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**BECTA - Final Report**

**Leeds Metropolitan University**

**School of the Built Environment**

**Virtual maths in an industrial context: Learning with new and emerging technologies**

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**Summary**

While government ministers have advocated a need to develop open, universally accessible, educational resources that are engaging and stimulating (BECTA 2008a), the task still seems to evade educators. Coupled with the problem of lowering standards (Lowry 2009), the challenges seem to be the greatest in the areas of science, technology and mathematics.

This project has used Flash technology to create functional contexts for maths and science learning tools. The aim is to make maths and science more interesting and engaging. Virtual environments were created from panoramic photos of real locations. The working context for this project was construction and other built environments. The project has started with a focus on maths and the creation of a virtual maths environment. The ‘Virtual Maths’ tools created so far provide a few exemplars of interactive web based maths problems. These tools have been successful in engaging children, providing teachers with functional maths resources and have promoted additional interest in the subject area. From the initial research, it was found that maths and science set in a real world context was more interesting to the children than unapplied maths. Further research has shown that combinations of interactive features need to be used to meet academic demands and improve student interest. The more dynamic features, such as animation and video, were found to be more interesting to students than still images.

The appeal of the contextual images that were used to create the virtual environment resulted in variable interest depending on students’ personal preferences. Students were eager to suggest other vocational environments in which maths could be used.

To support understanding of where maths is used, further resources in various vocational and social situations should be created. In virtually all cases the contextual approach to demonstrating maths was found to add meaning and purpose. Without the use of the web and interactive tools, adding such relevance in the classroom is difficult to achieve. Making maths more understandable is possible with multimedia applications, but keeping the problems simple, clear and understandable is a challenge for teachers and web designers. The use of on-line multimedia packages, supported with posters and worksheets seems to be the most effective way of transferring the material into the classroom. To address teacher resource needs, full classroom exercises supported with teaching aids and theory packs that match curriculum needs should be provided.

While the project has received support and interest from academics in secondary and further education, it did encounter one academic that felt the project could be detrimental to the study of maths. The academic believed that such contextual approaches were not conducive to a comprehensive understanding of maths and its potential applications. He viewed this approach to maths education as coaching, believing that such methods curtailed a student’s understanding of where maths could be applied. In his view, maths should be delivered in its pure form. He felt that where teaching was delivered without the confines of context, students would have the freedom to apply the maths wherever it worked. He believed that contextual maths, could encourage children just to learn the maths for one situation. Because of the confined approach, students could fail to recognise that, with slight adaptation, formulae can be applied to many aspects of life. For this reason it was felt that some effort should always be focused on developing a real understanding of the maths and not just showing maths in context. Further development is needed to create interactive supportive materials that go back to first principles and ensure the theory is properly delivered ad explained.

Observations and feedback suggests that functional maths can be embraced in interactive web environments making maths more interesting and meaningful. With first principles being explained with the aid of audio, video and animation it is likely that understanding of basic maths will improve. Further research is required to develop and test interactive first principles maths tools that link to contextual information. Such tools will provide valuable support to functional maths.

There are very few sites that offer open access interactive maths and science teaching materials. Schools are encouraged to embrace and use ICT within their teaching, yet high quality resources to inform the maths curriculum are not readily available. Currently there are few sites to compare the Virtual Maths site against; the exception is the Bowland Maths project. Teachers and students find the links useful, searching for web sites is getting more time consuming as the number of sites, including dormant ones increase. Links, from the Virtual Maths site, to all of the sites that offer open access maths material have been provided.

**Background**

The QCA (2006) functional maths proposal calls for application of maths to ‘real world situations’. While it would be beneficial to take students out of the classroom to experience maths in the ‘real world’ such activity is resource heavy and time consuming. Equally, the potential dangers of some environments means that considerable effort is required to ensure risks are sufficiently reduced and controlled so that students can enter them. The practicalities of anything other than the occasional out of school trip makes the real world experience difficult and costly. However, through the use of multimedia technology maths can be set in a real world context. Using current Flash technology it is now possible to build interactive environments, with layers of information, supported by audio and visual effects that embed maths in the real world. The working context also adds meaning and purpose to the maths. As students navigate their way through the activities they can easily be exposed to aspects of life that they would not normally encounter. Working through the interactive work-based problems requires the students and teachers to take in information about the environment within which the maths is set.

