Naace
The Education Technology Association

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# Naace
# Editorial

*Author: Paul Heinrich*

*In which your editor considers the continuing importance of ICT and the issues around an entirely computer science approach.*

Reading of the wider pronouncements from the DfE on this issue makes it clear that Computer Science is only a part of the government's proposals. Certainly up till 2014 schools are still required to teach ICT at all key stages and can now develop their own curricula.

We cannot therefore become sidetracked by the Computer Science debate. Rather we need to revisit our perception of ICT – after all, the acronym means Information and Communications Technologies – in other words it is an umbrella term, albeit somewhat abused. Schools have tended to focus on the information and to a lesser extent communications aspects but have forgotten to teach about the technologies themselves, leaving pupils with little understanding of how computers work. This has to be addressed and Naace is doing so with its draft key stage 3 curriculum proposals which place a strong emphasis on technical knowledge and understanding including aspects of programming.

Many, (though not enough) primary secondary schools teach ICT extremely well, are innovative and get high standards. The schools obtaining the ICT Mark and other awards such as the Naace 3rd Millennium Learning Award are clear evidence that ICT is doing well in our better schools.

There is, however, an issue with key stage 3 and in particular key stage 4 where too many schools have promoted certain supposedly vocational courses, now discredited by Wolf and others in an attempt to meet GCSE targets set by the last government. These courses have been perceived as too easy and lacking rigour by many education professionals and by business.

Further, with many schools reducing key stage 3 to only two years there has been insufficient time to prepare pupils adequately for more rigorous courses such as Computing or Computer Science which are, in any case, perceived as difficult by pupils, have a low pass rate and have not been updated to meet current requirements. The tendency of some schools to focus on "quick win" activities such as simple presentations and basic office software skills that could be taught by non-specialist teachers has also served to downgrade the subject. This has to be addressed but focussing simply on Computer Science is not the answer.

There are, in any case, serious logistical problems in attempting to teach computer science – there simply are not currently sufficient available well trained and skilled teachers of ICT (which has been part of the subject's problem) let alone teachers of computer science. Schools already have difficulties recruiting good maths, physics and chemistry teachers and at least there are some people with suitable degrees willing to train to teach those subjects. Only a tiny number of computer science graduates - and there are few enough of these anyway – go into teaching. The profession is simply not attractive to them due to relatively poor pay and conditions compared to industry. This is not something we or the government can address quickly yet without well qualified teachers any reforms will fail.

Even if the resources are there to teach them will there be a growth in students wishing to take Computer Science and similar courses at GCSE and beyond? We have to face a fundamental issue here and that is the attitude of HE to some A-Level courses, while remembering that they largely ignore GCSEs. What HE tend to require for CS courses are students with good A-levels in further maths and physics who come fresh to the subject.
We therefore have a catch 22 – if universities don't demand CS at GCSE and A-level there is little point in schools teaching it to what will probably be small and thus expensive groups of GCSE students.

Even if we do produce far more Computer Science graduates will there really be jobs for them? Britain does well in some aspects of high technology (e.g. satellites) and media (e.g. SFX, games design) where highly specialist skills are required. No doubt there will be more jobs in these and similar sectors but overall numbers are likely to remain small. But for the majority? Well we already know that much general coding and systems development can be done much more cheaply in e.g. India. The bottom line is that simply creating more CS graduates does not guarantee that jobs that are currently outsourced will come back to the UK.

Producing students (at all levels) with a narrow range of skills is likely to be counter-productive in a world that demands and increasingly wide range of skills and the ability to adapt rapidly to a changing world. We need to take a broad view of the knowledge and skills needed by learners and by the future economy.

So how do we do that?

While young people have a familiarity with an incredible range of technologies, many of which did not exist when the current curriculum was written, they still need to be taught how to use that technology and associated tools and applications effectively and safely. That means knowing how these technologies work, how they can be applied in business and industry and how to make safe and effective use of them in their personal lives.

These skills and associated knowledge have to be actively taught - they will not be learned by some sort of osmosis. We must accept that the 'digital native' is a myth and ensure that we give learners the range of knowledge and skills they need for employment. Put simply they need a high level of 'digital literacy' in its widest sense.It is these wider skills that are essential today, with in-depth study of computer science or computing an extension for those with a real interest and aptitude. A good analogy is music - we all use music but only a few have the skills to play an instrument. Similarly we all use ICT but only a few have the interest or skills to programme or design systems.

And so to this issue of Advancing Education, which now has a more academic slant than previously. To begin we have a paper on Outstanding Teachers, Practice and ICT use from Andy Goodwyn and Carol Fuller – some useful messages here for teacher training and CPD. Julia Briggs explores a model for online learning in primary schools while the potential of 3D projection in the classroom is the subject for Professor Dr Anne Bamford in a paper produced by the Learning in Future Education (LiFE) project. Voting systems have been around for some time and in the paper by Samuel King their use in undergraduate mathematics teaching is explored, with lessons that go beyond that sector to include maths and science subjects in all phases.

Regular contributor Bob Harrison raises further key questions, this time asking if, "Will investment in ICT/Digital Technologies raise standards?" is actually the wrong question. We finish with our popular sponsors section with case studies on Ergo's 'Total Control' solution, a Steljes report on a BSF installation, an NEC paper on the use of 3D projection in a German school plus an example of Britannica Image Quest in a London school.
A wealth of information and ideas as always.

Paul Heinrich
Editor

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All views expressed in this editorial are those of the editor and do not necessarily represent Naace policy. Similarly all views expressed in articles and papers are those of the authors.

Naace

# From action research to a model for online learning

*Author: Julia Briggs, e-learning adviser Somerset LA*

*What does a model for effective online learning in a primary school look like? How can learners be allowed to independently develop their own learning? Are teachers likely to make the change to include online learning as a core part of the planned learning experiences?*

## The background

An action research module undertaken during 2011, supervised by Bath Spa University, initially focused on the question, 'Which strategies are effective in encouraging the home use of a Virtual Learning Environment?' This came from an assumption that, the possibilities offered by a Virtual Learning Environment (VLE) to involve parents in their children's learning, was an irresistible reason to plan for its development. The conclusion of Desforges (2003) that what parents do with children at home is the most significant factor in their learning, was a persuasive argument to encourage home learning. However, initial conversations with learners and with teachers provided evidence that learners wanted to use the VLE to be independent in their learning, as much as to share it with their parents; and teachers revealed barriers which existed to prevent development to make a VLE a sustainable tool to build a learning partnership with home.

In addition, the action research was taking place at a time when changes in Government funding and approaches to education were bringing the differences in adoption of online learning into clear focus. It became apparent that the Government target set in 2005 for pupils to access an online learning space was being put aside. Decisions made by schools to continue to invest money and time in future online learning, seemed to depend to a large extent on the attitudes of teachers to the use of a VLE.

Some primary schools had fully embedded online learning as part of their pedagogy, there were more where one or two teachers within the school had embedded it within their practise, and a large number where time constraints was the main reason given for not moving forward with the possibilities offered by this technology. As many schools were still at the planning stage for implementation (Underwood, 2010), when national changes took place, the driver for change in pedagogy placed additional importance on the level of teacher engagement in order for schools to continue to provide learners with online experiences as part of their education.

## The research

The action research began with a survey of ten primary schools to establish how they were making use of Fronter VLE (procured for all Somerset schools). Five of these schools agreed to become part of a project to identify effective strategies to encourage increased home use of Fronter. Using a generative transformational evolutionary model of research, McNiff and Whitehead (2010), I gathered evidence from these and two other schools which, together with consideration of key learning theories, were crystallised (Borkan,1999 in Robert Wood Johnson Foundation website) to identify a model for effective use of a learning platform in a primary school.

The three key theories of learning that contributed to the model that evolved were: the Vygotskian view of a child's cognitive development requiring not only talk with adults and other children but also the interaction with the predominant culture (Alexander, 2008); the benefits of dialogic learning (Lyle, 2008); and Tu's (2005) model of interactive online learning. These led to a recognition of the need for blended classroom, online and family learning.

The model of effective use which evolved went beyond the parental involvement that was the initial focus for my action research. The evidence collected demonstrated the inseparable link between teacher, learner and parental engagement and it became clear that teacher engagement was of paramount importance. Where teachers recognised the importance of including the technological experiences of learners at home (Sharples, 2009) as part of their learning experience at school, the commitment to involving parents was apparent. Where the understanding of this was missing the use of a VLE made little impact. It also revealed the importance of the use of a VLE as part of the learning planned for the classroom. Where the classroom learning was blended with online learning the confidence of the teacher with the technology was increased and the awareness of the learners to ways they could revisit, reinforce and develop their learning was increased.

## Engagement with theoretical frameworks

I've already refered to the way online learning provides an additional opportunity for schools to involve parents in their children's learning, and to the findings of Desforges (2003) that parental involvement in the learning is the biggest factor in a learner's achievement. This is further emphasised by Harris and Goodall (2008) who differentiates between the engagement of parents in the learning at home and the involvement of parents in the life of a school. Accessing a learning activity at home can be important, but it is the way this is shared with parents or peers to support the learner in developing their understanding that can make a difference. Vygotsky (1978 cited in Lyle, 2008) was interested in the relationships and talk between children, their families, peers and teachers which contributed to children making sense of their world. A VLE has the potential to blend the classroom and home talk. Furthermore the opportunities which can be part of the online activity can support Bakhtin's concept of dialogical meaning making (cited in Lyle 2008) so that the learner is active in talk at home and school but also in writing, where a blog or discussion is used as part of the process.

This interaction is part of the model for online learning suggested by Tu (2005). Rather than presenting information to learners online he recognises the cognitive web tools which can assist knowledge construction. These tools, such as blogs and wikis, are part of the world children are growing up in, where the Internet is a central part of human culture. Relating this to Bruner's idea (cited in Lyle 2008), of the centrality of human culture to children's development, a further emphasis is placed on the need for online learning to be integral to learning experiences. At the same time, consideration must be given to the learners who do not have access to the Internet at home (Sharples 2009); which may be the same children that have a qualitatively different experience of talk at home (Alexander, 2008). The online experience could impact on the quality of talk if the access to technology is made possible.

Tu (2005) describes the VLE or learning platform as the management tool which provides the access to online learning activities. It provides a structure accessed by the learner where they can independently explore ideas which can be within their zone of potential (Vygotsky cited in Alexander, 2008). They can choose to be supported by a peer, parent or teacher. The teacher relinquishes the choice and therefore their power to the child (Claxton, 2007) which can represent a challenge, perhaps partly explaining a reluctance by many to engage with the new possibilities offered by a VLE (Underwood, 2010).

Notwithstanding this barrier to change, the blending of classroom and online learning provides a way to make the out-of-school use of technology, and the dialogue which can take place between peers to increase their achievements in experiences such as those within Club Penguin (Gunick, 2010); part of the learning experiences being planned by educators and allows parents to be part of those experiences. This can be embraced as seen in the blogging experiences of the learners described in Deputy Mitchell's blog and described by Mr Mitchell and his learners at their presentation to BETT in 2011. http://mrmitchell.heathfieldcps.net/2011/03/01/our-bett-2011-seminar/

## Impact observed on children's learning, achievement and attainment

There are three areas I identified whilst collecting evidence from schools about home use of a VLE, where a direct impact was observed on children's confidence as learners and which could impact on their achievement:

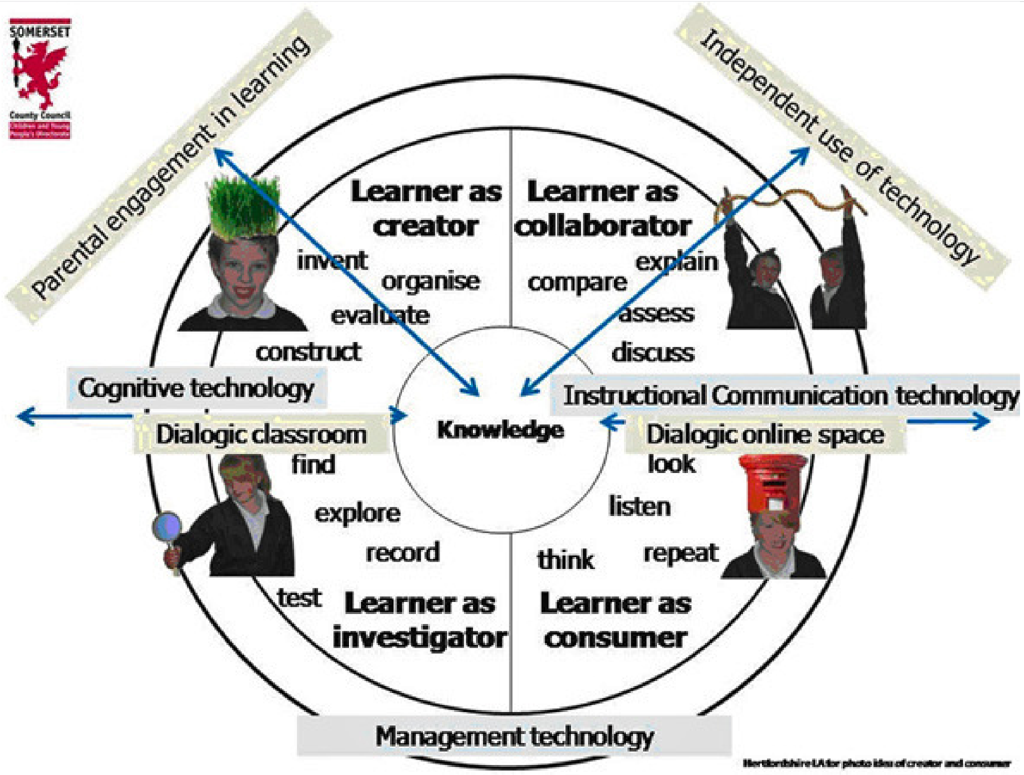
1. Making independent choices as learners
Interviews with learners (Somerset LA, 2011) provide a sequence of descriptions by the children of how they choose learning activities they know will help them to raise their achievement. This happened in classes where the teacher was confident to set up learning experiences which could be followed by learners as they chose.

2. Demonstrating understanding and confidence in e-safety issues
The interviews with learners at one of the project schools (Somerset LA, 2011) revealed the way in which they were becoming discerning and responsible users of the Internet. Their VLE had become the starting point for many of their activities and provided the link to an appropriate search engine to use when doing research. Their confidence to use the Internet appropriately demonstrated the way their teacher had provided a scaffold to move them towards independent use to support their learning.

3. Increased motivation for homework
Two of the project schools used the handing in of homework online to increase home use. The data collected from one school shows the increased motivation to complete the homework. For one lower achieving girl there was also an indication of this causing a change in attitude to physically handing in homework.

## Outcome

The model of interactive online learning put forward by Tu (2005) has been refined as a model for effective use of a VLE for a primary school. The model can be found on www.somersetelim.org and can be 'built' as part of considering a school considering a strategy for developing online learning.




The model recognises the use of technology that is already part of the home experience for some learners and harnesses it as part of the construction of knowledge. It provides a balance between classroom and online learning experiences as learners create, collaborate, investigate and consume knowledge. It encourages teachers to recognise the web 2.0 tools which can both instruct and help learners to build their own understanding. It also emphasises the need for both dialogue in the classroom about the online experiences, and the provision of opportunities for learners to respond to and revisit the classroom activities online. All this within a structure that puts the whole range of learning within the control of the learners and provides opportunities for parents to engage with the learning taking place.

