NMC Horizon Project

Technology Outlook

Australian Tertiary Education 2013-2018

An NMC Horizon Project Regional Analysis

Technology Outlook for Australian Tertiary Education 2013-2018

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An NMC Horizon Project Regional Analysis

is a collaboration between

The New Media Consortium

and

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Executive Summary

The *Technology Outlook Australian Tertiary Education 2013-2018: An NMC Horizon Project Regional Analysis* reflects a collaborative research effort between the New Media Consortium (NMC) and Open Universities Australia to help inform Australian educational leaders about significant developments in technologies supporting teaching, learning, and creative inquiry in tertiary education.

All of the research underpinning the report makes use of the NMC's Delphi-based process for bringing groups of experts to a consensus viewpoint, in this case around the impact of emerging technologies on teaching, learning, or creative inquiry in Australian tertiary education over the next five years. The same process underlies the well-known *NMC Horizon Report* series, which is the most visible product of an on-going research effort begun a decade ago to systematically identify and describe emerging technologies likely to have a large impact on education around the globe.

The *Technology Outlook for Australian Tertiary Education 2013-2018* was produced to explore emerging technologies and forecast their potential impact expressly in a tertiary education context. In the effort that took place over February and March 2013, a carefully selected group of experts was asked to consider hundreds of relevant articles, news, blog posts, research, and project examples as part of the preparation that ultimately pinpointed the most notable emerging technology topics, trends, and challenges for Australian tertiary education over the next five years.

Known as the 2013 Horizon Project Australia Advisory Board, that group of experts consists of notably knowledgeable individuals, all highly regarded in their fields. Collectively the advisory board represents a range of diverse perspectives across the education sector. The project has been conducted under an open data philosophy, and all the interim projects, secondary research, discussions, and ranking instrumentation can be viewed at aus.wiki.nmc.org. The precise research methodology employed in producing the report is detailed in a special section found at the end of this report.

Table 1: Comparison of "Final 12" Topics Across Three NMC Horizon Research Projects

NMC Horizon Report 2013 Higher Education Edition	Technology Outlook for Australian Tertiary Education 2013-2018	Technology Outlook for Australian Tertiary Education 2012-2017
Time-to-Adoption Horizon: One Year or Less		
Flipped Classroom	Learning Analytics	Cloud Computing
Massive Open Online Courses	Massive Open Online Courses	Learning Analytics
Mobile Apps	Mobile Learning	Mobile Apps
Tablet Computing	Social Media	Tablet Computing
Time-to-Adoption Horizon: Two to Three Years		
Augmented Reality	3D Printing	Digital Identity
Games and Gamification	Badges	Game-Based Learning
The Internet of Things	Information Visualisation	Open Content
Learning Analytics	Location-Based Services	Personal Learning Environments
Time-to-Adoption Horizon: Four to Five Years		
3D Printing	Flexible Displays	Digital Preservation
Flexible Displays	The Internet of Things	Massive Open Online Courses
Next Generation Batteries	Virtual and Remote Laboratories	Natural User Interfaces
Wearable Technology	Wearable Technology	Telepresence

The 12 "technologies to watch" presented in the body of this report reflect our experts' opinions as to which of the nearly 60 technologies considered will be most important to Australian tertiary education over the five years following the publication of the report. As Table 1 above illustrates, the choices of our experts overlap in interesting ways with those who contributed to the *NMC Horizon Report > 2013 Higher Education Edition,* which looked at technology uptake from a global

perspective, and the *Technology Outlook for Australian Tertiary Education 2012-2017*, which provides perspective on how the technology discussions in Australia have shifted in the past year.

All three of these projects' advisory boards — a group of 136 acknowledged experts — strongly agree that mobile learning, in some form, will likely tip into mainstream use within the next year — a trend that spans education across much of the world. However, that is where the commonalities stop between all three advisory boards. The Horizon Project Australia Advisory Board this year, as it did in 2012, again sees learning analytics in the near-term, while the global group placed the technology further out at around two to three years. On the Australian wiki, personalised learning and more authentic assessments were major discussion points, making learning analytics a highly valued and more pressing topic due to its potential to identify learning patterns and needs.

Table 2: Top-Ranked Trends Across Three NMC Horizon Research Projects

NMC Horizon Report 2013 Higher Education Edition	Technology Outlook for Australian Tertiary Education 2013-2018	Technology Outlook for Australian Tertiary Education 2012-2017
Openness — concepts like open content, open data, and open resources, along with notions of transparency and easy access to data and information — is becoming a value.	People expect to be able to work, learn, and study whenever and wherever they want.	People expect to be able to work, learn, and study whenever and wherever they want.
Massive open online courses are being widely explored as alternatives and supplements to traditional university courses.	Education paradigms are shifting to include online learning, hybrid learning, and collaborative models.	Increasingly, students want to use their own technology for learning.
The workforce demands skills from college graduates that are more often acquired from informal learning experiences than in universities.	Openness — concepts like open content, open data, and open resources, along with notions of transparency and easy access to data and information — is becoming a value.	Education paradigms are shifting to include online learning, hybrid learning, and collaborative models.

The 2013 Horizon Project Australia Advisory Board also placed 3D printing sooner on the adoption horizon than the global group, with some notable justification. In the short time since the *NMC Horizon Report > 2013 Higher Education Edition* was written, the technology has already gained significant footing, with more options for affordable 3D printers, and the high-speed trajectory of the Maker community associated with technology. Indeed, an increasing number of campuses are incorporating 3D printing across a wide spectrum of disciplines and courses in Australia.

The position of massive open online courses (MOOCs) on the near-term horizon in this year's report also reflects a tremendous progression from last year, when it was identified on the far-term horizon by the 2012 Horizon Project Australia Advisory Board. In the past year, several major Australian universities have partnered with fast-growing MOOC providers, such as Coursera, as well as establishing their own initiatives, such as Open University Australia's Open2Study. There is a clear and mounting emphasis on online learning generally and more ubiquitous access to learning opportunities in Australian tertiary education in particular.

A number of distinct choices distinguished the viewpoints expressed by the 2013 Horizon Project Australia Advisory Board from their counterparts in other regions of the world: information visualisation, location-based services, badges, and virtual and remote online laboratories, although considered by other recent panels, were seen as likely developments for Australia in the

mid- and far-term horizons, but were not listed at all by the global group. Additionally, the global group saw the Internet of Things as further along than the Australian advisory board.

The nuances of the technologies and their associated adoption horizons featured in this report are specific to Australian tertiary education, even if there are commonalities with other reports. Likewise, the key trends (Table 2 and pages 17-18) and significant challenges (Table 3 and pages 19-20) selected by the 2013 Horizon Project Australia Advisory Board distinctly reflect the current drivers and obstacles facing tertiary education in Australia over the coming five years. For example, the advisory board agreed that openness, whether in the form of open content, open access, or open educational resources, is a critical trend across the continent. This emphasis on openness is fuelling the rise of emerging technologies in Australia, such as badges, massive open online courses, and virtual and remote online labs.

