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May the Fourth Be with You: Creating Education 4.0

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Abstract: The paper looks back across dominant ways of delivering Higher Education until the present day and then looks forward. There is an approximate continuum described from Education 1.0 through 2.0 to 3.0. Education is mapped onto the emergence and development of the Web and the revolutions known as 'Industrial' over the last 250 years. Then some foresight is deployed with the particular lens of graduates' employment prospects and contributions to the future – dubbed 'Education 4.0'. The paper hopes to stimulate dialogue and promote preparedness and innovation for more changes arriving fast over Higher Education's wider horizons.

Keywords: Education 1.0., Education 2.0., Education 3.0., Education 4.0., Fourth Industrial Revolution, Artificial Intelligence, Industry 4.0, skills of the future, hindsight, insight, foresight, Higher Education transformation.

Introduction

From 2019 on, tectonic forces continue to reshape life, economies, industries and jobs around the world. The constantly changing and reshaped future world is where Higher Education students wish to benefit from and contribute to. Most of our current and future students ask – What will the future hold for me? How will my university education be relevant?

Do we have foresight for them?

We know that major transformations in education are slow. So drawn-out, that some great people at all levels and in different roles, sigh and give up. Others are genuinely concerned that things will go in a way they insist are truly wrong, and they can prove it. I do *not* see this as 'resistance' by those who don't 'get it', accused by those who do. Instead, I believe we must enable the dialogue and understanding to address the obvious stasis, the genuine confounding fears and the out-of-control feelings. We need to work together within the incredibly complex adaptive system that contours our existence, and then steer the sector towards our preferred and viable futures. It is a massive collaborative design task.

I hope this paper will provide pointers towards shaping the future for our students and graduates, led by those of us to whom this mission now falls, in these extraordinary times.

It's a funny thing writing papers about the future – the actual 'evidence', carefully refereed and referenced is a little hard to come by! So, I've started with a few stories from the past. Then, I have deployed much 'grey' literature, including blogs, analysis from public and commercial sources, recent reviews and informed speculation as well. Visioning the future requires imaging and thinking in systems, too, so I've included references to my favourite infographics. And some personal reflection and commentary.

My career has been spent in the Higher Education sector so that's what I write about. But foresight about the coming era of Education 4.0 may also be of interest to those in research, schools, skills training and corporate learning.

This paper is in two main parts. The first is a 'quick' review of the last 1000 years, deconstructed into three 'eras'. Of course, I can't do it justice in a few pages, but I hope it will provide the start of a framework that may be helpful for you and that you can add to, challenge, explore and make your own. You can look back with hindsight and also consider the present and future with new insights. Perhaps explore your own Megatrends (Naisbitt, 1982) to better understand concepts of uncertainty (Klein, 2017).

The second part explores what will and might be happening next.

I make a start in exploring the notion that the next generation, the 4.0 students, will wish to be equipped to tackle the world's biggest challenges in addition to their personal careers, and need to be considering their preparation for the new world of work, using all means at their disposal. We have a responsibility to them now. My suggestion is to start to apply strategic foresight to plan and design desired futures. It is most important to have distinctive visions and ways of achieving them.

The technologies that underpin the Internet as we head into the third decade of the 21st Century are powering the Fourth Industrial Revolution (Fourth IR and Industry 4.0). So here I begin to infer Education 4.0; what it might look like, how we can learn and partner with each other, and most importantly how we might positively reconstruct Higher Education to meet and create the future. I investigate Education 4.0 in terms of technology and curriculum in particular, but acknowledge that ideas need to be placed and understood within the wider waves of rapid change—digitalisation, globalisation, demographics, the environment, political uncertainties (Salmon & Asgari, 2019; Bakhshi et al., 2017) and indeed life on Earth (see Tegmark, 2018 – which has some visionary scenarios about life and artificial intelligence). I've risked a little personal commentary as a spark to start this dialogue. But I also get a bit serious here. Well, we might as well have ambitions – visions, passion and goals that fuel our achievement agendas.