The management structure could be a VLE or Learning Platform. It could equally be a blog or a website where learners follow links to a range of activities.

## The challenge

Schools will be making decisions about their future strategy for ICT. Online learning needs to be a part of this and teachers may need to think through their attitudes to the new technologies which challenge the traditional ways knowledge has been constructed by learners. The alternative is for children to continue to learn in school in ways they have always learnt; and then to choose to develop their knowledge through the tools they may, or may not, have access to at home.

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# Naace
# Britannica Image Quest at Latymer Upper School

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*Author: Paul Heinrich*

Cited in:
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*Latymer Upper School is an independent day school (11-18) based in Hammersmith, London. Since investing in Britannica Image Quest, the school has reported the positive effects the resource has had on its younger students' research skills.*

## What is Britannica Image Quest?

Britannica Image Quest is an online resource that contains over 2 million high-resolution images sourced from over 50 of the world's best image collections.'

## The Problem

Latymer Upper School's librarian Terri McCargar noticed that students of all ages within the school were keen to use images in project work. However, she could see from their computer activity that the majority, oblivious to copyright laws, were searching and copying images from the internet without understanding the source of the image, whether they had the right to use it or how to credit it.

## The Solution

When Terri discovered Britannica Image Quest in March 2011, after enquiring about another Britannica product, she believed that the image database would be an excellent tool for both students and staff at the school. On first seeing the product she commented: "Britannica Image Quest struck me as an attractive alternative to Google Images and other image providers, whose search results often prove too random and distracting for younger students. Image Quest seemed to be a more extensive and responsible resource that provided high-quality images that are copyright-cleared for school use."

After setting up the subscription, the challenge was to introduce it among students. The annual physics project, in which all Year 7 (166) students research a planet and make their own presentation, provided an ideal opportunity as the school librarians had already worked closely with the physics department to develop and deliver research training. In the first of four library-based lessons dedicated to the project, the librarians demonstrated how to search for and download images of a planet using Image Quest, and how to make a picture list (bibliography) of the images used. Students were instructed to use Image Quest for all their images and to cite them correctly. Each student was given two class handouts created by Terri: one to explain how to use Image Quest and the other to teach them how to cite images, a skill they will need later on in their academic careers. Students then worked independently during the remaining lessons, carrying out research in library books and online on their chosen planet.

## The Benefits

Since introducing the Year 7 students to Britannica Image Quest in November 2011, some teachers have reported an improvement in these pupils' awareness of copyright and their behaviour when researching images. Terri remarked: "I've had only a few questions on how to use Image Quest itself – it's quite a simple interface, so I hoped that would be the case. I've had a lot more questions on the referencing aspect, which is understandable – they're only 11. Having to record information like the title of the image and the copyright holder has added to their learning – it isn't necessarily just a pretty background; many students have been careful to choose something that illustrates what they've learned about their planet."

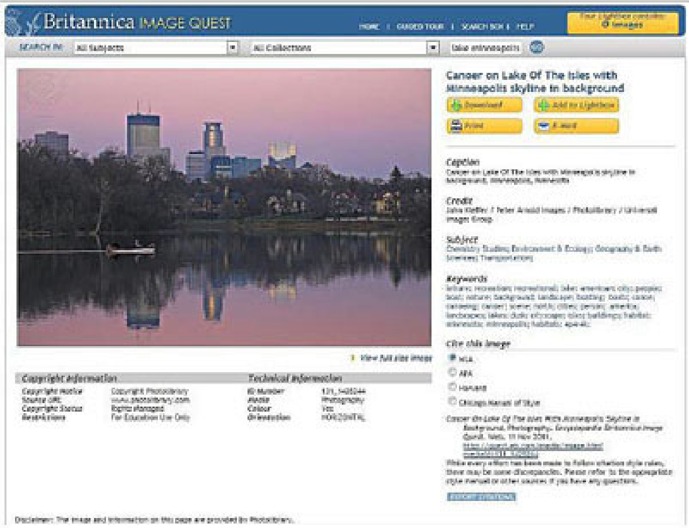
*"I've been looking for something like this for a long time. Image Quest is great as a first port of call for students' research as it is easy to use and trustworthy. Unlike with other search engines, here the students can see exactly what the image is and where it has come from." She added that the problem of unintentional plagiarism remains an ongoing challenge: "Today's students are really distracted by presentation and they're very savvy technically; they've been cutting and pasting images from the web into their school work for years by the time we meet them. And often teachers are themselves unaware that this is a copyright issue. Image Quest is a great tool for us to help tackle this. The earlier we can*

*make them aware of reliable alternatives that they are allowed to use, the better."*

## Using images from Britannica Image Quest

### Find an image

All images on *Britannica Image Quest* are cleared for your educational use. Once you've found something you want to use, click on the image or the "i" button for more information. You will then see a screen with the image and lots of information about it:




You have lots of options now, using the links at the top right. You can:

- **Download** the image.
- **Add to Lightbox** (this is like adding to your basket/trolley, for looking at later – but it seems to have some bugs currently!)
- **Print** the image. This will enable you to print the image out, with the title and credit (as listed on the page above).
- **E-mail** the image. This will send you (or someone else) an email with a link to the image in *Britannica Image Quest*. The email will include two attachments: one is the compressed picture file, and the other is a "media" text file with information about the image.



For more information on Britannica Image Quest go to www.britannica.co.uk/ebproducts/IQ.asp or email enqBOL@britannica.co.uk.

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# Naace
# An Ergo 'Total Solution' at Notley High School

*Author: Ergo*

*Notley High School & Braintree Sixth Form finds Total Control in Ergo's Solution*

Notley High School and Braintree Sixth Form is an oversubscribed mixed comprehensive school based in Essex. It was built in the 1970s and became a specialist Technology College in 2001. In 2006 it was awarded High Performing Specialist School status and used the additional funding to set up Braintree Sixth Form. In 2009 the school was graded outstanding by OFSTED. Notley High School and Braintree Sixth Form converted to Academy status in August 2011.

## The Challenge

In August 2009 Notley High School opened Braintree Sixth Form, which supported an additional 300 students. The schools current IT systems were struggling to cope with the existing number of students, so the increase of 300 pupils meant that Notley High School and Braintree Sixth Form needed to upgrade their IT servers to be able to run more efficiently. There was potential to upgrade their current servers with their existing supplier, however as the school had encountered numerous problems with their existing server infrastructure, Mark Fuller, Network Manager at Notley High School and Braintree Sixth Form, was eager to try something different.

Notley High School and Braintree Sixth Form were also using a virtual system (created in-house) to enable students to access resources from home; as systems changed parental engagement became a priority and it became clear that they needed a VLE (Virtual Learning Environment) that was fit for purpose. The school now needed a VLE solution that they could manage internally and have complete control over, but still have the support if anything were to go wrong.

## Our Solution

After contacting multiple suppliers, Mark Fuller decided that Ergo's complete solution was both cost effective and an ideal solution for what Notley High School and Braintree Sixth Form needed.

Firstly Notley High School and Braintree Sixth Form implemented a full virtualisation and server refresh to allow the school to successfully expand their IT infrastructure and more importantly have the peace of mind that their infrastructure could now cope much more efficiently with the increased demand on their systems, and also make life easier when integrating other systems on to the network.

To tackle the issue of their under-performing VLE, Ergo suggested that Notley High School and Braintree Sixth Form implement Scholaris and SharePoint 2010 because it perfectly fitted Mark's requirements of wanting an in-house manageable VLE that he could easily manage in house. Mark explains:

*"We needed a VLE that could be managed in-house so that we could control how it was used and what it looked like. The key benefit of Scholaris over other VLEs is its ease of use and its ability to involve the parents more in their child's school life."*

Along with server and infrastructure changes, Notley High School and Braintree Sixth Form has had a number of All-in-One As2 PCs and SecureDesks rolled-out within the school. Currently Notley High School and Braintree Sixth Form has deployed As2s for every classroom and used the SecureDesks to create a specialised ICT suite.

## The Benefits

Notley High School and Braintree Sixth Form saw the full potential of Ergo's complete solution and knew it could work for their school.

In terms of Scholaris and SharePoint 2010, Mark Fuller admits the school have not yet used Scholaris to its full potential and agrees 'it can do so much more'. However, their investment has already paid off because of the level of positive feedback they have received from both students and parents.

*"Scholaris and SharePoint are really useful tools that enable us to keep the parents involved, which they really appreciate and see the benefits of. In the future we would like to use Scholaris to its full potential and integrate it into more aspects of school life.*

*The highlight of the whole install was the hardware, the As2s are brilliant and they have significantly enhanced teaching within the school. Provisionally we have put one in every classroom, so that teachers don't have the burden of carrying laptops around the school. They are ideal because they are small and compact and fit perfectly on our teachers' desks. Our specialised ICT suite which incorporates Ergo's SecureDesks are fantastic in terms of security, but also how they have allowed us to maximise the amount of space we use. We are so thrilled with the SecureDesks that we are looking at rolling out some more next year."*

It's clear to see that Notley High School and Braintree Sixth Form have reaped benefits from Ergo's 'total solution' deployment, with Mark concluding, *"Overall, it was great working with Ergo because they were so helpful while also providing us a complete and cost effective solution. The support we have received from Ergo is fantastic, if we have any problems, their on-site engineers have got the issue resolved quickly and they make sure we are always happy with the resolution."*

Further information form Ergo Computing at www.ergo.co.uk

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# Naace
# Outstanding Teachers, Practice and ICT use

*Author: Dr Carol Fuller and Professor Andy Goodwyn, Reading University*

*Research about the characteristics of outstanding teachers allows us to improve our understanding of expert teaching and consequently construct better teacher preparation courses and staff development programs. Whilst much research recognises that the teacher is key, this paper also suggests that the voice of the student is also significant in developing teaching expertise.*

## Introduction and Background

There has been a rapid increase in the interest in recognising advanced/expert skills within teaching in the last decade in the UK, both within the profession and from politicians. England has developed the Advanced Skills Teacher model, introducing the role in 1998; more recently the Excellent Teacher has been introduced, from 2007. Scotland has introduced the Chartered Teacher from and Wales is following suit. Other advanced systems have alternative models that reflect this global trend. Whilst the common and explicit reason for these varying roles is the desire to retain the best teachers in the classroom, another, more recent justification is the increasing evidence that the teacher is the key variable in raising student attainment. Very rigorous research from figures like Hattie, 2003 supports this and more populist but highly influential, especially politically influential, reports such as The Mckinsey Report, 2007 are also very adamant about this recognition. In a further response, the introduction of the MTL in England has been justified partly on the grounds of increasing the expertise of all beginning teachers. Clearly then it is expertise, not just knowledge, that matters in the classroom. Yet defining expertise is problematic and, even within different systems, there is neither consensus nor an agreed measure for capturing expertise. However, common points of interest, across these various 'expert teacher' models, is the focus on improving teaching and learning and the remarkably slight attention throughout to the use of technology in expert teaching. Advances in technology mean that ICT now plays an important role in classrooms across the world (Quellmalz and Kozma, 2003; Armstrong et al., 2005) yet evidence of teaching standards, required for 'Advanced' teachers assessments, pay only lip service to ICT use. Many teachers, however, do chose to use ICT in their teaching and in ways that could be considered as expert. This paper explores the motivations of teachers, identified as outstanding for their ICT use, by their schools, to use ICT in their teaching practice and considers how this use might extend our understanding of developing teaching expertise?

Evidence pointing to the value of technology in the classroom, particularly on student learning outcomes, continues to grow. For example, research suggests that students experience increased enjoyment and motivation, increased levels of classroom participation and collaboration, greater levels of inclusivity and increased levels of self-confidence (Livingstone, 2009; Bell, 2002; Levy, 2002; Smith 2001). In addition research by BECTa (2004) found a link between increases in pupil attainment and ICT use, pushing grades up by more than a grade in subjects such as science, modern foreign languages and design and technology (see also Chandra and Lloyd, 2008). However, in two major reports trying to identify a strong cause effect link between ICT prevalence in school and increased grades, Becta (2001) also found that there was no consistency in improved attainment across subjects and concluded that how ICT was used in the classroom was therefore of great importance (ImpaCT, 2003). Yet in the UK appropriate and effective classroom use of ICT was found to be rare (Office for Standards in Education, 2001), with available technology often underused and poorly integrated into classroom practice (Hennesy et al., 2005).

It is not the purpose of this article to analyse the AST or ET role in great depth but it certainly is relevant to review where, if at all, 'expert' teachers are exemplified, in part, by the use of ICT, in terms of 'standards'. At the trainee teacher end of the standards' continuum, the only mention of ICT is that trainees must have passed the on-line ICT test and that they should know how to use skills in ICT to support their teaching and wider professional activities and develop their learners' ICT skills. Much more striking is that in the 10 standards that characterise the Post Threshold Teachers, there is no mention of use of ICT anywhere, the word technology does not even appear. Equally, in standards for the Excellent Teacher and for the AST, the same absence applies. It must be noted that this might be seen as a positive and deliberate absence, conceptualising ICT as a basic tool of use to all teachers (and students) but not to be confused with teaching and learning per se. It might also be argued that other standards that include terms such as innovation are more generic and might include new practices with ICT? Equally however, it might be inferred that such statements would be hard to evidence without some use of ICT in 2010. Given the high profile of ICT in schools and the massive investment in hardware, software, interactive whiteboards, networks and Virtual Learning Environments etc. this absence is surely an unquestionably striking one.

Previous research that explores ICT practice in the classroom has tended to investigate the generic characteristics of pedagogy, focusing on environments where the ICT infrastructure is strongly established. Research by Cox et al (2003; 2004) suggests that there is a lack of research evidence about what we know about effective teaching employing technology. Yet, even when good ICT use is identified, research by Anon (2003) suggests that what is conceptualised as good practice can be somewhat misplaced. In their research they found that good ICT practice can sometimes simply mean “extensive use” rather than “expert use”.

Even if the focus were not on expert teachers, then a better understanding of good practice in ICT use is of particular significance given the huge amounts of funding that has been devoted to the provision of technology. Government agencies and policy makers are constantly seeking for some justification for the moneys spent and for models of effective practice. Prensky (2007) states that to use twenty-first century’s rapidly emerging technology effectively for education we must invent best practices together, in other words we must examine emergent best practices, in practice. Yet clearly there are methodological issues in trying to define and capture what good ICT use is, particularly when wanting to link these practices to learning outcomes. Given these difficulties it is perhaps the practice of expert teachers who make good use of ICT, not ICT practice itself, that should be the focus for research. Many theoretical models that attempt to define teaching expertise assume differentiation in the ways that resources are used in the classroom as one of a number of important features that distinguishes an ‘expert’ teacher from a simply ‘good’ one (ANON, 2010). Hattie (2003) for example, notes that the way that content knowledge is transformed through pedagogic practice is an important distinguishing feature of teacher expertise. However, typologies of expertise often do not extend beyond descriptive categorisation, with the underlying motivations for developing this practice largely ignored. It could be argued that expert use of ICT does not necessarily equate with expert teaching and, vice versa, particularly when defining expertise may be encumbered with the same difficulties as defining expert practice. However, some of these issues may be addressed by focussing instead on outstanding teachers, identified by their peers, and their motivations for using ICT in their teaching practice.

