

# 2016 NMC Technology Outlook

Australian Tertiary Education

A Horizon Project Regional Report



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*A Horizon Project Regional Report*

<b>Executive Summary</b> .....	1
<b>Introduction</b> .....	2
<b>Key Trends Accelerating Technology Adoption</b> .....	5
<b>Significant Challenges Impeding Technology Adoption</b> .....	7
<b>Important Developments in Educational Technology:</b>	
<b>Time-to-Adoption Horizon: One Year or Less</b>	
▪ Bring Your Own Device.....	9
▪ Flipped Classroom .....	10
▪ Learning Analytics .....	11
▪ Online Learning .....	12
<b>Time-to-Adoption Horizon: Two to Three Years</b>	
▪ Adaptive Learning Technologies.....	13
▪ Location Intelligence.....	14
▪ Makerspaces .....	15
▪ Wearable Technology.....	16
<b>Time-to-Adoption Horizon: Four to Five Years</b>	
▪ Affective Computing .....	17
▪ Augmented Reality .....	18
▪ Machine Learning .....	19
▪ Networked Objects .....	20
<b>Methodology</b> .....	21
<b>2016 Horizon Project Australia Expert Panel</b> .....	23
<b>End Notes</b> .....	24



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A Horizon Project Regional Report*

is a collaboration between

The New Media Consortium

and

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## Executive Summary

The *2016 NMC Technology Outlook for Australian Tertiary Education: A Horizon Project Regional Report* reflects a collaborative research effort between the New Media Consortium (NMC) and Open Universities Australia to inform Australian campus leaders and decision-makers about significant developments in technologies supporting teaching, learning, and creative inquiry in tertiary education across the continent.

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. The same process underlies the well-known *NMC Horizon Report* series, which is the most visible product of an on-going research effort begun more than 14 years ago to systematically identify and describe emerging technologies likely to have a large impact on education around the globe.

The *2016 NMC Technology Outlook for Australian Tertiary Education* was produced to explore emerging technologies and forecast their potential impact expressly in an Australian context. In the effort that took place from January through March 2016, a carefully selected panel 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 2016 Horizon Project Australia Expert Panel, that group of thought leaders consists of knowledgeable individuals, all highly regarded in their fields. Collectively the panel represents a range of diverse perspectives across the tertiary 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](http://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.

The expert panel identified 9 key trends, 9 significant challenges, and 12 important developments in educational technology. The 12 developments in educational technology 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, or four to five years. Every 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. Preceding those discussions are sections that detail the expert panel's top ranked trends and challenges, and frame them into categories that illuminate why they are seen as highly influential factors in the adoption of technology in Australian universities over the next five years.

The three key sections of this report constitute a reference and straightforward technology planning guide for educators, campus leaders, 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 *2016 NMC Technology Outlook for Australian Tertiary Education* is presented.

## Introduction

The NMC Horizon Project and the 2016 Horizon Project Australia Expert Panel recognise that technology adoption in tertiary education is accelerated by trends in policy, leadership, and practice. Therefore, key trends frame the discussion of technology use in Australian universities. Similarly, a number of challenges are impeding the proliferation of digital tools, and the panel has identified a set of significant challenges that distinctly reflects the current drivers and obstacles facing Australian tertiary education over the coming five years. The top three trends and challenges from those longer lists are included in the related tables in this summary, and are organised by categories described in the next sections of this report.

As Table 1 below illustrates, the choices of the Australian experts overlap in interesting ways with those who contributed to the *NMC Horizon Report > 2016 Higher Education Edition*, which looked at technology uptake from a global perspective, and the *2015 NMC Technology Outlook for Australian Tertiary Education*, which provides perspective from last year's Australian expert panel — altogether a group of 146 acknowledged experts.

**Table 1: Top-Ranked Trends Across Three NMC Horizon Research Projects**

NMC Horizon Report 2016 Higher Education Edition	2016 Technology Outlook for Australian Tertiary Education	2015 Technology Outlook for Australian Tertiary Education
<b>Long-Term Trend</b>		
Rethinking How Institutions Work	Rise of More Authentic Assessment	Rethinking How Institutions Work
<b>Mid-Term Trend</b>		
Redesigning Learning Spaces	Redesigning Learning Spaces	Proliferation of Open Educational Resources
<b>Short-Term Trend</b>		
Growing Focus on Measuring Learning	Increasing Use of Blended Learning Designs	Increasing Use of Blended Learning Designs

The Australian panel's highest ranked trends overlap with the global panel's selections in one area — redesigning learning spaces. Throughout the continent, tertiary education institutions are designing learning environments that better accommodate progressive pedagogies. For example, Queensland University of Technology's two-story Cube was built to support hands-on, interactive workshops and programmes by allowing visualisation, immersion, and interaction with research projects using advanced digital technology, including 14 high-definition projectors, 48 multi-touch screens, and advanced audio technology.<sup>1</sup> Deakin University has recognised that their students require an informal learning space that is always available. Inside the entrance of the institution's Waurin Ponds Library is a 24-hour area with couches and study nooks where students can access e-books and online resources within close proximity to refreshments.<sup>2</sup>

Both Australian panels agree that more universities are deploying blended learning strategies in order to create more flexible experiences for students and centre face-to-face time around more hands-on and immersive activities. This trend is further validated by the presence of both online learning and the flipped classroom on the near-term horizon for technology developments. The University of Adelaide is introducing its Echo360 Active Learning Platform to aid blended models by including lecture capture and real-time feedback on student engagement, all integrated with the university's learning management system (LMS).<sup>3</sup>

The 2016 Australian panel also surfaced an entirely new trend for this report — the rise of more authentic assessment. Institutions around the world are focusing on continuously measuring learning as student behaviours are easier than ever to track due to the growing sophistication of online environments. However, the Australian panel takes this notion a step further with the goal of ensuring that institutions evaluate more creative forms of student expression that are linked to real-world learning applications, such as creating a prototype within a makerspace.

Horizon Project panels in general have agreed that trends like these are clear drivers of technology adoption; the 2016 Australian panel 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, which are grounded in everyday realities that make it difficult to learn about, much less adopt, new tools and approaches.

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

NMC Horizon Report 2016 Higher Education Edition	2016 Technology Outlook for Australian Tertiary Education	2015 Technology Outlook for Australian Tertiary Education
<b>Solvable Challenge</b>		
Improving Digital Literacy	Creating Authentic Learning Opportunities	Creating Authentic Learning Opportunities
<b>Difficult Challenge</b>		
Personalising Learning	Under-resourced Campus Infrastructure	Scaling Teaching Innovations
<b>Wicked Challenge</b>		
Keeping Formal Education Relevant	Balancing Our Connected and Unconnected Lives	Defining and Transitioning to New Business Models

As noted in Table 2, above, both Australian panels agreed that creating authentic learning opportunities is a pressing but solvable challenge, and will rely on the integration of more hands-on and active learning experiences in university settings. Solutions are already well underway as Australian institutions can be considered models for other regions looking to facilitate more engaged learning that is closely tied to helping students acquire vital skills that set them up for career success. The engineering school at RMIT University is one such example; they are using project-based learning to bolster students' creativity and problem-solving skills. Students use emerging technologies, learn from industry practitioners, and work in teams to develop solutions to significant engineering problems.<sup>4</sup>

The 2016 Australian experts indicated that under-resourced campus infrastructure is a difficult challenge — regarded by the other two panels but deemed less significant. Constrained budgets along with inefficient staff and leadership structures hinder the spread of innovation. The growth of open online tertiary education is addressing the difficulties associated with maintaining and growing physical campuses. Open Universities Australia represents the future of tertiary education in many ways, providing more affordable and flexible opportunities for students while calling into question the need for traditional campus settings.<sup>5</sup> The concept of infrastructure is evolving from physical equipment to virtual tools that support anytime, anywhere learning.