Part 1: Tracking Change

One way of looking back for Higher Education is to consider the developments of the World Wide Web. The Web started off as transmissive (1.0), then social (2.0), and 3.0 (semantic). The big change from Web 1.0 to 2.0 was not the technology but in the way that it was used. I've used these ideas as a rough timeline for hindsight in Higher Education.

You might like to keep the overall timeline sketch by you as you work your way through the ideas.

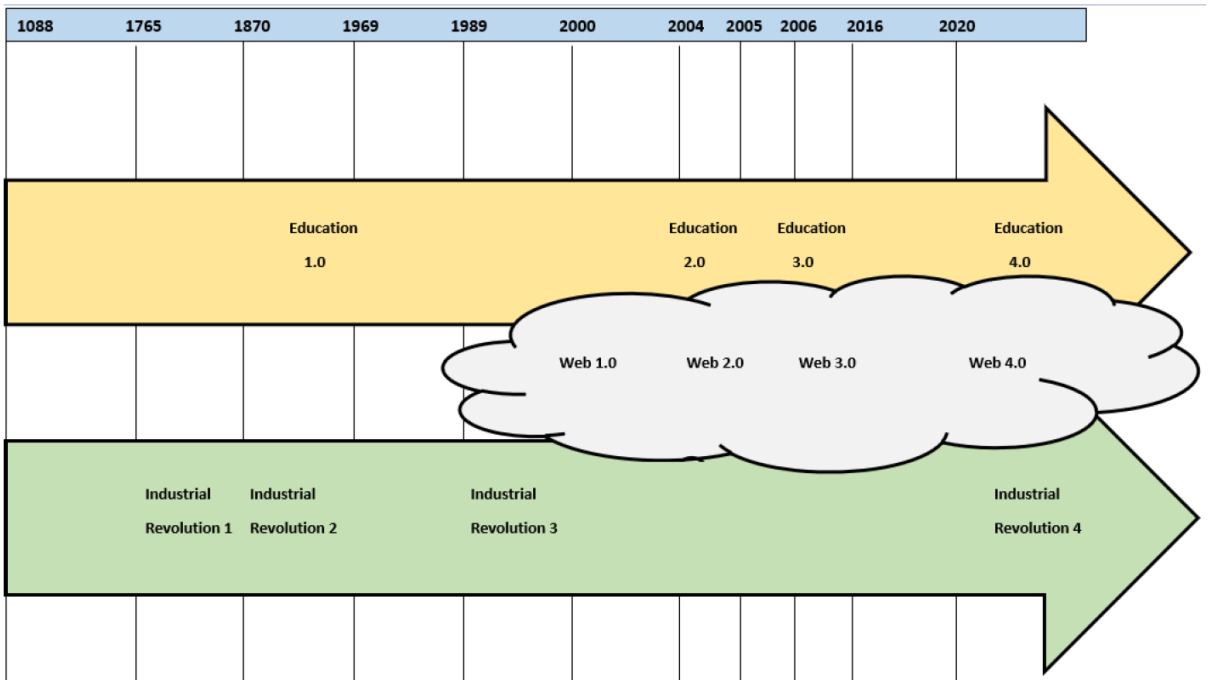

Figure 1: Moving towards the 4th Era

Education 1: Transmission

The first modern university in Europe was established in Bologna in 1088, followed by Paris, Oxford and Cambridge. From the beginning of modern universities, students were expected to *go* to a place to attend classes; generally, in a central and pleasant location where they could also live. They received knowledge from academics or their helpers, who supplied them with information by reading to them; in the form of a stand-up routine. The roots of the word 'lecture' mean to gather, choose and to read out (www.etymonline.com/word/lecture). There may have been follow-ups such as books, notes and handouts, places to visit, experiments to undertake and authentic resources and experiences – such as cadavers for anatomy and placements for trainee doctors and lawyers. The role of the visual and performing arts played a key part in promoting creativity, transmitting ideas and perpetuating cultures. Assessment was based on a test of the acolytes' acquisition of knowledge, originally through oral means and then written exams. Hence in Higher Education 1.0 students were largely consumers of information resources that were delivered to them for absorption.

