DEVELOPING MATHS SKILLS IN A VIRTUAL CONSTRUCTION CONTEXT: BENEFITS AND CHALLENGES

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There is a school of thought that maths set in a real context has greater relevance to students than theoretical maths that is taught without specific application. Using virtual e-learning it is now possible to link theory to practice, creating a more interesting and stimulating learning environment. Notwithstanding the advantage of seeing where maths can be applied, those engaged in pure maths believe that teaching the subject in a context may limit understanding. Advocates of pure mathematics consider that contextual learning is a form of coaching which limits application outside the subject area. However, for many students not being able to see the practical uses can make the study of maths meaningless. Applied maths is relevant and can be interesting. Capturing the interest of those studying maths is a key agenda for government as the general standard of maths in the UK is falling. Construction students that struggle to see the importance of maths and fail to recognise its use may benefit from multimedia applications that present the maths in a real context. In a virtual environment, with images taken from real sites, it is possible to apply maths to construction situations bringing the subject to life. With interactive platforms students can be guided through the maths problems. Working with industry some simple maths tools have been created and evaluated. Workshops with teachers and students were structured to obtain qualitative data on the tools. The interest levels and potential areas of development were a key consideration for the research. Feedback from teachers, specialists and students suggest that maths applied to construction context supported by web based multimedia has potential to capture interest and support teaching and learning in vocational and non-vocational environments. Reflections, criticism and comments from an initial evaluation are presented and discussed and areas of possible development suggested.

Keywords: education, information technology, and learning, maths, teaching.

INTRODUCTION: COMMON RESOURCES FOR ALL

There is a push to create innovate more resourceful methods of teaching and learning as the number of students entering further and higher education continues to rise. Largely the increase in students is being accommodated by flexible learning, distance learning and traditional face-to-face delivery supported by on-line study aids. E-learning is facilitating expansion of the education sector without increasing the physical footprint of the physical estate (JISC 2008). Although there are different

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delivery approaches the common theme is the increasing use e-learning and web based learning environments. As well as educational organisation making use of the internet for more cost effective and innovative delivery, students are increasingly demanding on-line access to learning materials.

Whether academics like it or not there is a culture shift and e-learning, for many, is the norm. Students, certainly those described as the 'net generation', who were born after 1982 and have not know life without the internet, have different learning habits with the web being an integral part of their lives (Oblinger 2008). Whether e-learning forms the main delivery or provides learning tools to support traditional pedagogic methods there is a need to recognise how e-tools impact on the teachers and learners and if they can improve development of specific skills. Appropriate use of e-learning technology can and is transferring into improved satisfaction, retention and achievement (JISC 2008).

Schools, colleges and universities are also creating their own bespoke resources, which in many instances are open to all internet users. With developments in multimedia technology it's now possible to create innovative learning tools with off-the-shelf software at a relatively low cost. Interactive resources can be created by most learning providers. Some schools, colleges and universities are using modified templates to make effective use of existing learning objects on the web (Taylor and Caselton-Bone 2008). The bank of image and text based learning materials on the web is quite extensive; however, Poulton, whose research reviewed on-line study aids, concluded that there is still a need for high quality, top end interactive resources (Taylor and Caselton-Bone 2008).

Currently the development of web-based course materials is sporadic and most are tailored specifically to the courses that develop them, which reduces the ability of the tools to be used by others. As educational objectives of university courses differ and the combination and sequence of teaching methods used for them vary this is to be expected (Betts and Liow 1993), yet there are some core skills, which exist on most courses. As the diversity of students' academic backgrounds increase there is a need to pick up and strengthen some key skills so that students can succeed. Core skills are usually introduced and developed in schools, strengthened in further education and refined for use in professional settings in university. However, due to difference in educational background some people find themselves in higher education without all the necessary skills or needing to revises and refresh their understanding. In many cases the basic entrance skills needed for construction course are common. If open access learning materials were developed for construction students and specifically dealt with basic maths applied to construction they could also be used by students studying alternative curriculum in secondary schools and further education colleges. There is growing concern about core skills, specifically maths. Use of e-learning materials may assist teachers and help learners develop core skills.