Given the focus of this article is on use of technology there is an interesting irony in the fact that the Dreyfus brothers’ model was essentially developed to make explicit their view that Artificial Intelligence would never match human expertise. A rather more directly relevant point comes from their assertion that in any field of expertise, whether chess or teaching, an individual may produce expert performance in parts of the domain whilst performing at other levels, including novice, in other parts. This is particularly pertinent to the research reported below as there has been much evidence that more experienced teachers had been slow to make use of technology in their teaching. Another implication might be that relatively inexperienced teachers might still be very expert in certain domains whilst still at early stages elsewhere. This point is backed up by many research studies [ref] which have identified that the generation that was adolescent in the late 1990s and early 21st century were the first ‘digital natives’, at ease with all aspects of technology. These generalisations are of some use although they do not predict that younger teachers will be able to transfer what might be characterised as domestic or social expertise with technology into their emerging pedagogy. However, it certainly makes it possible that some would develop more rapid pedagogical capability using technology.

In designing the research it was important not to exclude such teachers by implying that only very experienced teachers or teachers with status titles like ‘AST’ were the main focus. This is because whilst ‘Advanced Skills Teacher and ‘Excellent Teacher’ are concepts that suggest a level of excellence, they are not universally recognised terms. ‘Outstanding’ is an institutionally recognised categorisation of teaching proficiency, as it is one used by OfSTED. This paper therefore prioritises the evidence of teachers, identified by their schools as outstanding but who also make good use of ICT. Specifically, this paper considers why these teachers choose to blend their pedagogic practice with the use of technology and how this might extend our knowledge of models of developing teaching expertise.

## Methodology

### Sample

Data were collected using a mixed methods design. The teachers included were first identified as ‘outstanding’ teachers and then as being effective users of ICT by the head teacher and/or senior leaderships teams in their schools. The study uses selected sampling based on peer identification of outstanding teachers. Whilst not unproblematic (Weiss and Shanteau, 2003), using experienced professionals’ judgement was a useful strategy as it allowed for the identification of teachers who are not otherwise formally recognised by status e.g. Advanced Skills Teacher, Head of Department, Subject co-ordinator etc. In addition using ‘outstanding’ as opposed to ‘expert’ teacher as the basis for nomination reflects current evaluative terminology. OfSTED classify schools as ‘outstanding’; ‘good’; ‘satisfactory’ or ‘unsatisfactory’. As standards of teaching, which include individual lesson observations, are also graded using the same criteria, issues of potential differences in interpretation of the concept ‘outstanding’ should be addressed. In total 250 letters were sent to schools in partnership with the university. Head teachers were asked by letter to identify those teachers considered to be outstanding in their classroom practice and who also made good use of ICT. 35 schools replied with a total of 93 nominations. From these 93 nominations, 54 teachers agreed to be included in the study and are drawn from a mixed range of primary and secondary schools in terms of attainment and subject specialism. In terms of gender, 24 participants were males and 30 female.

Prior to commencing this study ethical clearance was sought from The University’s Ethics Committee and all ethical guidelines were complied with in carrying out this research.

### Data Collection and Analysis

Data were collected via semi-structured telephone interviews which sought teachers' views on what good teaching looks like, views of the usefulness of technology as well how nominated teachers adapt their pedagogy to improve student attainment and engagement. Biographical information was collected via survey questionnaire. Data from interviews was analysed using a simple content analysis and was explored in terms of teachers' views on their pedagogic practice as well as their perceptions of the role and useful of ICT in the classroom. Data was then organised in terms of similarities in patterns and themes. In the analysis for this paper, we focus on teachers' motivations for, and attitudes to, developing their practice.

From the 54 interviews, 13 teachers were then selected for an in depth follow up case study. Of these, 6 were male and 7 female. Participants were selected on the basis of their ability to use a range of technology in the classroom. Case studies incorporated a filmed classroom observation as well as two short semi-structured interviews; one before and one after the lesson observation. Data analysis of the classroom observations incorporates a similar approach to that of the interviews: a content analysis exploring emergent patterns and themes in relation to best practice.

## Findings

### Motivations for Using ICT

The teachers included in this paper do not consider themselves as ICT specialists; often requiring technical support in their ICT use. Nor are they determined by their age, although the newer generations have more such teachers. Teachers express an interest in ICT but this is not characterised by the attractions of gadgetry or the 'whizz bang' factor of ICT per se. For these teachers technology is just one more element in their domain of teaching practice. For 83%, ICT is primarily viewed as a significant tool for enabling student learning as well as a medium that affords greater organisational efficiency. ICT engages and motivates students and has huge benefits for classroom management, learning and student attainment and it is this that primarily underpins teachers' interest to incorporate ICT into their classroom.

More than half the teachers presented here express a deep passion and commitment to their subject. Chiefly however, they are concerned with the learning of their students. 76% expressed a strong motivation to connect with their students' lives using the mediums that students recognize and engage with. Teachers express recognition of the context dependency of learning and consider ICT as an integral part of that context. This view is demonstrated in the comments below:

> *[ICT] motivates kids differently, straight away you talk technology and you have them, they JUST know it. In fact, with plenty of teachers the kids tell them how to do it...they know what it is and it's what they like doing, that's why I use it*

> *…it's how the students respond to it that is my real motivation….use technology and they love it; they love using it and are so much better engaged…it's more motivating because it's their world; it's what they are being brought up with.*

> *Children today are part of a visual world so you need to stimulate them in the ways that they are used to.*

In considering this context in more depth, 60% of teachers acknowledge a considerable change in the social and cultural world of children and deem this to have resulted in a radical shift in the ways that young people want to learn and be taught. Thus teachers respond by adapting their teaching practice through ICT use:

> *Initially I thought [ICT] was something I could let pass me by but, you know, you just can't, you do need to try and keep up with them.*

> *…to be honest, these kids, they are way ahead of us in terms of what they know and, well they use it so much and they get so much out of it, you really should try and use it, if you want to reach them.*

> *…their learning journey is different, they are the digital age aren't they? They sit at home and they've got five or six things going – you know, Face book, MSN etc. And we get them in school and we say "here we are – sit still and do this one task".*

Teachers included appear to recognise an important link between engaging students in the classroom and the cultural and social world that young people inhabit. They recognise that technology is an integral part of the cultural landscape of young people; particularly in the ways that they interact with each other and spend their leisure time. An ability to engage students using mediums they recognise and enjoy is therefore a response to this recognition. ICT enables teachers to connect with their students, bringing them closer and providing common ground for communication. This notion seems to be very closely related to the argument that Sternberg & Horvath (1995) make for the need of expert teachers to understand the social and political context in which teaching occurs, stating that teaching must be adapted to the particular context. These teachers' motivations in developing their practice to incorporate ICT could therefore be considered as a broad recognition of the social and cultural world in which young people are embedded and is a reactive and proactive response to it.

### Developing Teaching Expertise with ICT Use

Just as Hattie (2003) notes, these expert teachers are passionate about teaching and learning, with more than three quarters stating that it is their commitment to their students that motivates them most in their teaching practice. This commitment appears to define their motivation to find new and engaging ways to reach and so teach their students:

> *I am committed to being as good as I can be and, you know, when you've spent lots of time and tried to make learning creative and then a pupil comes up to you and says "that was a really fantastic lesson", I think "yes!, that's why I do it!"*
>
> *I spend so much of my free time at home, just playing with it [ICT], trying to think of new things to do, trying out different ideas but, you know when you find something that works, it makes it all worthwhile.*

The type of ICT used varied from technologies that most teachers would be familiar with, for example, interactive white boards, digital camcorders etc., to those technologies that require a greater level of ICT knowledge and confidence; the use of wikis, on-line, interactive websites, GPS mapping equipment etc. However, regardless of level of confidence, most teachers appear to have normalized the use of digital and other technologies in the classroom, using technology in harmony with their fundamental teaching approach. Whilst these teachers stress the potential damage that can be done to learning if used incorrectly, they also stress the advantages of ICT for embedding more difficult concepts. They see as valuable the ways that ICT allows them to enhance the surface and deep learning of their students, another distinguishing feature of expertise:

> *[some] concepts…are often very difficult to convey, they can be too abstract. [ICT] makes it easy for students to see what the concept is, regardless of ability. ..ICT can offer that visual idea…so it's enabling them to access difficult ideas… and some very high learning too.*

The teachers identified in this study also value the perceived flexibility of technology. 56% of teachers specifically drawing attention to the ways that it permits for adaptation to better suit the more individualised needs of learners, offering greater inclusivity for those students who struggle or have particular difficulties:

> *...there are some children who really struggle with the writing side of things…they often feel that they can't ever achieve something…or that they are proud of. If I let them type it, they are happy to do it and are really happy that they have something up on the board like everyone else… this way, we keep their interest.*
>
> *It allows everyone to share in the same experience, regardless of ability.*

ICT also has many practical advantages in terms of organisational and personal efficiency, meeting an inherent need of these teachers to challenge and push themselves, to find solutions and to express their creativity. Similarly to Becker (1999), for teachers ICT is considered an avenue for more progressive teaching practices. However, it is the commitment of teachers for extending their practice, as opposed to the technology, which permits for classroom innovation. ANON notes (2010) that personal commitment to continuous professional developments is an important aspect in developing expertise; 46% of teachers explicitly appear to recognise this, as one teacher states:

> *I don't consider myself an expert; I think it's just about being creative. For me, that's all it is, teaching is about creativity and ICT allows me to be creative.*
>
> *In terms of developing actual practice, 68% of teachers claim to be self-taught, with self*

*motivation providing the impetus to master the technologies they use by themselves:*

> *I would say that 80% of it, I have taught myself. I think that's because of my interest. The more you play with the technology, the more you learn and the more confident you feel*

> *No, I haven't had any training, basically I just taught myself. I wasn't afraid to play around with it, even if something does go wrong. I was afraid to push buttons!*

> *No, not training as such. Sometimes I will ask a colleague to show me what they do and then I have a go myself*

> *I had an introduction session to using the white board but, it's quite general. I just had to practice.*

Many teachers discussed the amount of time they spent, overwhelmingly their free time, in practicing and 'trying out' ideas in addition to the regular teaching preparation. One older teacher in particular, described buying herself a laptop on which she could experiment at home so that she could do so without fear of "destroying" the school's equipment. This investment in time [and in the one case, resources] clearly demonstrates a high level of commitment to ICT and underpins their motivation to develop their own skills in ICT use.

### Training

There is evidence that short courses (Day et al, 2007), especially of the one day kind, are useful for refreshment but are not really developmental. Our teachers support this view suggesting that whilst generic training can show a teacher how to operate for example, an interactive white board, becoming competent and using it to deliver content specific teaching is dependant on the individual. These experiences echo the findings of other research (BECTA, 2004) which comments on the importance of in-service support and training as well as stressing the need for opportunities to experiment through 'trial and error'. They suggest that without these, it is unlikely that less technically literate teachers will be aware of, or be able, to exploit the potential affordances of new technologies. These ideas also resonate very strongly with the views of our teachers, who state that training alone is not enough:

> *The courses that are run in our local authority are really, really good for helping teachers understand the skills that they are using and the software that they are using but you need a bit of time to experiment with it and, that is one thing in the profession that you don't really get a lot of, but you need to experiment, to get confident.*

> *You need opportunities to see other peoples practice really, to help get ideas...next to that, you need access to time for practice, it is so important.*

A desire to see how other teachers use ICT, in particularly how it is used within the curriculum in subject specific areas was overwhelmingly considered as being of great value. Exposure to what other teachers are doing was considered to be important, not just to their own ICT development but, also as crucial to the development of less ICT confident teachers.

Finally for a fifth teachers, developing ICT use also requires a high level of reliability and technical support, so as to minimise problems when they occur. This is especially important because, as teachers note, they are teachers not technicians. Their focus is on the efficacy of learning, thus adequate technical support is essential so as to free them to focus on optimising the learning environment:

> *The most fundamental thing is technology support and this is what always gets ignored by government initiatives – if you don't give real support, with people to come in an instant when things go wrong, then you're stuck…sometimes it can take two weeks or longer before things get fixed. [Female, Secondary, Music]*

Many of the teachers discussed the frustration of having to abandon a planned lesson using ICT because equipment was not working. A lack of resources for example, demands limiting access to ICT suites, was less of a concern that faulty and unmaintained equipment. For some, the uncertainty around the reliability of the technology hindered the ways they planned for their lessons and was viewed as constraining for the development of their teaching practice.

### Discussion

This research has not made distinctions between teaching environments and how these may help or hinder the adoption of new technologies. Nor have we considered how other institutional factors, such as the range and availability of ICT resources, may impact on ICT use. Such considerations, whilst significant to the facilitation and development of teachers in this area, were beyond the scope of this small scale study. What we have explored is how personal commitment and motivation to teaching has led to some teachers to develop their use of ICT in the classroom, despite being largely unsupported in this respect. The teachers nominated as outstanding, that we present here, seek opportunities to expand their knowledge and competence as teachers, as well as find mediums by which to reach their students. Driven by passion for their subject, a desire to teach well and a personal need to develop professionally; technology is the creative tool that enables them to do these things. Whilst these teachers do not necessarily consider there to be anything exceptional or exemplary about what they do, that they are achieving in the classroom was acknowledged and emphasised by nominators through the initial recommendation process.

The teachers included here express a strong commitment to the development of their own practice and without articulating it as such, are also hearing and responding to 'children's' voices;' modifying and adapting their content delivery and teaching approach in response. The teachers presented in this paper invest their time and energy to use ICT to enter students' worlds, as opposed to attempting to entice students into theirs. They also devote significant amounts of their free time in this endeavour, as they attempt to find space to develop their technology use in ways they consider innovative and engaging. This suggests that in developing practice, commitment, enthusiasm and recognition of value is important in terms of motivations. The impetus is this respect is also clearly not just about the technology and engaging students per se but is, in addition, is an explicit articulation and expression of teachers own need for professional development. Clearly though, for teachers to develop their practice, they need space to learn, opportunities for observations as well as adequate support to enable them to do this. These considerations become more relevant when considering the development needs of less confident and less motivated teachers.

In considering the development of teacher expertise, and in particularly the formal ways that expertise is recognised with grades and awards such as Advanced Skills Teacher status, a consideration of the influence of culture on the context of learning would appear as relevant, indeed essential. Within current teaching assessment standards and criteria, is it possible, within the 21st Century, to ignore an explicit focus on ICT competencies 'in practice' and its role and uses within teaching and learning? In light of employers skill demands likely to be required in future labour markets as well as increasing global competition; such an omission would be seriously disadvantageous to today's young people. As mentioned earlier in this paper, whilst being a good user of ICT does not automatically equate with expertise in other domains of teaching, whilst a good teacher is no less expert because they do not use ICT well, a level of computer literacy would appear crucial to raising standards in teaching. Whilst many teachers may not be as committed or, as motivated to the use of ICT, as the teachers presented here, it is simply incomprehensible to imagine teaching today without ICT; one that extends beyond the use of PowerPoint and interactive whiteboards. Teachers and particularly those involved in the Initial Training of the teachers of tomorrow need to be able to hear and take seriously the life worlds of their students and to find value in the ways that, if used well, ICT can both enhance learning and improve the attainment of the young people that they teach.