Typically, however, because they were co-located, they participated in activities based around those resources. Sometimes they engaged in lots of personal reading and discovery study, if they were so inclined, using the locally provided library. They also deliberated, discussed, debated, challenged and learnt with each other. Only when some students became researchers, did they develop hypotheses of their own, maybe leading to undertaking and publishing more formal research, and contributing back to the knowledge corpus.

You may wonder why I've explained all this—it's so 'normal' and expected isn't it? It's what's brought nearly all of us to this point in our lives – as university-educated people. That's why it's embedded in our psyche and shocks our identity to surface, address challenge and *change it*.

So, the model of Education 1.0 – 'going to university' and the transmissive way of learning served well for centuries. But only to a tiny percentage of the population.

From around 60 years ago, in many countries, there was a trend towards considerable growth of the numbers of students entering ('going to') university. As basic schooling improved, more and more young people became eligible for Higher Education. Lectures became even more important to reach large numbers on an industrial scale. Efficiency and the drive for lowering costs of teaching developed significance and the lectures got ever bigger. So did the exams. Textbook publishers flourished. Access to physical libraries and archives was even more important. The model was essentially still the same but massively scaled up (Altbach et al., 2009). Many new buildings were constructed on university campuses, (and they still are) to accommodate the model. Universities had always attracted scholars from around the world to their campuses but now 'international students' began to be counted in the thousands and the viability of mobility across countries (for some lucky students) improved. Education 1.25 had arrived.

Around this time, mass technology had a hand in the greatest education innovation of the 20th Century – the (UK) Open University (OU). It was originally inspired by the huge reach of TV broadcasting (Francis, 2013). The OU bucked the trend that rationed access to Higher Education to those with prior qualifications – offering true 'open entry'. It also hugely challenged the idea that most of a student's time had to be spent on campus. Instead provision was made for 'distance and flexibility', for working and domestic responsibilities to be continued during study. Early on, the OU struggled to establish its credibility in the taken-for-granted campus world, but it soon did, by demonstrating quality education and its students' successes. Its graduates became its most significant and vociferous ambassadors and champions, and they still are. Other countries sought to emulate the OU model through distance learning (Daniel, 2018).

Enter here the first tracings of a student-centred view of learning. Also, the radical idea that spending rare and precious time co-located could be used for guided peer engagement rather than sitting in serried ranks. The OU used regular campus universities' facilities to provide spaces for otherwise remote learners to get together — during evenings, weekends and summertime residentials. Taking this approach enabled a wide range of curricula to be offered at a distance, from science to arts. It worked! Thousands (now around two million) studied, graduated and benefitted by their 'second chance' and a little later in life than was traditional. I was one of those. However, the main model was nevertheless the provision of transmission – through broadcasts, (later videos), wonderfully produced printed booklets sent by post, and home kits for personal study. Students were tested mainly by location-based exams. But still, mobility and flexibility rather than hallowed halls and dreaming spires started to be valued. And distance learning in campus-based universities also gradually grew; usually not in a highly strategic manner but typically first driven by passionate academics wishing to spread their knowledge further. The spirit of online learning floated in and a little understanding of designing once, delivering many times. Let's call it Education 1.5!

From around 20 years ago, Education 1.75 landed. Virtual Learning Environments/ Learning Management Systems, (LMS/VLE) came into being and educators started attempting to enhance face-to-face learning with the Web. Libraries became more and more digital and gradually morphed into study and group spaces rather than book repositories. Mostly though, this reflected the Education 1 model and continued the 'knowledge transmission' paradigm of teaching. VLEs/LMSs dominated the

digital part of what is now called blended learning, with the system typically provided by vendors external to the university. VLEs/LMSs are now used by millions of students and academic staff across the world. There was a similar continuum for distance and remote learning from print and videos to digital and mobile.

Education 2: Social

From around, 2005 web sites increasingly allowed and enabled people to interact and collaborate, also to create and contribute ideas and photos. It was called the 'read-write' Web or Web 2.0. It began with what has been called the great democratization of the Web, reflecting the power to express opinion and to add to rather than just receive. New platforms of all kinds emerged — enter blogs, wikis, sharing sites, music, images, video.