During recent years there has been some concern that the standard of mathematics in United Kingdom is falling. "…secondary schools have tumbled down an international league table of reading and maths standards" (McSmith 2007). McSmith notes that such findings have raised concern that the UK economy will suffer if pupils are not taught basic subjects properly. du Sautoy (2008) claims that the lack of mathematicians is already costing the UK economy 9bn, with China and India taking the business and filling the gap. General interest in maths is a problem, it has become difficult to attract and retain good teachers. Even where specialist teachers have the

skills and interest to teach the subject properly, maths resources are limited and valuable teaching time can be spent developing basic resources. With the expansion of the web it would expected that there would be a wealth of good quality interactive maths teaching tools that teachers can tap into, but this is not the case (Taylor and Caselton-Bone 2008). Clearly there is a case for open access on-line teaching resources, but if time is to be devoted to developing such tools they must engage the teachers and learner. There are moves to make more education vocational, giving learning a focus; such approaches are considered by some academics to be more engaging for students.

Learning by doing and experiencing

While the national curriculum has been criticised for dumbing stifling potential creativity, new vocational qualifications may provide an avenue for setting maths in real and stimulating contexts. New academic pathways are being created for children aged 14-19, some have been specifically tailored to construction, but there is already some concern regarding the standard of maths that will accompany such programmes. Professor Smith said: "These new qualifications present an opportunity to provide students with a broad, flexible education all the way up until age18. However, we must ensure that they do not shut off opportunities for students in their future studies or careers because they have not been given the opportunity to study maths to an appropriate level." (ACME 2008). Others, such as du Sautoy (2008) have argued that attempts to make maths more relevant has made it boring. While making maths real and relevant it must also be able to stretch interest levels beyond the context in which it is taught. At all levels there seems to be a need for applied learning and a recognition that the core subjects such as maths must be delivered, and the standard must be improved.

Regardless of the course of study, for learning to take place students must be engaged. Research evidence suggests that learning is more effective when people are experiencing and reflecting on the task, rather than merely, by abstract conceptualization (Race 1989). Race's view on the 'learning by doing' style has an association with the self motivated learner. Jaggar and Ross (2003) add that self motivation can be encouraged by using interesting and supportive learning aids such as that which can be provided through multi-media applications in addition to the normal pedagogic techniques. With multimedia applications becoming more affordable and the cost of web tools, photography and video falling, it is possible to develop e-learning and virtual context that resemble real world from which images were taken. Learning tools can be produced within 'real' contexts and made interactive.

A case for the development e-learning that uses real environments has been made, but there is still a need to understand how such materials should be developed and what aspects of e-learning capture the learners' interest and those issues that create challenges.

METHODOLOGY

The research method adopted for this project can be best described as 'active experimentation'. The project is ongoing and data collection is constant helping to develop and refine the web based teaching and learning resources. The study is aimed at getting a better understanding of lecturer, teacher and student needs with regard to web based resources. The interactive tools being developed in this case are those to

assist teaching and learning of mathematics. The maths tools being developed use basic maths, normally taught as part of standard secondary education, but are applied to construction situations.

Figure 1: Image from Virtual Site Classroom showing overlay and interactive button

Two examples of interactive maths problems were developed and set in a construction context. It was considered that both applications, which were focused on basic maths skills, could have potential use in schools, colleges and universities. The first problem centred around the calculation of the volume of concrete needed for a pile foundation. To ensure that students understood what a pile was and how it was constructed video images, animation and some explanation were given. The vehicle that set the maths problem in context was a spherical image of a construction site where pile foundations were being driven. Using Flash technology hotspots and interactive buttons were positioned on the screen and used to activate video clips and the maths problem. The spherical image is totally navigable so that users can move around the screen in any direction to see the surrounding construction site.