**Potential for parental access and involvement**

The Virtual Maths project goes someway to meeting government and educational agendas. The maths on the site is functional and makes the connection between education and the workplace more obvious. The project also helps to expose the learner to real work environments and provides links and access to other information that may assist with careers and general understanding of working life issues. Such tools, which connect education with wider social and vocational topics, could be interesting to parents, encouraging greater parent pupil engagement.

Open access tools can be designed with supporting information so that they can be used by parents. Parents could be informed of their use in class before they are used allowing parents to revisit and learn the maths themselves before engaging in learning activities with their children. The NCETM (2009) states that parents are much more likely to assist with their children’s learning if suitable activities and support systems are provided. Parents can view open access resources at home, or in-school sessions could be arranged to encourage parent involvement. With BECTA (2009) and Byron (2009) reporting that parents feel excluded by their children, information that is open access offers one method of helping parents engage in school life and a potential method of encouraging conversation.

**Integrated learning and unravelling complexity**

QCA (2006) have advocated the need to take students through contextual problems, which can be complex. Using web technology it is now possible to demonstrate and explain theories in multiple ways. The use of different deliveries supported by audio, video, text and various other graphics makes it easier to unravel and explain problems. Different delivery formats and styles should increase the potential of achieving understanding.

By integrating maths with vocational information, the benefits go beyond the immediate educational experience. Such aspects of integrated learning have already been identified as an important benefit of e-learning (BECTA 2008a). As well as being exposed to the general and vocational knowledge, students also acquire ICT skills. Learning by doing has been found to be the most common method of developing ICT skills (National Statistics Office 2007); it is also considered that the learning-by-doing rule can be applied to the maths. Skills required in industry can be replicated in school and the connection to professional practice can be made clear through multimedia resources. Technology should be used to make teaching more functional and effective.

Surprisingly, ICT is used less to support the delivery of maths in secondary education than it is in primary schools. In secondary schools, ICT is used more for English than maths (National Statistics Office 2007). The statistics are unusual when considered against a real world that makes extensive use of technology to process numeric tasks.

**Making maths appropriate to the learner and raising the standard of maths**

There is a clear need to develop support material that ensures teachers have a range of options at their disposal to accommodate different learning styles and capture student interests (Clausen-May 2005). While there is debate over teaching and learning styles and their impact (Bose and Bahr 2008), it is obvious that if teachers have a range of resources at their disposal they are more likely to be able to accommodate the needs of students. Although the use of ICT in the classroom has increased, the potential to assist maths teaching and learning has not been harnessed. This is surprising considering the speed with which ICT has readily assumed its place in manufacturing and industry. The web is world wide, yet there are few sites that offer open access interactive maths resources for use in the teaching maths. While other developed countries are also experiencing problems in the standard of maths education there is no real evidence of resource support being provided on the internet.

The issue of standards in mathematics and science is not just a UK problem. Kuenzi (2008) reporting to USA Congress stated that “There is growing concern that the United States is not preparing a sufficient number of students, teachers, and practitioners in the areas of science, technology, engineering, and mathematics (STEM). A large majority of secondary school students fail to reach proficiency in math and science, and many are taught by teachers lacking adequate subject matter knowledge.” While in this study the UK ranked slightly higher than the USA, concern regarding the standard of maths education is just as evident in the UK. Lowry (2009), Chairman of the Institute of Civil Engineers stated that “…employers have noted that there have been many years of decline in the standards of maths and science knowledge. If children are unable to understand maths at primary school it will be much harder for them to progress to diplomas and university courses in order to become qualified and knowledgeable engineers.”

Speaking at the start of National Science and Engineering Week, Lord Drayson said: “As we enter tough economic times and look to boost British expertise in areas such as high tech manufacturing, the foundation for which is Science, Technology, Engineering and Maths skills, it is more crucial than ever that employers join the drive to inspire young people about the possibilities of studying and pursuing a career in these areas” (STEMNET 2009). The need to improve the standard of maths education and experience and the push to engage with industry is evident.  
 

**Research method: Iterative research, development and evaluation**

Using the Leeds Metropolitan University - School of the Built Environment’s ‘Virtual Site’, five maths problems have been created using Flash technology. The technology has enabled maths problems to be set in a virtual context created using spherical panoramic photography and videos of real situations. Each maths problem was created sequentially and immediately made live enabling the designer to work with feedback from users as the next learning object was being developed. The iterative development enabled the designers to experiment with different tools and environments.

The overall aim of the project was to work with school and college students and teachers to develop open access maths, science and technology web resources set within the context of engineering and construction.

