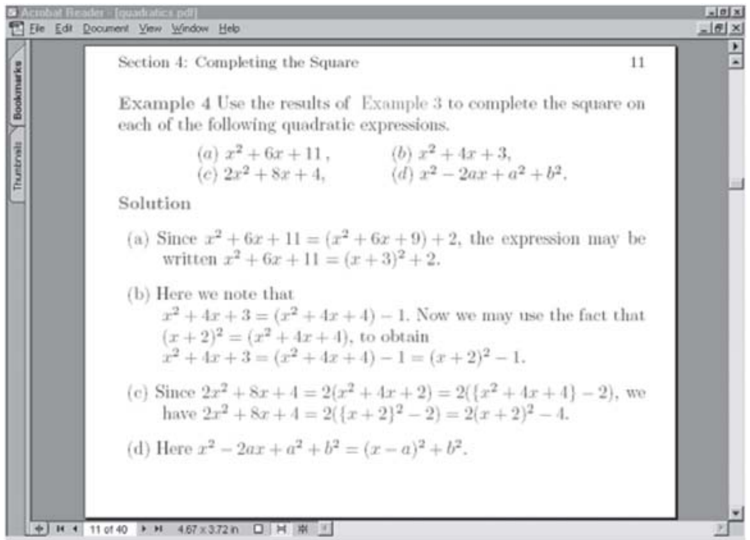

Figure 2: Screen capture showing a worked example

The examples are used to introduce topics and are followed by a series of exercises and quizzes. Each page is deliberately designed to be uncluttered to make the learning process as simple and non-threatening as possible. The pictures in Figures 3 to 6 illustrate the types of screen encountered as the student progresses through the package. An important feature is the use of exercises.

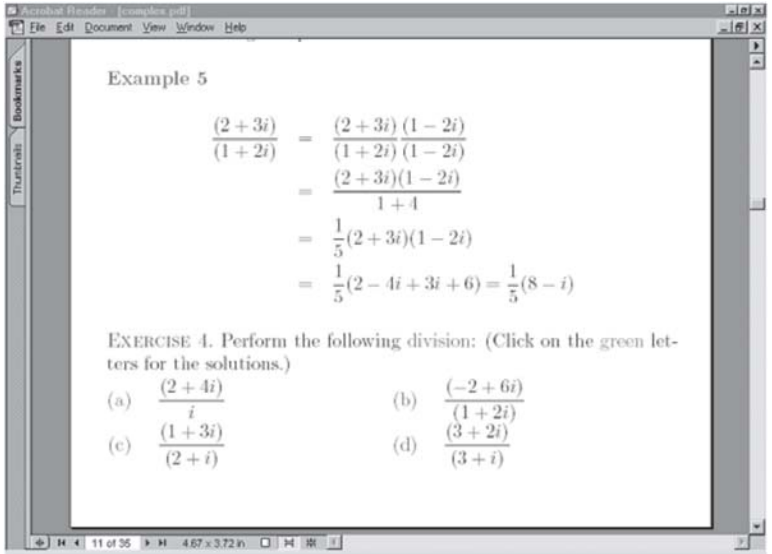

Figure 3: Example on complex numbers with exercises

Figure 3 shows a topic, rationalising complex numbers, being introduced by an example. The example is then followed by some exercises on this topic to provide the student with some practise. Students are directed to attempt the exercises and only then check the solutions, which are hidden. The solutions may be reached by clicking on the green letters. For this example one of the solutions, to exercise 4(d), is shown in Figure 4.

It is important to give a detailed solution so that students can check their work and, if necessary, see where they have gone wrong. This level of detail reinforces their learning of the material. Additionally, the provision of a model answer should help improve their presentation of technical arguments. Clicking on the green square returns the student to the exercise so that they can continue their progress through the package.

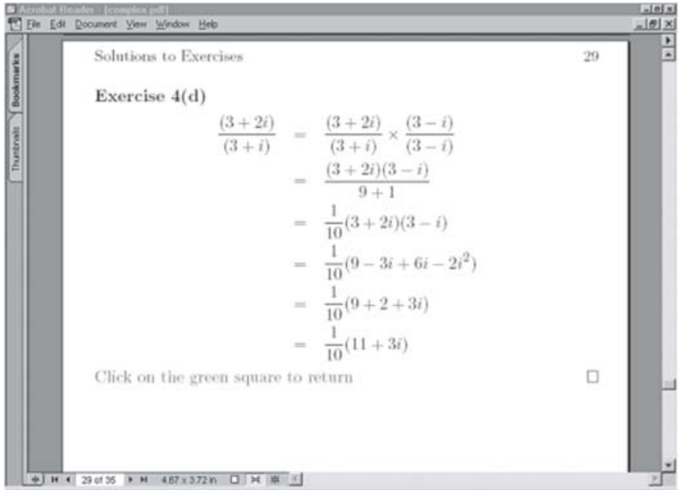

Figure 4: Solution to an exercise

Various short quizzes build upon the use of exercises to enable students to test their understanding in a varied fashion. An example of a short quiz is shown at the bottom of the screen in Figure 5.

