Transformation or evolution?: Education 4.0, teaching and learning in the digital age

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ABSTRACT
This paper, originally written just before the outbreak of COVID-19, will provide a review of Education 4.0 in a select range of UK and international higher education providers and offer an initial discussion of the role and importance of digital personal assistants and online and lifelong learning in delivering world-class learning and teaching. This has been validated through a literature review and four case studies using scenario-planning methodology which draw on real-world examples from the UK (University of Bath), Singapore (Nanyang Technological University) and Australia (Deakin University). What can the sector learn from these pioneers; are there opportunities still to be explored; and what impact might this have on how educators teach and deliver their curriculum in the future?

Introduction
This paper was originally written just before the outbreak of COVID-19; in a few short months, the delivery of Higher Education around the globe has altered dramatically, with most institutions having shifted their teaching and assessment online – sometimes in a matter of days and with very little time for staff (and student) training and support (Clune, 2020; Hack, 2020). Whilst it is too soon to tell what the long-term impact of the global pandemic will be on the sector, some are already noting that we should not conflate emergency online teaching with well-planned, well-designed and pedagogically effective online teaching that will meet the needs of learners and future employers (Golden, 2020; Weller, 2020). Indeed, before the global outbreak, some institutions were already laying the groundwork for a new approach to Higher Education (albeit one which may now look very different). They were investing in new technologies to deliver educational experiences and exploring how the sector might respond to the future needs of industry and jobs.

Certainly, the potential of data, artificial intelligence (AI), machine learning, robots, internet of things (IoT) and automation as part of a Fourth Industrial Revolution (Industry 4.0) has been widely discussed (Lasi, Fettke, Kemper, Feld, & Hoffmann, 2014, pp. 239–242; Schuster, Groß, Vossen, Richert, & Jeschke, 2016, pp. 477–487).
Studies are also beginning to explore how the job market is shifting in response to new technologies, highlighting the skills needed for future jobs and the importance of developing lifelong learning (Bakshi, Downing, Osborne, & Schneider, 2017; Ehlers & Kellermann, 2019; PricewaterhouseCoopers [PwC], 2018a; Szabó, 2017). A 2018 report by PricewaterhouseCoopers (PwC), for example, identified that increased training in digital skills and Science, Technology, Engineering and Mathematics (STEM) will be required, and that ‘softer’ skills that cannot easily be automated by machines, such as creativity and flexibility, will be prized (PwC, 2018b, p. 4). This is a significant challenge as highlighted by Microsoft, which suggests that within the next two decades over 90% of jobs will require some level of digital proficiency; yet, as Lloyds Bank (UK) estimated in 2019, 22% of people in the UK lacked even the basic digital skills needed for day-to-day life (Lloyds Bank, 2019, p. 4; Microsoft, 2020).

Recently, attention has turned to the impact these challenges will have on Higher Education. Questions asked include: what does Education 4.0 mean; how will the curriculum and pedagogical frameworks respond; what part do technologies such as AI have to play in learning; and to what extent will ‘smart’ campuses deliver improvements in the educational experience (Elkington & Bligh, 2019, p. 3; Ellahi, Ali Khan, & Shah, 2019, pp. 699–708; Feldman, 2018; Salmon, 2019, pp. 95–115; Smith, Gamlem, Sandal, & Engelsen, 2016)? Education 4.0 is a nebulous term, and no standard definition has yet to emerge; it is more a general approach or trend to preparing a future workforce for Industry 4.0 than a single or specific intervention. For the purposes of this article, we have adopted a generic definition that appears to be common to most of literature we have reviewed: that is, Education 4.0 encompasses the different ways and approaches that Higher Education institutions can, and are, aligning their services and curricula to prepare future graduates for work (See, for example, Hussin, 2018, pp. 92–98). This prompts us to ask if Education 4.0 will require a fundamental transformation in our approach to the design and delivery of teaching and learning, and the provision of smarter learning spaces, services and learning tools? Further, how, in this period of disruption, can Higher Education institutions plan to educate for the future (Daanen & Facer, 2007, p. 3; HolonIQ, 2019, pp. 16–25)?

This paper will provide a critical review of the current literature on Education 4.0, identifying trends that are emerging and the challenges that Higher Education might face. We do not wish to impose a value judgement on the different approaches being adopted; we are in a period where experimentation needs to proceed before we can discern the clear implications or outcome(s) of what Education 4.0 might entail for the future of education. Further research still needs to be undertaken, and we offer here our initial findings based on a review of the current literature and validated through the observations of four scenarios based on the methodology of scenario planning (Chermack & Lynham, 2002, pp. 366–383; Drew, 2006, pp. 241–257; Snoek, 2003, pp. 9–19; Snoek et al., 2003, pp. 21–26). The paper is organised as follows: we first review the literature and set out our research questions; the second part discusses the methodology and application of scenario planning; the third section outlines four scenarios and case studies; the fourth part offers a short discussion and suggestions for future investigation.
**Literature review and research questions**

It’s a funny thing writing papers about the future – the actual ‘evidence’, carefully refereed and referenced is a little hard to come by! … I have deployed much ‘grey’ literature, including blogs, analysis from public and commercial sources, recent reviews and informed speculation as well. (Salmon, 2019, p. 95)

In her paper, Gilly Salmon charts the history of the dominant ways in which Higher Education has been delivered and offers insight into the future of that delivery; she also draws on a comprehensive list of references – both formal and informal – relating to Education 4.0. Like us, she notes that Education 4.0 is an emergent field and has been subject to increasing interest within educational blogs, mainstream media, technology providers and government agencies (Feldman, 2018; Hao, 2019; JISC, 2018b). A comprehensive set of answers as to how institutions should design buildings, learning spaces, digital services and the curriculum to best prepare the graduates of the future has yet to appear from the literature. To date, there is no primer for how to plan, teach or deliver Education 4.0. Further, it is worth remembering that not all countries or institutions are the same and depending on the social, economic or political context, each will move at different rates – it is also hard to plan for external disruptors such as global pandemics (COVID-19), changes in government policy and new technologies.