Initially, social media was quite separate from the careful safe, 'true' and enclosed university and professional knowledge world. Only very brave lecturers experimented with Facebook groups for their students. Podcasts became quite important, borrowed from the media world – transmission again but done a bit differently. The LMS/VLE providers caught on after a while and offered functionality that went beyond the original, rather bland, repositories and discussion groups on their systems. They added journals, e-portfolios, blogs and wikis to their offerings. Meanwhile, some academics started to subvert and adapt Web 2.0 technologies in the service of learning to enhance traditional approaches to education. Open Education Resources and crowd-contributed content enabled different approaches to more accessible and/or free information and knowledge.

Even at that time, though, we did not really see the key processes of education being transformed significantly, although some groundwork was done, some cracks and fractures occurred in long held assumptions of learning and teaching. The hugely dominant and previously largely unconscious models of Education 1.0 were occasionally called into question, usually at ground level. The debate and aspirations about the openness of knowledge began to gather force (Boulton, 2017).

Education 2.5 started to be seen. Talking about 'blended learning' became popular (Khe Foon & Kwan, 2018). There was some challenge to 'transmission' of information. An example was the 'flipped classroom' (Cheng et al., 2018). This means moving information transfer out of the lecture room – often for students to access and work on themselves – and shifting information assimilation, application and learning together to times when they are co-located. As mobile technologies and better integration became possible, flipping attracted interest. New platforms to try and solve the challenge of volume also came about, such as academic integrity and plagiarism — a small nod to replacing lecturers' work through digital means. MOOCs arrived and stirred up many Higher Education traditions. By the way, MOOCs didn't invent online learning, but they did raise the potential and profile of large-scale entirely online learning and reach, and got the sector talking about 'digital'.

Education 3: Digital lives and Mobility

Semantics is the science of machine comprehension of text. The World Wide Web inventor Sir Tim Berners-Lee uses the term Semantic Web, to describe a complex system of data and information that can be processed by machines. Many claim that this was Tim Berners-Lee's original intention (Berners-Lee et al., 2001). The term Semantic or Web 3.0 has been coined as a result of the evolution, maturing and integration of the Web to describe applications which are capable of 'talking to' and

exchanging data automatically between each other. Typically, this makes applications 'smarter', faster and more focussed for the user. The importance of connectivity also looks ahead to making meaning and some notions of 'intelligence'. The huge development and adoption of mobile devices and ubiquitous Internet access have made the Web 3.0 experience available anywhere at any time. The Web became omnipotent and super-integrated.

As a result, the Internet has become the defining thread of most societies and a huge 'picture window' onto and integrated with the physical world. The Web influences many people's ways of thinking, doing and being, for good and bad, often much more than more formal, safer and truer sources, and to the annoyance of many. Universities are no longer the only source of 'truth' and learning, and therefore 'transmission' alone is insufficient.

Most undergraduates entering universities now, (I write in 2019), have grown up in a world that has always had the Internet. The students and the employees of Education 3.0, 'live online' for their everyday lives 24 x 7 with the vast majority carrying one or more highly personalised smart mobile devices, with constant interaction with others. Most 'content' is visual and mobile, sometimes immersive. In 2019, 68% of Internet traffic is via mobile devices, more of the world's population has a mobile device than a telephone or a desktop, and of those more than half are 'on' four hours a day or more. These statistics are rising and the percentages shifting rapidly towards mobility, especially in Asia and Africa. In many countries, people own several mobile devices. However, the potential for mobile learning – immersive, personalised—had not been realised (Traxler, 2016). Strange. There was a rise in interest in educational design (Dobozy & Cameron, 2018), some small growth in the recognition that creating excellence in higher education is best done in teams, rather than by a lone academic (Daniel, 2018), hence some challenge to 'unconscious' and 'taken for granted' modes of learning and teaching began.

