

Xlr8tr: Learning about spreadsheet tools for Environmental Engineering Students

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Abstract

The use of advanced features of spreadsheet software by undergraduate engineering students is investigated from the point of view of their previous experience, the types of learning resources currently available and the degree to which these meet the needs of the students. A survey of staff and students was conducted to determine features required in a new learning web site, which was subsequently written and implemented. Evaluation of student perceptions of the web site are also reported, and indicated that initially voluntary use was low even though surveyed students had easy access to the web site and many indicated that they would use it in future. Relatively minor changes to the manner of introduction of the web site to the students lead to increased usage levels. Students judged the web site as a valuable tool with about half of the class claiming significant benefits from using the site. Different learning styles resulted in not all students finding the web site useful when presented as an adjunct to problem based learning.

Keywords

Spreadsheets, Engineering, Education, Evaluation, Web based learning

Background Observations

Use of common office productivity software such as word processors, spreadsheets, email and internet software has become common at most levels of education. Many of the current cohorts of University students in Australia will have been exposed to these tools at primary school. The majority would have used them extensively in secondary school. Over the same period, the style of education for many activities in the school system has moved away from the didactic tradition to other forms of learning. As a result, the actual instruction in the use of software is generally very limited. Apart from basic file operations, editing and formatting, most features of software applications are likely to have been learnt by exploration as the need or curiosity arose.

My observation is that this has lead to the current cohort of students having, on average, a shallow understanding and familiarity with many features that are often the most powerful in the software applications. Based on my experience of reviewing electronic submissions of university students' work, semi-advanced features of word processing software, such as "styles", and spreadsheets, such as using absolute cell referencing or variable names, are almost never used. While this may be acceptable for home use, the demand for an understanding of moderate to advanced techniques for tertiary student and professional use is great.

Engineering students generally have high numerical and analytical ability. Commonly over half of their courses deal with gaining an understanding of engineering systems in such a way that mathematical analysis and synthesis can be applied. Software applications such as spreadsheets, statistical packages, and mathematics equation processors are often used to assist student understanding and perceptions of mathematical systems and as productivity tools to allow them to attempt sophisticated, data intensive design problems. However, their detailed knowledge of spreadsheets is generally lacking and often unrecognised by the students themselves, since they have been “using” spreadsheets for many years.

Existing resources

Having taught advanced spreadsheet skills to engineering students over a number of years, I have had opportunity to review teaching resources for students. Books, both paper based and on-line, interactive tutorials and software help files are typical resources that are available to students. While these are generally quite comprehensive for the novice user, they are often of limited use for more advanced users. This stems from the need for these resources to appeal to a wide audience and to cater to a wide range of user academic abilities. Some typical resources are reviewed here.

Books

Paper based books¹⁻⁴ are common learning aids for software applications. Being a more structured form of learning aid, and given that most people tend, at least in the first instance, to read or scan the book in a particular order determined by the author, books are more likely to present novice users with a systematic knowledge of the software. Unless very comprehensively indexed, they lack the power of searching possible with electronic resources. A major problem with books is the presentation of examples. They tend to present a problem to which the majority of the audience don't particularly relate. Business, marketing and financial examples are common themes in office software. These are often a long way from the driving reason for engineering students to learn the software. Descriptions of problems to be solved in spreadsheets often go to the exact detail of specifying cell addresses of formulae to be entered. While this ensures that given enough patience and accuracy in setting up the examples, they are guaranteed to work on the software, they discourage active learning and exploration of the concepts that are being taught.

Especially for audiences like those that I face, less structured guidance through problems that they are interested in may well lead to a faster, more comprehensive and translatable learning experience than exact reproduction of a recipe.

Help files

The on line help files of the principal software package most students use (Microsoft Excel) is quite comprehensive. Like most manuals, it suffers from the problem of using them requires a certain command of the language used by manual writers in order to effectively access the manual. Users tend to dive into these hyper-linked documents when looking for solutions to problems, rather than learning the software in a systematic way. For the novice user the help files may be impenetrable. A conclusion is therefore that a means of translating the language the students are likely to use searching for solutions into the language of the help file would be useful. The requirements are probably quite specific for a given group of students and the type of use they wish to put the software to.