Given the future of Higher Education and Education 4.0 is uncertain and currently unclear, we have drawn on Salmon’s approach in our own literature review by adopting a broad definition of ‘evidence’. We searched a range of existing literature and synthesised this to create a coherent picture of the diversity of approaches to Education 4.0. We acknowledge – and embrace – the fact that a multitude of approaches exist, and we do not attempt to offer here a judgement of one approach over another. Nor do we claim that our review is ‘complete’ – the situation is such that the field is constantly being (re) written. Our review, is, as Dawson notes in his comprehensive study on rubrics, ‘presented as a starting point rather than as a complete set’ (Dawson, 2017, p. 349).

In summary, we used the following approaches to identify the relevant literature:

- Consulting the content and references of review studies and recent reports (e.g. Barnes & Proctor, 2019; JISC, 2019a; Salmon, 2019, pp. 95–115)
- Keyword searches in relevant journals (e.g. *British/Australian Journal of Educational Technology*)
- Keyword searches on Google, Google Scholar and online databases and libraries (e.g. JSTOR and Zetoc)
- Consultation with researchers and practitioners face-to-face and via online meetings.

First, we examined recent reports by the UK not-for-profit company, Joint Information Services Committee (*JISC*), whose role it is to support post-16 and higher education and research, by providing advice, digital resources and network and technology services. *JISC* has also explored future scenarios themselves, such as the virtual reality experience of Natalie 4.0 (Barnes & Proctor, 2019; JISC, 2019b). The UK government, through the Department for
Education (DFE), has also introduced a strategy focusing on raising the profile of technology in education, reviewing online learning and artificial intelligence, and working with the UK Education Technology (EdTEch) industry to overcome perceived barriers and drive innovation (Department for Education, 2019, p. 48).

On an international level, much attention has been paid to China, which is playing a significant role in AI developments. AI itself relates to a field of computer science studying the ability for machines to simulate human intelligence and cognition. Subsets of AI, such as Machine Learning, Natural Language Processing and Computer Vision are being applied by educational institutions to improve student experience and teaching and learning outcomes through personalised predictive analytics, enabling intelligent digital assistants and improving security. According to the Chinese Ministry of Education, it is the world’s largest education sector with over 518,000 schools and 276 million students and, to manage such numbers effectively, the affordances of big data and AI are being explored to provide personalised learning experiences (Zhang & Zou, 2019). Elsewhere, in Abu Dhabi, United Arab Emirates, the first AI University was launched in October 2019 (Asfa-Wossen, 2019).

Indeed, early trends are becoming apparent, both from within the literature and from digital leaders who are pioneering emergent technologies (Davies, 2019). Summarised below in Table 1, drawn from the findings in the 2019 JISC Horizon Report, is a list of the key challenges that Universities face in relation to Education 4.0, alongside emergent technologies that are currently being used. It is worth noting that since the publication of this report in March 2019, there have been further developments in some of these areas, such is the pace of change.

In the area of accreditation and validation, blockchain is increasingly being explored to securely evidence learning and assessment across a range of providers and geographic locations. Blockchain is primarily a digital ledger of records which supports a range of characteristics differentiating it from more traditional electronic record systems or databases. Some of these differentiating characteristics are the immutability of transactions and data by linking records using cryptography, distributing the ledger of records across a peer-to-peer network in order to validate the data through a shared consensus model and to remove central risk and management mechanisms where all data are held by a central system. The most popular educational applications of blockchain at the current time appear to be focused on areas such as the recording, management, validation and sharing of digital educational credentials (The Open University, 2016).

In the context of smart campuses and buildings, emphasis has been placed on new mobile technologies such as 5G and the affordances of high-speed mobile connections. At Imperial College London, for instance, there was a recent

| Key Challenge                        | Emergent Technologies                                                                 |
|--------------------------------------|----------------------------------------------------------------------------------------|
| Student Experience                   | AI, Chatbots, Learning Analytics                                                      |
| Skills Gap                           | Immersive Technologies, Simulations, AI                                               |
| Data and Estates                     | Big Data, Robotics, Smart Library Management                                          |
| Innovations in Teaching and Learning| AI, Personalised Learning Environments, Chatbots, Immersive Technologies               |
| Metrics                              | Data Analytics                                                                        |
| Open Science and Research Infrastructure | AI, Machine Learning, Robotics, Automated Experimentation, Knowledge Discovery, Connected Research Equipment |
| Cyber Security                       | IoT (Security Risks)                                                                  |

Table 1. Key Education 4.0 challenges and emergent technologies based on report by JISC (2019b).
demonstration of a lecture hosted in multiple classes and locations simultaneously through the use of the holographic projection of speakers into the learning space (Chowdhury, 2018; McKie, 2019). Others have explored the use of smart learning spaces which monitor and, in certain circumstances regulate, the temperature, humidity, lighting and CO₂ levels in buildings. Room utilisation, automatic time- tabling, wayfinding and the occupancy levels of the library and cafeteria have also been explored (Clay, 2018a, 2018b; Manchester Metropolitan University, 2019; Staffordshire University, 2019).