Many drivers for and questions about the traditional models of Higher Education have come to the fore during the gradual move towards Education 3.0, including access and diversity for staff and students and the interest in 'relevance' of university curricula for employability. Students have become more conscious of the ways they are learning, and being taught, how these turn into an outcome on graduation and prepare them for the future. Students are frequently surprised about the limitations on what's on offer, especially in terms of digitalisation of their education. Meanwhile the long-term, embedded nature of the way universities go about doing everything, based on Education 1.0 with a bit of 2.0, has made it extremely challenging to accommodate change in university business processes and especially in modes of learning and teaching. For an excellent roadmap to incorporate valuable digital learning across the campus and curriculum see JISC (2019a).

Perhaps as we move towards Education 3.5, educational characteristics might include rich, cross-institutional, cross-cultural, educational opportunities within which the learners themselves play a key role. They could become creators of knowledge artefacts that are shared. Social networking and social benefits for learning may play a strong role, on and offline. The distinction between artefacts, people and process may become blurred and many traditional boundaries could start to break down. Maybe, too, institutional arrangements, including policies and strategies, preferred and often 'unconscious' approaches to learning, will finally change to meet the challenges of the immense opportunities presented.

I recall that, in 2004, when I was awarded the title of Professor of E-learning and Learning Technologies', (at the University of Leicester in the UK), many people were surprised that professors could be appointed with that kind of corpus of knowledge. There is now a much higher level of awareness and recognition of the need to transform amongst university leaders. Appointments such as 'digital learning professor,' 'digital directors' and 'pro-vice-chancellors for innovative learning' and the like are becoming more common. This arena is also attracting research and new research centres for emerging futures (e.g., https://www.swinburne.edu.au/new-workforce/). There are some signs that university leadership is exploring digitising beyond the small-scale efficiency improvements and into core business (Salmon & Asgari, 2019). It also appears that Education 3.5 is bringing with it the rise of students, not just in receipt of knowledge, but as informed consumers. In 2019, there are students-led calls for increased personalisation, adaption, transformed assessment and increased mobility (Kernohan, 2019). There is a rise of the exploration and interest in ways of achieving transformation within institutions and of the potential for working with private companies to share risk and benefits and attract investments (Salmon, 2019). The power of inertia within established institutions is still very real, though, for many (Salmon & Asgari, 2019).

Adding and Tracking Industrial Revolutions

As I'm now moving on to considering employability, I briefly recap here the revolutions impacting on economics and working lives over the last 250 years or so. On a longer-time frame compared to Web developments, there have been three previous Industrial Revolutions. There has always been a recognition by governments and businesses that Higher Education has a major contribution to make to the economy, and more recently to sustainability (Mendoza et al., 2019). So, I here briefly add another 1.0-3.0 continuum to the mix so that we can reinforce the important link from Higher Education to industry and employability. Again, I'm sure you know about the Industrial Revolutions, but I invite you to consider the impact for your context with hindsight and insight, in your university.

The First Industrial Revolution (First IR), from around 1760, used water and steam power to mechanize production — the impact was mass transportation, mobility of populations, urbanization and factories, and a boost to economies. This First IR demonstrated that machines can do some things better than people. In the industrial nations, publicly available compulsory schooling slowly began, and there was some appreciation that Higher Education was not just for the nobility.

The Second IR used electric power to create mass production—fertilizers, engines, cars, planes and the rise of consumerism. There was growth in education, but strong gender and class differences, to prepare people for designed roles in their future working lives. In many countries, new location-based universities were established, often with government and philanthropic funding and with high aspirations. The impact of mass industrial processes also began to show up in education— such as standardization, rote learning and very large classes—mass education for the industrialised system. The OU came into being towards the end of this time (see my paragraph about it under Education 2). The term 'knowledge economy', built on the innovation of the 'Information Age' (first coined by Drucker in 1969) focussed on and reinforced the links between research, Higher Education and a country's success (Thelen, 2019). A key concept of the knowledge economy is that knowledge and education are often referred to as *human capital*—a recognition that advancement and value at every level begins with greater reliance on intellectual capacities and capabilities.