Table 3: Top-Ranked Challenges Across Three NMC Horizon Research Projects

NMC Horizon Report 2013 Higher Education Edition	Technology Outlook for Australian Tertiary Education 2013-2018	Technology Outlook for Australian Tertiary Education 2012-2017
Faculty training still does not acknowledge the fact that digital media literacy continues its rise in importance as a key skill in every discipline and profession.	Faculty training still does not acknowledge the fact that digital media literacy continues its rise in importance as a key skill in every discipline and profession.	Economic pressures and new models of education are bringing unprecedented competition to the traditional models of tertiary education.
The emergence of new scholarly forms of authoring, publishing, and researching outpace sufficient and scalable modes of assessment.	Most academics are not using new and compelling technologies for learning and teaching, nor for organising their own research.	Appropriate metrics of evaluation lag behind the emergence of new scholarly forms of authoring, publishing, and researching.
Too often it is education's own processes and practices that limit broader uptake of new technologies.	The demand for personalised learning is not adequately supported by current technology or practices.	Most academics are not using new and compelling technologies for learning and teaching, nor for organising their own research.

The experts spent a fair amount of time researching and discussing relevant trends and challenges in the context of Australian tertiary education teaching, learning, and creative inquiry. A full discussion of trends and challenges identified by the advisory board begins on page 17; the top three from those longer lists are included in the related tables in this summary. Horizon Project advisory boards in general have agreed that trends like these are clear drivers of technology adoption; the 2013 Australian group especially saw such a linkage. At the same time, these panels of experts also agree that technology adoption is often hindered by both local and systemic challenges. Many challenges impacting technology uptake are grounded in everyday realities that often make it difficult to learn about, much less adopt, new tools and approaches.

The 2013 Horizon Project Australia Advisory Board agreed with the global group that digital media literacy is not nearly pervasive enough in faculty training. There is a need for more training before being asked to teach, and for more professional development opportunities once in the profession. This key challenge is underscored by the widespread belief that most academics are not leveraging emerging technologies for their own work, whether that be in the classroom or in support of their own research. While a lack of adequate training opportunities is a part of the challenge, ultimately a change in the mind sets of disciplines and individual faculty will be required, along with cultural shifts within institutions, before emerging tools and technologies are routinely adopted and implemented as a matter of course.

New this year to the top of the list of challenges facing Australian tertiary education is the concern that personalised learning, however promising it may be, cannot be realised at any practical level until the technologies to make it possible become available, along with the practices and procedures to incorporate them. More than ever, students are using ICT and new always-connected mobiles outside of the classroom to explore subjects that personally interest them. Institutions need to leverage and promote these informal learning experiences while integrating them with on-campus learning.

These points and comparisons provide an important context for the main body of the report that follows this summary. There, 12 key technologies are profiled, each on a single page that describes and defines a technology ranked as very important for Australian tertiary education over the next year, two to three years, and four to five years. Each page opens with a carefully crafted definition of the highlighted technology, outlines its educational relevance, points to several real life examples of its current use, and ends with a short list of additional readings for those who wish to learn more. Following those discussions are sections that detail the advisory board's top ranked trends and challenges and articulate why they are seen as highly influential factors in the adoption of any of these technologies over the coming five years.

Those key sections, and this report in general, constitute a reference and straightforward technology-planning guide for educators, researchers, administrators, policymakers, and technologists. It is our hope that this research will help to inform the choices that institutions are making about technology to improve, support, or extend teaching, learning, and creative inquiry in Australian tertiary education. Educators and administrators worldwide look to the NMC Horizon Project and both its global and regional reports as key strategic technology planning references, and it is for that purpose that the *Technology Outlook for Australian Tertiary Education 2013-2018* is presented.

Time-to-Adoption: One Year or Less

Learning Analytics

Learning analytics is an emergent field of research that aspires to use data analysis to inform decisions made on every tier of the educational system. Whereas analysts in business use consumer-related data to target potential customers and thus personalise advertising, learning analytics hopes to leverage student-related data to build better pedagogies, target at-risk student populations, and to assess whether programs designed to improve retention have been effective and should be sustained — important outcomes for administrators, policy makers, and legislators. For educators and researchers, learning analytics will provide crucial insights about student engagement both inside and outside of class. Students will also benefit from the deliverables of learning analytics through the development of mobile software and online platforms that use student-specific data to tailor support systems for their learning needs.

In many ways, learning analytics is "big data," applied to education. The term owes its beginnings to data mining efforts in the commercial sector that used analysis of consumer activities to identify consumer trends. The rise of the Internet triggered a huge transformation in the field of market research and metrics as web-tracking tools (web analytics) enabled companies to keep track of customers and their purchases. With the avalanche of data derived from consumers, businesses began to seek out analysts who could decipher meaning from gigantic sets of data and develop models and predictions about consumer behaviour to support marketing strategies. Similarly, educational institutions are embarking on their own explorations of the science of large data sets, with the aim of improving student retention and providing a higher quality, personalised experience for learners.

Relevance for Teaching, Learning, or Creative Inquiry

- If used effectively, learning analytics can help surface early signals that indicate a student is struggling, allowing teachers and schools to address issues quickly.
- The promise of learning analytics is that it will enable teachers to more precisely identify students' learning needs and tailor instruction appropriately.

Learning Analytics in Practice

- jPoll is an enterprise-wide tool developed by Griffith University in Australia, directed at engaging students in a range of interactive teaching situations and capturing the resulting data: go.nmc.org/jpoll.
- The SoLAR Southern Flare Conference in Sydney introduced the potential of learning analytics to practitioners, academics, researchers, and administrators: go.nmc.org/solar.
- Stanford University is exploring new ways to assess project-based learning activities through students' gestures, words, and other expressions: go.nmc.org/multimo.
- The University of Washington is developing processes for using big data to advance science and engineering research and innovation: go.nmc.org/uwescience.

For Further Reading

Big Data on Campus
go.nmc.org/ifmkx

(Marc Parry, *The New York Times*, 18 July 2012.) This article explores how universities across the world are increasingly using data mining software, especially for online education.

Learning and Knowledge Analytics (PDF)
go.nmc.org/laknow

(George Siemens and Dragan Gasevic, *Journal of Educational Technology & Society*, Vol. 15, No. 3, October 2012.) Seminal learning analytics experts George Siemens and Dragan Gasevic discuss the maturation of learning analytics and its impact on education.

Time-to-Adoption: One Year or Less

Massive Open Online Courses

When Stephen Downes and George Siemens coined the term in 2008, massive open online courses (MOOCs) were conceptualised as the next evolution of networked learning. The essence of the original MOOC concept was a web course that people could take from anywhere across the world, with potentially thousands of participants. The basis of this concept is an expansive and diverse set of content, contributed by a variety of experts, educators, and instructors in a specific field, and aggregated into a central repository, such as a web site. What made this content set especially unique is that it could be "remixed" — the materials were not necessarily designed to go together but became associated with each other through the MOOC.

A key component of the original vision is that all course materials and the course itself were open source and free — with the door left open for a fee if a participant taking the course wanted university credit to be transcripted for the work. Since those early days, interest in MOOCs has evolved at an unprecedented pace, fuelled by the attention given to high profile entrants like Coursera, Udacity, and edX in the popular press. In these new examples, "open" does not necessarily refer to open content or even open access, but only equates to "no charge." Ultimately, many challenges remain to be resolved in supporting learning at scale. The most compelling aspect of the proliferation of MOOCs is that it is helping frame important discussions about online learning that simply could not have taken place before the advent of actual experiments in learning at scale.