Relating to student wellbeing, increasing emphasis is now being paid to how technologies can help support the mental health of students within education. Learning analytics, for instance, when appropriately applied, can help to identify at-risk students. Further, digital assistants that are AI-driven and use natural language processing can act as effective communication channels with students (JISC, 2018a, 2019a, p. 43; Leeds Beckett University, 2017).

To conclude, through engagement with the existing literature, the research team identified the following questions:

1. What are the key affordances and challenges of Education 4.0 for Higher Education?
2. What challenges/advantages to established pedagogies and course design do these potentially disruptive technologies present?
3. How will institutions re-design curricula to support lifelong learning, online learning and developing skills for future employment (above and beyond those activities that are already embedded into courses)?
4. To what extent can new technologies and approaches be utilized to support learner interactivity, collaboration, communication, reflection and skills, and thus provide pedagogically rich learning environments that engage and motivate the learner?
5. What practical lessons can be learned from early adopters?

This paper will not (and indeed) cannot offer a definitive ‘answer’ or a one-size-fits-all model to all these questions. It is too soon to determine which approach should be adopted, and which learning opportunities and technologies will benefit certain students and learning activities. Given so much is currently in flux, the research team concluded that it would be most beneficial to reflect on what we can learn from those who are pioneering new approaches and technologies. The next step is to frame this into a research methodology, and to validate it with some real-world scenarios.

**Methodology and scenario planning**

The research methodology adopted here was based on scenario-planning methodology. This draws on the work of Marco Snoek and Paul Cautreels (Cautreels, 2003, pp. 175–180; Snoek, 2003, pp. 9–19; Snoek et al., 2003, pp. 21–36), and a modified version of the scenario method by Karim Benammar (Benammar, Dale, Poortinga, Schwab, & Snoek, 2006, p. 3–4). This methodology has been used in business planning to enable large-scale organisations to plan for different possible futures and to take an active part in designing the future they think is
desirable (Benammar et al., 2006, p. 16; Snoek et al., 2003, p. 21–36). In an educational context, Snoek has argued that the making and use of scenarios stimulate the imagination of people involved, increase awareness of decisions and important factors that influence education, and enable teachers to be proactive (Snoek et al., 2003, pp. 21–36). Benammar’s scenario method builds on this by presenting a ‘Facilitator Manual’ and an approach that can be used with students in a Higher Education – it designed to challenge their assumptions about the future, and to stimulate creative thinking. Specifically, students are guided through eight steps, as noted (see Table 2 below).

We adapted this scenario methodology by applying it to a research team investigating future trends in Higher Education. We followed the same eight-step approach and adopted the same ‘Facilitator’ and ‘Student’ roles, albeit not with actual students. Instead, a research team was formed, which consisted of two Facilitators (educational technologists) from the University of Bath (UK) – Dr Christopher Bonfield (Technology Enhanced Learning Manager) and Marie Salter (Digital Education Developments Manager), and three Participants (researchers and analysts at Deakin University – Australia) – Alan Longmuir (Emergent Technologies Manager), Matthew Benson (Senior Analyst and Genie Partner Engagement Manager) and Dr Chie Adachi (Director, Digital Learning). Collectively, the team has extensive knowledge of designing and, in some cases, delivering face-to-face and online education (for instance, Bonfield has over 10 years’ experience as a tutor and lecturer and Adachi over 15 years’ experience of Higher Education, holding multiple lecturer positions in a range of disciplines). The team also encompasses specialists in supporting academic and professional service staff in the use of educational technology to support teaching and learning; Longmuir and Benson also regularly evaluate new technologies that might disrupt or enhance current pedagogical practice. The scenario method we followed is set out (see Table 3 below).

**Key**

CB = Christopher Bonfield  
MS = Marie Salter  
AL = Alan Longmuir  
MB = Matthew Benson  
CA = Chie Adachi.
Steps 1 & 2: brainstorming visions and investigating trends

We drew upon our collective experiences of teaching, researching and providing services in Higher Education, an initial literature review (the team used a collaborative Zotero Reference Manager Library to collate references and notes) and our discussions with staff who had taught a lesson or course fully online, or had used emergent technologies. At this stage we were interested in identifying the trends in Education 4.0, and how and to categorise the main affordances and challenges of these new technologies and approaches. The Facilitators guided the discussions and co-evaluated the trends that were being discussed. As some in the team did not have an academic research

| Meetings          | When            | Who                                        | Action                                                                                                                                                                                                 | Steps |
|-------------------|-----------------|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| Face-to-Face      | January 2019    | CB and MS                                  | Deciding time frame, scope and theme                                                                                                                                                                    | Step 0 |
| E-Mail            | April 2019      | CB and MS                                  | Apply for, and awarded, an International Research Funding grant from the University of Bath (visit to Singapore and Australia)                                                                         | N/A   |
| E-Mail            | April–November 2019  | All                                      | (1) Sharing ideas, expertise and drivers for change; (2) expanding the literature review using a collaborative Zotero reference database; (3) identify range of Push and Pull factors and forces | Steps 1–3 |
| MS Teams Meeting  | November 2019   | CB, MS and AL (representing Deakin University) | (1) Discussed and agreed distinct, but complementary, approaches to Education 4.0 to be explored; discuss and agree scenarios and quadrants (See Table 4); (2) agree scenario format and template | Steps 3 & 4 |
| Face-to-Face      | November 2019   | CM and MS (along with colleagues at Nanyang Technological University’s Centre for Professional and Continuing Education – Singapore) | Flesh out Nanyang’s approach, generally, to Education 4.0 and discuss curricula offered to inform Scenario 4 (supplemented by online resources and research) | Steps 5 & 6 |
| Face-to-Face      | December 2019   | All – in Melbourne, Australia              | (1) Series of meetings to discuss Scenarios 1–3; (2) technical discussions around data and system integrations (3) pedagogical debates around use of student data and affordances of digital assistants in enabling autonomous learning | Steps 5 & 6 |
| E-Mail and MS Word Online | December 2019–March 2020 | All                                    | Reflection on the scenarios and evaluation of the four scenarios and future directions for research                                                  | Steps 7–8 |
Table 4. The four scenarios.