The Third IR used electronics and information technology to automate production and create global supply chains. Beginning in the 1950s, the Third IR brought semiconductors, mainframe computing, personal computing, and, ultimately, the Internet and the Web—the digital revolution. The move from analogue electronic and mechanical devices to pervasive digital technology dramatically disrupted nearly all industries and sectors. I've already noted the concurrent scaling up of universities (see Education 2). Also, these technological advances have shrunk the world—no element of information or news needs more than a few milli-seconds to traverse the globe. That ability has exposed and made very public many of the serious challenges confronting the graduates of tomorrow. For a wider visual look back see Yesterday's Future and Industry 1.0 to 4.0 (Ramge & Schwochow, 2018).

By 2010 onwards, most universities started to look differently at their recruitment and delivery of learning, and employability became the key watch word. With the rise of rankings, and metrics around 'onward destinations', as well as access, opportunity and diversity of the student body also became very important. Some voices continued to assert the importance of wider arts, culture and social science education both as disciplines and as ways of learning (Connor et al., 2015; Gunn, 2017). Some universities started considering their curriculum and modes of learning. Here, we've just caught up caught up with Education 3.0! But the biggest one of all perhaps for universities was the shift to huge emphases on employment skills and employability and also on student-centredness and experience—and so we come to Education 4.0.

Part 2: Education 4

Here I assume that current and future students will expect, perhaps demand, learning experiences that reflect and enhance the way live in the world (Davies, 2019; Feldman, 2018; Hussin, 2018).

But back to my Web metaphor first. The next Web—Web 4.0—is the 'symbiotic web'. The symbiosis is between artificial and human intelligences and how they interact and gain experiences from each other. They become a team— learning from each other. Here I am using the term 'intelligence' to mean the ability to accomplish complex goals (Tegmark, 2018). It is this development (which was preceded by and builds upon Web 1, 2 and 3) that takes Web 4.0 into the unknown, and points to an awakening of Education 4.0.

The technologies that underpin further developments and applications of the Internet in the third decade of the 21st Century, are powering the Fourth Industrial Revolution (Fourth IR). Whilst over quite a few years computers have been completing ever more complex tasks more speedily, Artificial Intelligence (AI) represents technological applications now becoming competent in aspects that we previously thought only human brains could undertake (Heaven, 2017). If you are interested in the philosophical and ethical pros and cons aspects of AI, including the Turing Test, see Heaven, (2017), for a great place to start. See particularly the timeline on pp. 22-23. There are barriers, as usual, to AI adoption (MIT, 2019).

But now a Fourth Industrial Revolution (Fourth IR) is building on the Third IR. First, to note that Education 4.0 and Industry 4.0 should be placed in an even wider adaptive system—Globalization 4.0 (Feldman, 2018; Schwab, 2018) —is out of scope for me in this paper but please read about the call for much wider engagement and dialogue (Samans, 2019).

And there is more. "Economies, businesses, societies and politics are being transformed by technological advances in such areas as Artificial Intelligence and machine learning, the Internet of things, autonomous vehicles, drones, precision medicine and genomics, advanced materials, smart grids, robotics and big data" (Samans, 2019). The Fourth IR is a complex notion based on the fusion of cyber and physical systems where machines are interconnected and able to independently communicate and cooperate throughout the manufacturing and production processes. At present, most of the interest is around manufacturing and 'end-to-end' transformation of industrial processes and the importance of embracing this change for the future of business and economies. But there is *so* much long-term change predicted and well outside the obvious deployment. But along with that, come the inevitable 'calls for action' and noting of the wide range of stakeholders, including research and educational institutions that need to transform and embrace 4.0 for the changes to be productive and constructive (PWC, 2019a).

Here is the big prediction about it:

> We stand on the brink of a technological revolution that will fundamentally alter the way we live, work, and relate to one another. In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before. We do not yet know just how it will unfold, but one thing is clear: the response to it must be integrated and comprehensive, involving all stakeholders of the global polity, from the public and private sectors to academia and civil society (Schwab, 2016, p. 1).

Most of the predictions that I can find are related to Industry 4.0 although the changes in demographics, life expectancy and the economics of retirement are also having a strong impact on personal, social and professional development. Implications for education may involve quite dramatic variations in the demand for knowledge and skills as well as expanding possibilities for teaching and learning (OECD, 2018). Babies born today not only will never know a world without the Internet, but one in three may live to be over 100, some to 120 or more (Taylor, 2017; Office for National Statistics, 2019; Roser, 2019). So, there is also a very strong case for a sustainable life-long love for learning and personal transformation (John, 2019).