Relevance for Teaching, Learning, or Creative Inquiry

- As new pedagogies emphasise personalised learning, there is a growing demand for learner-centred online courses for the masses; MOOCs, when designed effectively, have the potential to scale globally.
- Many MOOCs allow learners of all ages, incomes, and levels of education to participate in a wide array of courses without being enrolled in the physical institution.
- MOOCs make creative use of several educational technologies and emerging instructional approaches, including blended learning, video lectures, and badges.

Massive Open Online Courses in Practice

- Open Universities Australia launched Australia's first MOOC provider, called Open2Study, in March, 2013: go.nmc.org/ouamooc.
- Senior academic leaders at the University of Queensland have resolved to develop up to 12 open online learning courses over the next two years. Their main interest is in how MOOCs will enable new opportunities for campus-based students: go.nmc.org/uqmooc.
- The University of Melbourne became the first Australian university to join Coursera, a leading international online course provider. Macroeconomics and Epigenetics are two of the courses planned to go live by the end of 2013: go.nmc.org/auscou.

For Further Reading

College Is Dead. Long Live College!
go.nmc.org/ylazv

(Amanda Ripley, *TIME*, 18 October 2012.) When the Pakistani government shut down access to YouTube, an 11-year old girl continued her online studies using Udacity.

Credit for MOOCs Presents Challenges in Australia
go.nmc.org/credmo

(Charis Palmer, *The Conversation*, 7 November 2012.) Following the news that Antioch University was working with Coursera to offer credit towards a degree, Australian tertiary education providers debate the possible negative consequences of this approach.

Time-to-Adoption: One Year or Less

Mobile Learning

People increasingly expect to be connected to the Internet and the rich tapestry of knowledge it contains wherever they go. Mobile devices, including smartphones and tablets, enable users to do just that via cellular networks and wireless power. At the end of 2012, the mobile market consisted of over 6.5 billion subscribers, with a majority living in developing countries. The growing amount of users coupled with the unprecedented evolution of these devices has opened the door to myriad uses for education. Learning institutions all over the world are exploring ways to make their websites, in addition to educational materials, resources, and opportunities, all available online and optimised for mobile devices. The most compelling facet of mobile learning right now is mobile apps. Smartphones and tablets have redefined what we mean by mobile computing, and in the past four to five years, apps have become a hotbed of development, resulting in a plethora of learning and productivity apps. These tools, ranging from annotation and mind-mapping apps to apps that allow users to explore outer space or get a more in-depth look at complex chemicals, enable users to learn and experience new concepts wherever they are, often across multiple devices.

Relevance for Teaching, Learning, or Creative Inquiry

- As a one-to-one solution, mobile learning presents an economic, flexible alternative to laptops and desktops due to the devices' lower cost, greater portability, and access to apps.
- Mobile apps with built-in social features enable learners to share their questions or findings with each other in real-time. For example, productivity apps such as Evernote and Edmodo make it possible to exchange notes, assignments, drawings, videos, and more.
- Students can leverage the cameras, microphones, and other tools inherent in mobiles to do field work or create rich media. This is especially convenient for work done outside of the classroom as students can record interviews, collect data for experiments, and more.

Mobile Learning in Practice

- At the University of Wollongong, third-year students studying primary school science and technology education created animations for science concepts using the cameras in their mobile phones: go.nmc.org/smation.
- The Australian Digital Futures Institute is leading a project with the Australian National University and the University of South Australia to create a Mobile Learning Evaluation Framework: go.nmc.org/adfi.
- In a pilot program at Yale University's Department of Molecular, Cellular, and Developmental Biology, instructors are sharing images from their digital microscopes with students' iPads through a mobile app: go.nmc.org/yavis.

For Further Reading

Jobs Game Changer for NZ
go.nmc.org/jobsga

(Hamish Fletcher, *New Zealand Herald*, 26 February 2013.) A joint venture between Unitec and IBM aims to create 400 new jobs by focusing on software development. This software development will focus on mobile and learning technologies by employing undergraduate and postgraduate students.

Why Tablets are the Future of Electronic Medical Records
go.nmc.org/emr

(Richard MacManus, *readwrite*, 27 September 2012.) Tablets equipped with Electronic Medical Records mobile applications are enabling more efficient interactions between physicians and patients.

Time-to-Adoption: One Year or Less

Social Media

Today's web users are prolific creators of content, and they upload photographs, audio, and video to cloud-based social media sites, such as Facebook, Pinterest, Twitter, YouTube, Flickr, and many others by the billions. While the initial emphasis of social media was placed on producing and uploading media to these popular sharing sites, as the notion of social media has evolved it has ultimately become more about the conversations started and relationships formed via this media. When users log in to Facebook and Twitter, two of the sites that have the most subscribers and see the most daily traffic, they are there to see what their family, friends, and favourite brands and organisations are doing and who is talking about what.

For educational institutions, social media enables two-way dialogues between students, prospective students, educators, and the institution that are less formal than with other media. New tools, such as Facebook's social search engine, promise to mine these interactions using a concept known as the social graph. A person's social graph represents the sum of all of a person's online social connections (who he or she is friends with, who likes the things she or her friends are interested in, who among those connections is where, etc.) and provides a means to search and navigate those connections. Social graphs can be visualised in a variety of interesting ways, but far more interesting is the information embedded within the social graph and what it can tell us.

Relevance for Teaching, Learning, or Creative Inquiry

- Engagement in social media either as producers of content, or consumers, or aggregators of user-generated content will allow universities to more deeply connect with audiences.
- Social media outlets allow university staff and students to create powerful personal learning networks to direct and focus their own learning.
- Video platforms including YouTube and Vimeo enable educators to upload and share recorded lectures and other instructional videos that students can watch anywhere. Similarly, Google Hangouts allow them to connect with students outside of the classroom.

Social Media in Practice

- The Australian government's Your Say project leverages social media by using Facebook, Twitter, and other platforms to gather opinions from their citizens: go.nmc.org/yoursay.
- Faculty at Texas State University are encouraging students to use Facebook and Twitter both inside and outside the classroom to engage in discussions: go.nmc.org/txstate.
- Murdoch University and Duke University constructed a social map which students use to share observations about the ecosystems of Northwestern Australia: go.nmc.org/rljfg.

For Further Reading

The Global Search for Education: Social Learning
go.nmc.org/soclea

(C.M. Rubin, *Huffington Post*, 21 February 2013.) Edmodo is a social media platform that is being used to augment classroom activities. It acts in a similar way to Facebook, allowing users from around the world to connect with one another on course material.

How Higher Education Can Use Social Media To Attract More Students
go.nmc.org/howhi

(Joanna Schwartz, *Hobsons,* 7 March 2013.) The writer explains how social media creates opportunities for universities to provide information to current and prospective students and includes statistics depicting how social activity translates to increased enrolment.

Time-to-Adoption: Two to Three Years

3D Printing

Known in industrial circles as rapid prototyping, 3D printing refers to technologies that construct physical objects from three-dimensional (3D) digital content such as computer-aided design (CAD), computer aided tomography (CAT), and X-ray crystallography. A 3D printer builds a tangible model or prototype from the electronic file, one layer at a time, using an inkjet-like process to spray a bonding agent onto a very thin layer of fixable powder, or an extrusion-like process using plastics and other flexible materials. The deposits created by the machine can be applied very accurately to build an object from the bottom up, layer by layer, with resolutions that, even in the least expensive machines, are more than sufficient to express a large amount of detail. The process even accommodates moving parts within the object. Using different powders and bonding agents, colour can be applied, and prototype parts can be rendered in plastic, resin, or metal. This technology is commonly used in manufacturing to build prototypes of almost any object (scaled to fit the printer, of course) that can be conveyed in three dimensions.