Academic objectives

Having considered my experience and observations and reviewed existing learning resources, I determined that a need existed for a different style of resource that was more closely targeted at a particular type of student. Although the number of students I directly deal with is quite small (<200 per year), there are numerous similar groups around the world that could potentially benefit from such a resource.

Features of the audience I am interested in are;

- They are highly numerate.
- They have high levels of problem solving skills.
- They are academically very able. All are ranked in the top 10% of academic achievement in the secondary school population.
- They have limited time to learn new skills when the need is greatest (i.e. just before an assignment is due).

Specific learning goals that targeted different student skill needs were established. These were;

- To provide a resource to assist student learn the basic aspects of interacting with spreadsheet software
- To provide specific advice on increasing productivity when working with problems typically encountered by engineering students.
- To give advanced theoretical and practical advice on the use of implementing a number of mathematical techniques for engineering problem solving
- To provide a number of detailed examples of common problems that environmental engineers encounter in their training.

Pre-development Survey

A survey of staff and students was conducted to determine aspects of the content and design of the resource. A range of potential topics for inclusion in the resource were determined based on extensive personal use, review of books and subject matter of the undergraduate environmental engineering course at the University of Melbourne.

Survey Questions

Two types of questions were used. The first used a five level Likert scale response to gauge the importance of inclusion of a particular feature in the resource. Respondents could choose from “definitely exclude” to “definitely include”. A total of 49 questions of this type were asked to cover the four areas of basic techniques, increasing productivity, implementing engineering mathematical techniques and common problem examples.

The second type consisted of a single question with an open-ended response to allow respondents to suggest further features that could be considered for inclusion in the resource. The survey was conducted electronically with respondents entering answers into an online form. Anonymity of respondents was allowed.

Target groups

Questionnaires were directed at a four different target groups as follows;

- Undergraduate environment engineering students in their 2nd, 3^d and 4th year of study. These are the primary target group of the completed resource.

- First year civil engineering and environmental engineering students. This group represented students that had recently started tertiary study and should give an indication of pre-existing knowledge.
- Postgraduate environmental engineering students who had recently completed their engineering studies and could articulate some of the shortcomings and needs of undergraduate students with the benefit of hind-site and recent experience.
- Academic and research staff in the Department of Civil and Environmental Engineering that were involved in the teaching of undergraduate students.

Survey Results

Forty people responded to the questionnaire and most answered every “Lickert” style question. Figure 1 shows the distribution of response for the 49 questions. With the exception of two questions from the section on basic techniques, all items identified for inclusion in the resource were firmly endorsed by the survey of potential users.

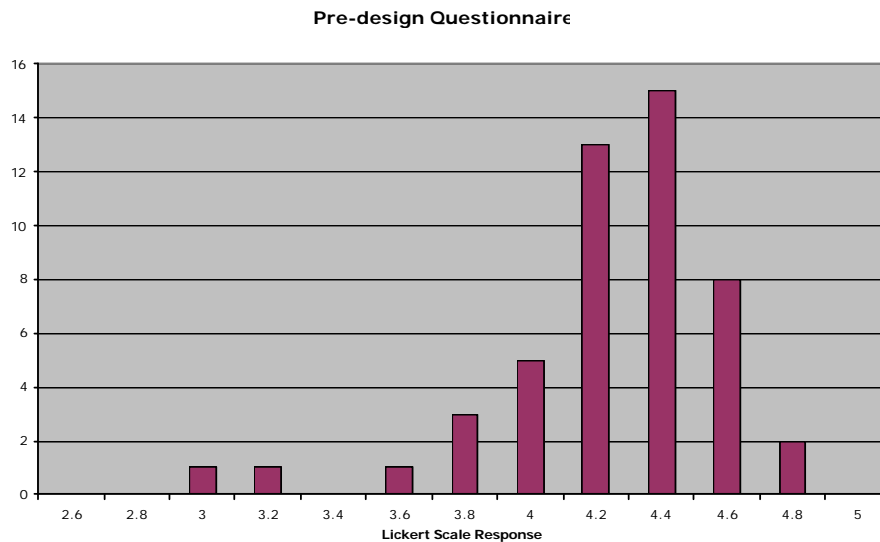


Figure 1. Frequency histogram of respondents’ rating of intended topics to be included in the online resource (1 = definitely exclude, 5 = definitely include).