**Project objectives included:**

* To provide a resource that is available to all with access to the internet. To ensure that internet access is not a limitation, by producing downloadable handouts that enable students and teachers to have access to the materials for none computer based learning.
* To create links between schools / colleges and the university ensuring better understanding of the learning needs.
* To provide support material to help students to develop the necessary skills to transfer from one establishment to the next. To develop open access tools, for use in secondary and further education helping to narrow achievement gaps.
* To develop flexible learning tools, that could be used to support standard and alternative curriculum while at the same time demonstrating the subject’s relevance to real world scenarios.
* To provide resources that could be used by those teaching the pure subject or those engaged in vocational education.
* To capture the interest of students that have underachieved or disengaged. To work directly with students increasing the potential of producing materials that can capture the interests of the widest student group. To use the web and downloadable resources to extending education to the ‘hard to reach groups’.

The use of the Virtual Site and the Virtual Maths project is not exclusive to Leeds Metropolitan University. The site is open access and can be used by all education and training establishments. A number of development agencies, education and training bodies have been in contact enquiring about potential use of the site. The Virtual Maths site can be found in the ‘Classroom’ at the following address: http://www.leedsmet.ac.uk/teaching/vsite

The development and research has been undertaken using action research methods. Initially, examples of a contextualised maths project were developed by a team of academics, web designers, construction professionals and maths specialists. The team put forward their ideas to create a scenario that would capture the interests of students. Once developed, the ideas were presented at schools and feedback was sought. At the same time as showcasing the tool, school children and teachers were asked for their ideas of situations within the built environment that could be used to develop interesting maths problems. A number of children suggested situations within their own school which could be used as a context and maths problems that could be developed. Four exercises set in the Schools have been created.

Once the ideas suggested by the schools were developed, further feedback was sought on their potential effectiveness as maths tools for self-study, teaching aids or potential learning packages.

The tools were presented at four workshops in secondary schools. Sessions were also held with pupils to see how they navigated their way through the tools, worked with them and used them as study aids. The project was also presented at a maths meeting, workshops for the regional West Yorkshire Life Long Learning Network, a construction sector group, the BECTA conference and the ARCOM conference. Feedback on the project was gathered from all meetings.

A list of schools and colleges that have been involved or shown the project are listed in the appendix.

**Working with children from the net generation**

The way children learn and the methods of accruing knowledge has changed; it is the norm for children to grow up with the technology and computers. By 2009 18.5 million households will have access to broadband (BECTA 2008). And, although all schools in the UK have computers, over 1.4 million children don’t have access to the internet at home (BESA 2007). Although initiatives are underway to develop access in libraries, schools and through mobile technologies, it was considered important for the Virtual Maths project to identify interim measures ensuring students can take away resources and learn without a computer. Resources that are downloadable, such as PDF files can be printed out and also accessed on many mobile phones.

Initially, all of the information was focused around the interactive web environment; however, feedback from teachers suggested there was a need for some breakaway activities that allowed students to come away from the computer and work through problems on worksheets. Students could still return to the computer for information, guidance and prompts, but it was clearly thought that engagement with their peers and working on paper was a good thing. It was obvious that computer work does not need to be an isolated learning process but can easily be used to foster and stimulate group activity and in-depth engagement with the problem. It was also considered that this type of computer – non computer interaction was more realistic of current real world problem solving.

Following the recent BECTA (2009) report that showed 82% of parents felt left in the dark about their children’s school day, initial feedback suggested that the Virtual Maths worksheets which included the web address would also provide links for parents to the school activity. While the worksheets have a practical use in the classroom, they can also be used to encourage parent-student learning at home. Worksheets can be used in the class or as homework. The online resources coupled with the worksheets used as homework provide a supportive framework for parents to assist and take part in the technology based learning activity. The Virtual Maths site has been shown to a number of professionals in the construction industry. As the delivery of the maths is set within a familiar context there is interest in the project. If maths resources are set within a wide range of industrial and social contexts, it is more likely that adult and parent interest will be captured. The site has potential for parent engagement and life long learning.

**Evaluation**

Virtual Maths has been used by teachers in schools, and although it does not form a key component of curriculum activity, it is used to demonstrate where and how maths is used in industry. Currently the tool offers an interesting snap shot of maths problems, but more activities need to be developed. To be fully effective as a teaching resource a more comprehensive range of teaching and learning tools are needed. Feedback from the teachers suggests that the maths tools have applications in schools; however, to be used as teaching resources, it was considered necessary to have a broader range of problems and examples in each maths topic.