Relevance for Teaching, Learning, or Creative Inquiry

- The exploration of the 3D printing process from design to production, as well as demonstrations and participatory access, can open up new possibilities for learning activities.
- Through replication, 3D printing allows for more authentic exploration of objects that may not be readily available to universities, including animal anatomies and toxic materials.
- Typically, geology and anthropology students are not allowed to handle fragile objects like fossils and artefacts; 3D printing shows promise as a rapid prototyping and production tool, providing users with the ability to touch, hold, and even take home an accurate model.

3D Printing in Practice

- At the University of Wollongong, researchers designed technology for printing living human cells, such as muscles, along with a special ink that carries the cells: go.nmc.org/uw3d.
- Researchers at Swinburne University decreased the time it takes to create components from metals via 3D printing: go.nmc.org/swin.
- Scientists at the University of Technology Sydney developed new techniques for nanofabrication, which have led to improvements in the quality of materials produced through electron beam induced deposition: go.nmc.org/uts3d.

For Further Reading

3D Printers are Finally Becoming Cheap Enough for Home Users
go.nmc.org/cheap

(Chris Griffith, *The Australian*, 5 June 2012.) 3D printing has become more accessible to the public due to the affordable prices of the newest models, including the UP Mini 3D.

'It is Absolutely Wild': 3D Printing in Canberra
go.nmc.org/wild

(Emma McDonald, *Canberra Times,* 25 March 2012.) Several universities in Canberra, including Australian National University (ANU), the University of Canberra, and Australian Defence Force Academy, are using 3D printing to enhance research and learning.

This Is What The First Lunar Base Could Really Look Like
go.nmc.org/lunar

(Jesus Diaz, *Gizmodo Australia,* 1 February 2013.) This article explores how 3D printing can turn lunar soil into habitable domes, which could enable humans to live on the moon.

Time-to-Adoption: Two to Three Years

Badges

Badges are seen as a way to grant certification for informal learning in the form of micro-credits. A key aspect of gamification is to build in easy to reach incentives, and badges are an simple way to bring that idea to learning. The concept behind badging draws on longstanding ways learning has been documented in other settings, such as the personal skills and achievement when a Boy or Girl Scout earns a merit badge. The approach is being used in learning environments like the Khan Academy, with promising results. People watch videos on specific subjects and earn new badges by doing so. Mozilla has published an open specification for badging — the Open Badge Initiative (OBI) — that enables providers and users alike to easily display their achievements on the web. Badges can be used as a way to incorporate some of the advantages of game mechanics as participants work through various levels or stages to achieve credentials. While badges are not by any means pervasive in education systems, they appeal to many educators because they are considered to be more authentic signs of knowledge comprehension and skill acquisition than standard tests, grades, or course credits.

Relevance for Teaching, Learning, or Creative Inquiry

- Badges gamify the learning process, incentivising learners to participate in projects and activities that publicly demonstrate their knowledge in order to achieve recognition.
- Badges challenge the authority of tertiary education institutions as the sole providers of learning certification, as any organisation can become a badge issuer.
- With their flexibility to provide institutional as well as peer- and self-accreditation and validation, badges acknowledge skill acquisitions of all kinds.

Badges in Practice

- BadgeStack is an open source initiative that certifies and recognises the informal learning that happens in communities, museums, extracurricular activities, and more. The platform allows badges to be earned, managed, and shared by learners virtually anywhere on the web: go.nmc.org/badgestack.
- Badges for Vets turns users' military training into badges that translate into relevant experience for prospective employers, including engineering, construction, and finance: go.nmc.org/vets.
- Smarterer is a badge-based system that tests learners on specific skills, including Java programming and graphic design, and reveals to them the concepts they are missing and how they can improve: go.nmc.org/smarterer.

For Further Reading

Badges Lend Gravitas To Free Education Revolution
go.nmc.org/gravitas

(James Marshall Crotty, *Forbes,* 25 February 2013.) This article explores the journey of badges over the past year, citing how they have evolved from demonstrating general competencies to showcasing the depths of specific talents and skills across MOOCs.

Show Me Your Badge
go.nmc.org/showme

(Kevin Carey, *The New York Times,* 2 November 2012.) Purdue University, Carnegie Mellon University, and many others are part of the digital badge movement being spearheaded by the Mozilla Foundation. The metadata within Carnegie Mellon's "Cortex Principles of Advanced Programming, Level 2" badge, for example, provides the date the badge was issued, the name, title and organisational affiliation of the teacher who verified the badge, the score the student received on the final exam, and a link to exam questions.

Time-to-Adoption: Two to Three Years

Information Visualisation

Information visualisation blends highly advanced computational methods with sophisticated graphics engines to tap the extraordinary ability of humans to see patterns and structure in even the most complex visual presentations. Currently applied to massive, heterogeneous, and dynamic datasets, such as those generated in studies of astrophysical, fluidic, biological, and other complex processes, the techniques have become sophisticated enough to allow the interactive manipulation of variables in real time. Ultra high-resolution displays allow teams of researchers to zoom into compelling aspects of the renderings, or to navigate along interesting visual pathways, following their intuitions and even hunches to see where they may lead. New research is now beginning to apply these sorts of tools to the social sciences as well, and the techniques offer considerable promise in helping us understand complex social processes like learning, political and organisational change, and the diffusion of knowledge.

Relevance for Teaching, Learning, or Creative Inquiry

- By learning information visualisation techniques, students can make sense of complex scientific subjects such as a 3D rendering of a molecule.
- The emergence of learning analytics in education has fostered massive amounts of data; information visualisation dashboards can help educators and institutions to better understand and interpret the data, which could uncover aspects that were previously hidden in the learning process, and facilitate more authentic assessment.
- Information visualisation in social networking applications enables educators to map interactions between students and better track patterns from discussions.

Information Visualisation in Practice

- At the University of Wyoming, a professor is helping scientists analyse their research using 3D information visualisations: go.nmc.org/uw3dviz.
- The Digital Scholarship Lab at Brown University Library houses a large-scale visualisation wall where students can display their interpretations of information: go.nmc.org/digscho.
- OOM Creative and Melbourne Water designed a series of interactive data visualizations that depict water as an urban resource, based on a series of prints from an exhibition in Melbourne's State of Design Festival: go.nmc.org/oomc.
- The University of Illinois at Chicago created CAVE2, a system with a screen that encircles viewers and facilitates large-scale information visualization: go.nmc.org/cave2.

For Further Reading

Data Visualisation Techniques to Drive Improved Educational Outcomes
go.nmc.org/astdviz

(ASTD.org, accessed 14 March 2013.) In this podcast, the Universal Mind data visualisation team explores the value of using web-based visualisation tools to illustrate and make sense of complex data in education.

How One University Puts Big Data Into Curriculum
go.nmc.org/howone

(Gary Flood, *InformationWeek*, 11 March 2013.) This article explores how UK business schools are using a free visual analytics tool to identify patterns hidden in complex data.

The Information Visualisation Community Platform
go.nmc.org/infovis

(Info Vis Wiki, accessed 13 March 2013) This wiki space provides up-to-date news, research, resources, and more for anyone interested in learning about information visualisation.

