



TECHNOLOGY LYNDAL WILSON

A NEW DIMENSION

THE USE OF 3D PRINTING IN SCHOOLS

3D printing has been identified as an emerging technology with the potential to have a significant impact on both school and higher education. *Independence* Editor Lyndal Wilson spoke with several AHISA members' schools about how – and why – they are using the technology.

IN ITS 2013 report, Horizon Project shortlists 3D printing as an emerging technology likely to have an impact on teaching, learning and creative inquiry in school education, with an adoption horizon in the United States of four to five years.¹

Here in Australia, some AHISA members' schools have been early adopters of the technology; some have just invested in it. No matter what stage schools are at in their use of 3D printing, the enthusiasm for the technology and its potential to support student learning is palpable.

Adding a dimension

We are all familiar with 2D printing. We press 'print' from within a software application such as Microsoft Word and text or images are printed on sheets of paper via a linked inkjet or laser printer. In 3D printing, a file created in a computer-aided design (CAD) program directs the creation, layer by successive layer, of a tangible three-dimensional object that may be printed in polymers, resins, metals or metal alloys.

While the technology is commonly used in engineering and manufacturing to build prototypes, it has rapidly gained the attention of individual users as

the cost of printers tumbles. Even with some printers priced at less than AUS\$2,000, ownership of a printer is no longer necessary to engage with the technology; there are online companies that will not only print your 3D designs, but sell them, too.² Further evidence that wider take up of the technology is expected is Microsoft's June 2013 announcement that Windows 8.1 will make 3D printing 'as easy as writing and printing a Word document'.³

In schools, reasons for investment in 3D printing vary. For some, purchase of a 3D printer was in part prompted by the need to reflect industry practice in senior school design, technology and engineering courses.

'We believe it is important to keep a relationship between education and industry, and between school and the tertiary sector,' said Chris Graham, Senior School teacher at Westminster School, SA. 'We want to support our senior students who have an interest in computer-aided design (CAD) and manufacturing (CAM). Students work with an industry standard CAD software program, SolidWorks, which is used internationally and supported by universities in Adelaide. Being able to use the same program and to

experience, although on a smaller scale, an additive manufacturing technology like 3D printing encourages students to consider tertiary studies in industrial design and engineering. It gives them an advantage in their further education.'

Westminster first purchased a 3D printer in 2010 and now has three printers supporting senior studies in all phases of design, from concept modeling to functional testing and assembly verification.

John Paul College, QLD, is also an early adopter of the technology. In 2009, with a move to a new building planned, the College's Design Technologies learning area was given the opportunity to create a 'wish list', and an industry standard 3D printer was purchased.

'One of our main focuses is design, whether product or graphic design,' explained Bruce Middleton, Curriculum Assistant for the College's Design Technologies learning area. 'With the opportunity to match current manufacturing methods we decided to move to computer controlled equipment – including a laser cutter, a CNC (computer numerical control) router and mill, and a 3D printer.'

As at Westminster, John Paul College's printer is used mostly with senior school students in design technology courses.