Striking a balance between technology dependency and mindful use is considered the most wicked challenge by the 2016 Australian panel. The proliferation of always-connected devices, particularly mobiles, has made learning possible anywhere. With technology usage, however, there is a fine line between convenience and addiction. There is freedom in being able to

communicate with peers and find information any time, but if these online activities are not balanced with self-reflection and analysis, technology can become a crutch — an excuse not to engage in the kind of critical thinking that leads to meaningful discovery and deep understanding.

Fuelled by the key trends and impeded by significant challenges selected by the panel, the 12 important developments in technology presented in the body of this report reflect the experts' opinions as to which of the nearly 50 technologies considered will be most important to Australian tertiary education over the five years following the publication of the report. All three of these projects' expert panels strongly agree that the Bring Your Own Device (BYOD) movement along with the flipped classroom are on the cusp of widespread adoption — trends that span education across the world. Indeed, with the benefit of this big picture, the NMC plans to retire both BYOD and online learning from the Horizon Project in 2017, a step taken when developments and accompanying practices become commonplace.

**Table 3: Comparison of “Final 12” Topics Across Three NMC Horizon Research Projects**

NMC Horizon Report 2016 Higher Education Edition	2016 Technology Outlook for Australian Tertiary Education	2015 Technology Outlook for Australian Tertiary Education
<b>Time-to-Adoption Horizon: One Year or Less</b>		
Bring Your Own Device Flipped Classroom Learning Analytics/Adaptive Online Learning	Bring Your Own Device Flipped Classroom Learning Analytics Online Learning	Bring Your Own Device Cloud Computing Flipped Classroom Learning Analytics
<b>Time-to-Adoption Horizon: Two to Three Years</b>		
3D Printing Augmented/Virtual Reality Makerspaces Wearable Technology	Adaptive Learning Technologies Location Intelligence Makerspaces Wearable Technology	Badges/Microcredit Mobile Learning Open Licensing Wearable Technology
<b>Time-to-Adoption Horizon: Four to Five Years</b>		
Affective Computing Next-Generation Batteries Quantified Self Robotics	Affective Computing Augmented Reality Machine Learning Networked Objects	Adaptive Learning Technologies Augmented Reality Quantified Self Telepresence

In the past year, makerspaces have increased in importance to Australian universities, propelled by the shift towards more active and immersive learning. Educators value the affordances of exposing students to high-calibre equipment with the purpose of encouraging iteration and experimentation. At the University of New South Wales, the Michael Crouch Innovation Centre enables students and faculty to bring their big ideas to fruition by providing them with support around technology use and creative projects.<sup>6</sup>

A number of unique choices distinguished the perspectives expressed by the 2016 Australian panel from their counterparts. For example, they perceive location intelligence as an important development in technology on the mid-term horizon. The ability for universities to deliver specific content and recommendations to mobile app users based on their location on campus is enhancing the discoverability of helpful resources. Another unique selection, machine learning, represents the next step in humanlike artificial intelligence — software that *learns to learn*. While learning systems that can adapt without expressly being programmed to do so are years away from mainstream use, the potential for more personalised learning is compelling.

These points and comparisons provide an important context for the main body of the report that follows.

## Key Trends Accelerating Technology Adoption

The technology developments 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 panel member identifies and ranks key trends that are currently affecting teaching, learning, and creative inquiry in Australian tertiary education, and uses these as a lens for the work of predicting the uptake of emerging technologies. These nine trends, which the panel agreed are very likely to drive technology planning and decision-making over the next five years, are sorted into three categories: long-term trends that will become increasingly pervasive in institutions for five or more years, and mid- and short-term trends that have surfaced more recently and whose impact on institutions may be briefer.

### Long-Term Trends

#### *Driving Ed Tech adoption in Australian tertiary education for five or more years*

**Increasing Value of the User Experience.** User experience (UX) refers to the quality of a person's interactions for computer-based exchanges with mobile devices, operating systems, and websites.<sup>7</sup> Easy navigation, digestible content, and practical features — among other components — are encompassed in effective website and database designs. Companies such as Amazon and Google are identifying patterns in users' online behaviours to better tailor search results at the individual level, and direct feedback from users in the form of ratings on websites helps companies customise content and adjust user interface design.<sup>8</sup> For institutions, there has been so much focus on data management that only recently have education professionals shifted their attention to designing a high-quality experience with the aim of helping researchers and students navigate massive amounts of data.

**Rethinking How Institutions Work.** Changes in tertiary education are upending the traditional notion of the university and transforming the paradigm for how postsecondary learning works. These developments are being fuelled by a growing body of research that highlights the disconnect between the demands of the 21st century economy and what college graduates are prepared to do when they leave academia.<sup>9</sup> Part of the effort to make students more work-savvy is taking place through new policy initiatives, programmes, and curriculum that encourage students to work with peers from different disciplinary backgrounds on innovative solutions to complex problems. Curtin University's undergraduate degree in entrepreneurship exposes students to business development activities with the goal of helping them launch their own enterprises. The way students in the programme are arranged in working teams reflects the realities of the contemporary workforce.<sup>10</sup>

**Rise of More Authentic Assessment.** In line with the increasingly authentic approach to learning design, Australian tertiary education institutions are ensuring that the assessments that measure associated learning outcomes are fair, valid, and constructively aligned to real-world outcomes. At Queensland University of Technology, the Real World Learning 2020 vision includes the goal of deploying authentic assessment in all units over the next four years.<sup>11</sup> Vocational education and training (VET) programmes, which are linked to learners acquiring very specific skillsets, especially depend on strategies that validate specialised subject mastery.

### Mid-Term Trends

#### *Driving Ed Tech adoption in Australian tertiary education for the next three to five years*

**Growing Focus on Measuring Learning.** The growing focus on measuring learning describes a renewed interest in assessment and the wide variety of methods and tools that educators use to evaluate, measure, and document the academic readiness, learning progress, skill acquisition, or educational needs of students.<sup>12</sup> As societal and economic factors redefine



what skills are necessary in today's workforce, institutions must rethink how to define, measure, and demonstrate mastery of subjects, skills, and competencies.