## Conclusion

There is a significant and welcome trend towards the recognition that the individual teacher is the key variable in any educational system (McKinsey, 2007). Research about the characteristics of outstanding teachers allows us to improve our understanding of expert teaching and consequently construct better teacher preparation courses and staff development programs. Whilst much research recognises that the teacher is key, this paper also suggests that the voice of the student is also significant in developing teaching expertise. This research has provided some evidence of the motivations of those teachers, considered by their schools to be outstanding in their practice, to adapt their pedagogic approach using ICT in the hope of impacting in positive ways on students' learning in the classroom. In this paper we do not make any claims as to a causal relationship between ICT use and student achievements; clearly more systematic evidence is necessary to support such a relationship. The group of teachers we present here really do appear to try and harness technology for the benefit of all their students learning suggesting that policy should shift towards developing and supporting the type of teacher expertise required of the 21st century, rather than an obsession with technology more broadly.

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**SPECIAL TOOLS**

Renew Membership
My Profile
Change password
Add article to CMS
Moderate articles in the CMS
Resource finder
Advancing Education
Computer Education
Naace Communities
Naace CPD
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# Naace
# Keith Memory Blog

*Author: Claire Griffiths*

*An online project recording memories of the old Keith Primary before it was replaced by a new school in February 2012.*

At the beginning of February 2012 the rural town of Keith gained a new primary school. The old school, built in 1864, educated generations of Keith children serving the community well for 148 years. While assessing the change about to happen to the staff and children, I wondered how the community might be feeling about the closure. Many were once there as children hanging up their coats in the corridor, sitting in the classrooms, listening for the bell and running around the playground. I thought it would an interesting and valuable project to capture the memories of those children, now often parents and grandparents, alongside the many memories of current children and staff before the school's closure. The result was the Keith Primary School Memory blog created using a free Wordpress blog.

Memories were submitted in a variety of ways. The youngest children were simply asked for their thoughts which were then written down. Others completed a form with or without an explanatory drawing. The latter were then scanned and added to the memory post. Finally, some used the online form or accessed the blog's dashboard (control panel) under supervision and added the post directly and then published it. As the children were still in the old school they often spoke directly about their immediate surroundings. The opportunity was then taken to capture exactly what they had described in their memory e.g. a view from a window, the sound of the school bell or corner of a room. By using a variety of recording equipment the children were involved in capturing life in the old school during its last days. Many of the blog posts have been wonderfully enriched by the children's individual drawings, photographs and sounds.

On Moving Day members of the school gathered in the old school playground along with many parents and grandparents. Inside, the school register was called for a final time followed by the original brass school bell being rung to signal it was time to begin the short journey to the new school site. Led by Keith's pipe band, the procession made its way across as interested onlookers and local press lined the route. Several pages on the blog are devoted to the walk across, ribbon cutting ceremony, first assembly (with a recording of the school song) and finally pictures of the new school, inside and outside.

Strong local links have been strengthened by the project. Keith and District Heritage Group, church guilds, and 50+ club along with the local newspaper, Banffshire Herald have supported the blog since its creation by submitting their own memories along with photographs, many of which appear in the gallery, and book extracts describing the history of the school. Also sepia tinted photographs were taken of each of the children in the old school. Each child sat next to an old blackboard, desk and satchel.

It continues to be a very successful project with over 260 memories (posts) added spanning the 1920s to the present day. There are 30 pages to look through and the site has had over 7000 or so hits to date. It has provided a effective way of allowing the children and the wider community to share and value their memories of the old school, capturing evidence of the school's place in people's lives and those of previous generations.

The school community are now settling into life in their new school. Follow the blog to see pictures of the new school and comments by the children about it.

http://keithmemoryblog.wordpress.com/or search Google for Keith Memory Blog Claire Griffiths can be contacted at claire_griffiths2@btinternet.com

RSS What is RSS?

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Moderate articles in the CMS
Resource finder
Advancing Education
Computer Education
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# Naace
# “Will investment in ICT/Digital technologies raise standards?” The wrong question?

*Author: Bob Harrison*

*“Will investment in ICT/Digital technologies raise standards?” Bob Harrison considers whether this is the wrong question.*

When Kenneth Baker, the first Minister for Information Technology in 1981 became secretary of state for education in 1986 and the first to to recognise the need for investment in ICT for schools he approached the treasury for investment.

Unfortunately and unwittingly he based his request on a “false premise” which has haunted his successors and continues to distort the debate about learning and the use of digital technologies to this day. You can imagine his conversation with the then Chancellor of the Exchequer (or more likely a conversation between two “yes minister” civil servants.

“So Ken you want how much? …HOW MUCH? That’s an awful lot of taxpayers money you know…. and what will we get in return…. improvements? …. I should say old chap….a rise in standards is the least we will expect?”

And here comes the crunch and the root of our current problem which so irritated Karen Cator, at the ALT conference this year - http://www.agent4change.net/events/conferences/1181-karen-cator-a-weather-vane-for-assessment-at-alt-c.html

Instead of Sir Humphrey from the DfE responding with “I am sorry that is the wrong question” He was so desperate to get the money and please his boss he replied “Of course…raised standards of attainment and achievement…otherwise why would we be asking!”

The precedent was set and consequently every financial negotiation since, between education and the treasury which has had the letters ICT in it has been predicated on the false assumption that investment in technology will automatically raise educational outcomes.

Plainly, with hindsight, and a wealth of research under the bridge, that is just WRONG! And this debate has continued to bedevil and distract from the real question. See http://www.nytimes.com/2011/09/04/technology/technology-in-schools-faces-questions-on-value.html?pagewanted=all

In his defence he could not possibly have foreseen at that time the innovations and advances in technology that have impacted on society in recent years.

Who could? But why is the education system so slow to catch up with the rest of our digital lives and get the real value from the technologies which we take for granted in everything else we do as human beings and digital citizens?

Sadly some of us still remember the days of overhead projectors, VHS video, Banda machines, (oh the smell comes back to me now) and the excitement of unpacking the boxes of the shiny new BBC micro, ZX Spectrums, Tandy TRS 80 and RM 380Z’s.

But we didn’t know a deal had been done with the standards devil and it would haunt us and all future generations of teachers, lecturers and policy makers across all education sectors.

Of course there is abundant evidence (sadly much of it is archived now since the closure of Becta) here in the UK, at the OECD and in the USA that investment in ICT/Digital technologies will have an impact on teaching and learning.

But evidence of a causal link between investment in ICT and better SATS, GCSE, AS or A level or any other test results is more difficult to track down.

This Government has been reluctant to acknowledge that technology might improve education. Recently however there is a glimmer of light in Michael Gove’s epiphany illustrated by his speech at the Schools Network annual conference and interview with the pupils from Catmose College, Rutland: http://www.agent4change.net/events/event/1338-gove-pledges-fresh-ict-to-schools-network-students.html

But we need to be alert to the “ Baker false premise” and attempt to ensure it is not still driving the agenda? Kenneth Baker can be congratulated for his endeavour (which incidentally he continues to pursue to this day in his work with UTC’s) but he could not have foreseen the developments of the www, the age of Goggle and Microsoft let alone Facebook, Twitter, virtual reality and Skype. Nor could he, (or us?) predict how soon we will have paperless, wireless, no handwriting, voice recognition, learning analytical, online anytime assessment schools (real and virtual) in the future?

So what should the question be? How about?

"What will be the cost if we do not invest in our children to ensure they are able to survive and thrive as a digital citizen and contribute to the world constructively, collaboratively and economically?

What would your response to the treasury question be?

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Naace

# The Impact of Using Electronic Voting Systems for University Mathematics Teaching: A Multi-institutional Perspective

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*ABSTRACT*

*This study focused on the research question: What is the impact of using the educational technology, Electronic Voting Systems (EVS), for undergraduate mathematics teaching? The question is addressed from two perspectives. First, a survey study was designed to ascertain the views of academics from multiple institutions in the UK on how they have incorporated the use of EVS in their undergraduate teaching. This showed that the EVS use influences instructor pedagogical principles for creating and using mathematics questions in undergraduate classrooms. It has also catalyzed active instructor-student feedback in real time, while facilitating student (cognitive) engagement through the provision of mathematical problem solving in real time. Secondly, a finer grained evaluation study was conducted, based on classroom observations and limited student interview data, and showed that, pedagogically, the use of specific EVS-based mathematics questions has helped in aligning teaching with learning, so as to achieve intended learning objectives. Its use has also helped in enhancing student cognitive engagement through feedback predicated on deliberate practice. However, the study did not show any demonstrable impact of EVS use on student performance, attendance or retention.*

*Keywords: Electronic voting systems/clickers, impact/effectiveness, technology-enhanced teaching/learning, pedagogy, feedback, student engagement*

## 1. Introduction

This article is designed to answer the research question. What is the impact of using the educational technology, Electronic Voting Systems (EVS), i.e. clickers or Student/Audience Response Systems, for undergraduate mathematics teaching? First, academic staff who have used EVS to teach undergraduate mathematics in universities across the UK were surveyed in order to ascertain their views on the impact of EVS usage on teaching and learning outcomes. Second, to provide a deeper analytical context for the survey results, a case study derived from observational, interview and documentary evidence from a single instructor's implementation of EVS for undergraduate mathematics teaching is presented.

A main contribution of this study is that it presents three dimensions that the use of EVS has had on undergraduate mathematics instruction. These dimensions are, from a pedagogical perspective, the use of EVS-based mathematics questions as a way of aligning instruction with learning objectives, the use of feedback as a way of making visible students' deficiencies and how these may be addressed; and an exploration of the impact of using EVS on student academic performance. Further, the (survey) study is a novel investigation about the views and experiences of academic staff, from various UK institutions, on the impact of EVS as a tool for university mathematics teaching. Research studies on EVS have largely consisted of descriptions of research on EVS within specific institutional contexts (e.g. see Simpson & Oliver 2007). In contrast, this study presents evidence of EVS effectiveness for mathematics teaching from academics working in 14 different institutional contexts. These types of studies are required in order to adequately assess the evidence (e.g. Sloane 2008) on technology-based educational interventions.

The article outline is as follows: The study background and (survey) methodology are presented, followed by the presentation and analyses of the survey results. Then the case study, comprising the methodology and results showing the impact of EVS use in three dimensions of undergraduate mathematics instruction, is presented; and this is followed by a brief conclusion.

### 1.1 Rationale for Using Electronic Voting Systems

The barriers to learning mathematics at the tertiary level (e.g. maths anxiety) are well documented (e.g. Hawkes & Savage 2000; NMAP 2008; NRC 2001). Consequently, a number of initiatives have been implemented to overcome these barriers, and to promote active learning (e.g. Croft & Ward 2001; Novak et al. 1999; NMAP 2008). One of these initiatives is the use of EVS to promote problem solving and hence active learning in university mathematics education.

The use of EVS affords an academic the means to give students, especially in a large class, the opportunity to engage with course material by having them answer questions during a lecture, with subsequent provision of feedback to students. The students answer the questions by clicking the corresponding alphanumeric answer choice on their EVS handsets (Fig. I). Student responses are then displayed, in real time, in the form of a suitable chart (Fig. II). The lecturer may then decide to elaborate on any relevant issues arising out of the question and answer display session. For instance, a lecturer should address why options (1), (2) and (4) in Fig. II, which 54% of the students in a class had selected as the correct option, are in fact incorrect. Hence the use of EVS may be viewed as an educational intervention to promote active learning in the university classroom. EVS may therefore be, and has been, used in courses which emphasise real-time problem solving, especially in university lectures (e.g. Bruff 2009).

*Fig. 1 Students using (TurningPoint) EVS handsets to answer questions in class*

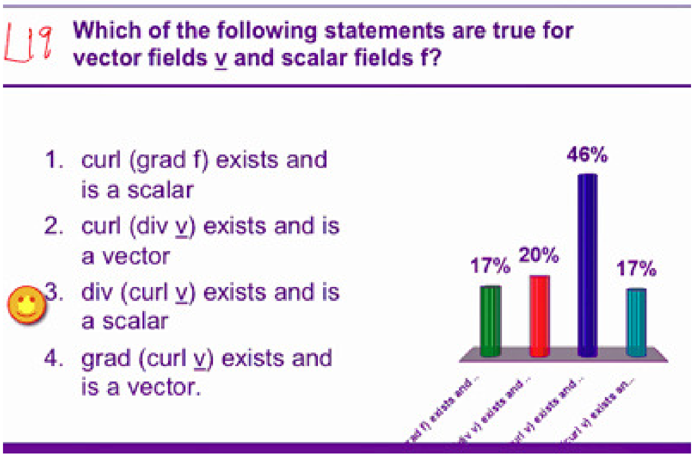


*Fig. 2 Chart showing student responses to an EVS mathematics question. Only 46% of the class got the right answer (i.e. Option 3)*

### 1.2 Background on Electronic Voting Systems

Electronic Voting Systems are ubiquitous in university classrooms around the US, a phenomenon which Abrahamson (2006) described thus:

> *Today, at almost every university in the USA, somewhere a faculty member in at least one discipline is using a response system in their teaching.*

In the UK, there are at least 47 universities where EVS handsets are being used[1]. As a result of the widespread interest, a number of publications – including three highly regarded books (Bruff 2009; Banks 2006; Duncan 2005) - have been written on EVS. These publications largely consist of descriptions of EVS implementations in specific institutional contexts (e.g. Cline et al. 2007; Bode et al. 2009) and also to support specific approaches (e.g. Mazur 1997; Hake 1998, Beatty et al. 2006), although a few of these are reviews (e.g. Simpson & Oliver 2007; Fies & Marshall 2007). Many of these publications are positive on the impact of EVS usage on teaching and learning in tertiary education. However, recent studies have also highlighted the potential drawbacks of using EVS, including the cost to students and institutions and the lack of (any significant) learning benefits accruing from EVS usage (e.g. Bugeja 2008; Johnson & Robson 2008).

In general, research literature indicates that EVS usage offers three significant benefits. The first is reported learning gains, partly as a result of using EVS, especially in the peer discussion mode (e.g. Lasry, Mazur & Watkins 2008). However, most articles do not present evidence of this benefit. The second benefit is increased student engagement – this includes increased student participation in lectures and enhanced interactivity in lectures (Bruff 2009, p. 199), although there is limited evidence on whether and how EVS use might actually facilitate cognitive engagement with learning material. The third benefit is that the constant feedback produced during EVS usage not only presents academics with a relatively accurate and timely information about student comprehension, this also allows them to change the pace or content of lecture delivery to as to accommodate student needs (Boyle 2006, p. 302)

## 2. Methodology (survey)

The survey study employed a cross-sectional research design, based on a *descriptive survey* research paradigm (Cohen, Manion & Morrison 2007 p. 205), and was aimed at answering the research question, 'What is the impact of using the educational technology, Electronic Voting Systems (EVS), for undergraduate mathematics teaching?' by ascertaining the views of academics from multiple institutions in the UK on how they have incorporated the use of EVS in their undergraduate teaching. Particular focus is placed on pedagogy, with emphasis on principles for using questions and evaluating their effectiveness; cognitive engagement and feedback. While the design for the survey study is descriptive, the design for the case study of one instructor's practice, which will be presented in Section 6, will incorporate a finer grained analysis of the specific ways that EVS use has impacted undergraduate mathematics instruction in terms of pedagogical alignment of instruction with learning objectives, instructor-student feedback, student cognitive engagement with learning in real time during classroom instruction, and impact of EVS use on student academic performance.

### 2.1 Instrument

The main data collection instrument was a web-based, semi-structured self-completion questionnaire, which consisted of a mix of closed and open-ended questions (see Appendix for questionnaire). The surveys were administered via the Bristol Online Surveys (BOS)[2], developed by Bristol University.

