Epsilon – A First Year Mathematics Computer Based Tutorial System

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Abstract

Epsilon is a computer based interactive mathematics tutorial for first year mathematics developed to address the needs of our students, to be used as a supplement for lecture material, as a revision resource, in tutorials, and in distance education. This paper describes the software and its role in university teaching programs, and discusses student evaluation results.

1. Introduction

Mathematics is a core subject for many disciplines; most mathematics students undertake university mathematics to acquire the mathematical skills necessary for formulating and solving their discipline related problems. The literature on transition to university suggests that technically based first year courses require additional support in mathematics [1]; many first year students find mathematics to be a very hard experience and the short and rigid lecture/tutorial teaching mode is not adequate to overcome weaknesses. At the same time, the highly competitive university system is urging academics to introduce new flexible teaching modes by making use of the sophisticated educational technology available to them which offers new alternatives for supporting on-campus and distance education teaching.

The availability of easy-to-use multimedia authoring software allowing free distribution of their runtime versions led to the decision to develop *Epsilon*, an interactive first year computer based mathematics tutorial tailored to the needs of our students.

2. What *Epsilon* is and what it isn't

The development of *Epsilon* aimed at providing an alternative computer based learning resource for our first year students undertaking mathematics across all campuses[1] and by distance education, which would present mathematics in an attractive and interactive format. The program was designed as a resource for individualised instruction, to assist in tutorial sessions, to be used for revision for tests and exams, and to be used in distance education offerings. *Epsilon* does not replace any existing material but rather provides an additional resource for students who prefer the computer assisted environment to work on their background deficiencies, for revision, and to learn at their own pace.

Epsilon is a highly structured tutorial which provides a substantial amount of information, illustrated with examples, applications and practice exercises. Although some of the exercises are challenging, and several animations are included, *Epsilon* is not intended to offer exploratory or open ended activities; it focuses on the development of basic understanding of the first year mathematical methods concepts and mastery of the related computational skills.

The early stages of the development of *Epsilon*, technical details and implementations are explained in [2] . The current version, version 2.0, is organised in four sections: Numbers and algebra, Calculus, Matrices and systems of linear equations, and Vectors and vector calculus. Each section

[1] For science, engineering and computing courses offered on three campuses of Monash University.

has a number of modules, and each module has three parts: Concepts, Applications and Exercises. The modules of *Epsilon* are:

Numbers and Algebra

- Basic algebra rules
- Complex numbers
- Sequences and series

Calculus

- Limits and continuity
- Introduction to differentiation
- Differentiation techniques
- Maximum and minimum values
- Introduction to integration
- Integration techniques
- Taylor approximations
- Differential equations
- Functions of several variables

Linear Algebra

- Matrices
- Determinants
- The inverse of a matrix
- Systems of linear equations
- Linear transformations

Vectors and vector calculus

- Vectors in three-dimensional space
- Vector functions
- Eigenvalues and eigenvectors

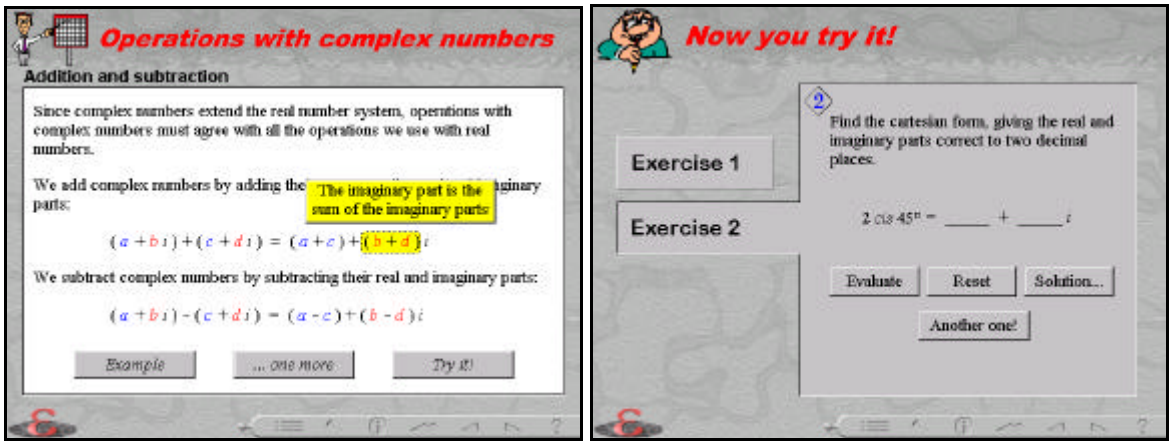

Figure 1: Left: An information screen in the module of complex numbers: when the cursor is positioned on the different parts of the equation, relevant information si displayed. Right: An exercise screen.

Navigation through *Epsilon* is achieved using menus and navigation buttons. There is a main menu that gives access to the four sections, the modules and their sub-modules with concepts, applications and exercises. Each module has a menu to move to the units within it. The navigational buttons are

the usual *next page*, *previous page*, *previously visited page*, and *exit* to the main menu. Although there is freedom for navigation, there is also a natural linear structure which could be followed by using the *next page* button. The navigation bar also provides access to a toolbox consisting of a grapher, the calculator, lists of useful formulae, integrals and derivatives, and on-line help.

