Premier's Teachers Credit Union Mathematics Scholarship

The digital education revolution in the senior school

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Introduction

With the roll-out of laptops to Year 9 students in 2009 as part of the Commonwealth Government’s Digital Education Revolution initiative, many resources were produced to help teachers integrate this technology into Stage 5 Mathematics (e.g. TaLE). However, finding resources suitable for Advanced, Extension 1 and Extension 2 Mathematics proved to be more difficult. In theory, the use of student laptops, together with the introduction of interactive whiteboards into the Mathematics classroom should have heralded the perfect opportunity to finally shift the focus away from teachers and textbooks, creating a learning environment in which students are more actively engaged in the learning process and allowing more scope for class discussion. My own experience showed me that I was unwilling to relinquish my control in the teaching and learning environment unless I felt completely confident that using the technology had tangible learning benefits for my students.

Focus of the Study Tour

My main objectives in visiting schools and universities across the USA and UK were to:

* + Observe the ways in which a “one-to-one” programme of student laptops has been integrated into calculus-based Mathematics courses in comparable systems of education;
  + Explore future directions of e-learning by attending the National Council of Teachers of Mathematics conference in Philadelphia;
  + Liaise with experts in the field of education who have studied what impact using technology has on the pedagogy of teaching Mathematics, the learning outcomes of senior students and the changing role of the teacher and student in the classroom.

The Urban School, San Francisco, USA

The Urban School implemented its 1:1 laptop programme for its students in 2000. Students and staff are currently issued with MacBook Airs, which contain specialized software such as [Cabri Geometry](http://www.cabri.com/) – an interactive software package which allows users to build and manipulate figures in 3D. Each student also uses a TI-89 graphing calculator. Unlike earlier models of TI graphing calculators, the CAS (computer algebra system) capability of the TI-89 graphing calculator “can evaluate and simplify algebraic expressions symbolically[[1]](#footnote-1)”

Weekly lesson plans (lesson objectives, classwork, homework) and additional resources (e.g. notes from textbooks, handouts with instructions and exercises) are organised into a "Conference Centre" on the school network. Students can also use the Conference Centre to ask each other (and answer) questions about any aspect of the lesson. There is also an IM (Instant Messaging) facility available to the students.

The school aims to integrate technology into its daily curriculum in a holistic way, to promote and develop critical thinking skills. By not teaching computing as a stand-alone subject, students are introduced to software as they need it, learning and refining their skills in the context of a larger problem to be solved. Students work in small groups on a project that can take a number of weeks to finish.

One lesson that I observed was on Analytical Geometry (an advanced elective class). Students used Cabri 3D on their laptops to create a model of a 3D figure (a sphere). When the basics of creating a sphere and a plane through three points were mastered, time was then spent on working on creating a model of the Earth and rotating vectors to calculate sunrise and sunset at a particular location, depending on its position. This question had been handled procedurally in previous lessons but the idea behind using Cabri was to look at the problem without being bogged down by the calculations and mathematical processes involved. The investigative, collaborative nature of the task kept the students focused and interested during the lesson – they helped each other out with technical issues, leaving the teacher free to move between the groups, answering questions that modelled higher-order thinking.

University High School, San Francisco

Each student has the use of an iPad, which is mainly used as a substitute for textbooks. Teachers use Dropbox folders to place documents that can then be downloaded directly to the student’s iPad. Students feel that the iPad is easier and lighter to manage and transport instead of using multiple texts. However, it is not possible to print from them and teachers are not able to post resources created on the iPad directly to the school’s Intranet.

Students and teachers use [Geometer's Sketchpad](http://www.dynamicgeometry.com/) for graphing and various apps for the iPad (e.g. [Wolfram Alpha](http://www.wolframalpha.com/examples/Math.html)). They also use an app called "[Notability](http://www.gingerlabs.com/cont/notability.php)" which helps them take and organise their class notes.

According to the school’s website, there are three key areas involving the 1:1 iPad initiative that warrant further research:

* **Digital Course Material:** What are ways we can increase digital course material, e.g. digital textbooks, ePubs [electronic publication]?
* **Systems and Software:** What are the best systems and apps for reducing paper use?
* **iPad Augmentation:** How can we make better use of the iPads, e.g. find robust word processing and flash solutions?