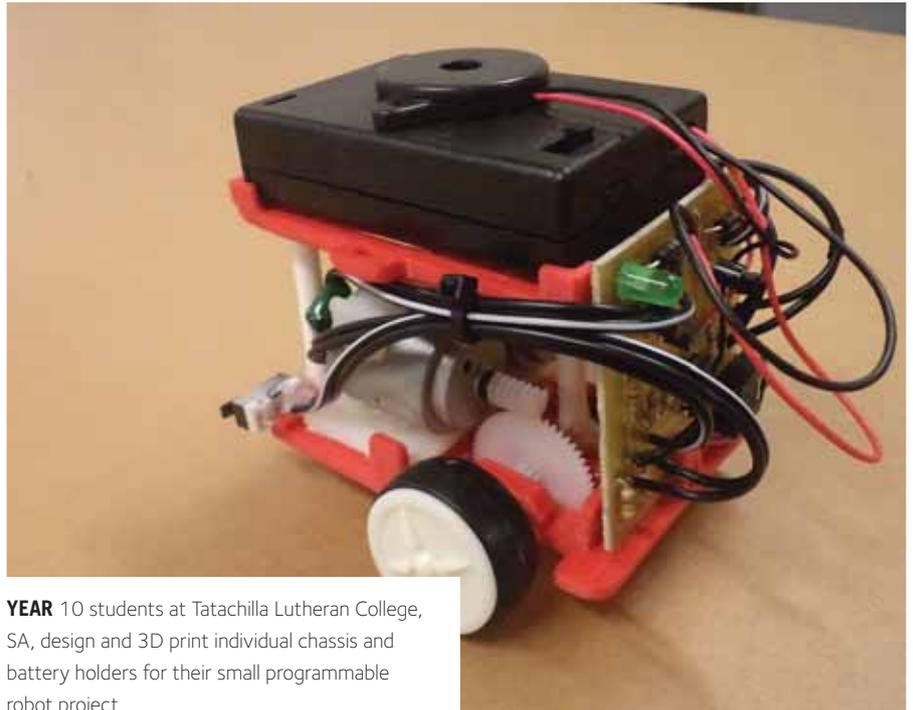
'Our 3D printer is a high-end industrial model with a high quality, high precision print,' said Bruce. 'The materials it uses are also quite expensive, so it is not economically viable to use it across the College, although art students use it occasionally for a particular work. We are now looking at cheaper models for wider application.'

21st century learning

The rapid cost dive of 3D printing has succeeded in capturing the attention of schools who see the potential of the technology to support 3D learning. According to Anthony Crawford, Design & Technology teacher at Scotch Oakburn

TECHNOLOGY

“ 3D printing, which allows students to match their drawings to a physical object, is seen as an important means of grasping concepts such as line, angle, plane, space and dimension.



YEAR 10 students at Tatachilla Lutheran College, SA, design and 3D print individual chassis and battery holders for their small programmable robot project.

College, TAS, the development of easy-to-use CAD software is also helping to promote interest in 3D printing.

‘It used to be difficult to master CAD programs,’ explained Anthony. ‘Now, our students have a range of CAD ware on their netbooks. For teaching we focus on Vectorworks and Rhino, but there are several programs we also recommend for student use, including SketchUp, Autodesk’s 123D and 123D Sculpt, and another program called Blender, which is suited to designing more organic shapes.’

These kinds of tools are helping even very young students to learn 3D drawing, and many schools identify this as an essential skill students need in the 21st century. 3D printing, which allows students to match their drawings to a physical object, is seen as an important means of grasping concepts such as line, angle, plane, space and dimension.

As Adrienne Erwin, ICT Integrator at Inaburra School, NSW explains: ‘Students need to come to an understanding of the difference between two and three dimensions. For example, they need to understand

that a cube is not lots of 2D shapes put together. Six planes do not make a cube! Those six planes are simply joined together to look like a cube. It is initially frustrating for students, but schools must help students develop spatial intelligence and 3D printing offers exciting possibilities to support this.’

3D printing is also helping schools create a bridge between virtual and real world teaching.

‘Our Design & Technology department at Scotch Oakburn College encompasses both the digital world through the teaching of computer aided design and the physical world through the teaching of more traditional technology based subjects,’ explained Anthony Crawford. ‘As a department, we identified the need to try and bring these two discrete subjects together.’

This led Scotch Oakburn College staff to explore digital fabrication, including CNC routing, laser cutting and 3D printing.

‘With 3D printing we are able to give our furniture design students the option of approaching their work in a holistic way, designing and producing every aspect of their concept, right down

to the handles, hinges and knobs,’ explained Anthony. ‘And the technology gives our graphic design students an authentic opportunity to include the physical experience within their design process and concept realisation.’

Richard Baird, now Deputy Principal at Great Southern Grammar School, WA, agrees that 3D printing is adding a new dimension to learning and teaching in design.