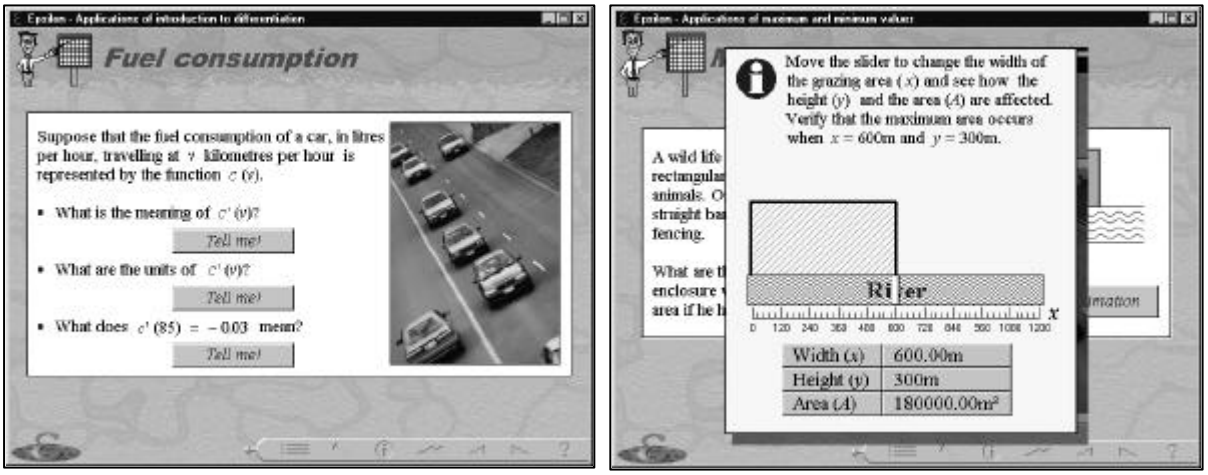

Figure 2: Two examples from Applications modules, one showing the module navigation facility (left) and the other an animation so the student can check the analytical answer obtained in a problem which required finding the maximum value of a function.

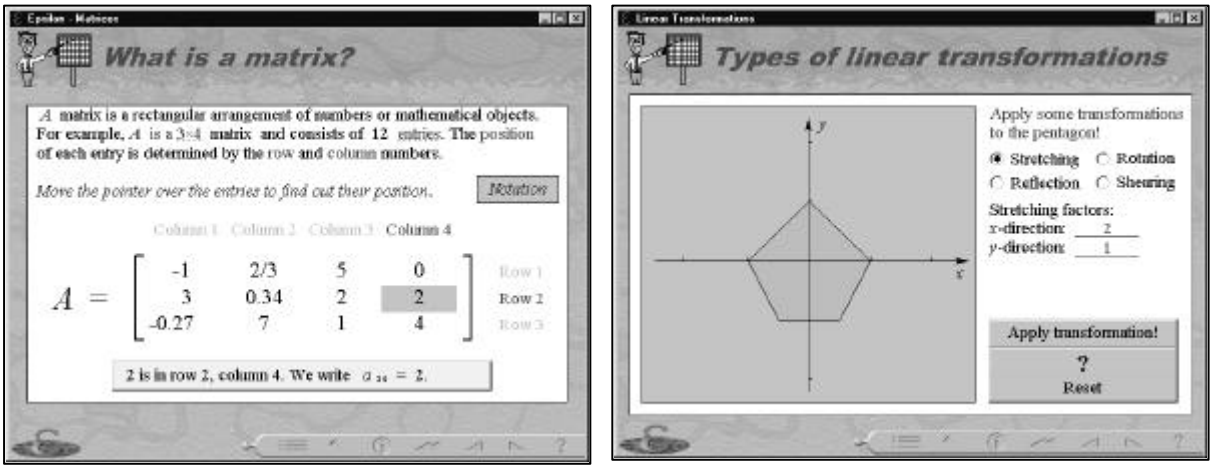

Figure 3: Left: from the matrices Concepts module: when the cursor is positioned over an entry, its column and row numbers as well as the notation are displayed. Right: An interactive activity within the module of Linear transformations.

The textual content of the concepts and applications modules has been specifically written for *Epsilon*. Aims were clearly defined before writing each module and are stated at the beginning of each module and also at the end so students can check whether they have acquired the intended skills and knowledge. Each Concepts module is subdivided into smaller units. Each unit consists of three parts: (i) information page(s), (ii) step by step example(s), (iii) exercises. The information pages were designed to be as simple as possible while giving at the same time all the necessary information. Definitions and conclusions are shown in coloured boxes; additional information such as definitions, motivations, graphical illustrations, notations, and proofs are disclosed using click on buttons and hotwords. The number of information pages is therefore kept to a minimum. This design was to suit the multiple purposes of the program. Students using it for revision, may wish to focus on the basic

key information without having to flip through many pages to reach the next topic; distance education students and students wishing to gain insight can disclose further information using the buttons and hotwords. Whenever possible, information pages are illustrated with interactive animations and graphs. The pages were developed with the authoring software and current computer standards in mind; in each of them, a compromise between the number of objects per screen and the time needed to display it had to be found. The examples are presented step by step. At first only the question to be investigated is shown, the user decides when he/she is ready to proceed with the solution. The solution is also disclosed by the student step by step, either by drawing a "curtain" or by clicking on buttons and hotwords. The exercises, usually three per unit, are of different formats: numerical answers, multiple choice, true/false, drag and match. The answers are marked as right or wrong. All exercises have a fully worked out solution which the user has access to after a solution has been given.