Time-to-Adoption: Two to Three Years

Location-Based Services

Location-based services provide content that is dynamically customised according to the user's location. These services are commonly delivered to mobile devices, but almost any Internet-capable device can make use of most location services. (Cellular tower coordinates are often refined with GPS data to ensure a high level of accuracy in locating mobile devices.) Current common applications for location-based services include advertising, news, social networking, and similar services. For example, users are able to access popular social media sites Facebook or Foursquare to see which friends are in close proximity and to "check-in" to places based on their locations. Similarly, many news outlets deliver stories targeted to a reader or viewer's physical location.

In the consumer sector, many businesses are capitalizing on this by rewarding users who check-in to their locations; a discounted meal might be offered from a nearby restaurant, for example, or information on a museum exhibition that is currently on display. Location services have become an almost transparent way to generate actions triggered by a user's interest data and his or her location. The next and most compelling development for location-based services is the prospect of indoor GPS, which could provide visitors or students with very specific information about buildings they are in, or even rooms. It is not unimaginable that a student in a science course would be able to locate a specific piece of equipment in the laboratory using a mobile application that might also track his or her experience levels with that type of equipment.

Relevance for Teaching, Learning, or Creative Inquiry

- Effective for learning outside the classroom, location-based services enables immersive activities including collective mapping, scavenger hunts, and fieldwork.
- Mobile apps offering location-based services (e.g. Nru and Wikitude) can provide students with information about their surroundings and details about nearby cultural sites.
- When location-based services are integrated with social media and networks, they can suggest places nearby where students can visit to learn more about a specific subject.

Location-Based Services in Practice

- The EmergencyAUS mobile app alerts users to any crises in their proximity, including car accidents, fire observations, and major storms: go.nmc.org/emerg.
- Google's Field Trip mobile app notifies users when they are near a place of interest, including historical sites: http://go.nmc.org/field.
- Highlight's app enables users to share photographs from their location and find other photographs taken by others in close proximity: go.nmc.org/highlight.

For Further Reading

Beyond Foursquare: Geolocation Services Proliferate, Mature
go.nmc.org/beyond

(J.D. Lasica, *PBS Idea Lab*, 28 February 2013.) This article explores the current market for location-based services, including apps focused on travel and smart recommendations.

Mobile GPS for Indoor Use: Just Around the Corner?
go.nmc.org/zeydv

(Canadian Heritage Information Network, 1 October 2012.) Advancements in GPS that pinpoint a user's location based on magnetic fields may make indoor GPS a reality soon.

New Positioning Technology Could Compete with GPS
go.nmc.org/newpos

(David Hambling, *New Scientist,* 3 January 2013.) Locata is using ground-based equipment to project a radio signal that is one million times stronger than GPS over a localised area.

Time-to-Adoption: Four to Five Years

Flexible Displays

When organic light emitting diode displays (OLED) began to enter mass markets in 2004, consumers found that the new screens were lighter, brighter, and more energy efficient. In contrast to traditional glass-based LCD units, these new displays could be manufactured on thin, pliable plastics, prompting the term "flexible displays." The popularity of OLED screens is largely due to their electroluminescence, which makes for more readable displays. The arrival of the world's thinnest OLED display in 2008 by Samsung introduced a screen that was pliable and could easily be folded — features that gave rise to ideas for unbreakable smartphones and bendable tablets. By 2009, popular news outlets including CBS and Entertainment Weekly were including "video in print" inserts in smaller circulations of their magazines, demonstrating the new technology. In late 2012, LG, Samsung, and Philips, among other major players in the electronics industry, announced plans to mass-produce flexible displays by 2013, and Apple recently patented its own pliable display.

As flexible displays gain traction in the consumer market, researchers, inventors, and developers are experimenting with possible applications for teaching and learning. Opportunities offered by flexible OLED screens in educational settings are being considered for e-texts, e-readers, and tablets. Additionally, flexible displays can wrap around curved surfaces, allowing for the possibility of scientific and other instruments that can teach a user how to operate them.

Relevance for Teaching, Learning, or Creative Inquiry

- Flexible screens can easily be attached to objects or furniture, regardless of their shape, and can even be worn — making them far more adaptable and portable than standard computer screens and mobile devices.
- Prototypes for flexible displays in the form of "e-paper" that can be crumbled up and discarded just like real paper may cause e-book manufacturers and others to rethink the construction and applications of digital textbooks and e-readers.

Flexible Displays in Practice

- Kent State University is forging a new application of liquid crystal technology within flexible display devices for the energy and medical technology sectors: go.nmc.org/kent.
- Queen's University, in partnership with Plastic Logic and Intel Labs, has created a paper-thin tablet that is bendable and stackable: go.nmc.org/papertab
- Researchers at Arizona State University's Flexible Display Center are developing a lightweight display for soldiers that could show data, including maps: go.nmc.org/voqne.

For Further Reading

Bend Me, Shape Me: Flexible Phones 'Out by 2013'
go.nmc.org/fle

(Katia Moskvitch, *BBC News*, 29 November 2012.) There is an array of options for flexible mobile devices as companies including LG, Philips, Sharp, Sony, and Nokia plan releases.

HP's Future Computing Vision: Flexible Displays and Super-Fast Storage Circuitry
go.nmc.org/hpflex

(Alex Kidman, *Gizmodo Australia,* 11 May 2012.) In an effort to offer lighter tablets and curved and wearable personal displays in the coming years, HP is developing transparent flexible displays using their Self-Aligned Imprint Lithography technology.

Tablet with Flexible Screen Could be Available in 5 Years
go.nmc.org/tabflex

(Agam Shah, *ComputerWorld*, 7 January 2013.) This article reviews the latest PaperTab prototype, which is still in development with a 27.2 cm flexible screen.

Time-to-Adoption: Four to Five Years

The Internet of Things

The Internet of Things conveys information communicated by network aware objects that connect the physical world with the world of information through the web. It does so through TCP/IP, the set of standards that enables network connections and specifies how information finds its way to and from the myriad of connections it contains. TCP/IP was formulated in the 1970s by Vinton Cerf and Robert E. Kahn. The advent of TCP/IP v6, launched in 2006, added enormous new addressing capabilities to the Internet, and enabled objects and the information they might carry in attached sensors or devices to be addressable and searchable across the web. This expanded address space is particularly useful for tracking objects that monitor sensitive equipment or materials, point-of-sale purchases, passport tracking, inventory management, identification, and similar applications. Embedded chips, sensors, or tiny processors attached to an object allow helpful information about the object, such as cost, age, temperature, colour, pressure, or humidity to be transmitted over the Internet. This simple connection allows remote management, status monitoring, tracking, and even alerts if the objects they are attached to are in danger of being damaged or spoiled. Traditional web tools allow objects to be annotated with descriptions, instructions, warranties, tutorials, photographs, connections to other objects, and any other kind of contextual information. The Internet of Things makes access to these data as easy as it is to use the web.

Relevance for Teaching, Learning, or Creative Inquiry

- Attached to scientific samples, TCP/IP-enabled smart objects already are alerting scientists and researchers to conditions that may impair the quality or utility of the samples.
- Pill-shaped microcameras are used in medical diagnostics and teaching to traverse the human digestive tract and send back thousands of images to pinpoint sources of illness.
- TCP/IP enabled sensors and information stores make it possible for geology and anthropology departments to monitor or share the status and history of even the tiniest artefact in their collections of specimens from anywhere to anyone with an Internet connection.