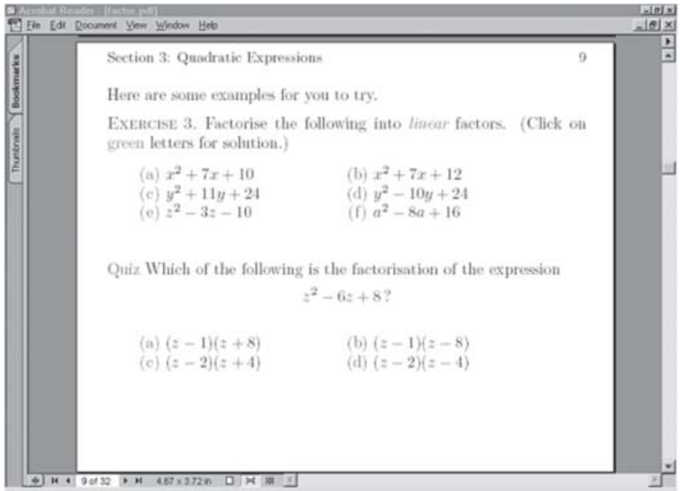

Figure 5: Example of a short quiz after the exercises

This change in the testing method breaks up the process of working through the package and helps maintain student interest and attention. Clicking on the wrong answer generates a pop up window that tells a student that an incorrect choice was made, while picking the correct answer takes the student to a page where a detailed solution, similar to those for the exercises, is given.

The packages generally end with a longer quiz, the aim being to provide the student with some measure of their understanding. The quiz is automatically marked by clicking on the End Quiz button. A picture showing an example of a (marked) final quiz is presented in Figure 6. Here the answers 1(a), 2(a), 3(a) and 4(a) have been chosen. The automatic marking shows that only 4(a) is correct. In the other cases, the correct answer is indicated by the coloured discs. This is the final part of the package and is intended to provide some assessment of the level of understanding attained.

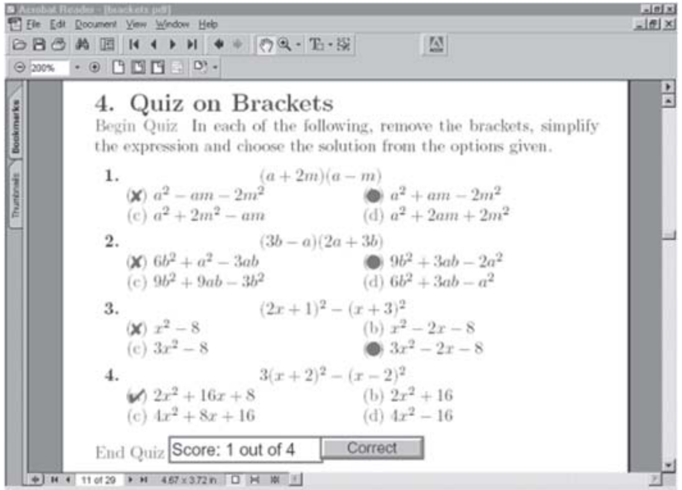

Figure 6: Example of a marked final quiz

6. Conclusion

The LaTeX /PDF approach to producing mathematics support software has a number of excellent features. The output is technically of a very high quality, the software used for the production is essentially free, and the packages produced are easy to use and require no special software. (There is a certain amount of investment required in learning to use LaTeX but the time spent is well worth it.) The packages that have been produced so far have proved popular with students who like the flexibility of being able to use them on their own machines. They also like the varied nature of the packages, with the different features outlined above. The packages are deliberately designed to be short so that students gain a sense of achievement after working through them. This enhances student confidence. Each file is very small and a floppy disk can store about five packages, making them quick to download and easily transportable. There is a web site [1] that contains all the currently constructed packages, and these are freely available to anyone who wishes to use them. Feedback from the web site indicates that there are a growing number of external users who are unconnected with the University of Plymouth and geographically distant from the region. At the time of writing, the authors have just received an email from one person who, as a result of finding our site and working through some of the material, has decided to become a student of the Open University. Future plans include making the packages available to schools via CDs.

Acknowledgements

Part of this work was funded by a development project grant from the LTSN Physical Sciences Centre [8]. A large number of the packages have been constructed as part of the HEFCE FDTL4 PPLATO project [9]. A debt of gratitude is owed by the authors to both organisations for their financial support.

References

[1] http://www.plymouth.ac.uk/mathaid
[2] http://www.w3.org/Math/
[3] http://www.tech.plym.ac.uk/maths/staff/dmcmullan/tex.html
[4] http://www.math.uakron.edu/~dpstory/
[5] http://mathstore.ac.uk/articles/maths-caa-series/may2004/
[6] http://www.math.uakron.edu/~dpstory/acrotex.html#%technical
[7] http://www.adobe.co.uk/products/acrobat/readstep2.html
[8] http://dbweb.liv.ac.uk/ltsnpsc/
[9] http://www.rdg.ac.uk/AcaDepts/sp/PPLATO/publish/index.htm