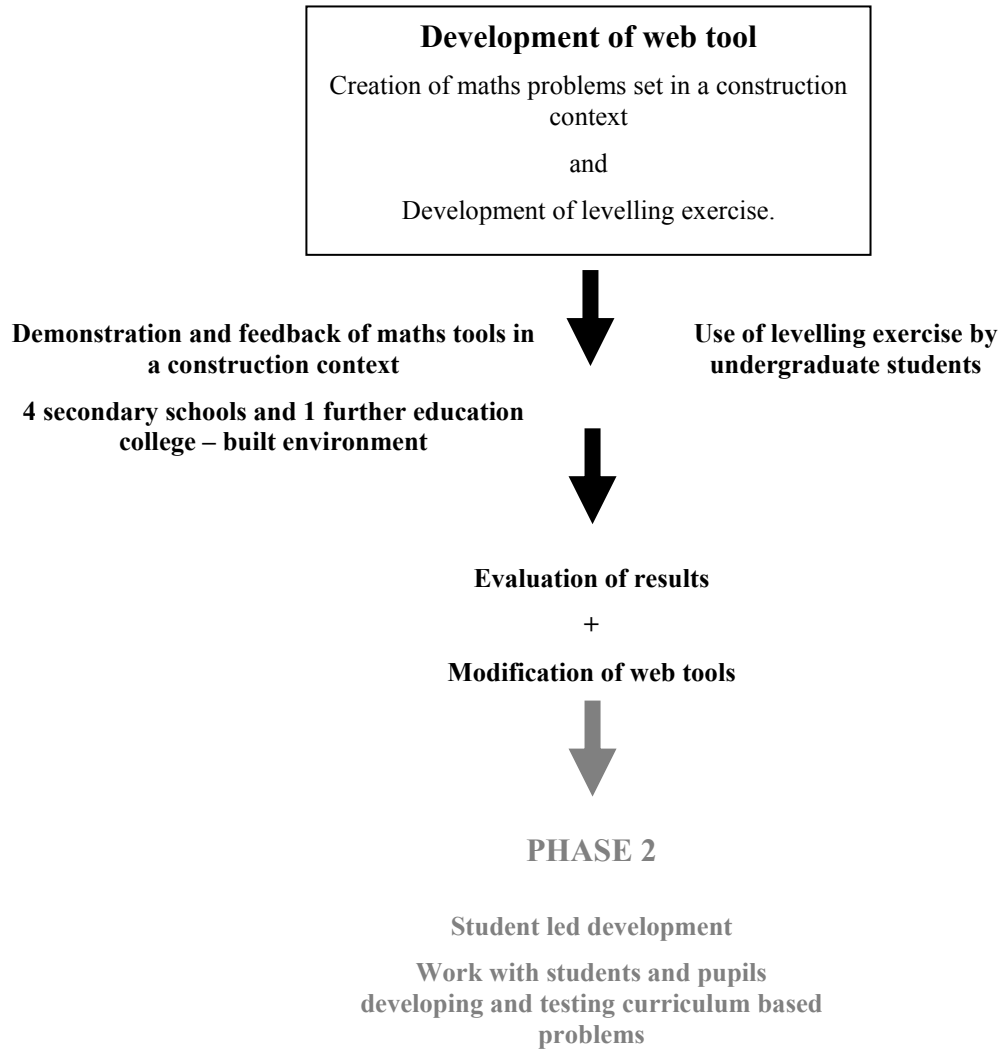

Figure 2 Activities and phases associated with data collection

The second problem was a simple trigonometry calculation set against a refurbishment project. Using an image of a theodolite, on screen measurements and overlays that show a protractor, the scene is set to measure the height of a structure. A theoretical triangle is shown to take students through calculations (see Figure 1). A sequence of screens activated by clicking the interactive button takes students step-by-step through the calculation. The images and instructions help to visualise the maths problem and set them in context.

Using the same technology a simple levelling exercise was also developed to assist teaching of surveying and measurement classes, this tool has been used within a module. The impact on the undergraduate student experience was evaluated by interviewing first year students that had benefited from the interactive resource within their module and also asking final year students, who had took the module without the benefit of e-learning resources to comment. Qualitative data was collected and the common and critical themes are presented below.

Once developed the examples were shown to built environment lectures in a further education college and maths and alternative curriculum teachers in 4 secondary schools. A presentation was also made at a FE/HE Life Long Learning group. In

each case qualitative data was gathered on potential use, problems and areas of improvement.

RESULTS AND DISCUSSION

Feedback from the teachers suggests that the maths tools have applications in schools, however to be used as a teaching resources, it was considered necessary to have a broader range of problems and examples in each aspect of maths. To accommodate students that quickly grasp the problem there was a need to have more advanced and challenging problems. Teachers felt that the top end of the class would quickly lose interest if there were not a full range of problems for them to work through. At the other end of the scale, the way some of the formulae were presented was considered too taxing for weaker students. Clearly to deal with those who need more help and maintain interest of those who can process maths problems quickly the range of problems needs to be quite broad.

The link to the real construction contexts and situations is something that captures the interest of students, Jagger and Ross (2003) considered the sense of realism to be an important factor when designing effective web based teaching resources. All of the teachers who were shown the tools were keen to use them to assist their core teaching.

One teacher used the tool at the end of a trigonometry session to show the pupils where trigonometry could be applied. However, to make the tools an effective part of the curriculum more and varied examples of problems are need. A teacher commented that there are a few similar web sites available, but they don't have enough resources on the site to be used as proper teaching aids. It is clear that the tools do have potential, but the range of problems and examples must be expanded.