Internet of Things in Practice

- By using tiny sensors installed in residences, Linköping University aims to improve energy efficiency by showing residents the impact of their consumption: go.nmc.org/saven.
- Ubi is a device with sensors that monitor temperature, humidity, air pressure, and ambient light and also contains a microphone and speakers so users can listen for commands: go.nmc.org/ubi.
- The UK Maker community is joining Falmouth University's Academy of Innovation and Research in the creation of Internet of Things-enabled objects. Formal residencies will enable designers to invent prototypes that will allow for new types of interactions, such as a music memory box for those with Alzheimer's: go.nmc.org/threecon.

For Further Reading

10 Things You Should Know About the Internet of Things
go.nmc.org/10things

(Patrick Gray, *TechRepublic,* 10 January 2013.) This article provides a helpful list of relevant ideas related to the Internet of Things, including a description of its uses and the value it holds for businesses.

Futurist's Cheat Sheet: Internet of Things
go.nmc.org/cpfez

(Dan Rowinski, *Read Write Web*, 31 August 2012.) The author explores a world where objects have their own IP addresses and can communicate with each other via WiFi or cellular networks.

Time-to-Adoption: Four to Five Years

Virtual and Remote Laboratories

Virtual and remote laboratories reflect a movement among education institutions to make the equipment and elements of a physical science laboratory more easily available to learners from any location, via the web. Virtual laboratories are web applications that emulate the operation of real laboratories and enable students to practice in a "safe" environment before using real, physical components. Examples include an optical networking virtual lab and a virtual lab for programmable logic controllers. Students can typically access virtual labs 24/7, from wherever they are, and run the same experiments over and over again. Some emerging virtual lab platforms also incorporate reporting templates that populate with the results of the experiments so that students and teachers can easily review the outcomes. Remote laboratories provide a virtual interface to a real, physical laboratory. Institutions that do not have access to certain high-calibre lab equipment can run experiments and perform lab work online, accessing the tools from a central location. Users are able to manipulate the equipment and watch the activities unfold via a webcam on a computer or mobile device. This provides students with a realistic view of system behaviour and allows them access to professional laboratory tools from anywhere, whenever they need. Additionally, remote labs alleviate some financial burden from institutions as they can forgo purchasing specific equipment and use the remote tools that are at their disposal.

Relevance for Teaching, Learning, or Creative Inquiry

- Because virtual laboratories do not involve real equipment or chemicals, students can feel more comfortable making mistakes and running experiments as often as they like.
- Educators can play back videos of the experiments students have run online, pinpoint areas of improvement, and acknowledge students who have excelled.
- Virtual and remote laboratories increase access to science tools, allowing learners from all over the world to use them via wireless or cellular networks; laboratory work is no longer limited to spaces on physical campuses.

Virtual and Remote Laboratories in Practice

- The Genome Research Computing at the University of Queensland and the Victorian Life Sciences Computation Initiative have proposed the establishment of a Genomics Virtual Laboratory, in partnership with the University of Melbourne: go.nmc.org/genomics.
- MIT's iLabs provide web-accessible labs for students within or outside of the university to conduct experiments: go.nmc.org/mitrem.
- Nectar Australia's Marine Virtual Laboratory models ocean circulation and wave environments through a web-based portal: go.nmc.org/nectar.
- Northwestern University's remote online lab is increasing the use of technology in math and science by facilitating access for tertiary and secondary students: go.nmc.org/projacc.

For Further Reading

The Advantages Of Remote Labs In Engineering Education (PDF)
go.nmc.org/advrem

(Doru Popescu and Barry Odbert, Agilent Technologies, April 2011.) This paper details the benefits of remote labs for engineering education and explores the enabling technologies.

It's Lab Time! Connecting Schools to Universities' Remote Laboratories
go.nmc.org/labtime

(Anne-Christin Tannhäuser, UniSchoolLabS, 9 March 2012.) An approach to connect learners to remote labs offered by universities and science centres is described in this presentation.

Time-to-Adoption: Four to Five Years

Wearable Technology

Wearable technology refers to devices that can be worn by users, taking the form of an accessory such as jewellery, sunglasses, a backpack, or even actual items of clothing such as shoes or a jacket. The benefit of wearable technology is that it can conveniently integrate tools, devices, power needs, and connectivity within a user's everyday life and movements. Google's "Project Glass" features one of the most talked about current examples — the device resembles a pair of glasses, but with a single lens. A user can see information about their surroundings displayed in front of them, such as the names of friends who are in close proximity, or nearby places to access data that would be relevant to a research project. Wearable technology is still very new, but one can easily imagine accessories such as gloves that enhance the user's ability to feel or control something they are not directly touching. Wearable technology already in the market includes clothing that charges batteries via decorative solar cells, allows interactions with a user's devices via sewn-in controls or touch pads, or collects data on a person's exercise regimen from sensors embedded in the heels of their shoes.

Relevance for Teaching, Learning, or Creative Inquiry

- Smart jewellery or other accessories could alert wearers to hazardous conditions, such as exposure to carbon monoxide.
- Wearable devices and cameras can instantly capture hundreds of photographs or data about a user's surroundings that can be later accessed via email or other online application.
- Wearable technology can automatically communicate information via text, email, and social networks on behalf of the user, based on voice commands, gestures, or other indicators.

Wearable Technology in Practice

- A new robotic suit created by Koba Lab from Tokyo University of Science provides support to the wearer's back, shoulders, and elbows, enabling them to carry more weight and perform more difficult physical tasks: go.nmc.org/lift.
- Researchers at Melbourne's Bionic Institute are creating implantable bionic devices, including electrodes that can be inserted into the brain to detect abnormal activity and deliver treatment: go.nmc.org/brain.
- The Wearable Computer Lab at the University of South Australia develops augmented reality-enabled wearable devices and specialises in human-computer interaction techniques: go.nmc.org/unisa.

For Further Reading

Here's Proof That Wearable Tech Is The Next Big Thing
go.nmc.org/nex

(Megan Rose Dickey, *Business Insider*, 5 Jan 2013.) In the consumer market, wearable technology has taken off in the form of electronic drum machine t-shirts, waterproof bikinis that absorb sunlight to charge electronics, and boots that use the heat a wearer creates from walking to charge a smartphone.

Wearable Tech Pioneers Aim to Track and Augment our Lives
go.nmc.org/wea

(Jane Wakefield, *BBC News*, 17 October 2012.) This article highlights the potential of wearable technology, including cameras that automatically snap photos, watches that sync with email accounts to display emails and reminders, and more.

Top Ten Trends Impacting Technology Decisions

The technologies featured in the NMC Horizon Project are embedded within a contemporary context that reflects the realities of the time, both in the sphere of education and in the world at large. To assure this perspective, each advisory board researches, identifies, and ranks key trends that are currently affecting the practice of teaching, learning, research, and information management in education, and uses these as a lens for its work in predicting the uptake of emerging technologies in whatever sector is their focus.

These trends are surfaced through an extensive review of current articles, interviews, papers, and new research. Once identified, the list of trends is ranked according to how significant of an impact they are likely to have on education in the next five years. The following trends have been identified as key drivers of technology adoptions in Australian tertiary education for the period of 2013 through 2018; they are listed here in the order they were ranked by the advisory board.