**Redesigning Learning Spaces.** More universities are helping to facilitate emerging models of education, such as the flipped classroom, by rearranging learning environments to accommodate more active learning. Educational settings are increasingly designed to enable project-based interactions with attention to mobility, flexibility, and multiple device usage. Wireless bandwidth is being upgraded in institutions to create "smart classrooms"<sup>13</sup> that support web conferencing and other methods of remote, collaborative communication. Large displays and screens are being installed to enable collaboration on digital projects and informal presentations. Deakin University has been a leader in catalysing discussions around revamping learning spaces to meet the needs of 21<sup>st</sup> century students through their Learning Spaces initiative; while their work is primarily based in K-12, many of the underpinning philosophies are transferrable to tertiary education.<sup>14</sup>

**Shift to Deeper Learning Approaches.** There is a growing emphasis in tertiary education on the mastery of content that engages students in critical thinking, problem-solving, collaboration, and self-directed learning. As the enabling role of technologies for enhancing learning crystallises, educators are leveraging these tools to connect the curriculum with real-life applications. These approaches are decidedly more student-centred, allowing learners to take control of how they engage with a subject, even brainstorming solutions to pressing global problems and beginning to implement them in their communities. At RMIT University, the engineering school adopted a project-based learning model to nurture students' creativity and problem-solving skills, while accessing the latest technologies.<sup>15</sup>

## Short-Term Trends

### *Driving Ed Tech adoption in Australian tertiary education for the next one to two years*

**Growth of Competency-Based Education (CBE).** CBE is defined by the Competency Based Education Network as an academic model where students "acquire and demonstrate their knowledge and skills by engaging in learning exercises, activities, and experiences that align with clearly defined programmatic outcomes."<sup>16</sup> In the VET sector, it is particularly important for students to master subjects in often highly specialised areas, making CBE a natural fit. While CBE has not reached widespread adoption yet in Australia, institutional leaders are looking to successful examples in the US, such as Western Governors University.<sup>17</sup>

**Increasing Use of Blended Learning Designs.** Drawing from best practices in online and face-to-face methods, blended learning is on the rise at universities.<sup>18</sup> Its flexibility, ease of access, and the integration of sophisticated multimedia are among the list of appeals. An Accenture survey of students in Australia and several other countries found that 85% of respondents pinpointed institutions' digital capabilities, including the availability of online learning options, as a key determinant in their tertiary education programme selections. In 2015, the Blended Learning conference in Sydney brought together leading universities across the continent to share best practices.<sup>19</sup> More collaboration and communities of practice like the conference will continue to cultivate higher-quality hybrid learning opportunities.<sup>20</sup>

**Increasing Use of Collaborative Learning Approaches.** Collaborative learning, which refers to students or instructors working together in peer-to-peer or group activities, is based on the perspective that learning is a social construct. The approach involves activities that are generally focused around placing the learner at the centre and emphasising interaction and working in groups. An added dimension to this trend is an increasing focus on online global collaboration where contemporary digital tools are used to engage with others around the world to support curricular objectives and intercultural understanding.

## Significant Challenges Impeding Technology Adoption

Along with the trends discussed in the preceding section, the expert panel noted a number of significant challenges faced in Australian tertiary education that are impeding the uptake of emerging technologies. Because not all challenges are of the same scope, the discussions here are sorted into three categories defined by the nature of the challenge. The NMC Horizon Project defines solvable challenges as those that we both understand and know how to solve; difficult challenges are ones that are more or less well understood, but for which solutions remain elusive. Wicked challenges, the most difficult, are categorised as complex to even define, and thus require additional data and insights before solutions will be possible.

### Solvable Challenges

*Those which we both understand and know how to solve*

**Blending Formal and Informal Learning.** As the Internet has brought the ability to learn something about almost anything to the palm of one's hand, there is an increasing interest in the kinds of self-directed, curiosity-based learning that have long been common in museums, science centres, and personal learning networks.<sup>21</sup> These, along with life experience and other more serendipitous forms of learning, fall under the banner of informal learning. Tertiary education institutions have not yet been able to incorporate such experiences at scale, though the blending of formal and informal methods of learning can create an environment that fosters experimentation, curiosity, and creativity.<sup>22</sup> The goal is to cultivate the pursuit of lifelong learning. However, methods of formally acknowledging and rewarding skills both instructors and students master outside of the classroom are compounding this challenge.<sup>23</sup>

**Creating Authentic Learning Opportunities.** Authentic learning is still all too uncommon at universities, though it has great potential to increase the engagement of students who are seeking some connection to the world outside of class. Use of learning strategies that incorporate real-life experiences, technology, tools that are already familiar to students, and interactions from community members are examples of approaches that can foster authentic learning. These practices may help retain students in school and prepare them for careers and citizenship in a way that traditional practices are too often failing to do. An increasing number of Australian institutions, including University of Technology Sydney, are adopting a flipped classroom approach, enabling learners to engage in practice-based activities during class.<sup>24</sup>

**Improving Digital Literacy.** With the proliferation of the Internet, mobile devices, and other technologies that are now pervasive in tertiary education, the traditional view of literacy as the ability to read and write has expanded to encompass understanding digital tools.<sup>25</sup> This new category of competence is affecting how universities and VET address literacy issues in their curriculum objectives. Lack of consensus on what comprises digital literacy is impeding many institutions from formulating adequate policies and programmes that address this challenge. Discussions among educators have described digital literacy as competence with a wide range of digital tools for varied educational purposes, or as an indicator of the ability to critically evaluate web resources.<sup>26</sup> However, both definitions are broad and ambiguous.

### Difficult Challenges

*Those we understand but for which solutions are elusive*

**Competing Models of Education.** New models of education are bringing unprecedented competition to the traditional models of tertiary education where students typically receive instruction per credit hour on-campus. Institutions are looking for ways to provide a high quality of service and more learning opportunities at lower costs.<sup>27</sup> A range of adult learning programmes are creating innovative models that emphasise human interaction and

multidimensional learning by cultivating skills such as intercultural communication and social entrepreneurship. As new platforms arise, there is a need to frankly evaluate the models and determine how to best support collaboration, interaction, and assessment at scale.

**Rethinking the Roles of Educators.** Educators are increasingly expected to be adept at a variety of technology-based and other approaches for content delivery, learner support, and assessment; to collaborate with other instructors both inside and outside their institutions; to routinely use digital strategies in their work with students; to act as guides and mentors to promote student-centred learning; and to organise their own work and comply with administrative documentation and reporting requirements. Students add to these expectations through their own use of technology to socialise, organise, and informally learn.

**Under-resourced Campus Infrastructure.** Critical school 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 outdated, pre-existing technology and learning management systems. To address this challenge, institutions are making investments in virtual resources that can be deployed to support entire campuses. The DV Capability@Griffith project at Griffith University, for example, provides a suite of Create Your Own Digital Video Studios for students and staff.<sup>28</sup>

## Wicked Challenges

*Those that are complex to even define, much less address*

**Balancing Our Connected and Unconnected Lives.** To prevent students from getting lost in the abundant sea of new media, universities should encourage mindful use of technology while making them aware of their digital footprint.<sup>29</sup> As education aligns closer with technological trends, instructors will have to promote a balance, facilitating opportunities where students pursue sensorial experiences that are crucial to developing character and integrity. Guiding learners to personal success in their own habits is especially critical for incoming generations of students that have come to rely on technology. Institutions also have a responsibility to ensure that when students are connected it is with the purpose of transformation, not just replicating an experience that could take place without technology.<sup>30</sup>

**Keeping Formal Education Relevant.** Today, a degree no longer guarantees gainful employment. Rising youth unemployment rates and labour market research about the global skills gap leave many concerned that current universities do not prepare learners for the workplace's rapid modernisation. CEDA released a major report focused on the future of Australia's workforce and what skills will be needed to maintain a strong economy, citing a digital disruption.<sup>31</sup> Although VET has been framed as a promising solution, negative cultural perceptions are still driving students into formal education.<sup>32</sup> Addressing this challenge means envisioning new ways to earn a degree that equip students with industry-specific skills while maintaining the ethical training and credibility of academia.