‘The technology helps develop 21st century learning skills such as collaboration, problem solving skills and creativity along with supporting students to explore why things are the way they are,’ said Richard. ‘Students look at ergonomics, size, shape and spatial awareness. The technology also takes students into the area of material properties, which is very important. It opens up questions about the way we produce and manufacture products and the properties of the materials we use to achieve our product goals, which is fundamental to developing global awareness.’

Richard introduced 3D printing at Westminster School, SA when leading that School’s Design & Technology



faculty. He is enthusiastic about the learning and teaching potential of the technology right across the curriculum and is now leading its introduction at Great Southern Grammar.

‘We have begun by using the technology to support a transition in thinking, from two to three dimensions,’ explained Richard. ‘As a start, we have worked with students in Years 7 and 8, on projects that have relevance to them. For example, students have designed covers for their iPhones or iPods, or stands to hold their iPads vertical, and some have made identifying tags for their bags by 3D printing their name. This has had two unexpected outcomes. The students’ work was highly visible around campus as they moved from class to class or school to home and they had to respond to the questions fired at them by other students. This helped the learning flow outside of the classroom. It also helped promote interest in design and technology, and in 3D printing!’

Design and technology focus

In some schools, interest in 3D printing emerges from within the design and

technology area and its use across year levels and subject areas remains limited. This can be because the nature of the school’s printer makes wider application difficult, as with John Paul College’s industry-grade printer, or because of the high-end CAD software used, as with Westminster’s professional SolidWorks CAD program.

At Tatchilla Lutheran College, SA, which also uses a sophisticated CAD program, Creo 2.0, the interest in 3D printing grew out of a frustration that students’ learning in CAD was limited to creating engineering drawings.

‘It is good to have drawings available for use in the workshop,’ explained Jim Brown of the College’s Design & Technology faculty, ‘but to be able to produce a model of what you’re going to create adds significantly to the design process. It was the prototyping function of 3D printing that first attracted us to the technology.’

According to Jim, the College’s professional CAD software can sometimes be a barrier to cross-curriculum projects.

‘3D printing goes hand in hand with CAD software,’ he explained. ‘All our

BAG tags individually designed and 3D printed by students in Years 7 and 8 at Great Southern Grammar School, WA, effectively promoted student interest in 3D drawing and printing, and in design and technology courses at the School.

Years 8 to 12 students have a laptop and the 3D software is available to them. But the teaching of that software currently occurs only within the Design & Technology faculty. Teachers outside of our faculty would need to make it a priority to learn the CAD software if they wish their students to use it, and due to time constraints this hasn’t happened yet. It is possible to download ready-made 3D designs from the internet, but that defeats the purpose. We want students to go through a design process and make something that is unique to them.’

Tatchilla has, however, expanded use of the technology across year levels by introducing a new Year 9 digital technologies course. As part of the course, students design and print a simple robot or figurine that incorporates a small wind-up mechanism.

‘This has been very successful,’ said Jim. ‘Printing of the robot takes about an hour and costs roughly \$2, which makes it affordable. It is motivating for the students to have something to take home with them, and it has created a stir of interest in other students.’

The College’s Design & Technology staff members also work with individual students from other faculties who may want to use the 3D printer for a specific project. Most recently, they worked with a Year 12 art student whose project examined different forms of sculpture, including digital sculpture.

Scotch Oakburn College’s Design & Technology department also makes students outside the department welcome.

‘If a student comes and asks about the printer, even if they are not in a Design & Tech class, we will work with them,’ explained Anthony Crawford. ‘I

“ In some schools, cross-curricular approaches have governed interest in the technology from the time of its adoption.

tell them that if they are enthusiastic enough to download a CAD program, learn how to use it, design an object and then bring the file to me on a data stick, I will look at it and we'll print it at lunch time.'

At Scotch Oakburn College, the 3D printer is used across Years 9 to 12 in the Design & Technology department, but mostly accessed by senior students. It is also available to enterprise students, for example to support an e-commerce project, and the department is also working closely with the art department. Discussions are also underway with the mathematics department and with the Junior School, where students are already using 3D software. However, Anthony warned that it is important to have staff members on time release to support cross-curricular links.