1) People expect to be able to work, learn, and study whenever and wherever they want. Life in an all the time more busy world where learners must balance demands from home, work, school, and family poses a host of logistical challenges with which today's ever more mobile students must cope. Work and learning are often two sides of the same coin, and people want easy and timely access not only to the information on the network, but also to tools, resources, and up-to-the-moment analysis and commentary. These needs, as well as the increasingly essential access to social media and networks, have risen to the level of expectations. The opportunities for informal learning in the modern world are abundant and diverse, and greatly expand on earlier notions like "just-in-time" or "found" learning.

2) Education paradigms are shifting to include online learning, hybrid learning, and collaborative models. Students already spend much of their free time on the Internet, learning and exchanging new information — often via their social networks. Institutions that embrace face-to-face/online hybrid learning models have the potential to leverage the online skills learners have already developed independent of academia. Online learning environments can offer different affordances than physical campuses, including opportunities for increased collaboration while equipping students with stronger digital skills. Hybrid models, when designed and implemented successfully, enable students to travel to campus for some activities, while using the network for others, taking advantage of the best of both environments.

3) Openness — concepts like open content, open data, and open resources, along with notions of transparency and easy access to data and information — is becoming a value. As authoritative sources lose their importance, there is need for more curation and other forms of validation to generate meaning in information and media. "Open" continues its diffusion as a buzzword in education, and it is increasingly important to understand the definition. Often mistakenly equated only with "free," open education advocates are working towards a common vision that defines "open" as free, copiable, remixable, and without any barriers to access or interaction.

4) Massive open online courses are being widely explored as alternatives and supplements to traditional university courses. Led by the successful early experiments of world-class institutions (like MIT and Stanford), MOOCs have captured the imagination of senior administrators and trustees like few other educational innovations have. High profile offerings are being assembled under the banner of institutional efforts like edX, and large-scale collaborations like Coursera, the Code Academy, and in Australia, Open2Study. As the ideas evolve, MOOCs are seen more and more as a very intriguing alternative to credit-based instruction. The prospect of a single course achieving enrolments in the tens of thousands is bringing serious conversations on topics like micro-credit to the highest levels of institutional leadership.

5) Increasingly, students want to use their own technology for learning. As new technologies are developed at a more rapid and at a higher quality, there is a wide variety of different devices, gadgets, and tools from which to choose. Utilizing a specific device has become something very personal — an extension of someone's personality and learning style — for example, the iPhone vs. the Android. There is comfort in giving a presentation or performing research with tools that are more familiar and productive at the individual level. And, with handheld technology becoming mass produced and more affordable, students are more likely to have access to advanced equipment in their personal lives than at school.

6) As the abundance of resources and relationships made easily accessible via the Internet grows, we are ever more challenged to revisit our roles as educators. Institutions must consider the unique value that each adds to a world in which information is everywhere. In such a world, sense-making and the ability to assess the credibility of information are paramount. Mentoring and preparing students for the world in which they will live and work is again at the forefront. Universities have always been seen as the gold standard for educational credentialing, but emerging certification programs from other sources are eroding the value of that mission.

7) There is a growing interest in using new sources of data for personalising the learning experience and for performance measurement. As learners participate in online activities, they leave a clear trail of analytics data that can be mined for insights. Learning analytics experiments and demonstration projects are currently examining ways to use data for enrichment. Dashboards filter this information so that student progress can be monitored in real time. As the field of learning analytics matures, the hope is that this information will enable continual improvement of learning outcomes.

8) The technologies we use are more and more cloud-based, and our notions of IT support are decentralised. The continuing acceptance and adoption of cloud-based applications and services is changing not only the ways we configure and use software and file storage, but also how we conceptualise those functions. It does not matter where our work is stored; what matters is that our information is accessible no matter where we are or what device we choose to use. Globally, in huge numbers, we are growing accustomed to a model of browser-based software that is device independent. While some challenges still remain, specifically with notions of privacy and sovereignty, the promise of significant cost savings is a driver in the search for solutions.

9) Social media is changing the way people interact, present ideas and information, and judge the quality of content and contributions. More than one billion people use Facebook regularly; other social media platforms extend those numbers to nearly one third of all people on the planet. Educators, students, alumni, and even the general public routinely use social media to share news about scientific and other developments. The impact of these changes in scholarly communication and on the credibility of information remains to be seen, but it is clear that social media has found significant traction in almost every education sector.

10) The workforce demands skills from university graduates that are more often acquired from informal learning experiences than in universities. Informal learning generally refers to any learning that takes place outside of a formal school setting, but a more practical definition may be learning that is self-directed and aligns with the student's own personal learning goals. Employers have specific expectations for new hires, including communication and critical thinking skills — talents that are often acquired or enhanced through informal learning. Online or other modern environments are trying to leverage both formal and informal learning experiences by allowing for more open-ended, unstructured time where they are encouraged to experiment, play, and explore topics based on their own motivations. This type of learning will become more and more important in learning environments of all kinds.

Top Ten Most Significant Challenges

Along with the trends discussed in the preceding section, the advisory board noted a number of important challenges faced in Australian tertiary education. Like the trends, the challenges described below were drawn from a careful analysis of current events, papers, articles, and similar sources, as well as from the personal experience of the advisory board members in their roles as leaders in education and technology. The ten challenges ranked as most significant in terms of their impact on teaching, learning, research, or information management in Australian tertiary education in the coming five years are listed here, in the order of importance assigned them by the advisory board.

1) Faculty training still does not acknowledge the fact that digital media literacy continues its rise in importance as a key skill in every discipline and profession. Despite the widespread agreement on the importance of digital media literacy, training in the supporting skills and techniques is rare in teacher education and non-existent in the preparation of faculty. As lecturers and professors begin to realise that they are limiting their students by not helping them to develop and use digital media literacy skills across the curriculum, the lack of formal training is being offset through professional development or informal learning, but we are far from seeing digital media literacy as a norm. This challenge is exacerbated by the fact that digital literacy is less about tools and more about thinking, and thus skills and standards based on tools and platforms have proven to be somewhat ephemeral.

2) Most academics aren't using new and compelling technologies for learning and teaching, nor for organising their own research. Many researchers have not had training in basic digitally supported teaching techniques, and most do not participate in the sorts of professional development opportunities that would provide them. This is due to several factors, including a lack of time and a lack of expectations that they should. Many think a cultural shift will be required before we see widespread use of more innovative organisational technology. Some educators are simply apprehensive about working with new technologies, as they fear the tools and devices have become more of a focus than the learning. Adoption of progressive pedagogies, however, is often enabled through the exploration of emerging technologies, and thus a change in attitude among academics is imperative.

3) The demand for personalised learning is not adequately supported by current technology or practices. The increasing demand for education that is customised to each student's unique needs is driving the development of new technologies that provide more learner choice and control and allow for differentiated instruction. It has become clear that one-size-fits-all teaching methods are neither effective nor acceptable for today's diverse students. Technology can and should support individual choices about access to materials and expertise, amount and type of educational content, and methods of teaching. The biggest barrier to personalised learning, however, is that scientific, data-driven approaches to effectively facilitate personalisation have only recently begun to emerge; learning analytics, for example, is still in the very nascent stage of implementation and adoption within tertiary education.