The open-ended question was answered by 11 respondents. Three significant aspects were suggested in these responses. One respondent indicated the inclusion of pivot tables was very important; subsequent discussions have convinced me of the importance of this tool. Extending the resource to include material on the use of macros or visual basic modules for automation and advanced data manipulation was advocated by several respondents who were from the postgraduate group. Two people advocated that “words of warning” of the shortcomings of trusting any computer software implicitly should be included in the resource.

Site Development

Encouraging students to return to the site multiple times to learn new and more complex tasks was a primary consideration in developing the main interface of the site. Colour and text design were used to focus attention at different levels of the resource. It was known that users would have a wide range of initial skills so ensuring all users could access material

appropriate to their level directly from the initial screen was an important consideration. Figure 2 shows a screenshot of the main interface illustrating at the top level the four focus areas ranging from “Basics” through “Tips” to “Techniques” and “Examples”. In each quadrant, seven subtopics were developed and for each subtopic, a short description of the content of the subtopic is outlined. Experience has shown that one of the key aspects that prevent students from making rapid progress in developing software skills is the language barrier of knowing where to search in the printed or on-line manual. Therefore, an attempt has been made to explain each access point to the learning material in two different manners. Brief advice on how the “Basics” and “Tips” quadrants are best approached is readily accessible from the main screen. In the learning files associated with each quadrant a similar format has been used to help student recognition and navigation. Extensive use has been made of fragments of screen shots to illustrate the key points so that a student who is working through the examples with Excel software can easily relate them to the web site. In the more complex “Techniques” and “Examples” quadrants, many example Excel files are provided to allow students to download fully worked examples that can be explored, modified and combined to develop deep understanding of the software and the problems being tackled.



Figure 2 Main screen of web site⁵. <http://www.ecr.mu.oz.au/~xlr8tr/>

Student use surveys

Two student surveys were conducted after the development of the site; one in early 2004 and the other in early 2005. As will presently be described, the latter survey was conducted after changes to the style in which the site was presented, because of the first survey, to the students during classes.

Opinion and perceptions of the site was sought from students ranging from 1st year through to final year in early 2004. In all cases, the site was not a formal part of the curriculum, but

offered as a resource that can be accessed to assist self-development of computer skills and methods of exploring engineering problems through numerical methods. One or two emails and up to three references to the site in lectures were used to alert students to the existence of the site. For all students access to the site was available by way of links from the website of relevant subjects.

Approximately 50 of 200 students responded to the online survey. Only 10% of all respondents had used the site and most were from later year students. The level of awareness of the site was low however almost one third of respondents indicated they would use the site in future. Those students that used the site rated it as “useful” or “very useful”. The next section addresses a response to this situation and a deeper investigation of student learning styles.

Learning Spreadsheet Skills and the Role of Xlr8tr.

Because of the low adoption rate, a more proactive approach was taken to marketing the benefits of the site to a group of 3rd year students conducting a design project. The project involved proposing a means of sustainable development of a water supply and wastewater treatment system for a rural town. A variety of historical data from various sources was provided, along with encouragement to analyse that data and then develop mathematical models of the existing and proposed systems to aid in the design process. A more complete description of the design learning process used in the subject is published elsewhere⁶.

Direct references to specific examples and techniques in the xlr8tr web site was given to students during computer laboratory sessions and group work classes. This sometimes took the form of providing the URL to the exact location and sometimes showing the specific location either individually in the computer lab or as a class via projection of a live demonstration of the web site.

Twenty-seven of 34 students surveyed (80%) provided their insights into learning of spreadsheet skills and techniques. The students are mostly now in their final year of their engineering degree. Seven multiple choice and multi choice questions and one text response question was posed via the anonymous online survey.