Cross-curriculum interest

In some schools, cross-curricular approaches have governed interest in the technology from the time of its adoption.

At St Andrews Christian College, VIC, one of the first projects undertaken using a 3D printer involved eight Junior

AT DANEBANK Anglican School, NSW, 3D printing made possible the creation of a locking mechanism essential to a unique vehicle tray designed by a Year 12 student.

School extension maths students. The students were given the task of modelling a cylinder that would match the volume of a cube with the same height. Once the students had developed their formulae, using SketchUp software they drew corresponding shapes in 3D (personalised with letters and symbols) and then printed them. To test their calculations, they filled one printed shape with water and then poured the water into the other shape.

The College purchased their 3D printer last year after head of IT at St Andrews, Nathan Alison, saw a demonstration of 3D printing at a conference.

'I could see the benefits of the technology to develop creativity and problem solving,' explained Nathan. 'For example, as well as applications in maths, we are incorporating a task in an expanded IT elective on 3D graphics that requires students to model and print a small child's toy with separate moving parts.'

Inaburra School, NSW, first became interested in 3D printing as a means to expand students' experience of computing.

'Computing allows children to be creative in ways they may not otherwise imagine as possible,' explained Adrienne Erwin. 'They are not limited by a lack of skills in sawing, drilling or welding for example; on a computer, you can create an object and if you make a mistake you simply delete it and start again. I wondered how much 3D printing would expand these creative opportunities.'

The technology has already been successful in creating excitement around computing. Across year levels, Senior School students are working with Junior School children on 3D drawing and printing, and there is mounting interest across curriculum areas.

'Our engineering staff will be using the technology in a bridge building project that examines stress and other structural issues,' explained Adrienne. 'Our geography teachers are very keen on the possibility of printing 3D maps, and our science coordinator is exploring the possibility of printing skeletons as a cost saving. Our art department sees it as a way to give students an experience of manufacturing in a different process and with different materials.'

Preshil, The Margaret Lyttle Memorial School, VIC, has only recently obtained



a 3D printer, which was donated by parents. At the time of writing, teachers were in the process of learning the technology and discussing how it could be used across the School.

‘The technology fits in very well with our Preshil philosophy in terms of creativity, challenge and hands-on learning,’ explained Bronte Howell, Preshil’s Maker-Lab Coordinator. ‘We can gain a deeper understanding of how something works by physically creating it through 3D drawing and printing, which is task and project oriented, and which has exciting potential for students of all ages. We are passionate about STEAM – science, technology, engineering and mathematics, plus art – and 3D printing really supports that. It dovetails very well with project and inquiry based interdisciplinary programs.’

Student demand

In some schools, uptake of the technology has been driven by the demands of student design projects. For example, the interest of Danebank Anglican School, NSW in 3D printing was sharpened when the technology

offered the best production solution for a design project undertaken by a Year 12 student.

‘Our student wanted to make a tray to fit inside a car,’ explained Danebank teacher Mark Gregory. ‘The idea was to be able to lock cake trays into the vehicle tray so that the cakes would not slide around and be damaged during delivery. The locking mechanism had tiny sections inside it that were hollow and 3D printing (an additive process) was a better option than machining (a subtractive process).’

According to Mark, the design process itself was much richer for the student. ‘The student first had to become self-sufficient in a CAD program to draw the parts she needed. She was able to test out her design by printing it, and refine it until she had exactly the right fit. Being able to design things from scratch, then refine and recreate them is a great learning opportunity.’

Because the School’s 3D printer was originally placed in a computer room, the printing of the student’s design attracted the attention of others in the room.

‘Other students then asked to design and print objects, too,’ said Mark. ‘We had been using Autodesk’s 123D software with Year 8 design students to create cardboard models for laser cutting. Now we are using the 3D printer instead.’

Faith Lutheran College, SA, has two 3D printers. Teacher Jason Rosenzweig said students become fascinated when they see an object built by a 3D printer, and observe the transition from the virtual to the real. Students also appreciate the time they save by using a 3D printer.