WT White High School, Dallas

Each mathematics classroom is equipped with a document camera. Students and teachers both use [TI-nspire](http://education.ti.com/calculators/products/US/Nspire-Family/) graphing calculators, which connect wirelessly to the school's network. In addition, teachers can monitor their students' activity using TI software called "[Navigator](http://education.ti.com/educationportal/sites/AUS-NZ/productDetail/aus-nz_nspire_navigator.html)". From the Navigator console, teachers can also lock the student calculators if needed or project their work onto a big screen. Unfortunately, during my visit, the school was experiencing connectivity issues with the TI calculators and I was not able to observe the considerable potential of Navigator.

This was my first experience of a government high school in the USA and the stark differences between WT White High School and the private schools I visited earlier in terms of class numbers, access to resources and teacher attitudes towards technology made me challenge my preconceived notion that technology could “level the playing field” in education.

Ursuline Academy, Dallas

Laptops have been an important teaching and learning tool in the school for over 15 years. Students and teachers use either a Toshiba or Fujitsu tablet PC. Teachers are encouraged to incorporate new and emerging technologies in the classroom - and professional development is ongoing. In the staffroom, each teacher has access to a tablet PC and a laptop docking station on his/her desk connected to a larger flat-screen monitor. Each classroom has a document camera and a screen that can be connected to the teacher's tablet PC.

Students are encouraged to cultivate an awareness of the importance (both functional and aesthetic) of Mathematics in the natural and built world. For example, concepts such as optimisation and simultaneous equations are applied in the development of a project related to either a business or service opportunity.

* TI-Nspire CX calculators

While the full functionality of the calculators is available to students on their laptops, it is important that students are proficient in using the calculators as they can be used in the external examinations. In the lesson I observed on Volumes by Slicing, students were able to input the integral and limits into the calculator to find the volume of a solid. Further, the teacher was able to download documents from his computer to the students' calculators. Graphing calculators are also used to illustrate geometrical concepts with vectors. The [TI website](http://www.education.ti.com) also has many teaching resources available to support the use of the calculators in the classroom.

* Geometer's Sketchpad

This program is used extensively in geometry and also used to reinforce concepts and establish connections with algebra and calculus. "Algebra in Motion" and "[Calculus in Motion](http://www.calculusinmotion.com/)" are two animations programs used with Geometer's Sketchpad to dynamically illustrate concepts which were traditionally difficult to visualise. In the lesson I observed, the base of a solid was drawn (e.g. a circle), chords were then drawn which were part of the solid's cross-section, and then those cross-sections were animated to show how the solid is formed.

* Flipped classroom

The flipped classroom inverts traditional teaching methods - course content and instruction is delivered online (video) and outside the classroom. Students are able to learn at their own pace and interact with their peers and/or teacher. The start of the classroom lesson then involves students doing a warm-up problem to gauge their level of understanding, followed by either more time to work on activities or reinforce concepts where necessary. The role of the teacher shifts from being "the sage on the stage" to "the guide on the side". While in theory this fits in nicely with the idea of self-directed learning, it is still relatively new and there has been some opposition from students to embracing the flipped classroom.

* My Math Lab

[MyMathLab](http://www.mymathlab.com/) is a series of online courses that teachers can customise to provide individualised remedial support to students who may be struggling with aspects of the curriculum. It is modular, self-paced and accessible (via Internet access) outside the classroom. Teachers can track their students' progress through the module.

* Dyknow

[Dyknow](http://www.dyknow.com/) is a program that allows a teacher to oversee and manage the functionality of the calculator and laptop of his/her students from one console. Aside from the classroom management benefits, students are able to access, personally annotate and store the teacher's notes to be replayed anytime, anywhere.

* Interactive Digital Textbooks

A conscious decision was made to better integrate the various strands of the curriculum rather than simply follow the sequence of a textbook. This precipitated a shift towards using interactive digital textbooks ("[Haese Mathematics](http://www.haesemathematics.com.au/home.asp)" and "[Kinetic Books](http://www.kineticbooks.com/)") which incorporate animation, self-tutorials and an online homework centre.