### 2.2 Recruitment

Using a variety of strategies, e.g. dedicated sites for UK EVS users, the Mathematics, Statistics and Operational Research (MSOR)[3] network, etc; 20 academics were identified as using EVS to teach mathematics i.e. this is the *population*, as far as we were able to ascertain, and these were then invited to complete the web survey; sixteen academics eventually responded. Further, three of these four academics who did not complete the questionnaire provided valuable comments about their use of EVS through email and informal conversations.

### 2.3 Sample

The sample consisted of four female and 12 male academics in the UK who have used or currently use EVS to teach mathematics to undergraduates. It is important to note that this sample is 80% of identified users of EVS in this context, and thus representative of the population. Further, the mathematics subjects taught with EVS ranged from engineering mathematics, further calculus, linear algebra (tutorials) and introduction to pure maths to complex analysis and numerical analysis.

The level of students taught by respondents ranged from pre-university, i.e. foundational year to final year students.

### 2.4 Data Analysis

The techniques adopted in analysing survey data include the use of frequency tables and correlation or cross-tabulation tables (e.g. Table I), and thematic analysis for the open-ended questions.

## 3. Reliability, replicability and validity

To ensure that the findings of the study are credible, reliable and valid, we adopted the measures described below.

### 3.1 Survey Pilot

The survey instrument used in the study has undergone *two piloting cycles*. First, the instrument is based on a previous survey that was piloted for an explorative study. Second, the current survey has also been piloted with two academics, whose views are not presented in this study. This is because one used EVS to teach the mathematical component of a Statistics course, while the other is based in Germany.

### 3.2 Face Validity

As part of face validity measures, the initial drafts of the survey instrument were submitted to two academics with statistical expertise who provided useful comments. The draft instrument was also submitted to two mathematics lecturers who provided formative feedback. As a result of the pilot and face validity measures, we effected changes to 16 items in the survey instrument.

### 3.3 Respondent Validation

To minimise invalidity or ensure internal validity, respondent validation was employed, suggested as a measure of the validity of quantitative research (Cohen, Manion & Morrison 2007, p. 145). All respondents were emailed with a copy of their individual submissions to the survey questions. Respondents were also provided with a draft of the findings and interpretations, which they were requested to corroborate, or object to as appropriate (Lincoln & Guba 1985, p. 329).

Subsequently, useful suggestions were incorporated from the feedback received. We also adopted measures to minimise the impact of question sequencing and the primacy effect (Cohen, Manion & Morrison 2007 p. 336, 226).

## 4. Presentation and Analysis of Survey Results

In this section, the survey results together with related analyses are presented, based on the impact of EVS use on pedagogical principles for using and evaluating question effectiveness, cognitive engagement and feedback. Also, to conserve space, a few illustrative excerpts, rather than all relevant respondent comments, are presented.

### 4.1 Pedagogical Principles For Using Electronic Voting System Questions

Based on respondent comments to the open-ended item, 'What were your guiding principles or goals in choosing/setting EVS questions?', four main themes were identified as the guiding principles for the creation and use of EVS questions in lectures. The first of these was the desire to receive and provide feedback in real time on student performance, and grasp of the relevant subject matter. The comments below, from different respondents, illustrate this:

> *'To gain feedback on students' progress and to highlight common mistakes made by students';*
>
> *'To be able to quickly assess the level of the students; to provide more informative and instant feedback to students';*

The second main theme was the use of EVS questions to reinforce ideas or topics. This had two expressions: The creation of questions to assess student recall of previously covered material, and assessment of student efficacy in applying newly introduced material:

> *'Immediately reinforce each new idea with an EVS question. (ii) Include some more difficult or extended questions to stretch the better students and provide practise solving problems';*
>
> *'I designed questions to make students think about how they could use the techniques they'd just been taught but also to make sure the techniques were being used appropriately';*

The third main theme identified was the use of EVS questions to catalyse engagement, specifically student interaction and participation in class. This is particularly pertinent for those teaching large classes:

> *'Student participation in large class environment';*
>
> *'Getting students to work together and build simple ideas up in a fun way';*

Last, the importance of selecting and creating good distractors was identified as a main principle guiding the use of EVS questions:

> *'Good distractor answers. Questions cannot be too complicated otherwise students will be unable to answer. Students should be able to answer questions in a short period of time. Also, the students shouldn't be able to determine the correct answer by a process of elimination from the available selection'.*

The last comment about questions being elimination-proof indicates that not all questions would adequately task students mentally. In Section 6.3, we will present a classification of EVS-based mathematics question types, based on one instructor's practice. We would also highlight in that section how EVS may be used to achieve an overriding pedagogical principle of aligning instruction with learning objectives.

### 4.2 Evaluating Question Effectiveness

In response to the multiple-answer questionnaire item, 'How do you evaluate whether a question has been effective?', respondent submissions indicated that the most frequently (n=12) used criterion is 'when student response leads to the identification of problem areas'. This essentially means that EVS is seen as a means of providing feedback on student strengths and weaknesses.

Respondents also noted that a question could be considered effective as long as it elicited a response from students, with even a low response rate viewed as positively contributing to learning:

> *'I'd evaluate a question as INeffective [emphasis respondent's] if none of the students answered it!';*
>
> *'Practically no response is "useless", so in a sense all questions are effective. If a majority of students respond in some way, the results are always effective either in indicating that they've grasped the material or in helping me target a problem area…'.*

The 'practically no response is useless comment' suggests that a low student response rate could be as beneficial to an alert academic as a high response rate.

### 4.3 Cognitive Engagement

When respondents were asked in an open-ended question about the 'impact (or otherwise) of EVS usage on the mental processing or problem solving of in-class material during lectures' (Bransford et al. 2000; see also Guthrie & Carlin 2004), many (n=10) stated that they had observed a positive correlation. In the excerpt below, a respondent observed that EVS usage had had a 'very significant impact' on student mental processing of problems during lectures. S/he also added that this has implications for learning outside of the walls of the classroom:

> *'Very significant impact. Before EVS I suspected that a few students worked through problems on the board ahead of me, most watched me solve problems and tried to understand what I did. Now all students have to try problems before they have seen the answer. They need to think how to solve a problem - not just understand my answer - I think this is a very important difference and I think that they will be in a much better position to try other problems out of the lecture setting.'*

Another respondent commented that 'all students' are able to 'switch their brains on' during EVS lectures, as opposed to the pre-occupation with note-taking that sometimes occurs in non-EVS lectures:

> *'It encourages ALL [emphasis respondent's] the students to switch their brains on there and then. In non-EVS lectures some students are fully engaged while others sometimes seem to just be taking notes for future use. Some (Maths) students in particular can feel threatened and react adversely (not attending) to lecturers' attempts to encourage participation. The advantage of using EVS is that it is non-threatening. If anonymous there is no reason not to participate'.*

However, two respondents were undecided about the impact of EVS usage on cognitive engagement, citing insufficient evidence; while four others stated that they had not observed any impact on mental processing of in-class material. Later in Section 6.4, we will show through an instructor's practice and corresponding student comments how, within a problem solving framework, the use of the EVS-based mathematics question does help students to 'switch their brains on', i.e. mentally engage with learning material during classroom instruction. In Section 6.3, we will highlight how there are different EVS-based mathematics question types, and how these differ in terms of the learning approaches they may elicit in students, while in Section 6.5, we will present data on whether there is any correlation between EVS use and student academic performance.

### 4.4 Feedback

Along with increased student engagement, the one other main benefit of using EVS, cited in literature, is the provision of feedback to both students and academics about the level of understanding in a classroom. So the question may be asked, 'What types of (student) feedback do academics receive?' Judging by recurring frequency - in response to the multiple-answer item, 'Could you describe the kinds of feedback you have *received* from student answers to EVS questions?;' the most important types of feedback that academics have received from students are:

> *'Identification of common student errors or misconceptions' (n=14);*
> *'Identification of components of topics students find difficult' (n=12);*
> *'Student understanding of previous lessons' (n=11);*
> *'Ease/Difficulty level of a question(s)' (n=10).*

Similarly, respondent submissions to the multiple-answer item, 'Could you describe the kind(s) of feedback you provide to students after they have submitted their answers to the EVS questions used in class?', indicate that the most important types of feedback provided by academics to students are:

> *'Explanation of why the alternative options provided are incorrect ' (n=14);*
> *'A step-by-step solution of the problem' (n=11);*
> *'Discussion of the distribution [or spread] of students' correct and incorrect answers' (n=11).*

It should be noted that the information or intelligence (Russell 2008) provided by the types of feedback from students highlighted above, if acted upon, can or should ideally help academics improve their teaching, while aiding student learning. The limited evidence suggests that academics are indeed utilizing the feedback received. Most respondents (n=13) stated that they had incorporated feedback from students into their teaching. This incorporation is either in the form of long-term revision and updating of course notes or 'on the fly', contingent teaching response in real time within a lecture session:

> *'Each year, when I revise my course material, I bear in mind what I've learned (from EVS as well as other feedback) about the difficulty of various topics, and I try to set questions to challenge common misconceptions. I've altered the pacing and the sequence in which ideas are introduced for similar reasons';*
>
> *'Only in an "on the fly" sort of way - in that, if lots of students get a question wrong after discussion then I will spend more time going over the ideas behind that question'*

The importance of feedback was further highlighted when respondents commented about the differences in feedback between EVS and non-EVS lectures'. The predominant response (n=12), in response to the open-ended item, 'In general, are there any differences between the feedback provided in a typical mathematics lecture where EVS are used and one in which EVS are not used?', was that feedback played a far more important role in EVS lectures for three reasons. First, the volume of student feedback (including from shy or reticent students) received is much higher than in traditional lectures:

> *'Hugely more feedback with EVSs. And from different people - e.g. shy people, less keen people, etc.';*
>
> *'Profound differences! In a typical lecture, IF [emphasis respondent's] a question is asked by the lecturer, typically, the same students will answer each time, and little or no discussion ensues.';*
>
> *'You cannot expect to get feedback from "all" students in a standard lecture environment with 90 students'.*

Second, EVS usage helps provide an accurate picture of student comprehension of lecture content, and this knowledge of what students actually know or understand may be at odds with academics' presumptions or erroneous impressions about the level of student understanding, which a respondent suggested are often formed by 'talking only to the smart students':

> *'Without EVS it's easy to be misled about students' talents and impression of the course by only talking to the smart students who ask questions';*
>
> *'Yes I can be more focused on one particular misconception rather than having to explain misconceptions which might not be present'.*

Third, academics are able to provide more targeted feedback to students, based on insights into student comprehension as indicated by student answer choices:

> *'In an EVS session, if a majority of students give an incorrect answer, I feel I have to first run through the correct solution AND discuss why students felt the alternatives may have been correct';*
>
> *'Yes when EVS is used it allows much more targeted feedback to the students and therefore they find it more relevant and useful'.*

In Section 6.4, we will illustrate how feedback is a function of the deliberate practice instructional environment (Bransford 2000) that is created when EVS-based mathematics questions are used in real time during classroom instruction.

## 5. Discussion

We have presented the methodology, data analysis and results of a survey study designed with a view to answering the research question, 'What is the impact of using the educational technology, Electronic Voting Systems (EVS), for undergraduate mathematics teaching?' In particular we have provided academics' perspectives on the impact of the use of EVS on teaching outcomes, i.e. pedagogy, cognitive engagement and feedback, in university mathematics classrooms.

Pedagogically, the four principles enumerated by respondents as their rationale for using EVS - to receive feedback on student understanding, reinforce lecture material, enhance student engagement, and create good questions that would challenge students - seem to indicate that they are not using the technology just because it is available, but as a means for achieving specific teaching and learning objectives.

Moreover, frequent use of EVS questions enhances student (cognitive) engagement with learning, as their use 'provide each student with a chance to think about and respond to a question before hearing other students' answers' (Bruff 2009, p. 199).

A major component of EVS usage is the provision of feedback. Feedback from students provides academics with a means of monitoring student comprehension both in real time and over the course of a module. Academics are also able to use this student feedback to provide more targeted instructional measures. It is important to note that these two forms of feedback, which are an integral part of EVS-enabled lectures, are either largely absent from, or used infrequently in typical mathematics lectures.

In conclusion, the survey findings show that EVS usage has significantly influenced the way academics assess student understanding, and how students gauge understanding of learning material. Moreover, EVS use has also helped in catalysing enhanced student engagement and student-academic feedback, with an emphasis on problem solving in real time in university mathematics lectures. This survey is hence a contribution to the evaluation of the impact of technology-facilitated teaching (and learning) on university mathematics instruction, from a multi-institutional perspective.

## 6. Case Study: Impact on Teaching and Learning

We have just presented a cross-section of views of instructors' perceptions of the impact of EVS for teaching. Moreover, 93.8% of participants either 'strongly agree' or 'agree' with the statement, 'Based on my experience, EVS is a tool that can significantly enhance the teaching of university mathematics' (Table I). But what would the implementation of EVS look like in an undergraduate university mathematics classroom, and how would that impact the mathematics being learned in such classrooms? Therefore to answer the research question, 'What is the impact of using EVS for undergraduate mathematics teaching?, from a second perspective, i.e. to present a finer grained analysis of the survey outcomes, we present data from one instructor's (one of the authors of this paper) use of EVS. The target sample for the study was second-year Automotive (auto) and Aeronautical (aero) Engineering students who were taught an engineering mathematics module in the 2008/2009 academic year, with a total class size of about 150 students. This data is based on classroom observations of the instructor using EVS for teaching a mathematics module (Table II), limited interview data from students taught by the instructor, and documentary evidence (e.g. module specification and student grades).

**Cross Tabulation**

Results are cross tabulated by question "32. Based on my experience, EVS is a tool that can significantly the teaching of university mathematics."

| **18.** Based on your experience, please rate the value of EVS as a tool for the teaching of university mathematics: | Strongly agree | Agree | Undecided | Disagree | Strongly disagree |
|---|---|---|---|---|---|
| Strongly advantageous | 4 | 1 | 0 | 0 | 0 |
| Advantageous | 0 | 8 | 0 | 0 | 0 |
| Undecided | 0 | 2 | 0 | 0 | 0 |
| Disadvantageous | 0 | 0 | 0 | 0 | 0 |
| Strongly disadvantageous | 0 | 0 | 0 | 0 | 1 |
| **Totals** | 4 | 11 | 0 | 0 | 1 |

*Table I A correlation of two relevant survey items show that academics consistently rated the usefulness of EVS for mat teaching highly.*

Sequel to the survey results, three dimensions of the possible impact of using EVS for undergraduate mathematics teaching will be explored. These dimensions are, first, the use of EVS-based mathematics questions as a way of aligning instruction with learning objectives (see Section 6.3); second, the use of EVS-based formative assessment and feedback as a mechanism for enhancing student cognitive engagement through deliberate practice; and third, an exploration of the impact of using EVS on student academic performance. These three will be addressed based on analysis of classroom observation and interview data, supplemented by documentary evidence. Therefore, the observational protocol and interview methodology are briefly presented in the next section.