| Scenario 1: Smart Campus Programme (Deakin University) | Scenario 3: Online Postgraduate Degrees (Deakin University) and Individual MOOCs (University of Bath) |
| Scenario 2: Deakin Genie Digital Assistant (Deakin University) | Scenario 4: Lifelong Learning and SkillsFuture Courses (Nanyang Technological University, Singapore) |

background – being instead located in Professional Service teams responsible for the delivery of technical solutions – the Facilitators also steered discussions around the variety of sources that could be consulted (including informal sources such as Blogs and YouTube videos), and how to evaluate these effectively.

Steps 3 – 5: selecting driving forces, forming a scenario template and developing the scenarios

These steps formed the heart of the team’s discussions, and where we developed a deeper understanding of underlying trends and future possibilities. We started by reflecting upon an expanded literature review and our different experiences as practitioners of driving technological and pedagogical change in educational institutions. We noted that there were many similarities between Higher Education institutions in the UK, Singapore and Australia (such as the curricula offered and general learning and teaching approaches), but also marked differences such as financing models and levels of investment in technologies and infrastructure. Next, we concentrated on those factors which might have the most impact on the adoption of Education 4.0, those which were most unpredictable and those that could be used to differentiate between different scenarios. We narrowed these down and labelled them ‘push-pull’ factors: Push factors include Social Learning, Personalised Learning, Machine Learning and Connected Smart Services and Infrastructure; and Pull factors comprised Technology, Time, Resources, Digital Skills and Existing Infrastructure. In general, we were in consensus that these factors are common to most scenarios that are both currently evolving, but also likely to be factors influencing future scenarios too.

In the discussions that followed, we selected the most important factors which could be each represented with two possible approaches to emphasise the differences between the scenarios. For one approach, we identified both bite-size online degrees and Massive Open Online Courses (MOOCs), and online courses and more traditional face-to-face provision which aligned with a clear industrial strategy and vision of lifelong learning to deliver the skills of the future. For the other, we examined two different but complementary approaches to supporting smart, personalised learning and learning spaces. For the next step, and to ensure consistency between each of the four scenarios that would develop, a general template was agreed: Introduction and Scenario; Discussion; Conclusion (including Affordances and Limitations).

As suggested by Snoek (2003), in undertaking scenario planning we have not attached a value to each of the different scenarios; we have not assumed that one scenario is preferable or ‘better’ than another. In other words, each scenario carries equal weight, and we recognise that each scenario could be applied differently, depending on the cultural, political, economic and geographic context. Indeed, each scenario was deliberately distinct and while the scenarios we selected were complementary, they were
intended to demonstrate that the pathway to the future is unclear, and different approaches may emerge and disappear over time (see Table 4 below).

**Steps 6 – 8**
Step six took place in a series of meetings, both in person in Australia in December 2019, and subsequently online thereafter. In our face-to-face meetings, the participants broke off into different scenario groups and discussed these with the Facilitators. For Scenarios 2 and 3, for instance, we discussed various technical and security considerations around using student data (especially in the light of the EU’s General Data Protection Regulations – GDPR), and the level of comfort that students might have being ‘tracked’ on ‘monitored’ in a Smart Campus. We also debated how the use of tools such as the Deakin Genie Digital Assistant facilitate or replace learning, and if access to a continuous supply of ‘on demand’ information is good for student wellbeing and resilience (Universities UK, 2015). To conclude, for steps seven and eight we reflected on the fact that the four scenarios, whilst each representing a current or emerging trend, are ‘one-offs’, experimental and collectively do not represent a single pathway into the future. Instead, we discussed that scenario might be the most desirable, or most achievable in the short/medium term, and what repercussions these might have for teaching and learning.

**Scenario one: smart campuses**

**Smart campus programme at Deakin University (Australia)**

**Introduction and scenario**
Deakin University, located in Victoria, Australia, was established in 1974 as a regional university providing distance education. It is now ranked in the top 1.1% per cent of the world’s universities in the prestigious Academic Ranking of World Universities (ARWU, 2019). Deakin continues to be first in Victoria (fifth in Australia) for learning satisfaction and second in Australia for learning resources (QILT, 2019). In the 2018 Excellence for Research in Australia outcomes, 95% of Deakin research rated at or above world standard (Australian Research Council, 2019). Further, Deakin has over 61,000 students including almost 13,000 international students, and over 15,000 students studying predominantly online. Deakin has international presence in South Asia, China, Indonesia, Sri Lanka, Latin America, Europe, Malaysia, Vietnam, Pakistan and Singapore. Through the **LIVE the future Agenda 2020**, Deakin’s vision is to be Australia’s premier university in driving the digital frontier to enable globally connected education, for the jobs of the future (Deakin University, 2017b).

Deakin has been undertaking a journey towards Education 4.0 through a range of strategic initiatives – one of which is their Smart Campus programme. Launched in 2015, the Smart Campus programme was aimed at using cutting-edge digital technologies to digitise Deakin’s physical campus environments in order to provide campus users with a smart, personalised, responsive and enriched campus experience.