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 could quickly lose interest. Capable students need 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. To cater for the needs of the less able students and to maintain the interest of those who process maths problems quickly the range of problems needs to be quite broad.

There has been some evidence that students can quickly find their way through tasks, but do not necessarily understand the basis of the maths problems. To aid students who find the tasks difficult, lower level problems need to be provided and, to ensure that the learning takes students through key concepts, the theory needs to be explained. The advantage of multi media is that explanation and support materials can be delivered in multiple formats increasing the potential for understanding. Much of the maths theory lends itself to illustration using animation and video.

Dealing with differences in student ability can be more challenging in maths. Boston (2006) suggested that the range of difference in mathematics is greater than in the vast majority of other subjects; and this poses particular challenges for mathematics curriculum, teaching and assessment. At the same time he voiced concern that “… curriculum, teaching and assessment regimes should extend the most mathematically able young people to the far limits of their potential, as well as stretch the less capable and build a universally numerate society.”

Through development of multiple resources, e-learning has a great potential to challenge the advanced learner and support those that need more guidance. To ensure that the tool receives greater use, more supportive material need to be developed so that packages of work can sustain whole classroom activity. Set around the interactive examples of web media, multiple tasks and worksheets can be developed to ensure students can work at different levels, developing and stretching understanding.

The link to the real construction contexts and situations is something that has captured 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, to demonstrate a real application of the theory.

Tools have been used in the classroom to demonstrate where maths problems are applied. The tools set around the construction context, utilising plant and equipment on the construction site tend to stimulate interest. The sites with more interactive features tend to generate greater interest. The dynamic 360o photographs with embedded learning objects have also proved more successful than still images. However, to make the tools an effective part of the curriculum more and varied examples of problems are needed. The material and features need to be matched to curriculum and student needs. A teacher commented that there are a few similar web sites available, but currently there are insufficient resources on the sites to be used as full teaching and learning activities. It is clear that the tools do have potential, but the range of resources should be expanded.

The way the materials are delivered has also captured the interest of teachers and students. At the maths workshop where the Virtual Maths tools were demonstrated one teacher noted that “there are similar sites on the web, but none of this quality using real photos and video images”. Teachers were surprised that the site was free and open access. Teachers were under the impression that such sites need passwords, which is not the case with the Virtual Maths site. Feedback from the teachers would suggest that sites which do have passwords or require user information to gain entry are establishing an additional barrier to their potential use.

**Working in pairs and small groups**

A few teachers and maths consultants suggested that the students often work better on functional maths tasks when working in pairs or small groups. It was suggested that additional activities based around the interactive environment could promote discussion and deeper understanding of the problems. Ideas were proposed similar to the Bowland Maths project (Bowland 2008). It is believed that games and activities based around the interactive environment, supported by video, animation and audio clips could assist paired and group activity, making them more stimulating.

**Pace and recap**

Each exercise is supported with controls that take the students step-by-step through the exercise. The interactive tools, with forward and backward controls, allow students to learn at their own pace. However, it was noted that when students sit close together they are aware of their neighbour’s progression. In some instances it was noted that students would skip sections to catch up with their peers. If students had noticed an image or scene on another person’s computer that they found more interesting some students were inclined to move to that section. The interesting aspects of the site can both engage the students and cause distraction. With a little classroom management, such distractions are easily overcome. In some of the workshops student were encouraged to play with the tools for a couple of minutes, allowing them to skim over all of the interactive features, before undertaking the maths problem. Children chatted about the tasks and were quick to note any peculiarities and interesting aspects of the site. After a few minutes of exploring, students were asked to complete one of the maths tasks; this helped focus their concentration on the exercise. When students worked in pairs on computers there seemed to be improved engagement and interest.

The forward and backward feature was considered useful by teachers and students alike. The resources are being used by teachers as introductory and refresher exercises. With the forward and backward pass control teachers also use the tools and the graphics, adding their own explanations to help students understand the theory. In this instance teachers are using the graphics in similar ways to Powerpoint presentations. To support the project images can also be offered as Powerpoint slides.

**Students learning, revising and refreshing on their own**

Some older college students had noted that with maths problems they had often been embarrassed to admit to their tutor that they were struggling with maths. These students suggested that such resources were useful for catching up and revision, especially since they could be used outside the classroom when studying alone. 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. As the amount of resources are built up around topics the potential for understanding should increase. Eventually hotlinks could be introduced to link topics to other relevant theory providing additional information to help understanding.