### 6.1 Observation Protocol

To evaluate the impact of the use of EVS-based mathematics questions on student learning, one of the authors observed the use of EVS for classroom instruction on the undergraduate mathematics module highlighted earlier for a semester during the 2008/2009 academic year. During the observations, detailed notes were taken about the types of questions used during instruction and the time points during a lecture that they were used (the purposes for using these questions were later clarified through face-to-face discussions with the instructor). Student responses to the questions – how many voted, the percentage of students who got the answer right or wrong, etc were also noted. In addition, instructor response to how students voted – did the instructor review the questions and provide detailed feedback to the students, etc – were also noted. In addition, the time it took to present and complete the process for answering a question was noted. General classroom dynamics – did students appear engaged during question time, or were they using the time to talk to their peers, was also noted. Finally, this observation protocol had earlier been *piloted* with a different group of instructors who had used EVS to teach a range of undergraduate courses.

The results that will be presented in this section are largely based on data from classroom observations. This is supplemented, in the case of assessing the impact of EVS use on student engagement, by excerpts from interviews with students. Therefore, the interview methodology is presented in the next section.

### 6.2 Interview Methodology

We also conducted student interviews to evaluate the impact of the use of EVS-based mathematics questions on student learning. Four female and six male students from auto and aero volunteered for the interviews. It should also be noted that the interviewing author had no connection whatsoever with the module and/or the students.

This cohort of second-year engineering students had been introduced to the use of EVS in one of their first year mathematics modules, taught by another instructor. It could thus be expected that their views on EVS use would be more mature or at least be immune to an extent from the novelty effect of EVS use, than students who had just been introduced to EVS.

A semi-structured interview approach was employed to interview the 10 volunteer students. During the interviews, each participant was presented with a set of EVS-based mathematics questions (see Figures III, IV, V and VI in the Appendix) that had been previously used in class for the engineering mathematics module under investigation. The questions were based on the topics that had been covered in class, including Multiple Integration, Eigenvalues and Eigenvectors and Vector Calculus. The main rationale for the inclusion of the questions was to assess whether and/or how the use of the EVS-based questions had influenced student learning. But due to space constraints and fidelity to the research question posed for this study, only excerpts relating to the impact of using EVS on student engagement will be presented in this section.

To ensure *face validity* for the interviews, we submitted the materials used in the interviews to members of the academic units the authors were a part of. Moreover, sections of the interview protocol/materials had earlier been *piloted* with another group of students. To negate or limit the influence of the *acquiescence factor* (Cohen, Manion & Morrison 2007, p. 151), interviewees were reassured at the beginning of each interview session that all their contributions would be treated with confidentiality, and that even the instructor would appreciate genuine feedback about the perceived benefits and drawbacks of EVS use.

In the next sections, we will sequentially present the impact of using EVS on undergraduate mathematics instruction, based on the three dimensions earlier described.

### 6.3 Alignment of Instructional Tasks with Learning Objectives

There is considerable agreement in the educational research community that aligning teaching practices with learning objectives can lead to enhanced student learning outcomes (e.g. Biggs 1999). The use of EVS helps to facilitate this. In this case, the instructor used EVS technology to create and present mathematics questions that helped to align classroom instruction in real time with the learning objectives for the mathematics module being investigated.

**Aims**

The aim of this module is:
- to cover adequately those mathematical topics which are fundamental to all engineering disciplines. An over-rigorous approach is avoided.

**Intended Learning Outcomes**

On completion of this module students should be able to:

Knowledge and Understanding
- know how to use double/triple integrals to find volumes, masses, centres of gravity and moments of inertia;
- know some of the basic results of vector field theory including the divergence theorem and Stokes' theorem;
- understand how eigenvalue techniques can be used to convert matrices to diagonal form and solve coupled systems of ordinary differential
- understand how an arbitrary periodic function can be expressed as a sum of sinusoidal components of different frequencies;
- know how to apply some of the techniques learnt to simple engineering problems;

Subject-specific Skills
- evaluate double integrals in cartesian and plane polar coordinates;
- evaluate triple integrals in cartesian, cylindrical and spherical polar coordinates;
- evaluate the gradient of a scalar function;
- evaluate the divergence and curl of a vector field;
- evaluate simple line integrals;
- identify conservative vector fields and find the associated scalar potential function;
- evaluate simple surface integrals;
- find the eigenvalues and eigenvectors of simple matrices and the corresponding modal matrix;
- find the trigonometric Fourier series of simple piecewise smooth functions;
- find half range Fourier sine and cosine expansions;

General Skills
- manage time effectively.

*Table II Module specification showing the Intended Learning Outcomes for the mathematics module investigatec*

The module specification, including the learning objectives (see Table II), clearly indicate that the focus of the module is on problem solving, a focus that lends itself well to the use of EVS. The instructor was thus able to create specific EVS-based mathematics questions types to promote fluency in attaining the different problem solving skills anticipated in the learning objectives. A summary of the categorisation of the types of the EVS-based mathematics questions used by the instructor, and the correspondence of these questions to the revised Bloom's Taxonomy (Anderson & Krathwohl 2001) is presented in Table III.

**Table III Correspondence between the EVS question types and Bloom's Taxonomy[4].**

| EVS-BASED MATHEMATICS Question Types | Bloom's Taxonomy Equivalent | Descriptive Verbs |
|---|---|---|

| | | |
|---|---|---|
| **Revisions**<br>(Used principally to identify student prior knowledge – Fig. VI) | **Comprehension**<br>(i.e. test for understanding of knowledge) | Classify, convert, describe, explain extend, give examples, interpret |
| **Applications**<br>(Used to assess student efficacy in applying previously covered or recently introduced material – Fig. IV) | **Application**<br>(Ability to apply laws and formulae to solve mathematical problems) | Apply, compute construct, demonstrate, discover, modify, operate, produce |
| **ConcepTests**<br>(Used to assess conceptual understanding of a topic – Fig. V) | **Analysis**<br>(Seeing the whole picture from its constituent parts) | Analyse, relate, associate, discriminate, distinguish, infer, order, separate |
| **Introducers**<br>(Used to introduce a topic, such that it gets students thinking in a different way about a particular topic than they are accustomed to – Fig. III) | **Analysis**<br>(Seeing the whole picture from its constituent parts) | Analyse, relate, associate, discriminate, distinguish, infer, |

6.4 Enhancement of Student Cognitive Engagement based on Formative Assessment and Feedback Predicated on Deliberate Practice

The use of formative assessments in mathematics can lead to increased precision in how instructional time is used in class and can assist teachers in identifying specific instructional needs. (NMAP 2008, p. 48)

The use of these EVS question types in real time facilitates deliberate practice, i.e. the implementation of appropriate [classroom] practices that enhance performance and also includes active student monitoring of their own learning experiences (Bransford, Brown & Cocking 2000, pp. 175-176, 59). This is because students are given opportunities, while the learning material is still fresh in their minds, to work on related problems through the use of the EVS question types, and are subsequently provided targeted feedback. This not only reinforces learning objectives, but also helps students to diagnose their level of understanding of a specific learning object, as what is activated when a student is merely presented with new learning material which s/he only has to think about, and what is activated when a student actually performs that activity are very different (Olive & Makar 2009, p. 154).

In this regard, one of the students on the module who was interviewed commented that:

> *'Well, when you go through an example, or maybe [the instructor is] teaching you something, I sometimes think 'oh, I get that', but it isn't until you do a question that you actually know if you can or not'.*

Another student commented that the use of EVS questions gave him/her an 'idea of what's going on' with respect to the lecture content (I = Interviewer, S = Student):

> *I: You say 'it's helped my progress as in lectures, as in lectures we're required to take a lot of notes and I find that I don't take in much information, concentrate much'.*
> *S: Yeah. Like, it's like, 'cause we're writing down notes constantly, almost constantly...I find it hard to, um, actually listen to what the lecturer's saying while I'm writing down. So I don't really take in that much. So when we have the questions, it gives me time to read over it and actually, like, have to put it into practice, so I...like, instead of going away from the lecture and reading over my notes... I kind of have an idea of what's going on.*

Further, this diagnosis, i.e. level of understanding with respect to a task, is visible to the instructor, via the EVS technology interface, so the instructor may then be able to make any necessary instructional adjustments.

So it could be argued that the creation of a formative instructional environment through the iterative use of different mathematics question types benefits all students, because they all get the chance to mentally engage with concepts in real time and to somewhat adapt their ideas about a particular subject domain, in response to how they performed on a related question, and instructor feedback. As had been shown earlier through comments from survey respondents, this feedback is invaluable to instructors as well. Similarly, Boyle (2006) claimed that the use of 'audience responses systems have changed the classroom. Those of us who use them could not return to the conventional lecture – you get "hooked" on interpreting the feedback and finding out what is going on in students' minds – and it is different every year' (p. 302).

6.5 Impact on Student Academic Performance

A critique of research on EVS impact on learning to date is the tendency for such research to mainly present findings on student attitudes or views of EVS usefulness (e.g. Kaleta & Joosten, 2007; Simpson & Oliver, 2007), which are only one measure of impact. Therefore, a goal of this study was to evaluate whether EVS use has had any impact on student performance, as determined by mean student grades, attendance and retention.

To do this, we compared the mean academic grades of four cohorts of students on a second-year engineering mathematics module taught by the same instructor (this is the same instructor/module combination that respondents for this study were selected from) over the 2006/7, 2007/8, 2008/9, 2009/10 academic years (see Table IV). It should be noted that apart from the 2006/7 cohort in which EVS was not used, the classroom experience for all the other three cohorts included regular EVS use. Also, coursework was intentionally made more demanding for the 2007/8, 2008/9 and 2009/10 cohorts. Otherwise, the three cohorts are directly comparable, as course content and assessment modes remained unchanged across the four cohorts.

The results (Table IV) show that EVS use does not appear to have had a positive or negative impact on student performance, as indicated by the mean overall grades of the four cohorts. Observations of lectures also indicated that EVS use did not have beneficial impact on student attendance. Further, EVS did not appear to have any positive impact on the student failure rates. Further, recent statistical as well as qualitative evaluations do not report any significant learning gains accruing from EVS use (e.g. Bugeja, 2008; Johnson & Robson, 2008).

However, the finding that EVS use appears to have no positive impact on student performance might need to be interpreted with caution. This is because the EVS questions that have been used for the engineering mathematics class investigated tend to be structured into short, specific problem sets. In contrast the module examination, which accounts for 80% of the overall module grade, typically consists of longer calculation and application questions. It is therefore plausible that the type of procedural fluency skills that students acquire through exposure to EVS use, especially through deliberate practice, are not being assessed within the current examination structure, which has been in place prior to the 2006/7 session.

**Table IV** The academic performance of students on a second-year engineering mathematics module over a four-year period

| Cohort Characteristic | 2006/7 | 2007/8 | 2008/9 | 2009/10 |
|---|---|---|---|---|
| No. of students | 145 | 147 | 156 | 146 |
| Coursework average | 81.3 | 58.9 | 64.7 | 58.3 |
| Exam average | 59.2 | 62.0 | 58.4 | 60.4 |
| Overall average | 63.2 | 60.3 | 59.7 | 60.0 |
| % of students failed | 13.8 | 14.9 | 7.7 | 16.4 |

Moreover, research evidence indicates that benefits from technological intervention in the classroom often start to appear from the second year of implementation (e.g. Somekh et al., 2007). Further, as instructor skill and confidence with using EVS in the formative teaching mode increases, this could be expected to somewhat impact student performance (e.g. Boyle, 2006; Crouch & Mazur, 2001; Boyle et al, 2001). So it is still quite plausible that EVS use might show a positive correlation with academic performance in the long term. Also, evidence from other institutions (e.g. Boyle et al, 2001) indicates that regular EVS use may help improve the scores of weaker students. Also, the instructors earlier surveyed appeared committed to using EVS for undergraduate mathematics instruction (Table V).

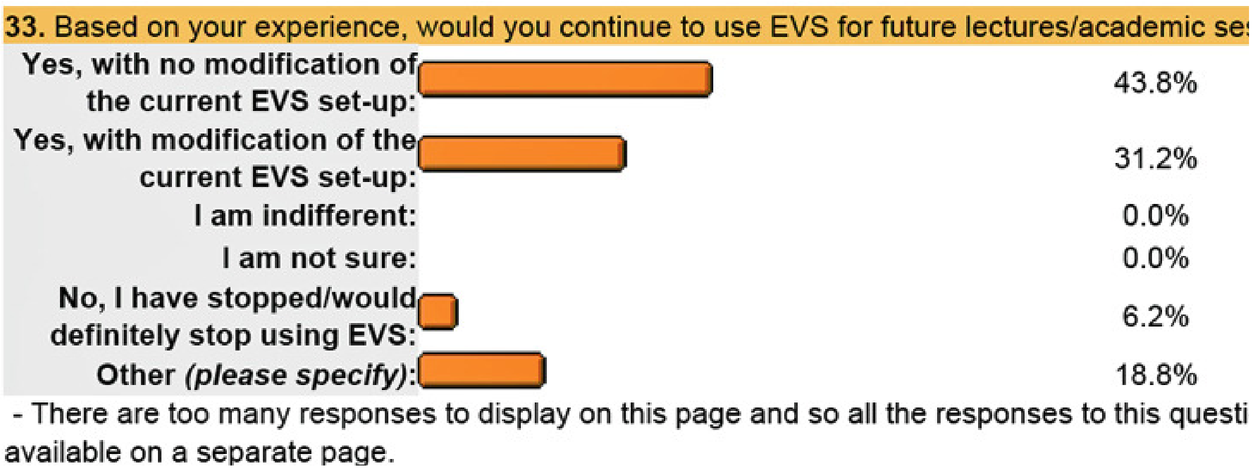


*Table V Data showing the commitment of most respondents to continuing to use EVS*

## 7. Conclusion

This study focused on the research question: What is the impact of using EVS for undergraduate mathematics teaching? The question is addressed from two perspectives. First, a survey study was designed to ascertain the views of academics from multiple institutions in the UK on how they have incorporated the use of EVS in their undergraduate teaching. Secondly, a finer grained evaluation study was conducted, based on classroom observation and student interview data. The survey study showed that EVS usage influences instructor pedagogical principles for creating, and assessing the effectiveness of mathematics questions used for undergraduate mathematics teaching. It has also catalyzed active instructor-student feedback in real time, while facilitating student (cognitive) engagement through the provision of mathematical problem solving in real time. However, these views are based on self-reports of the efficacy and impact of EVS use on undergraduate mathematics instruction from respondents from multiple institutions.

A finer grained evaluation of the impact of the EVS use, a case study, was therefore conducted to highlight the congruence between general instructors' submissions and the observed impact of EVS use on one instructor's mathematics teaching, with respect to pedagogy, (student) cognitive engagement and feedback, and academic performance. This second study, based on classroom observation and student interview data, plus documentary evidence, showed that the use of specific EVS-based mathematics questions has helped in aligning teaching with learning, so as to achieve intended learning objectives. Its use has also helped in enhancing student cognitive engagement through feedback predicated on deliberate practice. Finally, we highlighted how EVS use has not had any demonstrable impact on student performance, attendance or retention, based on data from one instructor's practice.In future studies, we will investigate the views of academic staff using EVS in multiple countries about their views of the efficacy of using EVS for undergraduate mathematics teaching. Further, we will study whether the use of specific EVS-based mathematics questions, as highlighted in this study, influence students to adopt particular learning approaches to answering the questions. We will also explore further whether there is any correlation between EVS use and student academic performance. Finally, we will explore how alternative EVS technologies, such as the use of free polling systems, networked tablet PCs, TI Nspire Navigator and smart phone-based applications (e.g. Twitter) could impact undergraduate mathematics teaching and learning.