**Scaling Instructional Innovations.** Institutions are not adept at moving teaching innovations into mainstream practice.<sup>33</sup> Innovation springs from the freedom to connect ideas in new ways, but universities generally allow educators to connect ideas only in prescribed ways, which can lead to rote learning. Promotion structures rarely reward innovation and improvements in teaching and learning. There is promise in the form of universities willing to experiment with new approaches; University of Adelaide adopted a new model that involves phasing out lecture-based instruction in favour of more active approaches.<sup>34</sup>

## Time-to-Adoption: One Year or Less

### Bring Your Own Device

BYOD, also referred to as BYOT (Bring Your Own Technology), is the practice of people bringing their own laptops, tablets, smartphones, or other portable devices with them to the learning or work environment. Intel coined the term in 2009, when the company observed that an increasing number of its employees were using their own devices and connecting them to the corporate network, leading to major productivity gains. By 2025, millennials will represent 75% of the global workforce,<sup>35</sup> and as a group generally accustomed to mobiles being at the centre of their lives, there is now an expectation that they can use them for many aspects of their work life. In formal education, the BYOD movement addresses the same reality; many students are entering the classroom with their own devices, which they use to connect to the institutions' networks. While BYOD policies have been shown to reduce overall technology spending, they are gaining traction more so because they reflect a contemporary lifestyle and way of working and learning. Even in the absence of concrete strategies, institutions across the world are increasingly accommodating and even encouraging the use of mobile devices for a wide range of teaching and learning activities. Australia's ACT Education and Training Directorate published guidelines for institutions looking to deploy BYOD initiatives.<sup>36</sup>

### Relevance for Teaching, Learning, or Creative Inquiry

- Because BYOD allows students access to the same devices at school and at home, it can extend learning opportunities to times and places outside of the lecture hall.
- BYOD policies allow students to work with technology with which they are already comfortable and familiar.
- BYOD programmes eliminate the support and other demands placed on universities that accompany paying for and maintaining institution-provided devices.

### BYOD in Practice

- After analysing student needs and pathway skill requirements for English language acquisition, the Monash University English Language Centre developed a BYOD policy as a foundation for a fully integrated blended learning programme: [go.nmc.org/byodmonash](http://go.nmc.org/byodmonash).
- The MLEF project, led by University of Southern Queensland, Australian National University, and University of South Australia, joined researchers from a range of disciplines to develop a framework that will support tertiary education leaders and educators to provide sustainable mobile learning opportunities to students: [go.nmc.org/mléf](http://go.nmc.org/mléf).
- On behalf of the Australian National Vocational Education and Training sector, the Flexible Learning Advisory Group created a set of standards, guidelines, resources, and tools to aid registered training organisations in their BYOD implementation: [go.nmc.org/byodvet](http://go.nmc.org/byodvet).

### For Further Reading

*BYOD in Registered Training Organisations*

[go.nmc.org/ausmari](http://go.nmc.org/ausmari)

(Australian Government Department of Education and Training, accessed 29 April 2016.) This case study describes how Australian Maritime College has designed their "any device" access policy to benefit both on-campus and online students by ensuring their digital learning resources are accessible anytime, anywhere, and compatible with any device.

*How Do Students Use Their Mobile Devices to Support Learning?*

[go.nmc.org/byodstudentuse](http://go.nmc.org/byodstudentuse)

(Helen Farley et al., *Journal of Interactive Media in Education*, 2015.) A study conducted to explore student use of mobile devices at the University of Southern Queensland found that students are leveraging mobile technologies to support their learning, but university systems, infrastructure, and pedagogies are hindering their efficiency.

## Time-to-Adoption: One Year or Less

### Flipped Classroom

The flipped classroom refers to a model of learning that rearranges how time is spent both in and out of class to shift the ownership of learning from the educators to the students. In the flipped classroom model, valuable class time is devoted to higher cognitive, more active, project-based learning where students work together to solve local or global challenges — or other real-world applications — to gain a deeper understanding of the subject. Rather than the instructor using class time to dispense information, that work is done by each student after class, and could take the form of watching video lectures, listening to podcasts, perusing enhanced e-book content, or collaborating with peers in online communities. Students access the online tools and resources any time they need them. Faculty can then devote more time to interacting with each individual. After class, students manage the content they use, the pace and style of learning, and the ways in which they demonstrate their knowledge; the instructor adapts instructional and collaborative approaches to suit their learning needs and personal learning journeys. This technology development is becoming more pervasive in Australia; the University of Wollongong Australia recently published a toolkit to highlight the model's benefits for teachers and students, strategies for its successful implementation, along with resources for additional training.<sup>37</sup>

### Relevance for Teaching, Learning, or Creative Inquiry

- Flipped classroom concepts and providing students with a more diverse set of learning resources can support self-directed learning.
- More active learning is an important component of the flipped classroom: lectures can be watched with ensuing online discussions unfolding at home, while instructors can use class time for hands-on activities or trips outside of the building.
- The online component of the flipped classroom enables students to repeat vital learning activities, such as re-watching video lectures and running virtual experiments as often as needed, in order for them to fully grasp the subject matter.

### Flipped Classroom in Practice

- The Australian Government Office for Learning and Teaching has funded a collaborative project between six Australian and US universities to explore how flipped classroom models can benefit course development: [go.nmc.org/coursed](http://go.nmc.org/coursed).
- An Australian National University physics professor's flipped classroom design has bolstered student participation and improved their grades: [go.nmc.org/joehope](http://go.nmc.org/joehope).
- The University of Adelaide is introducing its Echo360 Active Learning Platform to aid flipped classroom models by including lecture capture and real-time feedback on student engagement — all integrated with the university's LMS: [go.nmc.org/actlearn](http://go.nmc.org/actlearn).

### For Further Reading

*Orchestrating Teaching: the Implications of Flipped Classroom*

[go.nmc.org/monashuniversity](http://go.nmc.org/monashuniversity)

(Monash University, accessed 24 March 2016.) Abandoning the traditional lecture method in favour of a more interactive approach, a statistics professor from Monash University shares what makes his flipped classroom successful, urging instructors to develop a model that fits the specific needs of the students rather than a one-size-fits-all method.

*Re-engineering an Engineering Course*

[go.nmc.org/reen](http://go.nmc.org/reen)

(Elaine Khoo, et al., j-STEM, July 2015.) This paper describes an investigation in an undergraduate engineering course at New Zealand University on how a flipped classroom model can enhance student learning of threshold concepts.