One student noted:

“You can do this as many times as you want. If you don’t understand something you can go back and do it again.”

Another college 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.”

The level of interest and enthusiasm for the development of highly interactive web resources is quite clear. Resources that are open access enabling students to learn and catch-up on their own is important.

**Outside of construction: A real interest in vocation**

Teachers and children suggested other working environments that could be used to create interesting maths projects. When discussing various scenarios that interactive problems could be set in, the children were enthused and eager to put forward their interests. Ideas, such as, the maths problems that could be set around the fire service – calculations, for example working out the of volume of water used in a given time, trajectory of a jet of water, power needed to drive a hose to enable the water to reach the fire and other fire related scenarios were suggested. Sports activities were also put forward as areas that could easily be developed into interesting maths problems. As the project was based on construction much of the discussion centred around buildings and equipment. Skyscrapers, cranes, diggers seemed to generate interest. Construction management problems were also discussed, including the cost of a building, time taken to build or demolish a structure. Once the students realised that they were free to suggest their ideas, it was clear that they had interests in many areas that could be linked to maths. The ideas were varied, but all were functional and it was clear from the enthusiasm that the children thought their ideas would capture their own and other students’ interest.

School children and teachers also suggested ideas associated with gaming technology, which were beyond the realms of this study. Flash technology is a relatively cost effective way of developing interactive environments. The technology is getting easier to use, and as resources develop, teachers and technicians should be able to adapt Flash tools to meet current and changing demands. However, the type of gaming technology that the children alluded to is still expensive and although it is possible to develop simple games in Flash, this has not yet been attempted by the team. A review of maths games that are available on web sites shows that most are very simple and bear little comparison to the gaming console technology that students are familiar with.

**External review: Mathematics Education Consultant**

The following section is taken from a report produced by a mathematics education consultant written in response to the following questions posed in relation to the Virtual Site Classroom at January 2009. The comments are a reflection based upon the utility of the site to those teaching and learning Mathematics in secondary schools and colleges.

**Which aspects of the site are interesting?**

Reviews by academics and maths consultants found that the most interesting aspects of the Virtual Site Classroom were the use of dynamic and static images, the mathematical problems set in context and the ICT functionality.

The maths consultant noted that:

A review of the most recent publications on school and college Mathematics promises much. The Virtual Site Classroom is certainly the kind of learning opportunity envisaged by those responsible for developing the new Mathematics curriculum:

*“The curriculum should provide opportunities for students to:*

* *develop confidence in an increasing range of methods and techniques*
* *work on sequences of tasks that involve using the same mathematics in increasingly difficult or unfamiliar contexts, or increasingly demanding mathematics in similar contexts*
* *work on open and closed tasks in a variety of real and abstract contexts that allow them to select the mathematics to use*
* *work on problems that arise in* [*other subjects*](http://curriculum.qca.org.uk/key-stages-3-and-4/subjects/mathematics/keystage4/index.aspx#note5_1_a) *and in* [*contexts beyond the school*](http://curriculum.qca.org.uk/key-stages-3-and-4/subjects/mathematics/keystage4/index.aspx#note5_2_a)
* *work on tasks that bring together different aspects of concepts, processes and mathematical content*
* [*work collaboratively*](http://curriculum.qca.org.uk/key-stages-3-and-4/subjects/mathematics/keystage4/index.aspx#note5_3_a) *as well as independently in a range of contexts*
* [*become familiar with a range of resources*](http://curriculum.qca.org.uk/key-stages-3-and-4/subjects/mathematics/keystage4/index.aspx#note5_4_a)*, including ICT, so that they can select appropriately.”*

*National Curriculum, Mathematics, Key Stages 3 & 4 programme of study; QCA (2008)*

Furthermore the requirement for Functional Mathematics to be a part of this curriculum is an extra impetus for schools and colleges to use resources like the Virtual Site Classroom. It offers access to realistic, challenging Mathematics in engaging work-based situations, but can be assimilated into teaching without venturing out of the classroom. The Functional Mathematics guidance for teachers talks explicitly of such learning:

*“The key stage 3 programme of study lays the groundwork for pupils to apply their mathematics to real contexts in key stage 4. In addition, it requires that pupils be introduced to a range of real-life uses of mathematics, including its role in the modern workplace. When planning opportunities for pupils to develop and understand functional skills you should consider if you have:*