The exercise modules are a recent addition arising from the strong demand shown by students in the evaluation survey. As pointed out earlier, each Concepts and Applications module contains exercises for the relevant units within them. The exercise modules provide further opportunity for practice; these exercises also have the facility to evaluate students' answers and to display suggested solutions.

3. The role of *Epsilon* in teaching and learning

Epsilon is currently used at our University as it was intended: to provide an additional resource to the students and increase flexible opportunities in terms of the use of learning materials and in terms of self paced learning. *Epsilon* is given to the students undertaking the two first year engineering mathematics subjects at all campuses of Monash University where the subjects are offered, as a recommended resource together with other textbooks, none of which is a prescribed resource: students can choose which one to use to supplement lectures and tutorials. In any subject information handout, references are made to both printed and CDROM resources.

A significant number of on-campus students have purchased the CDROM, and there is anecdotal evidence that they are using the program; students will be surveyed early in semester 2 to verify this. On the other hand all distance education students have received a copy, and as is pointed out in section 4. they are keen users of the program.

Epsilon is also used in lectures as a visual aid to illustrate some concepts with images and animations, to provide summaries for some topics, and to refer to applications. This has proven to be a very successful approach to break the monotony of the lectures.

4. Student evaluation

The several stages of the development of *Epsilon* incorporated formative evaluation which involved focus groups of students, educational and graphical designers, academics, and school teachers [3].

After production of version 1.1 in 1998, students were surveyed to determine how they actually used the software in practice, and what they thought of it. This wasn't due to idle curiosity: we needed to know how best to use it in current teaching, and whether there were changes urgently needed for version 2, to be ready for the following academic year. Our focus was therefore on formative evaluation. A questionnaire was used with on-campus and distance education (predominantly mature

age) students doing first year mathematics and with Enhancement off-campus students[2]. The students surveyed were from a wide range of ages, several faculties, and different mathematical background. They were enrolled in six different subjects. The respondents comprised 56% Engineering students, 20% from Science, and 24% from Enhancement Mathematics (secondary school). 46% used the software throughout the semester, 29% used it occasionally, and 25% only for revision. 73% were enrolled for the first time with Monash, 22% were in their second year with the University, and 5% were in their third year of enrolment (most of the distance students enrol part-time).

Details of the questionnaire and responses to each question are given in [2]. Students rated the user interface dimensions (ease of use, navigation, control buttons and screen design) from good to excellent. We were surprised that the amount of interactivity received a reasonably favourable rating, as we had felt that the software was not as interactive as we would like it to be. It was also evident that students were pleased with the display of information, including the aims, the organisation of the information, and the buttons and hotwords which provided further information, examples and illustrations. Equally well rated were the presentation of information, the overall flow of information, the language used, and the content.

The students identified the most positive aspects of *Epsilon* to be its ease of use, simple and clear explanations, the many exercises with solutions, the self-learning dimension, and the good interface. They also made suggestions for improvements; these included the incorporation of more exercises, the tailoring of the tutorial to a particular subject, and also the extension of the software to cover other subjects. These suggestions were considered during the development of version 2.0, and implemented wherever possible.

5. Conclusion

Many of our students already spend more time reading from the screen than from books; the increasing access to computers is influencing the learning habits of our students. Academics are responsible for providing a variety of learning choices to them. Computer based instruction has considerable potential for use in mathematics teaching, it can enhance learning through visually appealing material, animations, links to other applications, graphical illustrations, and interaction. *Epsilon* provides a new approach to teaching mathematics which takes advantage of computer software to shape the style and content of the material, while retaining the advantages of the traditional textbook format. Student surveys show that they find such a resource useful and enjoyable for revision, for self-paced learning, and for supporting learning in lectures and tutorials.

6. References

[1] McInnes C, James R. and McNaught C, *First Year on Campus, Diversity in the initial experiences of Australian undergraduates* Australian Government Publishing Service, Canberra 1995, pp. 63–65.

[2] Varsavsky C, Epsilon–An Interactive Learning Environment for First Year Mathematics, in ed Chapman G M, Proc *Computer Based Learning in Science*, Leicester 1997, sec D.

[3] Varsavsky C & Carr A, Multimedia in Mathematics Teaching – Does it work?, to be published in Proc of CBLIS'99 *Computer Based Learning in Science*, Enschede, 1999.

[2] This is an enrichment program for very able final year secondary school students who undertake first year university studies.