4) New models of education are bringing unprecedented competition to the traditional models of tertiary education. Across the board, institutions are looking for ways to provide a high quality of service and more learning opportunities. MOOCs are at the forefront of these discussions, enabling students to supplement their education and experiences at brick-and-mortar institutions with increasingly rich, and often free, online offerings. As these new platforms emerge, however, there is a need to frankly evaluate the models and determine how to best support collaboration, interaction, and assessment at scale. Simply capitalizing on new technology is not enough; the new models must use these tools and services to engage students on a deeper level.

5) Our organisations are not set up to promote innovation in teaching. Innovation springs from the freedom to connect ideas in new ways. Our schools and universities generally allow us to connect ideas only in prescribed ways — sometimes these lead to new insights, but more likely they lead to rote learning. Current organisational promotion structures reward research instead of innovation and improvements in teaching and learning. The major consequences of student evaluations on teaching, as well as the direct impact on promotion and career options, translates to big risks associated with the failure of innovations and leaves little space for experimentation.

6) Appropriate metrics of evaluation lag the emergence of new scholarly forms of authoring, publishing, and researching. Traditional approaches to scholarly evaluation such as citation-based metrics, for example, are often hard to apply to research that is disseminated or conducted via social media. New forms of peer review and approval, such as reader ratings, inclusion in and mention by influential blogs, tagging, incoming links, and re-tweeting, are arising from the natural actions of the global community of educators, with more and more relevant and interesting results. These forms of scholarly corroboration are not yet well understood by mainstream faculty and academic decision makers, creating a gap between what is possible and what is acceptable.

7) Critical campus infrastructures are under-resourced. Rather than encouraging researchers to build on and extend core resources, leverage shared file systems, and open accessible service APIs, institutions are narrowing their focus to what they perceive as the minimal subset of enterprise services they can afford to sustain. As a result, educators are often trying to design new, innovative learning models that must be integrated with out-dated, pre-existing technology and learning management systems.

8) Too often it is education's own processes and practices that limit broader uptake of new technologies. Much resistance to change is simply comfort with the status quo, but in other cases, such as in promotion and tenure reviews, experimentation or innovative applications of technologies are often seen as outside the role of researcher or scientist, and thus discouraged. Changing these processes will require major shifts in attitudes as much as they will in policy.

9) Data mining is much more suited to courses run under business models that can scale. The statistical and computer science methods behind most data mining approaches presume that a large amount of data is generated in a relatively constant and continuous flow, which allows the statistical discovery of significant bits of information that would be missed when examining smaller data sets. The challenge in developing such methods for learning situations is that few of them are capable of generating such data streams, although there is considerable potential to do so in online learning environments, especially those with very large enrolments.

10) Commercial providers are delivering ever more credible educational content, providing a wide range of customizable offerings at quality levels that may dampen interest in traditional sources of scholarly work, such as university presses, and even open educational resources. Increasingly, publishers are either buying learning resource websites or creating their own virtual warehouses of digital textbooks and other educational content. iTunes University is a prime example of this, offering thousands of course materials for free from distinguished institutions and professors. This trend creates a related challenge for university presses that have traditionally been the publishers of much of the work of their faculties; there is a growing fear that they will become obsolete. Both open educational resources (OER) and those provided by university presses are at a critical juncture for different reasons, yet each is aggressively confronted with the need to adapt, evolve, or even reconstruct their roles in education over the next five years.

Methodology

The process used to research and create the *Technology Outlook for Australian Tertiary Education 2013-2018: An NMC Horizon Project Regional Analysis* is very much rooted in the methods used throughout the NMC Horizon Project. All publications of the NMC's Horizon Project are produced using a carefully constructed process that is informed by both primary and secondary research. Dozens of technologies, meaningful trends, and critical challenges are examined for possible inclusion in the report for each edition. Every report draws on the considerable expertise of an internationally renowned advisory board that first considers a broad set of important emerging technologies, challenges, and trends, and then examines each of them in progressively more detail, reducing the set until the final listing of technologies, trends, and challenges is selected.

Much of the process takes place online, where it is captured and placed in the NMC Horizon Project wiki. This wiki, which has grown into a resource of hundreds of pages, is intended to be a completely transparent window onto the work of the project, and contains the entire record of the research for each of the various editions. The section of the wiki used for the *Technology Outlook for Australian Tertiary Education 2013-2018* can be found at aus.wiki.nmc.org.

The procedures for selecting the topics that are in this report include a modified Delphi process now refined over years of producing the *NMC Horizon Report* series, and it began with the assembly of the advisory board. The board as a whole was intended to represent a wide range of backgrounds and interests, yet with each member bringing a particularly relevant expertise. To date, hundreds of internationally recognised practitioners and experts have participated in the NMC Horizon Project Advisory Boards; in any given year, a third of advisory board members are new, ensuring a flow of fresh perspectives each year.

Once the advisory board for a particular edition is constituted, their work begins with a systematic review of the literature — press clippings, reports, essays, and other materials — that pertains to emerging technology. Advisory board members are provided with an extensive set of background materials when the project begins, and are then asked to comment on them, identify those that seem especially worthwhile, and add to the set. The group discusses existing applications of emerging technology and brainstorms new ones. A key criterion for the inclusion of a topic is the potential relevance of the topic to teaching, learning, or creative inquiry. A carefully selected set of RSS feeds from dozens of relevant publications ensures that background resources stay current as the project progresses. They are used to inform the thinking of the participants throughout the process.

Following the review of the literature, the advisory board engages in the central focus of the research — the research questions that are at the core of the NMC Horizon Project. These questions are designed to elicit a comprehensive listing of interesting technologies, challenges, and trends from the advisory board:

1. *Which of these key technologies will be most important to Australian Tertiary education within the next five years?*
2. *What key technologies are missing from our list? Consider these related questions:*
    a. *What would you list among the established technologies that some Australian tertiary education institutions and programs are using today that arguably ALL institutions and programs should be using broadly to support or enhance teaching, learning, or creative inquiry?*
    b. *What technologies that have a solid user base in consumer, entertainment, or other industries should Australian tertiary education institutions and programs be actively looking for ways to apply?*

   c. *What are the key emerging technologies you see developing to the point that Australian tertiary education institutions and programs should begin to take notice during the next four to five years?*
3. *What trends do you expect to have a significant impact on the ways in which Australian tertiary education institutions and programs approach our core missions of teaching, learning, and creative inquiry?*
4. *What do you see as the key challenges related to teaching, learning, and creative inquiry that Australian tertiary education institutions and programs will face during the next five years?*

One of the advisory board's most important tasks is to answer these questions as systematically and broadly as possible, so as to ensure that the range of relevant topics is considered. Once this work is done, a process that moves quickly over just a few days, the advisory board moves to a unique consensus-building process based on an iterative Delphi-based methodology.

The responses to the research questions are systematically ranked and placed into adoption horizons by each advisory board member using a multi-vote system that allows members to weight their selections. Each member is asked to also identify the timeframe during which they feel the technology would enter mainstream use — defined for the purpose of the project as about 20% of institutions adopting it within the period discussed. (This figure is based on the research of Geoffrey A. Moore and refers to the critical mass of adoptions needed for a technology to have a chance of entering broad use.) These rankings are compiled into a collective set of responses, and inevitably, the ones around which there is the most agreement are quickly apparent.

For additional detail on the project methodology or to review the instrumentation, the ranking, and the interim products behind the report, please visit the project wiki, which can be found at aus.wiki.nmc.org.

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