* *provided opportunities for different skills you are focusing on in representing, analysing and interpreting to be developed in combination*
* *ensured that pupils understand that they are learning skills that they will use and apply in a variety of contexts*
* *given pupils the chance to select the skills and tools (including ICT) they need for a particular task*
* *provided opportunities for pupils to apply these skills for real purposes and contexts beyond the classroom.”*

*National Curriculum, Functional Skills in the Mathematics programme of study; QCA (2008)*

The most recent subject report on Mathematics was based upon evidence from lesson observation in 192 schools. Its key findings include a judgement about the ICT and cross-curricular opportunities that are generally offered to learners. This further highlights the potential value of resources like the Virtual Site Classroom:

*“The content of the mathematics curriculum in most of the schools surveyed was age-appropriate. However, the majority of pupils had too few opportunities to use and apply mathematics, to make connections across different areas of the subject, to extend their reasoning or to use information and communication technology (ICT). Higher-attaining pupils were not always challenged enough in lessons. Links with other subjects were insufficient.”*

*Understanding the score – messages from inspection evidence; Ofsted (2008)*

**In which ways can the materials be developed to produce full teaching and learning packages for use in schools and colleges?**

In its present form the resource could be used by schools and colleges who are given access and face-to-face training. To increase the possibility of extended use and of use by those who cannot engage in such training, the following developments should be considered:

* Online Professional Development module for use by departments or individuals (see NCETM site for examples)
* Curriculum mapping of tasks
* Key concept mapping of tasks
* Increase the number of hotspots in each area of the site to engage learners

The report offered by the external consultant is supportive of the project, projects like it and their general potential.

**New courses and links to functional maths**

The project has identified a need for contextual and functional learning and has identified one way of delivering multimedia content, including the use of Flash animation, which can assist in the delivery of maths. The project bodes well for the proposed pair of GCSE’s in mathematics, to be piloted from 2010. The two GCSE proposed are Formal Mathematics, focusing on the rigorous and coherent nature of mathematics and Contextual Mathematics, focusing on the application of mathematics (ACME 2008b). The new diploma will also benefit from such resources.

**Critical comments and areas of development**

When discussing the tool at a regional university forum, one maths lecturer 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 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. Indeed there were plenty of points put forward for contextual and functional maths, some members suggested that it was the only way they had managed to find to engage students. One tutor noted that without altering the way maths is taught many students just miss out on a maths education altogether.

The e-learning environments can be developed so that the maths tools that are applied to a construction context are also be produced without a context, in their pure form. Vocational learning, especially when it is built in an interactive web context does not have to preclude other methods of maths delivery. It is proposed that step-by-step approaches to the pure theory could sit alongside the contextual information. As the aim of this project was to capture interest and accommodate as many different learning styles as possible, this dual approach may be beneficial. As already discussed there is a need to clearly explain fundamental principles of the maths to support functional delivery.

**Opening up access and accommodating disabilities**

The issue of dyscalculia was 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 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 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 needs to be 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.

**Working within industry**

BECTA’s (2008c) recent call for closer co-operation to encourage innovation, share best practice and respond to the range of new curriculum, management and staff development challenges requires more than just those engaged in ITC to work together. To develop vocational tools that maintain their currency there is a need to work with industry. Through the work on this project partnerships have evolved that are allowing leaning and development opportunities on many fronts.

The web tools have been developed with help from industry. The construction companies and their staff have supported the project with access to construction sites, project information and technical support. Such relationships have been key to the project’s success, since feedback from teachers and experts often means that different problems and scenarios need to be found to match the level and nature of maths required.

The construction site is an interesting working environment with lots of maths, science and engineering problems; however, it is also very hazardous. The virtual environments can be used to access work environments and allow children and students to investigate aspects of work that they are normally precluded from. Exposing students to areas of life that is outside their general experience can create a certain amount of interest in itself.

**Expanding the project**

Currently there are a few exemplar projects that offer links between maths and vocation. The National Centre for Excellence in the Teaching of Mathematics ([www.ncetm.org.uk](http://www.ncetm.org.uk)), Centre for innovation in mathematics teaching ([www.cimt.plymouth.ac.uk](http://www.cimt.plymouth.ac.uk)) and Proskills (www.proskills.co.uk) provide functional maths resources that can be downloaded and printed out, similarly the Cre8ate maths project at Sheffield (http://cre8atemaths.cseprojects.org) has downloadable resources. The Bowland Maths ([www.bowland.org.uk](http://www.bowland.org.uk)) project is one of the few sites that offer open access interactive web material. Currently, the development of maths resources is sparse and sporadic. Currently, the Virtual Maths project stands alone, no other sites have been found that are utilising interactive 360o images, video and animation to take students through functional maths problems. Further development is needed to roll out the skills necessary to build similar functional maths and science environments.