**Discussion**
Education 4.0 is closely aligned with the themes and technologies associated with Industry 4.0, which suggests an amalgamation of physical and digital systems will
prove to be revolutionary (Ellahi et al., 2019, pp. 699–708). The Smart Campus programme at Deakin captures this by embedding emerging technologies within the physical environment, combining these with organisational vision and values and placing the Campus User at the centre of the experience (see Figure 1).

Deakin’s Smart Campus strategy focuses on providing seamless physical-to-digital experiences for students, staff and visitors on campus – essentially the ‘Campus User’. By embedding emerging technologies within the physical campus infrastructure, Deakin is on a journey to creating a campus that knows, guides and responds to the preferences, interests and needs of its campus users in a highly personalised manner. Certainly, Deakin’s Smart Campus (Longmuir, 2019) has the power to enhance safety, security and accessibility and assist us to sustainably manage our energy, waste, buildings and other facilities. It provides applicable insights into space utilisation and occupancy and the ability to share notifications and messages in real time. Additionally, it equips the business to make informed investment and planning decisions about our service offerings, facilities and environments.

The integration of ‘organisational DNA’, physical environments and technology ‘Foundation Enablers’ are all key to the success of this programme. Deakin’s Foundation Enablers (Deakin University, 2017a) are a core piece of the Smart Campus experience. Although largely invisible to the Campus User, they comprise a range of platforms, products and emerging technologies that are planned, designed and implemented for Deakin as a whole. Strong collaboration across the various areas within the university, skilled and knowledgeable staff, good planning and an appetite

Figure 1. Enabling a Smart Campus (illustration by Alan Longmuir).
for innovation ensure a collective agreement on these underpinning foundations which can then be used to deliver innovative and differentiating solutions and experiences.

**Conclusion (Including affordances and limitations)**

The long-term benefits for a Smart Campus supported by Deakin’s Foundation Enablers are evolving and the effects on teaching and learning will be analysed over time. It is already clear, however, that augmenting high-quality physical environments and stable, pervasive networking and systems infrastructure with the enterprise deployment of Location Services and Big Data alongside targeted Artificial Intelligence is proving to be popular with students. In 2019 alone the Deakin Genie and Deakin Scout applications each had over 20,000 users, which represents close to half of Deakin’s on-campus student population numbers. The large-scale adoption of services such as Deakin Genie (see Scenario 2) and Deakin Scout both utilise the foundation enablers in question to provide real-time assistance, locational and navigation services contextually relevant to the end user. Early stage concepts and development of further Foundational Enablers, such as enterprise scale AI, Digital Identity, Immersive Digital Reality and the IoT, are also displaying strong signs of end user and organisational value.

End user value is being demonstrated in these concepts through enabling new learning experiences, providing personalised and relevant support, placing the user in control of their data and identity as well as using the physical university environment to augment teaching and learning through living labs. Organisational value is also being demonstrated through reducing administrative overload, enabling academics to create new engaging experiences for teaching and learning, supporting research and providing the ability to discover insights previously not possible through disparate platforms and data.

These concepts, however, require further development to mature into enterprise-ready platforms and solutions. None the less, the early demonstration of the value of the Smart Campus Programme is such that there are key opportunities for further development in the near future, and an ongoing commitment to innovation and transformation.

Student, staff and organisational needs, for instance, are continually evolving, and the expectations of users are becoming more demanding as technology advances and competition in the higher education industry grows. Smart Campus Foundational Enablers need to be designed and deployed in such a way that they are secure, reliable and robust with interoperability and extensibility. These qualities are not always simple to design into large-scale enterprise solutions using emerging technologies such as Immersive Digital Reality and Digital Identity; the technologies are rapidly evolving and can lack the technology standards we expect and demand from more well-developed technologies. It is, therefore, important that thorough experimentation of Smart Campus technologies is supported by a well-defined and repeatable innovation process to understand both user and organisational value and technology readiness for deployment at an enterprise level.
Scenario two: digital assistants

Genie student digital assistant at Deakin University (Australia)

Introduction and scenario
Since 2011, Deakin University has aimed to transform the learning environment for all students, regardless of their campus or mode of study, ensuring their digital learning experience matches the sophisticated and seamless digital environments they will encounter in the rest of their lives. In 2017 Deakin introduced Genie – a smart digital personal assistant – to help students during their life at the University. This scenario will outline what Genie is, the types of enquiries it can answer and future development plans.

Discussion
Genie is available to all enrolled students as an app in Google Play or iTunes stores (Deakin University, 2019b, 2019a). Genie acts like a personal assistant or agent. Students can interact with the application by asking it questions, either talking or texting. Through Natural Language Processing, Genie can understand what the student is asking, and if the answer is unclear Genie will engage in conversation with the student until it understands what is required.

Deakin has evolved the conversations and Q&A content with subject matter experts to ensure accuracy and appropriateness and regularly test these with students through workshops and user feedback sessions. The conversational tone was developed by Deakin’s user experience team after a significant amount of user testing. Once Genie understands the question, it can interrogate any data source including student records, financial data, course and unit information, assessment data, library information and location data, and provide answers that are specific and personalised to the student. This is achieved with deep integrations with enterprise systems and using Deakin’s enterprise student digital profile.

The most common questions students ask are about their day to day life at university. The most popular questions are ‘show my assignments’ (see Figure 2), ‘see O week events’, ‘show my timetable’ (see Figure 3), ‘find unit resources’, ‘latest unit news’, ‘show my Deakin card balance’, ‘what’s on loan’ and ‘what’s on next’. Many students use Genie to access learning resources such as their reading lists and study help information, and to access learning support (see Figures 4 and 5).