## Time-to-Adoption: One Year or Less

### Learning Analytics

Learning analytics is an educational application of web analytics, a science that is commonly used by businesses to analyse commercial activities, identify spending trends, and predict consumer behaviour. Education is embarking on a similar pursuit into data science with the aim of learner profiling, a process of gathering and analysing large amounts of detail about individual student interactions in online learning activities. The goal is to build better pedagogies, empower students to take an active part in their learning, target at-risk student populations, and assess factors affecting completion and student success. For learners, educators, and researchers, learning analytics is already starting to provide crucial insights into student progress and interaction with online texts, courseware, and learning environments used to deliver instruction. Students are beginning to experience the benefits of learning analytics as they engage with mobile and online platforms that track data to create responsive, personalised learning experiences. Local organisation ascilite is highlighting the most innovative uses of learning analytics within Australian tertiary education through their Awards for Excellence programme, which honours universities who demonstrate practical uses of analytics to improve teaching and learning.<sup>38</sup>

### 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 science behind learning analytics in online environments can be used to create adaptive software that caters to a student's individual learning curve in real time.
- When correctly applied and interpreted, learning analytics will enable instructors to more precisely identify students' learning needs and tailor instruction appropriately.

### Learning Analytics in Practice

- Charles Darwin University and four other universities held a national forum on learning analytics with the goal of generating an implementation framework: [go.nmc.org/lets](http://go.nmc.org/lets).
- The Connected Intelligent Centre at the University of Technology, Sydney has initiated a number of learning analytics-related research projects, including creating a tool to provide formative feedback on students' academic writing: [go.nmc.org/utscic](http://go.nmc.org/utscic).
- University of Melbourne researchers developed a learning analytics dashboard and tested it on three groups of university students to understand how they interpreted and responded to the feedback delivery: [go.nmc.org/melbou](http://go.nmc.org/melbou).

### For Further Reading

*The Potential of Learning Analytics to Systematically Address Diverse Learning Needs and Improve Student Retention in Australian Higher Education*

[go.nmc.org/diverseLA](http://go.nmc.org/diverseLA)

(Henk Huijser et al., SIM University, 2016.) This two-part report provides educators with a comprehensive understanding about learning analytics and its role in increasing student retention. Beginning with a broad overview on the current use of analytics in tertiary education, the report concludes with survey results that identify areas of resistance.

*Student Retention and Learning Analytics*

[go.nmc.org/finalreport2016](http://go.nmc.org/finalreport2016)

(Shane Dawson et al., Australian Government Office for Learning and Teaching, 2016.) Co-authored by six Australian universities and supported by the Australian Government Office for Learning and Teaching, this report explores the challenges that inhibit many universities from adopting practical uses of learning analytics and poses insightful understandings of the field to foster better implementations.

## Time-to-Adoption: One Year or Less

### Online Learning

Online learning refers to both formal and informal educational opportunities that take place through the web. This topic experienced a surge of interest with the rise of massive open online courses in 2012, and has since been garnering greater acceptance as a mode of learning that can complement face-to-face instruction in blended learning approaches — or stand on its own. As leaders have gained a better understanding of this field, they have been conducting numerous related online learning experiments; educators are becoming more comfortable testing various levels of integration in their existing courses, and many believe that online learning can be an effective catalyst for thoughtful discussion on all pedagogical practice. At many Australian tertiary institutions, online learning is already commonplace and has proved to enhance face-to-face offerings as well. Indeed, it will cease to be considered as an emerging technology development for future-focused discussions in the NMC Horizon Project.

### Relevance for Teaching, Learning, or Creative Inquiry

- As new pedagogies emphasise personalised learning, there is a growing demand for learner-centred online opportunities. Online learning environments, when designed effectively, have the potential to scale globally.
- Online learning makes creative use of educational technologies and emerging instructional approaches, including blended learning, video lectures, and badges.
- When placed online, a diverse set of learning resources is easily accessible to students and can support self-directed learning.

### Online Learning in Practice

- As an innovator in flexible education, the University of New England has taken online learning beyond the mainstream with over 20,000 students completing some or all of their studies online: [go.nmc.org/uneonline](http://go.nmc.org/uneonline).
- A support site developed at Griffith University provides both staff and students with a comprehensive suite of blended learning resources: [go.nmc.org/griffithblended](http://go.nmc.org/griffithblended).
- The University of the Sunshine Coast curated a destination for their instructors to gain an overview of blended learning with access to tools and resources: [go.nmc.org/usclublended](http://go.nmc.org/usclublended).

### For Further Reading

#### *3 Key Requirements For Online Learning Validation*

[go.nmc.org/onlinevalid](http://go.nmc.org/onlinevalid)

(Michael Baron, *eLearning Industry*, 28 January 2016.) This article shares vital components for establishing an online course that captivates learners, including ensuring that the qualifications awarded will be validated by employers and academic bodies, and employing reliable systems for learning management.

#### *Online Learning Can Work if Universities Just Rethink the Design of Their Courses*

[go.nmc.org/onlinecanwork](http://go.nmc.org/onlinecanwork)

(Dror Ben-Naim, *The Conversation*, 25 November 2015.) Universities are investing in various organisational infrastructures, including hiring new staff that can work with educators in their online curriculum and course design.

#### *Universities Still Masters of Learning*

[go.nmc.org/onlinemol](http://go.nmc.org/onlinemol)

(Kylar Loussikian, *The Australian*, 2 April 2016.) Online learning has a high satisfaction rate in the increasingly competitive world of MBAs, but there are still challenges in integrating some benefits from face-to-face learning.

## Time-to-Adoption: Two to Three Years

### Adaptive Learning Technologies

Adaptive learning technologies refer to software and online platforms that adjust to individual students' needs as they learn. According to a paper commissioned by the Bill & Melinda Gates Foundation, adaptive learning is a "sophisticated, data-driven, and in some cases, nonlinear approach to instruction and remediation, adjusting to a learner's interactions and demonstrated performance level, and subsequently anticipating what types of content and resources learners need at a specific point in time to make progress."<sup>39</sup> In this sense, contemporary educational tools are now capable of learning the way people learn; enabled by machine learning technologies, they can adapt to each student's progress and adjust content in real time or provide customised exercises. In higher education, many faculty envision these adaptive platforms as new, patient tutors that can provide personalised instruction on a large scale. There are two levels to adaptive learning technologies — the first platform reacts to individual user data and adapts instructional material accordingly, while the second leverages aggregated data across a large sample of users for insights into the design and adaptation of curricula.

### Relevance for Teaching, Learning, or Creative Inquiry

- Adaptive learning dashboards are often viewable by students so they can gain a better understanding of what habits and activities are helping them learn more effectively.
- Adaptive learning technologies link specific concepts and skills from a course to how students are interacting with the material; a student, for example, may spend a disproportionate amount of time reading a single passage, signalling the algorithm to serve up more resources for them to better comprehend the concept.
- If applied effectively, adaptive learning can foster more personalised learning for students while providing institutions with key insights about the efficacy of their instruction.

### Adaptive Learning Technologies in Practice

- A lecturer at Central Queensland University worked with Smart Sparrow to create an interactive virtual lab; based on how students perform, adaptive feedback and pathways guide their personalised lab experiences: [go.nmc.org/central](http://go.nmc.org/central).
- Two professors at the University of New South Wales developed an adaptive engineering course with personalised support; they aim to enhance learning outcomes in a degree area that is usually marked with high dropout rates: [go.nmc.org/adaptUNSW](http://go.nmc.org/adaptUNSW).
- The University of Queensland employs several adaptive learning tools including Smart Sparrow and Cerego to provide students with feedback: [go.nmc.org/uqadapt](http://go.nmc.org/uqadapt).