**Conclusions**

The project has proved effective in capturing the interest of students and teachers. The potential of Flash and other web tools to contextualise learning materials to make them functional is clearly available. Students are inquisitive of the environments they explore and spend time looking at the problems in their context. Adding functionality to maths makes the subject more relevant, interesting and meaningful.

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. Most students are e-mature and quickly find their way around the web pages. Those students that are most capable explore the options at speed and work through the problems. Allowing students to work at their own pace is a considerable advantage; however, to maintain interest the options and activities available need to be extensive. For those students that need more guidance to understand the maths, help can be provided in a number of different ways in an interactive environment. Text, drawings, animation, audio and video can be drawn on to provide supporting information to help students to understand.

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. The research showed that what was obvious for one web designer or learner was not immediately understandable to another. Testing of web environments, their navigation tools and information is important.

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.

The use of computers to help understand maths does not need to be one which removes human interaction. The research has indicated that the use of interactive computer tools can capture interests and foster deeper learning and engagement in problem solving through peer and group activity. Packages of work centred around the interactive environment need to be developed and explored.

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 – one that can help and learn from each other. Closer links and cross-sharing of teaching and learning resources should assist the student transition, making it easier to move from institution to institution.

**Bibliography**

ACME (2008a) 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]

ACME (2008b) ACME Welcomes piloting of pair of mathematics GCSEs, report, *Advisory Committee on Mathematics Education* 12 December 2008 <www.acme-uk.org/news.asp?id=110> [accessed 16 12 2008]

BECTA (2008a) Universal access / parental engagement – A guide for school leaders. BEC1-15520, January 2008, *BECTA,*Coventry. <www.becta.co.uk> [accessed 15/12/08]

BECTA (2008b) Exemplary Progress: A network to share best practice. BEC1-15520, 26 November 2008, *BECTA,*Coventry <www.becta.co.uk> [accessed 16/12/08]

BECTA (2009) 82% of parents left 'in the dark' when it comes to their child's schooling. <<http://news.becta.org.uk>> [accessed 24/3/08]

BESA (2007). *Personalised Learning in Schools* – 2007 edition. ‘ICT in Schools’ series in association with National Educational Research Panel (NERP).

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

Bossé, M. J. and Bahr. D.L. (2008) The State of Balance Between Procedural Knowledge and Conceptual Understanding. *In Mathematics Teacher Education. International Journal for Mathematics Teaching and Learning*, 25th Nov 2008, Centre for Innovation in the Teaching of Mathematics <[www.cimt.plymouth.ac.uk/journal](http://www.cimt.plymouth.ac.uk/journal)> [access 11/1/08]

Bowland (2008) Bowland Maths: An imaginative resource for teaching mathematics Key Stage 3, *Bowland Charitable Trust* DVD learning package <[www.bowlandmaths.org.uk](http://www.bowlandmaths.org.uk)> [Accessed 10/11/08]

Boston, K (2006) Speech to the advisory committee on Maths Education, *Qualifications and Curriculum Authority* 8th March 2006 <www.qca.org.uk/qca\_8579.aspx> [accessed 14 12 2008)

Byron, T (2009) Oh Nothing Much Report: The value of after School conversation. BECTA, <[www.nextgenerationlearning.org.uk/ohnothingmuch](http://www.nextgenerationlearning.org.uk/ohnothingmuch)> [accessed 24/3/08]

Clausen-May, T (2005) *Teaching Maths to pupils with different Learning Styles*  
Paul Chapman Publishing, London

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, Vol. 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]

Kuenzi, J. J. (2008)Science, Technology, Engineering, and Mathematics (STEM) Education: Background, Federal Policy, and Legislative Action, *CRS Report for Congress, Congress Research Service.* March 21 2008 < [**www.fas.org**](http://www.fas.org)> [accessed 2/2/09]

Lowry, M (2009) Inspire Scholarship Work placement award launch. The ICE QUEST Undergraduate Scholarship, Ormeau Baths Gallery, ICE Northern Ireland – Speech, *ConstructionSkills* <www.cskills.org> [accessed 20/3/09]