‘3D printing can show students what their design looks like in a relatively short time frame,’ explained Jason. ‘It also produces needed parts more quickly. For example, our Year 10s make autonomous model cars, combining electronics with construction and mechanics. Rather than fabricating parts out of aluminium or timber or some other material, students design in CAD, print, and then assemble the parts. They can get a very accurate part in less time than when using other technologies.’

Into the future

Bronte Howell sees the growing interest at Preshil in 3D drawing and printing as linked to a new focus on design and technology worldwide.

‘Engineers and scientists are looking to team up with artists and designers to create products, and more young people are looking at design and technology options for their university studies,’ she said. ‘Maker labs and hacker spaces – fully equipped hi-tech workshops run by volunteers where people can buy time – are becoming increasingly popular overseas and starting to emerge in Australia. It has inspired us to attempt to build that culture here in the School, and 3D printing certainly has a place in it.’

JUNIOR School maths extension students at St Andrews Christian College, VIC, used 3D printing to test their modelling of a cylinder that would match the volume of a cube with the same height.



TECHNOLOGY

Mark Gregory predicts that in the future 3D drawing will gain a higher profile in the curriculum.

‘The reason 3D drawing hasn’t been fully integrated in the curriculum so far is that teachers with low-level computer skills are resistant to it,’ said Mark. ‘Some teachers have the attitude that if they can’t do it, they can’t teach it. This is a big sticking point with many teachers, but a little persistence will get teachers beyond this way of thinking. It is getting much, much easier to draw in 3D with the very simple CAD programs now available for tablets and PCs.’

According to Mark, the capacity to go the next step beyond drawing a 3D object, and printing it, will have a huge impact on everyday life, citing as an example being able to download and print a part for an old model vacuum cleaner.

‘3D printing is creating a new way of thinking,’ said Mark. ‘Inevitably, it must have a huge impact on education.’

All schools agreed, however, that the technology is not an end in itself.

‘At John Paul College we use the printer as just one of a range of possible technologies,’ said Bruce Middleton. ‘We are task oriented rather than technology oriented; the design process itself is the focus.’

Anthony Crawford concurred. ‘The 3D printer is just another tool used in the process of realising a design concept. That’s where the learning is, in the process.’ ■

NOTES

1 For more information about the Horizon Project and to download its reports visit <http://www.nmc.org/publications/2013-horizon-report-k12>.

2 For example, see shapeways.com, i.materialise.com and sculpteo.com.

3 Mark Wilson, ‘Microsoft makes 3D printing as simple as clicking “print”’, 26 June 2013. Accessed at <http://www.fastcodesign.com/1672910/microsoft-makes-3-d-printing-as-simple-as-clicking-print>.



SENIOR students at John Paul College, QLD, exploit the additive processing capabilities of 3D printing, which allow hollow shapes to be created within objects.

3D PRINTING TIPS

BUY a ready-assembled model; it takes up too much teacher time to build a printer.

BE aware of the costs of materials and maintenance. Does the printer allow for cheaper, generic materials to be used?

SIZE isn’t everything. Machines with a smaller (140mm³) print area are often more reliable, with fewer parts to malfunction.

PLAN for a lead-in period after purchase of the printer to give staff time to experiment with it and have it working properly before students are involved in the process.

PLACE the printer in a room where heat and moisture can be controlled.

RUN high-end printers at least once a week to ensure fine parts do not get clogged by materials as they dry out.

THE printing process can take some time; look into ways that multiple models can be printed simultaneously.

SHOW and tell with other faculties to get cross-curriculum ideas.

LOVE the trial, love the error, but don’t give up!

PLUS

NATHAN Alison of St Andrews Christian College publishes as ‘the3Dteacher’ on YouTube and has posted a beginner’s guide to creating a simple model in SketchUp, and printing it on the Up! Mini 3D printer. See <http://www.youtube.com/watch?v=2vJcrIqP7Aw>.

MARK Gregory of Danebank recommends Dr Henry Thomas’s series of eight video tutorials on 3D printing with the MakerBot Replicator 2, at <https://www.youtube.com/watch?v=DSMmtYX7aKs>.