### For Further Reading

#### *Early Adapters*

[go.nmc.org/earlyad](http://go.nmc.org/earlyad)

(Paul Fain, *Inside Higher Ed*, 29 May 2015.) Adaptive learning as a field is still in the early stages with various providers evolving their products based on pilot implementations and feedback. Personalised learning paths could potentially aid instructors in content delivery and provide valuable insight on how each particular student is progressing.

#### *A Framework for Adaptive Learning Design in a Web-Conferencing Environment*

[go.nmc.org/bower](http://go.nmc.org/bower)

(Matt Bower, *Journal of Interactive Media in Education*, 10 February 2016.) This study aims to unpack the most effective use of adaptive learning design in web-conferencing environments through two measures: type of knowledge represented and the nature of the interaction.



## Time-to-Adoption: Two to Three Years

### Location Intelligence

Location intelligence refers to the mapping of the geographic relationships associated with data. Resources including GIS are used to provide individuals and organisations with information about how people are interacting with various applications and services based on their location. Mobile devices are naturally driving the proliferation of this technology because of their built-in location-sensitive sensors. A growing facet of location intelligence is location-based services (LBS), which provide content that is dynamically customised according to the user's location. In Australian tertiary education, this is particularly helpful for students who are just getting acquainted with the campus. "Hello Curtin," for example, is a smart mobile app developed at Curtin University to provide students with location-based messages during their orientation week.<sup>40</sup> Advancements in the underlying technologies are extending that capability into buildings and interior spaces with remarkable accuracy. A recent development in LBS is the emergence of indoor geolocation, which is affording users with very specific information tailored to their exact location within a space, allowing fine-tuned information or services to be accessed from wherever they are in 3D spaces, so that even different floors of a building can be identified.

### Relevance for Teaching, Learning, or Creative Inquiry

- Location intelligence is increasingly integrated into mobile apps, allowing institutions to leverage their existing university apps to deliver new content to users based on their proximity to specific buildings.
- Tertiary education institutions can harness the potential of location intelligence to personalise on-campus experiences, directing students, faculty, or visitors to the resources that will be most helpful to them.
- Using indoor GPS on their mobile devices, researchers and students can better locate specific materials within campus libraries.

### Location Intelligence in Practice

- Students at Griffith University built "OnSite," an award-winning location-based app designed to bolster safety in the mining industry: [go.nmc.org/griffithonsite](http://go.nmc.org/griffithonsite).
- The University of Adelaide has incorporated the use of iBeacons and proximity technology to build "UA Xplorer," a guided interactive tour app creating a unique experience on or off campus for prospective students, visitors, and parents: [go.nmc.org/uaxplorer](http://go.nmc.org/uaxplorer).
- The University of Technology Sydney and Yahoo are developing a location-based algorithm for mobile devices to improve contextual awareness: [go.nmc.org/utsyaho](http://go.nmc.org/utsyaho).

### For Further Reading

*15 Uses of Beacons in Education*

[go.nmc.org/beaconsedu](http://go.nmc.org/beaconsedu)

(Vala Afshar, SlideShare, 3 April 2015.) This slide presentation illustrates the possibilities of beacon technology in education with applications including granting access to secure buildings and notifying students of space in libraries or study areas.

*GPS Sensor-based Mobile Learning for English*

[go.nmc.org/sensbase](http://go.nmc.org/sensbase)

(Jerry Chih-Yuan Sun, et al., *Research and Practice in Technology Enhanced Learning*, 17 November 2015.) This paper describes the findings from testing a GPS sensor-based mobile learning system developed as a smartphone app to facilitate language learning. The GPS system matched university students' positions with previously determined learning locations to enable contextually-aware experiences as students discovered and applied language concepts on campus.

## Time-to-Adoption: Two to Three Years

### Makerspaces

The turn of the 21st century has signalled a shift in what types of skillsets have real, applicable value in a rapidly advancing world. The question of how to renovate or repurpose classrooms to address the needs of the future is being answered through the concept of makerspaces, or workshops that offer tools and the learning experiences needed to help people carry out their ideas. The driving force behind makerspaces is rooted in the maker movement, a following comprised of artists, tech enthusiasts, engineers, builders, tinkerers, and anyone else with a passion for making things. The foundation of the maker movement was built on the success of the Maker Faire, a gathering that launched in 2006 and has since propagated itself into numerous community-driven events all over the world. Makerspaces are intended to appeal to people of all ages, and are founded on openness to experiment, iterate, and create. In this landscape, creativity, design, and engineering are making their way to the forefront of educational considerations, as tools such as 3D printers, robotics, and 3D modelling web-based applications become accessible to more people. Proponents of makerspaces for education highlight the benefit of engaging learners in creative, higher-order problem solving through hands-on design, construction, and iteration. At the University of New South Wales, the Michael Crouch Innovation Centre is a space for students and faculty to dream up new ideas and discover resources to help them implement creative projects, whether course-related or personal endeavours.<sup>41</sup>

### Relevance for Teaching, Learning, or Creative Inquiry

- Makerspaces equipped with technologies and construction supplies are all-purpose workshops that represent the power of creation in both the virtual and physical world.
- Makerspaces that can be accessed outside of scheduled courses provide a place for instructors and students to pursue making activities on their own or participate in extracurricular camps that promote design skills with a variety of tools.
- Pedagogies such as inquiry-based learning and design thinking, which encourage planning, construction, and delivery, can be carried out in makerspaces.

### Makerspaces in Practice

- Curtin Library Makerspace is exploring MinecraftEdu for establishing a virtual makerspace that people can interact with via a Kinect camera and projector: [go.nmc.org/minedu](http://go.nmc.org/minedu).
- Monash University's sensiLab is a hub for creative innovation through knowledge sharing by connecting designers, artists, engineers, computing experts, and business entrepreneurs in a space full of new technologies: [go.nmc.org/mon](http://go.nmc.org/mon).
- The University of Southern Queensland Makerspace is a community space for class projects, student clubs, and to test new ideas: [go.nmc.org/usqmake](http://go.nmc.org/usqmake).

### For Further Reading

#### *3D Printing and University Makerspaces*

[go.nmc.org/counter](http://go.nmc.org/counter)

(Robbie Fordyce, et al., *Digital Culture & Education*, 24 November 2015.) This paper leverages research based on interviews and surveys from participants in Australian University's School of Engineering Digismith workshops to describe the role of peer-to-peer learning and problem-based learning approaches within makerspaces.

#### *The Democratisation of Design and Design Learning (PDF)*

[go.nmc.org/makedesign](http://go.nmc.org/makedesign)

(Katja Fleischmann, *International Journal of Arts & Sciences*, 2015.) The accessibility of makerspaces has enabled more amateurs to enter the field of design, and institutions must rethink the traditional methods of design education delivery.

## Time-to-Adoption: Two to Three Years

### Wearable Technology

Wearable technology refers to computer-based devices that can be worn by users, taking the form of an accessory such as jewellery, eyewear, or even actual items of clothing such as shoes or a jacket. The benefit of wearable technology is that it can conveniently integrate tools that track sleep, movement, location, and social media interactions, or, in the case of Oculus Rift and similar gear, it can enable virtual reality. Australian tertiary education institutions have been instrumental in developing enabling technologies; scientists at the University of Wollongong, for example, harnessed the ultra-thin material graphene to create a lightweight, flexible battery-like structure that can store large amounts of energy within wearables and implanted medical devices.<sup>42</sup> There are even new classes of devices that are seamlessly integrated with a user's everyday life and movements. In recent years, Google Glass has been one of the most heavily discussed wearables, enabling users to see information about their surroundings displayed in front of them. Smartwatches from Apple, Samsung, Sony, and Pebble are already allowing users to check emails and perform other productive tasks through a tiny interface. Thanks to the quantified self movement, today's wearables not only track where a person goes and what they do, but now what their aspirations are and when those can be accomplished.