NCTM Conference, Philadelphia

10000 teachers from the US and around the world descended upon Philadelphia for four days of the annual National Council of Teachers of Mathematics ([NCTM](http://www.nctm.org)) Conference. The theme this year was “Technology and Mathematics”. The NCTM Position on the role of technology in the teaching and learning of mathematics is: “*it is essential that teachers and students have regular access to technologies that support and advance mathematical sense making, reasoning, problem solving, and communication. Effective teachers optimize the potential of technology to develop students’ understanding, stimulate their interest, and increase their proficiency in mathematics. When teachers use technology strategically, they can provide greater access to mathematics for all students[[2]](#footnote-2)”*

One presentation I attended was titled “Digital Textbooks for Mathematics: Promise and Reality”. The presenter, Amanda Thomas, stressed that the promise of a digital textbook should extend far beyond simply projecting the image of a print textbook on a screen and should incorporate the extra functionality of digital media – e.g. interactivity, searchability, “intelligent tutors”, support for different learning styles, online collaboration and sharing, online feedback for teachers. She cited two examples of digital textbooks currently in use and being further developed:

* CK-12 Flexbooks - [Free, web-based content](http://www.ck12.org/) created by teachers and can be downloaded in PDF, ePub or Amazon Kindle format. As of January 2012, the CK-12 Foundation partnered with Wolfram Alpha to develop an interactive version of the textbooks.
* iBooks - In January 2012, an agreement between Apple and three major textbook publishers means that digital textbooks can be downloaded directly to an iPad. Through the [iBooks 2 app](http://www.apple.com/education/ibooks-textbooks/), these textbooks can display interactive diagrams, video and audio.

Another presentation I attended dealt with “Connecting Teachers and Students Through Skype”. This presentation examined the role played by communications technology such as Skype in connecting students to the “outside world” (e.g. peers in other schools, industry experts, virtual field trips). Most students are already “tapped in” to the world beyond their physical location (e.g. via social networking sites such as Facebook or through online blogs such as blogspot.com). The challenge for teachers is to harness this connectivity to encourage a wider dialogue about Mathematics, extending the subject beyond the classroom.

Centre for Technology and School Change, Columbia University, New York City

I spent a very productive and enjoyable day with Dr Ellen Meier (co-director of the CTSC) and Rita Sanchez, a facilitator in Mathematics and Science. According to Dr Meier, current research shows that Maths teachers are the least likely of teachers to integrate technology into their lessons. There are essentially two levels of barriers:

* 1. Physical - no space, lack of equipment
  2. Teacher belief/orientation - contradiction between high stakes testing and moving into the 21st century.

Dr Meier and her team work with both trainee and experienced mathematics teachers to better integrate aspects of technology into their lessons. In a sad indictment of public school funding, it has been Dr Meier's experience that very few public schools have the resources to be able to use a high level of technology – in terms of equipment and/or staff who are trained in using digital tools. Consequently, graduating teachers who have gained familiarity in using the technology often end up in the private school system, further widening the gap between the public and private systems.

Millfield School, Somerset, UK

The school is moving towards using iPads for students and providing teachers with iMacs in the classroom. Currently, the students do not use laptops in their Maths lessons and, unlike the USA, graphing calculators are not widely used.

Geogebra is used extensively as a demonstration tool in the Maths staffroom. In one lesson I observed, the teacher was revising iterative methods for approximating solutions to equations. He went through the technique on the board, showed them how to do the calculations on their Casio calculators and then used a static diagram of the graphs on the smartboard (using “Notebook”) which he could annotate and print out a screenshot. He had created a button in Geogebra (similar to recording a macro in Excel) to do a series of steps. Each time the button was pressed, the program performed one iteration. The teacher also introduced me to [Geogebratube](http://www.geogebratube.org/) which has thousands of interactive activities created by teachers.

Devonport High School for Boys, Plymouth

DHSB has achieved a great deal of success in supporting its students through the use of online learning communities. The Head of the Mathematics Department, Andy Guy, has been instrumental in setting up these online learning support groups. Students sign up via Google mail and can ask questions or upload screenshots of their work. Both teachers and students can then use a piece of software called [Open Sankore](http://open-sankore.org/) to correct or annotate the work as needed and upload it to the group for its members to see.

The longer-term plan is to run online seminars using a team of student mentors. Funding has been given to purchase more graphics tablets and graphics pens to facilitate interaction with other students. As part of supporting students during the exam revision process, Mr Guy is interested in trialling online revision sessions for students at home - using chat windows, Bluetooth microphones and software called [Vyew](http://vyew.com/s/). The Maths department also incorporates videos from the [Khan Academy](http://www.khanacademy.org/) and the [MyMaths](http://www.mymaths.co.uk/) package to further support its students.