Conclusion (Including affordances and limitations)
The student uptake of Genie has been impressive with 33,900 users. Importantly, almost all of the 2019 cohort of new students are using Genie as they navigate university life. Indeed, Genie has been exceptionally successful in enabling students to quickly access specific information by sorting through vast amounts of complexity and detail. Evidence from student focus groups suggests this has reduced the cognitive demand of students. As students comment, they can ‘just ask Genie’, and they are less inclined to worry about transactional and administrative tasks. As one student commented: ‘It’s like having a Siri, but a Siri that organises your life.’

While most of the questions are transactional, many are related to complex personal challenges that require resolution. Conversations can be triggered if the student tells Genie they feel overwhelmed, unsafe, sick, stressed, anxious, or lonely. Deakin has worked closely
with counsellors and psychologists to ensure the conversation is appropriate and the student obtains the best possible help and guidance. In some cases, if the student conversation causes alarm – for example, the student indicates they intend to self-harm – Genie can alert the appropriate support services to intervene.

Certainly, Genie has provided particular value to students studying off-campus who do not necessarily have the opportunity to ask others or visit professional and academic staff face to face. In theory, this means they are better able to focus on learning activities.

Figure 2. A screenshot from Genie showing assignment due dates, personalised to the user.

Figure 3. The student’s weekly calendar is displayed in an easy to understand format.
However, the link between Genie use and improved learning outcomes is yet to be evaluated and will be the focus of further study and research.

Students are evolving in their use of Genie, which is resulting in the demand for additional support to be provided through the digital assistant. Deakin is planning to enable Genie to provide specific curriculum support: to provide teaching staff with a platform to
extend their ability to support students. This may be in the form of offering quizzes, answers to specific questions on subjects or assignments, or direct study assistance. The structure of Genie’s dialogue engine means that this is now technically possible (see Figure 6).

Deakin will be required to create more digital content as Genie is only as good as the target content that is available. Deakin will also undergo significant change management activities to prepare both staff and students for delivery of personalised teaching content on a large scale. Deakin is also about to embark on a new Deakin-wide strategy to take the university to 2030, and it is expected that Genie will grow to provide an increasingly innovative and personalised learning environment.

Scenario three: online learning and MOOCs

Two different approaches to developing FutureLearn MOOCs at the University of Bath (UK) – for individual short courses, and at Deakin University (Australia) – for postgraduate courses

Introduction and scenario(s)

The University of Bath was an early collaborator in the FutureLearn partnership, joining in 2013 and delivering its first MOOC in January 2014. While the University had delivered a small number of full postgraduate Masters’ programmes via distance learning for many years, its involvement in developing MOOCs was considered a first step into full online learning, and an opportunity to learn and explore how online delivery might benefit the institution. The primary strategic aim was to share the cutting-edge research being undertaken at Bath with a global audience. Significantly, there was not a focus on increasing student recruitment.
The initial courses followed a standard design that was common across the majority of the early FutureLearn MOOCs – a six-week delivery, with weeks generally broken down into three separate activities or topics – underpinned by a social learning structure based on Laurillard’s Conversational Framework (Laurillard, 2013). Timeframes for production of the first course were extremely tight, and the limitations of the emerging platform also affected design decisions.

In comparison, at Deakin University a project was conceived in 2017 with a view to launch eight postgraduate degrees, also on the FutureLearn platform. Driven by the DVCE office, it involved all four faculties with the three key aims:

(1) To expose Deakin’s premium online degree courses on a global stage
(2) To transform institutional practices around learning design work
(3) To increase a number of student enrolment across domestic and international markets.

Two years on, this scenario explores the ‘lessons learnt’ in this project and offers some insights into Deakin’s approach with the Degree Design Thinking framework (O’Donnell & Schulz, 2018) and its use in the future of online degrees within higher education (Adachi & O’Donnell, 2019, pp. 349–353). It also examines the impact of MOOCs for Bath; in acting as pioneers, the staff involved became advocates for online learning and its possibilities beyond the scope of MOOC developments.

Discussion
For Bath, a main concern the team identified prior to the first run of its first MOOC in 2013 was how to build teacher presence into the course (Garrison, 2007, pp. 61–72). The team tackled this in two ways. They built a number of synchronous sessions into the course where a panel took questions from the learners; some posted live during the event and other questions were posted to the platform prior to the event. It was also decided to include end-of-week wrap-up videos in which the educator summarised discussions and queries from the week. This model, which evolved over time, became the approach adopted for subsequent MOOC developments at Bath. It is a model that has continued to develop beyond the initial four courses as both the FutureLearn course offering has continued to change in conjunction with Bath’s own experience and strategy for MOOCs.

In contrast, Deakin University has adopted a more holistic approach to ‘design’ work in digital education (Carvalho & Goodyear, 2018, pp. 27–53) – its MOOC project created an opportunity to implement the Degree Design Thinking framework (O’Donnell & Schulz, 2018). This framework worked effectively for its professional practice degree courses – namely, IT, Leadership and Digital Learning Leadership courses. This framework has four key elements – portfolio design, learning design, service design and team design, each of which will be explored below.

Portfolio Design enabled course leaders to work at the macro-level of thinking around specific learner cohort and institutional gains in creating certain degree courses. In the case of the Graduate Certificate of Digital Learning Leadership course at Deakin, which fits within the professional practice degree courses that Deakin offers (Deakin University, 2019c), this course targets the specific learner cohort of professionals already working
within the field of digital learning and looking for opportunities to enhance their practice and advance their career.