Students assessed their current level of skills with one third of students classifying themselves as advanced students who can construct models and analyse data with limited guidance and two thirds describing themselves as having average skill levels who need assistance to devise and implement models. Only one respondent described their skills as below average and often had trouble knowing how to get started on engineering analysis problems.

When thinking about their use of spreadsheets for data analysis and modelling in the previous year's design subject, only 10% of students considered they did not need to increase their skills significantly during the semester to enable them to undertake the design. Fifty percent of students claimed that by the end of the subject they were confident in their ability to tackle similar problems but 30% chose the statement “*I struggled to apply spreadsheet analysis to this problem and I am still not confident of my spreadsheet skills in analyzing and modeling data encountered in this type of problem.*” to describe their skills at the end of the subject.

The Xlr8tr site was one of the general tools available to the students to help them improve their skills. Other tools included commonly available resources such as textbooks and on-line

help files. Students were divided evenly about their access to and use of the Xlr8tr site. About half said they accessed it minimally but didn't get much out of it, while about half claimed to have used the site and improved their spreadsheet skills as a consequence.

Students were asked to describe their learning styles when learning about software like spreadsheets, word processors and presentation software. More than one response was allowed. Two thirds described themselves as "just-in-time" learners. Twenty percent of respondents described themselves as curious about features of software packages and would investigate these features. Systematic learning of new skills was chosen by a quarter of the students, while one quarter said they were not motivated to learn the skills themselves and believe the University should specifically teach these skills. I find this a disturbing outcome for students who were in the top 10% of students as measured by their University entrance scores.

When asked "What are the main ways you learn about spreadsheet functions?" (multiple responses allowed), almost 70% learn by playing or self directed exploration, 65% by using the on-line help, 90% by asking others, 45% by using the Xlr8tr web site, and 25% used on-line tutorials. Less than 10 % used the following methods; printed textbooks, short courses and searching the Internet.

Students were invited to submit written comments about learning or using spreadsheets in their engineering course; 65% of students did add further comments. The comments were analyzed and classified into seven categories suggested by the data. Between one fifth and one quarter of all respondents made comments on four themes. The desire for explicit teaching of spreadsheet skills earlier in course was requested, although one respondent requested specifically that this not be done. More exposure to modeling of engineering problems and a requirement to use spreadsheets in assignments were each requested to enhance their course. Students were keen to understand the professional relevance of spreadsheets and other computing tools in order to assist in their motivation to learn about the tools. Other issues raised by smaller number of students were their continued use of Xlr8tr and an initial ignorance of what spreadsheets could be used for in engineering apart from drawing graphs. One student specifically indicated that Xlr8tr did not suit their learning style.

From these results it is apparent that a limited amount of direction was all that was required to change the rate of access of students to the Xlr8tr site from a very low level to very high levels. Once they had accessed the site, about half found it useful and persisted with obtaining information and significantly improving their skills. Considering the plethora of learning styles and preferences this is seen as a good conclusion to the development and deployment of the Xlr8tr site.

The stark contrast in the way students would like to learn provides some challenges to formulating the curriculum and syllabus of engineering courses. Significant proportions of students held diametrically opposing views on the issue of spreadsheet teaching, with some preferring a didactic approach, while others were interested in just-in-time and problem-based approaches. It is conceivable that both of these approaches could be offered, however, the regulatory and equity issues presented stipulating such alternatives would challenge the approval process in many institutions.

Conclusions

The trend to move from didactic teaching of tertiary skills to student-centred approaches to learning skills on demand has led to a need for innovation in aids to learning. Books available for learning high-level spreadsheet skills for engineering students are not valued as learning tools, which concur with the author's view that they are inadequate. A survey of environmental engineering academic staff and students identified key items considered essential for an online reference resource. These were incorporated into a website with a rich array of examples and downloads for students to learn advanced techniques. Without specific needs in mind, student users rated the site favourably, but the proportion of target students using the site was initially low. Incorporating exposure to the website in a design subject led to much higher rates of use by the students, who found the site useful in their learning. Varied students learning styles identified for basic computer skills still present challenges for engineering course design and delivery.

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Biographical Information

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