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Endnotes

1 http://www.psy.gla.ac.uk/~steve/ilig/people.html.
2 https://www.survey.bris.ac.uk/.
3 http://www.ltsn.gla.ac.uk/.
4 Data compiled from Carneson, Delpierre and Masters (1996) and Zimmaro (2004).

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# Britannica Image Quest at Latymer Upper School

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*Author: Paul Heinrich*

Cited in:

- Advancing Education Spring 2012

*Latymer Upper School is an independent day school (11-18) based in Hammersmith, London. Since investing in Britannica Image Quest, the school has reported the positive effects the resource has had on its younger students' research skills.*

## What is Britannica Image Quest?

Britannica Image Quest is an online resource that contains over 2 million high-resolution images sourced from over 50 of the world's best image collections.'

## The Problem

Latymer Upper School's librarian Terri McCargar noticed that students of all ages within the school were keen to use images in project work. However, she could see from their computer activity that the majority, oblivious to copyright laws, were searching and copying images from the internet without understanding the source of the image, whether they had the right to use it or how to credit it.

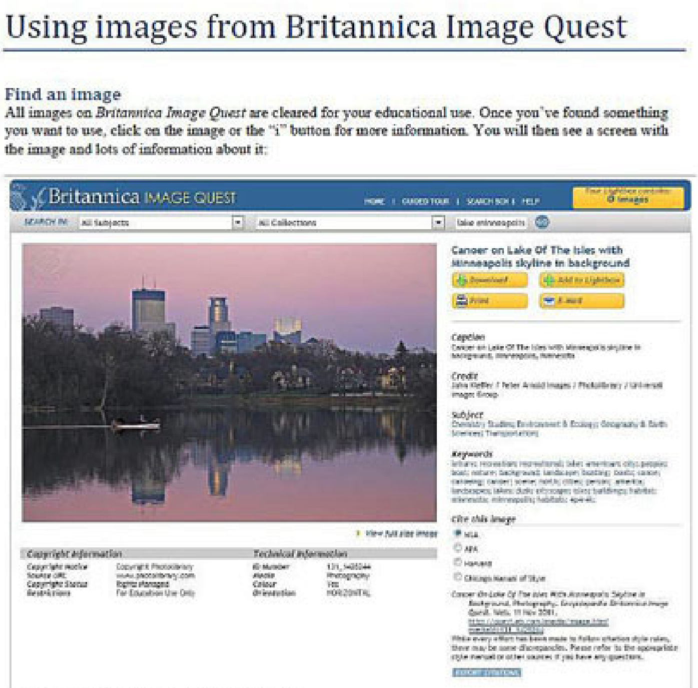
## The Solution

When Terri discovered Britannica Image Quest in March 2011, after enquiring about another Britannica product, she believed that the image database would be an excellent tool for both students and staff at the school. On first seeing the product she commented: "Britannica Image Quest struck me as an attractive alternative to Google Images and other image providers, whose search results often prove too random and distracting for younger students. Image Quest seemed to be a more extensive and responsible resource that provided high-quality images that are copyright-cleared for school use."

After setting up the subscription, the challenge was to introduce it among students. The annual physics project, in which all Year 7 (166) students research a planet and make their own presentation, provided an ideal opportunity as the school librarians had already worked closely with the physics department to develop and deliver research training. In the first of four library-based lessons dedicated to the project, the librarians demonstrated how to search for and download images of a planet using Image Quest, and how to make a picture list (bibliography) of the images used. Students were instructed to use Image Quest for all their images and to cite them correctly. Each student was given two class handouts created by Terri: one to explain how to use Image Quest and the other to teach them how to cite images, a skill they will need later on in their academic careers. Students then worked independently during the remaining lessons, carrying out research in library books and online on their chosen planet.

## The Benefits

Since introducing the Year 7 students to Britannica Image Quest in November 2011, some teachers have reported an improvement in these pupils' awareness of copyright and their behaviour when researching images. Terri remarked: "I've had only a few questions on how to use Image Quest itself – it's quite a simple interface, so I hoped that would be the case. I've had a lot more questions on the referencing aspect, which is understandable – they're only 11. Having to record information like the title of the image and the copyright holder has added to their learning – it isn't necessarily just a pretty background; many students have been careful to choose something that illustrates what they've learned about their planet."



Using images from Britannica Image Quest

Find an image

All images on *Britannica Image Quest* are cleared for your educational use. Once you've found something you want to use, click on the image or the "i" button for more information. You will then see a screen with the image and lots of information about it:



*"I've been looking for something like this for a*

*long time. Image Quest is great as a first port of call for students' research as it is easy to use and trustworthy. Unlike with other search engines, here the students can see exactly what the image is and where it has come from." She added that the problem of unintentional plagiarism remains an ongoing challenge: "Today's students are really distracted by presentation and they're very savvy technically; they've been cutting and pasting images from the web into their school work for years by the time we meet them. And often teachers are themselves unaware that this is a copyright issue. Image Quest is a great tool for us to help tackle this. The earlier we can make them aware of reliable alternatives that they are allowed to use, the better."*

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- **Download** the image.
- **Add to Lightbox** (this is like adding to your basket/trolley, for looking at later – but it seems to have some bugs currently!)
- **Print** the image. This will enable you to print the image out, with the title and credit (as listed on the page above).
- **E-mail** the image. This will send you (or someone else) an email with a link to the image in *Britannica Image Quest*. The email will include two attachments: one is the compressed picture file, and the other is a "media" text file with information about the image.



For more information on Britannica Image Quest go to www.britannica.co.uk/ebproducts/IQ.asp or email enqBOL@britannica.co.uk.

# Naace
# Now I Get It!

*Author: NEC Display Solutions Europe GmbH*

*NEC 3D DLP® projectors help school children engage with the learning experience in Germany.*

A hand reaches out for the hammer. It's right there, next to the anvil and the stirrup. But that small hand passes straight through, because this particular model of a human ear is just a 3D projection. Primary school pupils at Munich's "Grundschule an der Simmernstraße" are experiencing new ways of learning. And innovative technology is helping them better understand what they are learning. A special classroom has been set up with computers and interactive whiteboards, along with both 2D and 3D projectors.

The primary school is offering a glimpse into the possible future of education in Germany. This effort is, however, still just part of a study being conducted by the Ludwig-Maximilian University (LMU) in Munich. The room has been designed as a UNI classroom, and gives teachers and teacher trainers the chance to familiarise themselves with various types of technology-led learning. Classes can even be recorded onto high-quality video for in-depth analysis later on.

## The Challenge

*"We want to explore how combining traditional learning methods with multimedia PC programs and 3D projections can help children retain what they have learned,"* explains Dr. Michael Kirch, research associate in the Primary School Education department at the LMU. This is all part of a research initiative covering several European countries, which aims to investigate academic learning supported by 2D and 3D technologies. DLP Technology innovator Texas Instruments is supporting the project every step of the way. Professor Anne Bamford, an internationally recognised British education expert, is in charge of coordinating the project and evaluating its findings.

## The NEC Solution

Technology in the classroom offers a wealth of promising opportunities, not least because in recent years we have seen various technological innovations emerge that were practically destined for use in schools. Ultra-short throw projectors do not have to be installed at the other end of the room or suspended from the ceiling, but let you project onto a screen from only inches away. They produce no distracting shadows, and teachers are free to move around the room or stand right in front of the class. NEC's solutions are pioneering in this field. It has created a range of products with the education sector specifically in mind. *"Easy to use, robust enough to cope with day-to-day school life, low noise levels, and minimal operating and maintenance costs. These are just some of the features that schools and colleges look for,"* says Ulf Greiner, Product Line Manager Business Projectors at NEC Display Solutions Europe. *"Projects like this give us the chance to gather valuable feedback, which we take and incorporate into the continuous development of our solutions,"* he adds.

Short throw projectors are the perfect companions for 3D visualisation. NEC's new U Series of ultra-short throw projectors are 3D-ready and do not require any additional equipment or modifications, making them a popular choice in the education sector. "Universities and schools are hugely in favour of sustainability, and want products that work equally well in both 2D and 3D situations," says Greiner.

The entry-level V Series and ultra-short throw models in the U Series all feature the latest in DLP Technology. As with modern 3D-capable TVs, the device transmits images alternately for the left and right eye at 120Hz. Active shutter glasses separate out the images meant for each eye so that the image appears three-dimensional to the viewer.

The process of syncing a projected image with the glasses is essential, and DLP Technology accomplishes this by sending additional visual signals between video frames, which are picked up by a sensor integrated into the glasses. This eliminates the need for extra emitters and makes the set-up as easy as setting up traditional 2D projection.

However, Dr. Kirch does not believe that technology is a panacea for education. Used incorrectly, it could even detract from the true objectives of modern-day teaching: *"It's time to leave the 'teacher up front' approach behind. Let's get our children learning together in groups and motivate them to start teaching each other. For this to work, the children need* *to have their own interactive experiences.*" At the Munich primary school, pupils are assigned specific tasks that they have to complete in groups of two. Each of the individual 'stations' around the room gives them another clue to discovering the mysteries of acoustics. One of the most popular stations is the NEC 3D projector. At the moment there is only a limited amount of content available in German. *"Ultimately, the content will be the deciding factor in relation to how fast this technology spreads. Many 3D providers in various sectors are in the process of adding educational content to broaden their portfolios. Producers of more traditional teaching materials are in demand here on account of their pedagogic experience,"* says Greiner.

Dr. Kirch asked children who had taken part in 3D lessons whether they would prefer their teacher to give a presentation, or to try things out themselves via interactive content. The surprising response was that many children would actually choose the comprehensive explanation provided by a teacher first. Afterwards, however, they would like the opportunity to explore the various functions of the ear at their own pace. For example, to determine which part of the ear they want to find 3D information on next.

Another key finding of both Dr. Kirch's and Professor Bamford's studies was the notably high levels of media literacy in children when working with 3D content. Many of those surveyed had already seen several 3D films at the cinema or had a 3D television at home. *"Schools need to take account of the children's surroundings and incorporate that into their teaching concept. The omnipresence of 3D technology makes it a fantastic jumping-off point for learning as well,"* says Dr. Kirch.

## The Results

Using technology in lessons has definitely been worthwhile. Professor Anne Bamford describes a distinct, measurable effect in all the schools across Europe that were involved in the LiFE 1 project. *"The content that was taught was noticeably more present in before-after comparisons; the children were far better able to retain the material,"* according to Bamford. *"Many of the children said 'I understand much better now how hearing works'."* Dr. Kirch observed the same phenomenon in the Munich school. *"The results were overwhelmingly positive. The children were especially attentive when they were faced with 3D content."*

He nevertheless emphasises the fact that technology alone cannot replace lessons that stimulate all the senses. This is the only way to accommodate all types of learners and ensure that they receive the information they need. Haptic learning, using a physical model, for example, is just as much a part of this approach as traditional reading of a text. For Dr. Kirch, 3D technologies really come into their own when imparting facts that are almost impossible to present in other ways. Scientific processes are the obvious example, but another could be field trips that might otherwise be difficult to organise. A virtual visit to the pyramids, for example, or a journey through the inside of a human heart - all feasible in a single school day thanks to 3D. And that's why Dr. Kirch can say with certainty: *"3D technology enriches the learning experience enormously."*

## Site Information

Location:

Grundschule an der Simmernstraße, Munich, Germany

Project collaboration with:

Texas Instruments

Equipment and Benefits
NEC V Series 3D ready DLP projectors
NEC U Series ultra short throw projectors

NEC Display Solutions Europe GmbH can be contacted at infomail@nec-displays.com and www.nec-display-solutions.com

RSS What is RSS?

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# Naace
# The 3D in Education White Paper

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*Author: Professor Dr Anne Bamford, Director of the International Research Agency*

*This paper reports on the "Learning in Future Education" or "LiFE" project, a team of researchers led by Professor Dr Anne Bamford, Director of the International Research Agency, undertook a detailed research investigation of the impact of 3D on pupils' learning. The goal of the LiFE 1 project was to determine the most effective type of 3D experiences in the classroom, and to measure the value and impact of these experiences on pupil learning and achievement. The pilot research also examined learning strategies and teaching processes and measured the meaningful impact on educational outcomes.*

## What is 3D in the classroom?

Computer generated animation has been in development for some time with early work dating back to the 1960s. Not surprisingly, the first commercial use of three-dimensional (3D) animations was a representation of a human, known as the "Boeing Man." It was not until the 1990s that 3D within the general entertainment industry became more widespread. The release of "Avatar," the movie, broke all box office records and established a new level of sophistication in 3D imaging. The use of 3D in the classroom has emerged in the past 12 months and offers enormous potential as a tool in teaching and learning. DLP-powered[1] 3D projectors use millions of microscopic, digital mirrors that reflect light to create a picture. DLP imaging technology is so fast, it can actually produce two images on the screen at the same time: One for the "left" eye and one for the "right" eye. Then 3D glasses combine the two images to create a 3D effect. The single-chip version of DLP is used in many projectors, with the technology being used in over 50% of the projectors currently sold.

## Children and 3D

Children and young people own a lot of technological devices and use them regularly. As indicated by the recent pan European research[2], 90.1% of pupils had a computer, 85.3% had at least one mobile phone and 74.6% owned handheld games.[3] It also found that pupils are frequent users of online technology, with over 91% of pupils using the internet for at least one hour per day.

In terms of their experience of 3D, 90% of pupils had seen a 3D movie, with most pupils having seen three or more 3D movies. The pupils were very knowledgeable about general innovations in 3D and were highly informed consumers of the 3D products currently available. The pupils possessed very positive attitudes towards 3D and were keen to have more 3D in their lives and in their learning. The teachers that were interviewed acknowledged the importance of good quality technology for the pupils of today as they are "digital native" learners, as the following comments from teachers exemplify:

> *"The kids are into technology. We need something different in the classroom. It is more philosophical than just putting computer in the classroom. Technology is not just about learning the content. Technology will change the view of life. Children must have different points of view on life." - Teacher comment"*
> *The pupils wanted, and expected, very high quality animations." – Teacher comment*

## Why is 3D important?

Children find it hard to understand what is not visible. Visual learning improves the pupils' understanding of functionality and by seeing the whole of something, children are able to understand the parts. The research results indicated that the pupils had a strong preference for visual and kinesthetic learning, with 85% of the pupils preferring seeing and doing, while only 15% of pupils preferred hearing.

> *"Teachers talk a lot and you just sort of tune out, but when you see things it is there and suddenly it all makes sense." – Pupil comment*

Complex concepts become more easily digested when reduced to imagery. The research results suggested that the 3D animated models were able to represent information in the most economical manner to facilitate learning and comprehension, thus simplifying complex, abstract and impossibly large amounts of information into a coherent form. By rendering the world visually, the children were able to understand greater levels of complexity, as the animations allowed the pupils to see structures and to see how things worked. In particular, the 3D animations made it possible for pupils to move rapidly from the whole structure to various parts of the structure, including to the microscopic and cellular levels. This process of amplification and simplification seemed to be particularly effective as an aide to understanding.

> *"The 3D comes in to the lesson… Makes an infinite difference and then goes back again. It really makes a phenomenal difference." – Teacher comment*
>
> *"It gives the pupils a better chance to visualize various parts of the lesson. The children can easily imagine and it makes these imaginings visual." – Teacher comment*

The 3D content in the classroom appears to 'come out to' the pupils. The deepest 3D and the most animated content appeared to have the greatest effect on learning and retention. These highly vivid experiences make the learning very captivating to the senses. During class observations, 33% of the pupils reached out or used body mirroring with the 3D, particularly when objects appeared to come towards them and where there was heightened depth.