Within Deakin’s four credit point degree structure, the degree consists of a foundational theoretical unit at the start (1 credit), a practical, project-based capstone unit at the end (1 credit), and the bulk of credits coming from micro-credentials (2 credits) which target more transferrable skill sets. These can be acquired anytime outside of trimester cycle through the demonstration of students’ pre-existing knowledge and skillsets (for example, digital literacy, communication and critical thinking). This design element, therefore, enables course leaders to think critically about the macro design of the course. The portfolio structure also ensures that the course can be tailored to different learners and markets (for instance, global, local and non-traditional) for alignment with institutional strategy on course design and potential economical avenues.

In terms of Learning Design, the need for careful design for online learning has been ubiquitously argued in the recent literature (Bennett, Lockyer, & Agostinho, 2018, pp. 1014–1026; Goodyear, 2015, pp. 27–50; Laurillard, 2012). In Deakin’s case, the notion of social learning through the Conversational Framework (Laurillard, 2012) drove its micro design in constructing units within the FutureLearn platform. Through creation of learning design templates, it enacted the design of social learning through digital storytelling with multimedia and inclusive, written-for-the-web narratives and open-source resources where possible and relevant.

Deakin has also reflected that Service Design has enabled it to conceptualise the journey of online learners as a holistic experience. From the point where learners find out about Deakin’s online courses, to enrolling into its courses, and to learning online and graduating, this element encourages institutions to think about and mitigate against the pain points that can occur in the student’s journey, and to design transformative learning opportunities supported by just-in-time interventions and guidance. A team of student support in enrolment and marketing was put together for this purpose – where they thought carefully about the new processes with enrolment and advertising these courses in collaboration with the FutureLearn as prospective students often found out about Deakin courses on their platform, and provided support in counterbalancing the pain points in cumbersome and onerous process in finding more information and putting together an application.

Finally, in relation to Team Design, traditionally academics within higher education have worked in silos, allowing independent teaching to emerge in their classrooms. However, given such diverse design work required to create premium online learning experiences for online learners, it was impossible for solo academics at Deakin to create and engage with online learners on their own. The creation of premium online courses, therefore, required multi-disciplinary teams that brought expertise in learning design, digital assets, multimedia creation, copyright, digital accessibility and project management to deliver on the mission.

**Conclusion (Including affordances and limitations)**

At the crossroads of these design elements, inevitably, certain tensions emerged in the enactment of these design elements as diverse groups of people and their expertise come into contact. For example, one of the big pain points was around copyright – especially in the MOOC space where institutions need to be very cautious about citation and use of
open education resources (OER). Indeed, engagement with copyright officers caused a lot of back-and-forth discussions as to what the team could and could not use, which at times resulted in negotiating the content and design of courses due to availability and also in putting more time pressure under already tight timeframes in order to get courses ready in time.

At Deakin University, the affordances of adopting a degree design thinking framework included being able to think more holistically about the contextual factors which needed to be carefully designed and considered. On the other hand, the limitations of enacting some of these design elements brought with them considerable tensions, contradictions and challenges. On a practical level, turning design into reality and ensuring high standards and quality was made challenging by limited timeframes and resourcing.

From Bath’s perspective, MOOC development will continue to be of strategic interest, while, for the time-being, remaining low-key and small-scale. To ensure the sustainability of future developments, the model that is evolving is to include MOOC development costs within research grant bids, where applicable, and to follow-up with the learners on the impact of their MOOC studies to inform both widening participation and research impact agendas. The benefit of Bath’s flexible and responsive approach to MOOC development and delivery has been evident during the current COVID-19 outbreak, with the team rapidly responding to demand for access to online courses and scheduling MOOC runs at short notice, enrolling record numbers of learners (for Bath) in the process.

**Scenario four: lifelong learning**

**Centre for professional and continuing education and SkillsFuture Singapore (Nanyang Technological University, Singapore – NTU)**

**Introduction and scenario**

Singapore’s Future Economy Council (FEC) oversees the growth and transformation of Singapore’s economy for the future. The FEC oversees and supports SkillsFuture Singapore (SSG), which is a national movement to upskill and train Singaporeans of all ages (SkillsFutureSG, 2019). In 2016 SSG launched a Training and Adult Education Industry Transformation Map in collaboration with unions and industry (Ministry of Trade and Industry [MTI], 2019). The roadmap focuses on three areas:

1. **Driving innovation**, with a focus on helping to transform educational providers, and training delivery, in parallel with industry. In particular, to promote blended and workplace learning, and a modular curriculum design.
2. **Professionalising jobs and deepening skills** by developing a skills framework with information on career pathways, as well as existing and emerging skills required for job roles.
3. **Increasing productivity** by improving the accessibility of training programmes with the launch of the MySkillsFuture portal.

The MySkillsFuture portal brings together modular courses relating to Industry 4.0 into one platform and covers industries such as aerospace, data analytics and tech-enabled technologies such as robotics and predictive analysis (MySkillsFuture, 2019). This is further
enhanced by the fact that each Singaporean citizen aged over 25 is awarded S$500 SkillsFuture credit by the government for lifelong learning. Certain employers and Small and Medium Enterprises (SMEs) are also eligible for subsidies, and those who sponsor their workers aged over 40 and above can also receive up to 90% course fee subsidies. Education providers also offer certain discounts to their alumni; Nanyang Technological University, Singapore, for instance, offers graduates S$1,600 course credits for all courses that it provides via its Centre for Professional and Continuing Education (PaCE@NTU) (Nanyang Technological University, 2019b). It is PaCE’s offer that will be explored below.