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]

NCETM (2009) Parent power to improve pupils’ potential. *National Centre for Excellence in the Teaching of Mathematics <*[www.ncetm.org.uk](http://www.ncetm.org.uk)> [accessed 19/3/09]

National Statistics Office (2007) *Digital age: e-Education – 48% gain skills through learnin-by-doing*,15 March 2007, www.statistics.gov.uk/cci/nugget.asp?id=1712 [Accessed 14/12/08]

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

QCA (2006) Annual review 2006: quality, Confidence and Aspiration. *Qualification and Curriculum Authority.* Great Britain. [www.qca.org.uk](http://www.qca.org.uk) [Accessed 9/12/08]

QCA (2008) *National Curriculum, Mathematics, Key Stages 3 & 4 programme of study QCA <*http://curriculum.qca.org.uk*>* [Accessed 12/1/09]

*QCA (2008) National Curriculum, Functional Skills in the Mathematics programme of study; QCA* < http://curriculum.qca.org.uk>[Accessed 12/1/09]

Ofsted (2008) Mathematics: Understanding the scores – messages from inspection evidence. September 2008 London, <[www.ofsted.gov.uk](http://www.ofsted.gov.uk)> [Accessed 12/1/08]

ONS (2006) The ONS survey, ‘Office of National Statistics: First Release: Internet

Access, Households and Individuals (August 2006)’ *Office of National Statistics*

<www.statistics.gov.uk/pdfdir/inta0806.pdf> [Accessed 11/10/08]

ONS (2007) The ONS report, ‘Office of National Statistics: ‘Focus on the Digital

Age (2007)’ gives an overview of ICT use in the UK, *Office of National Statistics*

<www.statistics.gov.uk/focuson/digitalage> [Accessed 11/10/08]

Royal Academy of Engineering (2008) Mathematic exemplars from the Royal Academy of Engineering designed for Advanced Diploma in Engineering *Royal Academy of Engineering*, <www.raeng.org.uk/education/diploma/maths/default.htm>.  [Accessed 9/12/08]

STEMNET (2009) Minister leads call for industry backing of national Science and Engineering programme. March 2009, Science, *Technology, Engineering and Mathematics Network* < [www.stemnet.org.uk](http://www.stemnet.org.uk)> [accessed 23/3/09]

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]

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. *The Mathematical Association* <www.[m-a.org.uk/education/MAResponses/Lords0606/index.html](http://www.m-a.org.uk/education/MAResponses/Lords0606/index.html)>, 19th June [Accessed 25/4/08]

**Appendix**

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Ian Dickinson – Lead project technician – Lead developer in Virtual Site technology

Paul Whitehead – Senior lecturer and engineer - Lead maths designer

Claire Walker – Industry education coordinator

Martin Smith – Research assistant

Tony Shepherd – Maths consultant

**Key Collaborators**

Morely High School - Technology College Status

Leeds College of Building

St Hild’s CofE School - Specialist Technology School, Hartlepool

Northallerton College - Specialist Technology and Vocational School

Carlton Bolling College, Bradford

**Industrial partners**

BAM Construction (Previously HBG Construction Ltd North East)

Myddleton Construction Ltd

ROK Development

Taylor Woodrow

Jorday Group

The Union of Construction, Allied Trades and Technicians

(**UCATT**), Duncan Hutchinson [d.hutchinson@talktalk.net](mailto:d.hutchinson@talktalk.net)

**Virtual Site was presented at the Functional Skills Maths Workshop, hosted by Kirkleees Learning Services, Deighton Centre. Deighton Road, Huddersfield. HD2 1JP**

Schools that attended included:

Holmfirth High School

Castle Hall School & SLC

Westborough High School

Whitechapel Middle School

Salendine Nook High School and Technology College

Honley High School & College

The Mirfield Free Grammar & Sixth Form Centre

Earlsheaton Technology College

Moor End Technology College

St John Fisher Catholic High School

Shelley college - A Specialist Centere for Science

King James’s School

All Saints Catholic College

Birkenshaw Middle School

Spen Valley Sports College

West End Middle School

Colne Valley High School

Whitcliffe Mount – Specialist Business & Enterprise college

Netherhall Learning Campus

**Other educational establishments and organisations that Virtual Maths has been demonstrated to:**

Bradford College

Kirklees College (formerly Huddersfield Technical College)

Pro Skills

Calderdale College

Wakefield College

Park Lane College

Leeds College of Technology

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