Taking a HE perspective, but still considering the same tools, a senior university lecturer, commented on some of the challenges that are facing first year Civil's students and why such basic maths resources are needed:

> "Traditionally, Civil Engineering courses have required students to have a high level of ability in maths. Although in recent decades the curriculum of such courses have expanded so that there is less emphasis on purely mathematical subjects such as Hydraulics or Structural Analysis, Civil Engineering students still require a thorough grasp of the topic area. Our Civil Engineering courses require students to have a minimum standard in maths equivalent to a grade C at GCSE level. Even with this policy, some new students still struggle with the maths content of the courses. There are a number of reasons for this, including the comparatively high level of ability expected of students from the very start of the course, mature students entering the course years after they last studied the subject at school, and, it has to be admitted, some of the arcane maths employed in Civil Engineering. Even if they have a reasonable grasp of the subject, many students still experience difficulty with some basic areas of maths such as with units in calculations, the use of symbols and Greek letters in equations and the rearranging of simple formulae."

Although the tools could be used by secondary schools they also still have use within HE courses. Maths e-learning exercises are starting to assist students coming on to the degree enabling students to learn at their own pace. They are being used as introductory or refresher exercises. Students who may be embarrassed to admit to a tutor that they are struggling with maths can use the exercises to catch up in private study. The step-by-step approach allows students to unravel complex problems.

Backwards and forwards controls enable students to retrace steps, allowing for greater comprehension and understanding.

A Civil's student commented on her use of the virtual theodolite exercise:

> "I liked the height calculation exercise. It's like revision, taking you through the steps of how to do it. We should know our trigonometry, but having something that's easy to look at and tells you how to use your adjacent and hypotenuse and reminds you which angles are necessary for what you need to do, without having to find a book and look at equations [is useful in that] it pops out at you and it stays in your memory. The colour coding helped me to link the maths symbols to the practical worked example."

Comments were also gathered on the levelling exercise, which is quite specific to construction and can be used within further and higher education built environment courses.

A senior lecturer within a university noted:

> "…when doing levelling as a first exercise many students find this difficult and most have problems with computation of the results. The virtual levelling exercise offers an opportunity for students to stand back and see what is happening during this process and to benefit from the explanatory notes. The students appreciated the exercise as a learning tool and stated how it helped to clearly illustrate and consolidate what they had been doing on the practical levelling exercise. The results showed that the technology had clarified terminology. The increase in the confidence of the students after completing the exercise on Virtual Site was 'visibly obvious' and the ease with which they completed the computation for assessment was also apparent."

Students were also asked to comment on the virtual levelling exercise.

Comments made by the first year students on the BSc (Hons) Construction Management included:

> "You can do this as many times as you want. If you don't understand something you can go back and do it again. The tips are very useful. If I was at home with this, it has enough instructions for me to know how to read the foresights, backsights, etc., plot it onto the table and do the work without any help. It is designed well and is very realistic."

A final year student who had not had the benefit of the Virtual Site commented on the site: On seeing it for the first time recently and referring to her experience as a first-year student, she said,

> "I remember going to one of the tutors and falling apart because I didn't know how to do basic levelling, so this would have been really helpful. It's a brilliant tool and I think the first-year students are very lucky to have it. When you're new to it, levelling surveys can be mind-bogglingly confusing. I love the way you can produce resources like this."

The level of interest and enthusiasm for the development of highly interactive web resources is quite clear, but there are also some factors that were raised that also need to be taken into consideration.

CRITICAL COMMENTS AND AREAS OF DEVELOPMENT

When discussing the tool at a regional university forum one maths lecturer who teaches construction students suggested that such tools were potentially a cause of the lowering in standards of maths. The view presented was that maths should be taught from a theoretical base and, at least in the initial stages of learning, the theories should not be contextualised. The main concern raised was that contextual learning coached students through problems and narrowed the students' understanding of maths. It was thought that students who were coached through problems would only be able to copy the formula for assessment purposes and not apply it to other contexts. The view put forward here is similar to that recently suggested by du Sautoy (2008) who claimed that making learning relevant reduces the rigor and makes maths less interesting.

Although the regional university forum was attended by over twenty lecturers and skills teachers none of the other members of the group voiced the same level of concern about applying maths to a context. However, the e-learning environment can be developed so that the maths tools that are applied to a construction context and can also be produced without a context, in their pure form. It is proposed that step-by-step approaches to the pure theory could sit alongside the contextual information. As the aim of the project is to capture interest and accommodate as many different learning styles as possible this dual approach may be beneficial.

Opening up access and accommodating disabilities

Recently the issue of dyscalculia has been mentioned with reference to the e-learning environment. Broadly speaking dyscalculia is the inability to process numbers. Further research is necessary to understand the different learning styles that benefit dyscalculic students and to see how the site can be changed to better accommodate these students.