Discussion
PaCE offers a range of pathways and programmes, including a series which aligns to SkillsFuture, and also short courses, semester-long courses, executive programmes, mobile courses, and courses as part of a part-time Bachelor of Engineering Degree Programme at NTU. The short courses and semester-long courses encompass a range of themes and skills related to Industry 4.0, and in the case of the semester-long courses, these are credit-bearing, stackable towards a certificate, and can be taken from both the Undergraduate and Graduate full degree programmes as bite-sized options. They also encompass specialist certificates which enable working adults to update their knowledge and skills, and graduate certificates for those who already hold a bachelor’s degree and wish to develop further in their chosen career or to undertake a new career (see Table 5 below).

In terms of mobile learning courses, PaCE partnered with Delta Electronics to develop online training content specifically to equip people with the skills needed for Industry 4.0, and which could be accessed anytime and anywhere. These include 14 SkillsFuture funded courses and 27 flexible bite-size modules (each module lasting approximately 1 hour) which can be combined to obtain an e-Certificate of completion (Nanyang Technological University, 2019a).

Finally, with regards to specific SkillsFuture Series courses, PaCE offers three certificates based on Industry 4.0; attending any two seminars under each certificate topic results in a certificate. The three Certificates in Industry 4.0 are:

1. IoT Technology Innovation
2. Technologies Behind Industry 4.0
3. Digital Manufacturing and Business for Industry 4.0.

Conclusion (Including affordances and limitations)
With the notable exception of the mobile learning platform which is exclusively focused on delivering bite-size modules directly related to Industry 4.0, the majority of PaCE’s portfolio of courses are designed to be delivered face-to-face in a traditional classroom by an expert in
a formal teaching setting. These, however, are nonetheless designed as bite-size modules that allow for flexibility and enable the learner to build their own pathway through the courses as they work towards certification. Furthermore, the strong emphasis on developing skills and knowledge across a wide range of subjects that are closely aligned to future jobs and skills is notable, and provides, when combined with the wider MySkillsFuture platform, an extremely comprehensive and joined-up approach to lifelong learning.

Indeed, what is exceptional about both PaCE’s offer and the wider Singaporean approach is how joined-up, well-funded (when considering the initial S$500 credit and various institutional discounts), and future-ready the offer of lifelong courses is. At this point is too soon to determine what, if any, positive impact this will have on the industrial readiness of the country, and if these courses will play a significant role in upskilling Singaporeans. Take-up numbers are not readily available, and in many ways, Singapore is quite unlike other countries; it is hard to extrapolate wider conclusions that might be applicable to other countries and settings. Further, most courses on offer are very closely aligned to core technical and professional skills; whilst there are some courses focused on ‘soft’ skills around leadership and management, there is a notable gap when it comes to skills such as creativity and imagination.

Notwithstanding these potential limitations, the MySkillsFuture portal, and PaCE’s comprehensive offer of courses and modules, demonstrates one possible pathway into future lifelong education designed specifically to upskills citizens for Industry 4.0, and the types of courses and approaches that could be adopted by higher education providers.

**Concluding remarks**

As we have noted throughout, on the one hand, more data and research are needed in order to redress the fact that efforts in the field of Education 4.0 are largely driven by intuition and common-sense extrapolations, rather than being solidly underpinned by research-informed models and frameworks. This will need to be evolved in light of the new approaches currently being trialled, and perhaps in reaction to global shifts in the delivery of Higher Education post COVID-19. Questions remain, for instance, about the extent to which existing pedagogical frameworks and scenarios formed from observations and research in Industry are relevant to, and are suitable for, teaching in Higher Education in the future.

Moreover, more research needs to be undertaken around informal learning which takes place outside of the classroom and how this contrasts with learning in more formalised settings. To some extent, the requirement for a teacher’s presence or a formal, curated curriculum has previously been explored in the context of connectivism, learning communities and digital networks and formats (Downes, 2005; Kop & Hill, 2008). Yet, it remains open to debate if in Education 4.0 teachers might lose their status as all-knowing experts, and what the future classroom will even look like. Is a paradigm shift and new epistemology emerging, which acknowledges the web as a source of curriculum knowledge, and recognises that learners can occupy the role as content producers and sharers, and that the authority and ownership of knowledge is being transferred from teachers to students?

Thus, in reviewing the scenarios set out above, we do not intend to offer here definitive statements on the future of teaching and learning, or which technologies and approaches might be the most pedagogically effective to prepare learners for Industry 4.0. Instead, using scenario planning has enabled us to examine alternative approaches currently being adopted,
and to offer suggestions to help plan for future challenges in learning and teaching. However, we acknowledge that our findings are based on narrow observations, taken from selective examples, and further research is required in this area. We offer instead a set of suggestions for further research; a starting point to better understand, reflect and inform an ongoing strategic conversation about the future role and importance of Education 4.0.

On the basis of our scenario planning, we suggest that as technologies evolve, and as campuses and services become ‘smarter’, close attention is paid to the key affordances of Education 4.0; and educators and institutions continue to reflect on the extent to which established pedagogies and teaching approaches need to evolve. Further, whilst technologies such as AI and Machine Learning can make new learning tools and services possible, we might also want to take a step back and question what we are aiming to achieve. After all, just because something is technically feasible, it does not necessarily mean it should be done or that its effects will be overwhelmingly positive (Kane, 2016, pp. 131–147). In short, we need to be thoughtful in our application of curriculum design, learning environments and data, and always place the learner at the heart of any pedagogical intervention.

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