## The impact of 3D on academic results

The results of the research indicate a marked positive effect of the use of 3D animations on learning, recall and performance in tests. Under experimental conditions, 86% of pupils improved from the pre-test to the post-test in the 3D classes, compared to only 52% who improved in the 2D classes. Within the individuals who improved, the rate of improvement was also much greater in the classes with the 3D. Individuals improved test scores by an average of 17% in the 3D classes, compared to only an 8% improvement in the 2D classes between pre-test and post-test.

The marked improvement in test scores was also supported by qualitative data that showed that 100% of teachers agreed or strongly agreed that 3D animations in the classroom made the children understand things better, and 100% of teachers agreed or strongly agreed that the pupils discovered new things in 3D learning that they did not know before. The teachers commented that the pupils in the 3D groups had deeper understanding, increased attention span, more motivation and higher engagement.

The findings from the teachers was also evident in the findings from the pupils, with a higher level of reported self-efficacy in the pupils within the 3D cohort compared to the 2D control groups.

> *"I think I will get better test results. It is easier for me to remember with 3D. Then I will do well." – Pupil comment*

The pupils felt strongly (84% agreed or strongly agreed) that 3D had improved their learning. High levels of pupil satisfaction with 3D learning were also evident with an 83% approval rating.

The pupils in the 3D class were more likely to recall detail and sequence of processes in recall testing than the 2D group. Both pupils and teachers stated that 3D made learning more "real" and that these concrete, "real" examples aided understanding and improved results. The 3D pupils were also more likely to perform better in open-ended and modeling tasks.

During the research study, several tests were undertaken to test for regression. Teachers were asked to note the pupils' retention (memory) after one month, both in terms of qualitative and quantitative differences between the retention in the 3D-based learning and the non-3D-based cohorts. Open-ended tasks were given to determine the impact both on retention and on recall. The teachers noted changes in the manner in which the 3D and 2D pupils recalled the learning. For example:

- The 3D pupils were more likely to use gestures or body language when describing concepts
- The 3D learners had better ordering (sequence) of concepts
- The knowledge of concepts was greater in the 3D cohorts (especially when a new concept had been introduced through 3D)
- The 3D cohort had enhanced skills in describing their learning including writing more, saying more and being more likely to use models to show learning

> *"In this school we find that theoretical retention is a problem. As I see it, the 3D increases visual retention and this boosts learning." – School principal*

The pupils in the 3D classes could remember more than the 2D classes after four weeks. Not only were there differences in the quantity of material recalled, but the pupils who studied with 3D remembered in a more connected 'systems' manner. Pupils in the 3D class gave more elaborate answers to open-ended tasks and were more likely to 'think' in 3D. Many pupils, when answering test questions, used hand gestures and 'mime' to recreate the 3D experience and to enable them to successfully answer the test questions. To quote one teacher, “The children said ‘I won’t forget it.’ It was more in their faces.”

> *“When the teacher shows a model if it is small you can't see it, but with 3D even if the teacher moves around or a big kid is in front of you the 3D will always move in front so you can always see things clearly.” - Pupil comment*

## The impact of 3D on classroom interactions

The use of 3D in the classroom led to positive changes in pupils’ behavior and communication patterns and improved classroom interaction. The “on task” conversations and questions in the classroom increased after 3D was seen in a lesson. The pupils in the 3D group were more inclined to ask complex questions.

The pupils were highly motivated and keen to learn through a 3D approach. The teachers found that the use of the 3D technology led to a deepening of pupils’ understanding, increased attention spans, more motivation and higher engagement.

> *“In class with 3D you have the ‘Wow’ effect. This helps with behavior. The pupils are too interested to be disruptive. They get involved and forget to be naughty! I would like to keep using it and use it for different topics.” - Teacher comment*

The post-survey of teachers revealed that 100% of teachers felt that the pupils paid more attention in 3D lessons than other lessons, and 70% of teachers noted that the pupils’ behavior had improved when using the 3D. The main factor appeared to be that levels of attentiveness increased during and immediately after the 3D experience. On average, 46% of pupils were attentive at five minute interval tests during the non-3D part of teaching the lesson, compared to 92% of pupils being attentive at five minute intervals during the 3D part of the lesson. Interestingly, when the 3D part of the lesson was over, attentiveness continued to rise and would remain high for the rest of the lesson. For example, 96% of pupils were attentive in the five minutes following the 3D. It appears that the 3D experience and resulting questions continued to promote attentiveness. Boys and pupils with attention disorders showed the most positive change in attention levels and communication
(including asking questions) between 2D and 3D.

> *“The class certainly pays more attention in 3D. They are more focused. That is important in this class - 8 out of the 26 pupils in this class have attention problems, so I am thrilled with the impact of 3D. They sit up and are really alert.” - Teacher comment*

> *“3D in the lesson makes them concentrate more. They have to focus and concentrate.” - Teacher comment*

The teachers were more likely to adopt different teaching pedagogy in 3D lessons as compared to 2D lessons. The teachers encouraged more conversation and collaboration with pupils during the 3D lessons, and the pupils felt that their teachers were better and “nicer” when they taught with 3D.

> *“When there is 3D the teacher is sort of happier. I think because we like it, then he likes it. We understand things and there are better examples.” - Pupil comment*

> *“I can't describe it but in 3D lessons the teacher changes. She is better. Sort of happier… actually we all change.” - Pupil comment*

The teachers’ pedagogy often changed with 3D and this helped to maintain pupils’ motivation - 100% of teachers agreed or strongly agreed that pupils had fun learning in 3D and 87% of pupils found learning in 3D more interesting.

> *“As the teacher, I went to the back of the room. The pupils drive the computer and run the lesson.” - Teacher comment*

## Strategies for implementing 3D in the classroom

It is comparatively easy to implement 3D animations into the regular classroom environment. To begin teaching with 3D, a teacher would need access to:

- A DLP 3D-enabled projector: The majority of new projectors purchased for schools already have this capability, and future purchases of DLP projectors are generally no more expensive than those that are not 3D-capable.
- A laptop or PC with good graphic capability: Most standard PCs and laptops can be fitted with the necessary

upgraded graphics card for only a small cost. More recent laptops tend to have adequate graphics cards.

- 3D content: There are a number of 3D software content providers and currently more than 3,000 pieces of free 3D content available online.
- 3D active glasses: There are a number of companies making 'active' glasses. They vary considerably in quality and price. Ideally the pupils should have a pair of active glasses each so that the fit and comfort is suitable for the individual child. Class sets of glasses are also available.

The 3D animations work best in a normal classroom with low level lighting. Special screens are not needed and the 3D can be projected onto almost any surface. It works effectively for schools to share portable equipment, though teachers preferred using fixed equipment in the classroom so that setup time was kept to a minimum.

> *"We are sure that the system should be in every school and be available for every teacher." - Principal comment*

The teachers were able to effectively use 3D in the classroom without any specific professional development. They found it easy to integrate 3D technology into their
regular lessons with six out of the 15 schools also modifying their teaching and learning pedagogies in response to the introduction of 3D. The teachers and pupils also creatively proposed ways that 3D could be successfully integrated across the curriculum. The teachers felt that 3D animations allowed them to teach topics in more depth and use less time than conventional teaching methods.

> *"I have found that the 3D saves time. Of course not in the beginning as you get to know how to use it. But it certainly saves time in the lessons. It is the only tool of its kind that exists. The pupils can learn all at the same time and they learn a lot at once and so I find I can actually cover more in the same time." - Teacher comment*

There was an 8.8 out of 10 teacher satisfaction level for implementation of 3D in the classroom.

## Some fun activities to start using 3D

Try some of the following ideas…

- Have pupils move their bodies to 'feel' the virtual 3D
- Give pupils clay or dough to model as they watch the 3D animation
- Re-use 3D animations; for example, use a science-based animation in the art class or use the history animation in the language class
- Put the pupils in the 'driver's seat' and let them develop lessons around 3D content
- Get a 3D camera and start creating your own 3D content – start with images in nature
- Create your own 3D logo so that when the pupils see that on a worksheet, they know they can also see things in 3D
- Encourage pupils to make their own 'commentary' to accompany 3D animations
- Project the image on unusual surfaces – try your T-shirt or the surface of the desk
- Study a 3D artist or learn about how our eyes see 3D
- Compose music to accompany 3D animations
- Use 3D animations without the sound or labels to revise for tests
- Invent learning games to accompany the 3D animations

The pupils were asked to imagine how 3D animations might change their learning in the future. These are some of their ideas:

> *"All thinking and learning will be different in the future. We will always have 3D in the classroom and we will use it when we want. There will be books with 3D inside*
>
> *them. You hit on the image and then it becomes 3D. It will sort of come up from the page. I want this." – Pupil comment*
>
> *"We will have screens built into the tables and then we can touch things and they will be 3D." – Pupil comment*
>
> *"The classroom should be more like a planetarium. We would all sit in a circle and then the image would be all around us. Let us call it a 3Dtorium! We would not have chairs. We would sit on bean bags. We would not need to wear glasses and it would be interactive, like Kinect. Maybe we could program our own 3D and make PowerPoint presentation in 3D. Maybe there will even be 4D and we would have sensory experiences… jets of air, smell, great sound. There would be*

*simulators and we would follow the flow of the blood. We could have electronic text books on a kindle or iPad. Technology makes learning more interesting. Technology will never stand still. It will always be advancing and that is exciting. We will need to know technology for our future jobs." - Pupil comment*

## Background to the research

Known as the "Learning in Future Education" or "LiFE" project, a team of researchers led by Professor Dr Anne Bamford, Director of the International Research Agency, undertook a detailed research investigation of the impact of 3D on pupils' learning. The goal of the LiFE 1 project was to determine the most effective type of 3D experiences in the classroom, and to measure the value and impact of these experiences on pupil learning and achievement. The pilot research also examined learning strategies and teaching processes and measured the meaningful impact on educational outcomes.

The research took place between October 2010 and May 2011 across seven countries[4] in Europe. The study focused on pupils between the ages of 10-13 years learning science-related content. The research project involved 740 students, 47 teachers and 15 schools across France, Germany, Italy, Netherlands, Turkey, United Kingdom and Sweden. Equality of access is the law in Europe, so the schools included children from different backgrounds and with learning or behavioral challenges integrated into the general classes. The 15 schools in the study were selected on the basis of direct contact as well as from recommendations by local
education authorities. All schools voluntarily agreed to participate. The study involved: Private and public schools; single sex schools; city schools and rural schools; high and low academic achieving schools; technology-rich and technology-poor schools; large schools and small schools; primary, middle and secondary schools; and experienced and less experienced teachers. In each school there was a 'control' class and a 3D class. Both classes
had the same instruction, but the 3D class also had the 3D resources.

LiFE 1 has provided a unique insight into the impact of an immersive and interactive classroom experience.

### Endnotes

1 Digital Light Processing (DLP®) is a registered trademark of Texas Instruments.
2 Bamford, A 2011 Details provided at the end of the White Paper
3 Note: Many pupils had more than three different forms of technology.
4 Eight countries were included in the trial, including Finland, but Finland has been excluded from the research report as their data was collected internally and therefore not verifiable for inclusion in the research report.





## Suggested further reading

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# Naace
# Titus Salt School - Building on Success

*Author: Steljes*

*"…we were able to think very carefully within an established contractual framework about what was available in the market and how we could develop our strategy. As a school we're very keen to be at the forefront of educational change and development."*

*Ian Morrel, Deputy Head teacher and Chair of the Phase 1 Schools' Steering Group, Titus Salt School*

## Building on success – a SMART Story

Visionary leadership and a clear ICT strategy have helped to transform the fortunes of Titus Salt School in Bradford in recent years – and this turnaround was given a further boost by the move to a brand new building in September 2008. The school was originally built in the 1950s to accommodate 400 students, but by 2004, following a Bradford re-organisation from a three tier to a two tier system, 1,380 learners were squeezed into an unappealing range of buildings that were no longer fit for purpose and this fading infrastructure was becoming a major barrier to future improvement. *"As a specialist Maths/ICT school our use of ICT was well advanced, and we were moving towards having SMART Board interactive whiteboards in every classroom," says Head teacher Sue Mansfield, "but because of asbestos and other problems, the buildings were severely limiting our future technology development plans."*

Fortunately for Sue and her leadership team, a review of the entire school stock in Bradford coincided with the creation of the Building Schools for the Future (BSF) programme, and the city became a Phase 1 Pathfinder for the national project. Titus Salt thus became one of the first secondary schools in the country to benefit from the largest single schools capital investment programme for over 50 years.

*"The BSF journey has been quite an amazing one in many respects," says Ian Morrel, Deputy Head teacher and Chair of the Phase 1 Schools' Steering Group for ICT. "The partnership with Sun Microsystems, AMEY ICT and Steljes meant that we were able to think very carefully within an established contractual framework about what was available in the market and how we could develop our strategy. As a school we're very keen to be at the forefront of educational change and development."*

As it is involved in the majority of Phase 1 BSF projects, Steljes (the exclusive representative for SMART Technologies in the UK) was ideally positioned to help by offering valuable advice to the school on how to plan and develop its ICT. "We wanted flexible teaching and learning spaces with instant and universal access to ICT without having to think about it," Ian explains. *"Matthew Pearson of Steljes delivered a number of ICT training days over a two-year period, which expanded people's knowledge of what technology was available, and around 18 months before the building was due to be completed, we created ICT champions for each subject. This was part of our strategy to keep staff involved and informed at every stage of the design and development process so that their ICT preferences were accommodated where possible."*

As a result of this thoughtful and inclusive approach, the new building is equipped throughout with the latest interactive learning technologies to suit the needs of each department. Every space now has a SMART Board™ interactive whiteboard, and each faculty has a SMART AirLiner™ wireless slate as well as document cameras. According to Ian, this technology is already changing teaching practice: *"The use of this new technology allows us a great deal more interactivity with students, from touching a SMART Board to writing on a wireless slate is wonderful. We're actually moving beyond that now and saying 'here's an AirLiner, so you can work within groups and can move it around the classroom', and we are developing these new technologies."*

With its practical layout, pleasant workspaces and generous corridors, the state-of-the-art new school building is the result of a similarly collaborative approach. "There was a large degree of democracy in the design process," says Sue Mansfield. "Students, staff and our leadership team were all involved in a series of workshops, meetings with architects, and visits to other schools to look at interesting features. The new building is a direct reflection of what staff and students wanted, and we've deliberately planned out potential issues.

The superb new technology-enabled learning environment has already had a huge impact on the school's students. Reflecting on the improvements they have realised so far, Ian Morrel comments: *"What I and the other staff found quite striking is that the introduction of SMART Boards really did engage boys a great deal. As a school we were part of the Excellence in Cities programme looking at the gender difference as our boys were under-achieving in relation to girls. Through the use of SMART Boards and other curriculum changes we've reduced the gender gap for GCSE results from 25% down to 6%."*

Titus Salt School is committed to further developing its ICT strategy to provide students and teachers with an even broader choice of technology tools in future. *"Education should be leading rather than following industry, so that when our students get jobs they know how to use the latest technology," concludes Head teacher Sue Mansfield. "We therefore want to be at the forefront of using technology to drive our core purpose and help us to do the job more effectively."*

Further information is available from Steljes at www.steljes.com .





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