The e-tools have been colour coded to help student recognise and relate formula to the various parts of the visual image that support the maths. As soon as the colour was introduced concern was raised about the difficulties faced by colour blind users. Feedback from one user with this condition suggested using primary colours to reduce the problem. The emphasis of shade and texture in coloured text could also be explored. Further research is necessary in this area and alternative methods or relating the formula to visual aids explored.

Audio prompts and sound supports various parts of the site. Currently the sound used comes from the video and audio clips taken from the construction sites, however it is proposed to have some audio clips to provide an explanation of the maths to help students who may have difficulty reading the text. On visiting schools and colleges it was apparent that many computers do not have sound cards. The absence of sound cards was normally due to the potential sound pollution that could arise rather than the cost of the hardware. Thus, any audio support developed would have to be supportive rather than act as a core element of the site. Schools do have computers with sound cards, especially where this is required to support disabilities, so sound is important.

Phase 2

Research is ongoing, BECTA have recently funded a project to take the proposed model into schools and colleges. In this project students are encouraged to help design web based maths problems. Reactions from the students have been mixed. Some are keen to see how there ideas can be developed while for others the uptake of interest in the maths web site is slower. The first maths problems based on the

students ideas are currently under construction. Once the maths problems developed from the children's and teacher's ideas are developed feedback on their uptake, use and limitations will be sought. Examples of the maths problems that have been developed can be found at the following www.leedsmet.ac.uk/teaching/vsite/classroom.

CONCLUSIONS

Developing interactive e-learning supported by multimedia applications is getting easier. While many still argue the virtues of face-to-face learning, web based resources are becoming increasingly popular as teaching aids, revision and self-study packages. Some staff are resistant to use of web based resources, but for many students, especially the 'net generation', internet use is the norm. Students have probably reached e-maturity before staff and universities, but there is potential to catch-up and develop tools that inform.

The ability to release different media with the click of a button means that the potential to explain problems in ways that capture a person's interest is increased. However, such web sites and e-environments should not be confusing. It is clear that contextual learning does capture the interest of many, but there may also be a need to keep theoretical information clear and in some cases separate from contexts that may confuse or stifle an open mind. Designing open access web sites that accommodate all users is difficult, but such challenges should not prevent web developers pushing the boundaries so that abilities and disabilities are considered in the design. In this situation interactive tools, set in an industrial context, do have the ability to capture interest and assist the teaching and learning of core maths skills. An additional benefit of developing learning tools that connect schools, further education, higher education and industry is that they provide a central focus fostering a real learning community.

REFERENCES

ACME (2008) New Mathematics and level 3 diplomas Press Release Archive: *Government risks missing opportunity to raise maths standards*, Advisory Committee on Mathematics Education. <www.acme-uk.org> [accessed 26/4/08]

Betts, M. and Liow, S. R. (1993) The relationship between teaching methods and educational objectives in building education. *Construction Management and Economics*, **11**(2), 131-41

du Sautoy, M. (2008) Without big maths stories our numbers are plummeting, *The Guardian*, Tuesday 3/6/08 <www.guardian.co.uk/commentisfree/2008/jun/03/maths.education> [accessed 9/6/08]

Jaggar, D. and Ross, A. (2003) A survey into the effectiveness of web-based teaching of building design cost management. *In:* Greenwood, D J (Ed.), *19th Annual ARCOM Conference*, 3-5 September 2003, University of Brighton. Association of Researchers in Construction Management, **2**, 633-42

JISC (2008) Tangible Benefits of e-Learning: Does investment yield interest? JISC, March 2008 <http://www.jisc.ac.uk/publications> [Accessed 27/4/08]

McSmith, A. (2007) Reading and maths standards falling in Britain, says OECD, The Independent, 5th December, <news.independent.co.uk/education/education_news/article3223679.ece> [Accessed 20/4/08]

Oblinger, D. G. (2008) Growing up with google: What it means to education. Emerging Technologies for Learning, *BECTA Research Report*, BECTA **3**, March 2008, 11-30

The Mathematical Association (2006) A response from the mathematical association to the House of Lords Select Committee on Science and Technology: *Mathematics Teaching in Schools*. <www.m-a.org.uk/education/MAResponses/Lords0606/index.html>, 19th June [Accessed 25/4/08]

Taylor, P. and Caselton-Bone, S. (2008) *Teachers and learners look for attractive resources, Distributed E-Learning, regional stories*. JISC <www.jisc.ac.uk/whatwedo/programmes/programme_edistributed/regionalstories> [Accessed 25/4/08]