Ridgeway School, Plymouth

Ridgeway School is a specialist Maths/Science school in Plymouth. This was my first look at a state school in the UK. Sean Powell, the Head of the Mathematics Department, introduced me to [Triptico](http://www.triptico.co.uk/) - a site that currently contains 23 different interactive whiteboard resources which can be easily customised by teachers to transform a regular lesson into a more engaging activity for students.

One Year 9 class I visited had students working in small groups on the solution to a series of problems. Students then filmed themselves working through the solution and the results would then be played back to the class. It was the first time I had seen podcasting being used in the Maths classroom. It was interesting watching how the students responded to the challenge of being able to explain their solutions in a way that would make sense to their peers.

I also visited a Year 13 class in which the teacher showed me around the [MEI](http://www.mei.org.uk/) (Mathematics for Education and Industry) website - with notes, examples, worked exercises and access to past papers and solutions.

Thornleigh Salesian College, Bolton

Thornleigh Salesian College, just north of Manchester, is in the process of deciding how best to invest in technology. The school is networked and has recently bought a class set of iPads for student use.

Craig Barton, my point of contact in the Mathematics Department, is well-known in the UK Maths community for his website [MrBartonMaths](http://www.mrbartonmaths.com/)- "a treasure trove of free maths gems for pupils, teachers and parents". He is also the Secondary Maths Adviser for the [Times Education Supplement](http://www.tes.co.uk/), the largest network of teachers in the world.  
  
The classes I observed all used some form of technology as part of the lesson. The graphing software package, "[Autograph](http://www.autograph-math.com/)" was extensively used to dynamically illustrate the concept of tangents and parabolas. A lesson on constructions used the geometrical instruments that are part of the SMARTBoard's Notebook software – far easier to use than blackboard/whiteboard compasses.

Oundle School, Oundle, UK

Computers in the Mathematics classrooms at Oundle School seem to be used more for demonstration purposes rather than as personal tools for students. Interactive whiteboards have fallen out of favour with several of the teachers, who instead opt for graphics tablets used in conjunction with projector screens.

The Department's intranet site is well-developed. Staff members are allocated a year group and are responsible for developing web content for that group. Resources available for students on the intranet site include links to past exam papers, enrichment activities, and the electronic versions of the textbooks in use.

Comberton Village School, Cambridge

What was particularly remarkable about the work being done by the Maths Department was how it was using aspects of technology to support the learning of all students. I observed a Year 10 class of low-achieving students in a computer lab using [WisWeb](http://www.fi.uu.nl/wisweb/en/) to "build" solids based on their top, front and side views. Students worked in small groups and were actively engaged in trying to build the solid with the minimum number of blocks. At the end of the school day, I sat in on a Year 9 Geometry lesson in which Geogebra was used to illustrate the concepts of rotation, reflection and enlargement. It was a wonderful investigation exercise with minimal input from the teacher. At the end of the lesson, he brought the students back together and asked them to explain, in their own words, what they discovered about these concepts. The lesson flowed seamlessly and organically.

I also spent time with Jamie Freeman, who has been working on an app for the smartphone called "Imvoto". This app, when downloaded to the student's phone, will enable the student to participate in multiple choice questions, allowing the teacher to keep track of their progress. Students can also take photos of their working out and submit that to the teacher as well. The advantage of using mobile phones here is that students are more encouraged to do their working on paper (on a laptop, this might not be as likely). The software is still being developed but the aim is to map the questions used to the curriculum itself. Jamie indicated that the challenge at the moment is to develop questions in such a way as to make them suitable for the multiple choice format. There is considerable potential in the "Imvoto" app and it was an absolute pleasure to explore possible future directions for it.

The journey continues…

Areas I intend to follow up on:

* + Keep in close contact with the network of teachers I spent time with in the USA and UK
  + Update my class notes to include greater inclusion of Geogebra demonstrations
  + Trial the concept of the “flipped classroom” with my Extension 2 class
  + Set up an online community for my Extension 2 class to provide extra support for my students.

1. [T1-89 graphing calculator, Wikipedia](http://en.wikipedia.org/wiki/TI-89_series) [↑](#footnote-ref-1)
2. [National Conference of Mathematics Teachers](http://www.nctm.org/about/content.aspx?id=31734) [↑](#footnote-ref-2)