### Relevance for Teaching, Learning, or Creative Inquiry

- Effective wearable devices become an extension of the person wearing them, allowing them to comfortably engage in everyday activities, such as checking and responding to emails and other tasks that help instructors and students to stay productive on-the-go.
- The next wave of wearable technology, implantable devices, can be embedded under a person's skin to detect and even dispense treatment for health issues.
- Wearable devices such as Oculus Rift provide a virtual reality-enhanced experience for users, making simulation activities more realistic and immersive.

### Wearable Technology in Practice

- At Royal Melbourne Institute of Technology, scientists have created inexpensive and durable wearable sensor patches that can be worn on skin or incorporated into clothing to detect dangerous gases as well as harmful levels of UV radiation: [go.nmc.org/stresens](http://go.nmc.org/stresens).
- The Australian Institute of Innovative Materials at the University of Wollongong recently created a free online course through FutureLearn to explore the science of smart clothing and advancements in the wearable technology field: [go.nmc.org/wearmooc](http://go.nmc.org/wearmooc).
- Researchers at the University of South Australia are developing a polymer thin-film coating that conducts electricity on a contact lens to potentially be used for a range of personalised health monitoring applications: [go.nmc.org/eyes](http://go.nmc.org/eyes).

### For Further Reading

*Cern Social Experiment Yields Thoughtful Designs from Students*

[go.nmc.org/cern](http://go.nmc.org/cern)

(Della Bradshaw, *The Financial Times*, 22 March 2015.) Student teams from Swinburne University of Technology and several European universities partnered with scientists at Cern to develop wearables that provide solutions for the elderly and autistic populations.

*Designing Experiences with Wearables*

[go.nmc.org/blurr](http://go.nmc.org/blurr)

(Rafael Gomez, et al., Queensland University of Technology, November 2015.) Queensland University of Technology, Griffith University, and Hong Kong Baptist University facilitated an interdisciplinary and intercultural cloud workshop in which students cooperated to develop innovative wearable concepts blending art, design, and technology.

## Time-to-Adoption: Four to Five Years

### Affective Computing

Affective computing is the idea that humans can program machines to recognise, interpret, process and simulate the range of human emotions. This concept centres on the development of programs and hardware that create the faculties for a computer to do this, such as implementing a video camera to capture facial cues and gestures that works in conjunction with an algorithm that can detect and interpret these human affects. Not to be confused with facial recognition technologies associated with security, like those that facilitate secure payment transactions, affective computers recognise emotional and behavioural cues that trigger a reactionary process in the computer. A potential application of affective computing is in online learning situations wherein a computerised tutor reacts to facial cues of boredom in a student in an effort to motivate or boost their confidence. University of Sydney is leading the charge, having launched JSIENTO, an open-source platform for affective computing.<sup>43</sup> With researchers already working on educational applications and start-up companies exploring other novel uses, growth in the field of affective computing has deep implications for the future of human and computer interactions.

### Relevance for Teaching, Learning, or Creative Inquiry

- Affective computing applications can be integrated into online learning environments to help detect students' emotions and adapt activities and exercises accordingly.
- Computers that can recognise human faces, cues, and gestures can connect with students on an individual level and offer a more personalised learning path.
- When applied to robots, affective computing can help improve emerging teaching practices such as remote instruction through telepresence.

### Affective Computing in Practice

- At an Affectiva hackathon to create emotion-aware technology, participants worked on a variety of concepts ranging from an app to help autistic people in their interpersonal relationships to a tool for instructors to assess student comprehension and attention in real time: [go.nmc.org/affe](http://go.nmc.org/affe).
- Researchers at the University of Sydney are developing software for recording multimodal affective data to provide a deeper understanding of the processes involved in collaborative learning activities: [go.nmc.org/affectech](http://go.nmc.org/affectech).
- A robot named Tega developed in the MIT Media Laboratory is a socially assistive smartphone robot that can interpret the emotional response of the student it is working with to deliver personalised tutoring: [go.nmc.org/teg](http://go.nmc.org/teg).

### For Further Reading

*Analysing Reflective Text for Learning Analytics*

[go.nmc.org/reflective](http://go.nmc.org/reflective)

(Andrew Gibson and Kirsty Kitto, Queensland University of Technology, 2015.) Anomaly recontextualisation software can detect affective dimensions of an author's perspective in writing and communications, which could contribute new data on student interactions in digital settings.

*Imagine if Technology Could Read and React to Our Emotions*

[go.nmc.org/react](http://go.nmc.org/react)

(David Tuffley, *The Conversation*, 25 November 2015.) Emotion monitoring is already being embedded into current technologies and will continue to transform how humans interact with their devices, leading to much more intuitive interfaces that leverage body language and tone of voice to respond to each user personally.

## Time-to-Adoption: Four to Five Years

### Augmented Reality

Augmented reality (AR), a capability that has been around for decades, is shifting from what was once seen as a gimmick to a tool with tremendous potential. The layering of information over 3D space produces a new experience of the world, sometimes referred to as “blended reality,” and is fuelling the broader migration of computing from the desktop to the mobile device, bringing with it new expectations regarding access to information and new opportunities for learning. While the most prevalent uses of augmented reality so far have been in the consumer sector, new uses seem to emerge almost daily, as tools for creating new applications become even easier to use. A key characteristic of augmented reality is its ability to respond to user input. This interactivity confers significant potential for learning and assessment; with it, students can construct new understanding based on interactions with virtual objects that bring underlying data to life. Dynamic processes, extensive datasets, and objects too large or too small to be manipulated can be brought into a student’s personal space at a scale and in a form easy to understand and work with. In Australia, Deakin University has emerged as a leader in this field; they are building a platform that uses an augmented reality content management system to allow staff members to create AR content for any area of the university.<sup>44</sup>

### Relevance for Teaching, Learning, or Creative Inquiry

- Augmented reality constructs provide contextual, in situ learning experiences that foster exploration of real world data in virtual surroundings and simulations.
- Games that are based in the real-world and augmented with networked data give educators powerful new ways to show relationships and connections in computer science.
- Students doing outdoor fieldwork access AR applications to overlay maps and information about their surroundings, or to enter field observations and data that is automatically geocoded as the records are created.

### Augmented Reality in Practice

- As part of the Perth International Arts Festival 2015, a team of University of Western Australia students worked with local artists to create an AR Sculpture Park. Interactive AR artworks are experienced through a mobile app: [go.nmc.org/subi](http://go.nmc.org/subi).
- Deakin University is partnering with EON Reality Inc. to set up the Interactive Digital Centre Hub, offering AR learning programmes and courses so that students have an opportunity to become qualified AR developers: [go.nmc.org/eon](http://go.nmc.org/eon).
- Researchers from the University of South Australia and Monash University are leveraging AR technology to develop an app that allows users to obtain instant information, such as product reviews and health comparisons, displayed as an overlay on grocery store products scanned with mobile or wearable devices: [go.nmc.org/shopp](http://go.nmc.org/shopp).

### For Further Reading

*Sydney's Future Zoo Wants To Use Augmented Reality, Robots And Drones*

[go.nmc.org/fuzoo](http://go.nmc.org/fuzoo)

(Rae Johnston, *Gizmodo*, 7 April 2016.) Western Sydney University is collaborating with Sydney Zoo to host a hackathon aimed at generating ideas for how an AR app could enhance design, maintenance, management, and interactive visitor experiences.

*Unified Physical and Digital Experiences*

[go.nmc.org/arinter](http://go.nmc.org/arinter)

(Sun Tae Nam, ISEA2015, accessed 19 April 2016.) This paper presents a mixed reality framework for creating immersive environments and demonstrates how two AR projects employed the framework.

## Time-to-Adoption: Four to Five Years

### Machine Learning

Machine learning refers to computers that are able to act and react without being explicitly programmed to do so.<sup>45</sup> Practical speech recognition, semantic applications, and even self-driving cars all leverage machine learning via data systems that not only intake, retrieve, and interpret data, but also learn from it. To do this, the machine must make a generalisation, using algorithms to respond to new inputs after being “trained” on a different learning data set — much like a human learns from experiences and uses that knowledge to respond appropriately in a different encounter. In this sense, machine learning is widely considered by many as a step towards human-like artificial intelligence (AI). Recent incarnations of machine learning in the education space include a university-developed telescope that can automatically detect significant changes pointing to supernova occurrences.<sup>46</sup> The software Xapagy improvises dialogue and plot moves in stories fed to it by users.<sup>47</sup> While machine learning in libraries is still some years away, the potential of data management systems that can adapt and learn on their own is driving research around the world.

### Relevance for Teaching, Learning, or Creative Inquiry

- Machine learning models can potentially sort through learner-contributed observations about the world around them and create visualisations that identify crucial patterns.
- Software that employs machine learning to detect patterns in written work, speech, and other actions could better adapt to students’ learning styles and needs.
- Ultimately, machine learning promises to enable scientists and researchers to communicate more authentically with their devices — even in improvised ways, just as a colleague would. It is foreseeable that students will collaborate with machines on projects.

### Machine Learning in Practice

- The Holly Smart Home Project, a machine learning system developed by researchers at Deakin University, can alert healthcare providers when abnormal activity is detected in or around the home: [go.nmc.org/hollysmart](http://go.nmc.org/hollysmart).
- National ICT Australia’s Machine Learning Research Group works with its member and partner universities to provide infrastructure and support, including scholarship opportunities, cross-university collaboration, and machine learning events for post-graduate students: [go.nmc.org/nicta](http://go.nmc.org/nicta).
- A Perth-based company created a smart phone application at the University of Queensland that utilises machine learning to detect respiratory illness: [go.nmc.org/respdetect](http://go.nmc.org/respdetect).

### For Further Reading

*Cognitive Computing's Powerful Potential*

[go.nmc.org/cogcomp](http://go.nmc.org/cogcomp)

(Brad Howarth, *CIO*, 15 April 2015.) Deakin University in Victoria is using Watson Cognitive Systems to leverage information on university operations, services, and students’ personal profile data to personalise the user experience of their digital guide, DeakinSync.

*A Revolution is Coming in Computing and Australia is at the Forefront*

[go.nmc.org/ausforefront](http://go.nmc.org/ausforefront)

(Tim Dodd & Paul Smith, *Financial Review*, 12 March 2016.) An informal group of financial market analysts recently organised an event bringing financial traders and university students together in a hackathon to begin applying finance-related quantum computing theories in practice.

## Time-to-Adoption: Four to Five Years

### Networked Objects

Networked objects connect the physical world with the world of information through the web. They do so through TCP/IP, the set of standards that enables network connections and specifies how information finds its way to and from myriad connections it contains. 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 alerts if the objects they are attached to are in danger of being damaged or spoiled. Traditional web tools enable objects to be annotated with descriptions, photographs, and connections to other objects, and any other contextual information.

### Relevance for Teaching, Learning, or Creative Inquiry

- Big data will play a major role in the application of networked objects in education, as information transmitted from students' mobile devices will lead to improved understanding of learner behaviours.
- Integration of networked objects raises concerns about privacy, resulting in research efforts to identify incentives that encourage institutions, educators, and students to share data openly.
- Networked sensors make it possible to study objects that cannot be reached or touched, such as living things like marine life and ancient artefacts.

### Networked Objects in Practice

- Curtin University is partnering with Cisco to build an Internet of Everything innovation centre in which the potential of cloud, analytics, cyber security, and Internet of Things network platforms will be leveraged toward practical operations in areas including agriculture and astronomy: [go.nmc.org/cisc](http://go.nmc.org/cisc).
- James Cook University's Bachelor of Engineering in Electronic Systems & Internet of Things combines the study of electronic engineering with Internet technologies, wireless communications, sensor devices, industrial design, and cloud computing: [go.nmc.org/jcu](http://go.nmc.org/jcu).
- Macquarie University is using the AtHoc Networked Crisis Communications Suite that runs on a secure IoT cloud platform to share a single format message over multiple platforms in the event of a crisis on campus, or in the surrounding area: [go.nmc.org/macqu](http://go.nmc.org/macqu).

### For Further Reading

*Internet of Things Executive Handbook*

[go.nmc.org/iothandb](http://go.nmc.org/iothandb)

(Telit, 2016.) Telit's handbook reveals insights from a global, multi-disciplinary group of practitioners and industry leaders on how areas including education, artificial intelligence, and cloud computing will be transformed by the ever-growing network of objects.

*Understanding the Issues and Challenges of a More Connected World (PDF)*

[go.nmc.org/issu](http://go.nmc.org/issu)

(Internet Society, October 2015.) This report delves into opportunities of connected devices and calls for collaboration across a range of stakeholders to address the imminent security, privacy, interoperability, and legal challenges.

## Methodology

The process used to research and create the *2016 NMC Technology Outlook for Australian Tertiary Education: A Horizon Project Regional Report* is very much rooted in the methods used throughout the NMC Horizon Project. All publications of the NMC 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 panel of experts 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 trends, challenges, and important developments in educational technology 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 *2016 NMC Technology Outlook for Australian Tertiary Education* can be found at [aus.wiki.nmc.org](http://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 expert panel. The panel 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 thought leaders have participated in the NMC Horizon Project Expert Panel; in any given year, a third of expert panel members are new, ensuring a flow of fresh perspectives.

Once the expert panel 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. Panel 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 expert panel 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 panel:

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 developments in technology that some Australian universities and educational programmes are using today that arguably ALL Australian universities and educational programmes 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 universities and educational programmes be actively looking for ways to apply?*



- c. *What are the key emerging technologies you see developing to the point that Australian universities and educational programmes should begin to take notice during the next four to five years?*
3. *What key trends do you expect to accelerate the uptake of emerging technology across Australian tertiary education?*
4. *What do you see as the significant challenges impeding emerging technology uptake across Australian tertiary education?*

One of the expert panel'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 expert panel 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 panel 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](http://aus.wiki.nmc.org).



## 2016 Horizon Project Australia Expert Panel

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## End Notes

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