The idea of machines that think and act like humans has inspired imaginations since the Enlightenment (Ramge & Schwochow, 2018). Hao (2019) provides us with an interesting look back at the history of AI, from machine learning through knowledge-based systems and all kinds of experiments, and then to a pivotal moment in 2015 when DeepMind's AlphaGo, trained with reinforcement learning, defeated the human world champion in the ancient game of Go.

There are two kinds of AI. Strong machines that think creatively and develop 'self-consciousness' and deploy 'deep learning' using neural networks with multiple layers (Heaven, 2017). 'Weak' AI means taking on human activities, typically, automation of complex but routine tasks. (Ramge & Schwochow, 2018). There is a fair bit of weak AI around already but lots of research and experiments on strong AI, including machines that can understand their environment, learn and have the potential to create change (Heaven, 2017). We are only just at the very beginning.

A further shift is on the horizon, where new devices will offer less intrusive, more intuitive ways to amplify human intelligence. Because intelligent amplification builds upon existing human intelligence and all that it encompasses, it is more powerful than AI alone, and may even be an antidote to the

'robots are coming' fears (Golembiewski, 2019). On the fears and concerns, Heaven (2017) undertakes an exploration of moral and ethical issues, privacy and the role of prediction (see particularly Chapter 4). Governments are also starting to take an interest (see, for example, JISC, 2019b).

And, for education, the possibilities of billions of people connected by mobile devices, with unprecedented processing power, storage capacity, and access to knowledge, seem to me to be a critical domain for knowledge creation and learning. I would also add machine visioning and facial recognition; by 2022 there will be four billion embedded cameras in the world (Thompson, 2019). And these prospects will be multiplied by emerging technology breakthroughs in fields such as robotics, the Internet of Things, autonomous vehicles, 3-D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing and much more (Heaven, 2017). And not to forget 'big data' addressing much more than ever before—volume, variety, velocity and variability (Ramge & Schwochow, 2018). Data will become more and more important (Lewrick et al., 2018) —at present in Higher Education, deployment is in its infancy. These breakthroughs extend beyond our world into the rest of the universe. Recently astronomers used their technologies to create an "Event Horizon Telescope" to capture the first images of a black hole in the M87 galaxy 53 million light years from Earth.

Whenever you see a long list of technologies like that, there are always tentative qualifying words—'such as' or 'including'. This suggests to me that there is much more to come but we're not sure what it is. But we are truly just at the beginning of bigger transformations—many commentators claim a wide impact 'revolution' and decisions we make now will both prepare for and have a big influence on directions that are chosen. The key concepts of Education 4.0 and the differences in impact from Education 3.0 are the massive ubiquitous connectivity and the *symbiosis* between humans and machines and consequently our inability to understand or predict what this might mean in the long-term. With the massive turmoil going on in the educational environment—around fees, funding and fairness, accessibility, diversity and experience—it is difficult to lift your head above the parapet and take a longer, deeper look to Education 4.0, but in my view we can, and we should.

And it goes on. Like Web 1, 2 and 3, Industry 4.0 builds on the previous transformations but the claim is that there is no historical precedent for the speed or complexity of developments nor of the huge and wide influences on every industry and sector. There are already numerous examples of companies restructuring themselves and needing smaller, more agile workforces with different skills (Gallagher, 2019). So, it seems to me, that in Higher Education we need to move rapidly to Education 4.0, too.

And so, I move onto the foresights for Higher Education in order to help us to create it in the kind of ways that we prefer (JISC, 2018; Luckin, 2019; McGregor & Hamilton, 2019), not just to 'respond' but to contribute. As is noted by Xing (2019), Higher Education has always been a wider investment in the future, as a system, and gateway to valued careers for its graduates. So, for this paper, I've chosen to focus mainly on our responsibilities and the implications for the ongoing destinations of our students—particularly their employability.

Employability 4.0

First let's check we understand what Industry 4.0 might mean for the future employment of our students. In this section, I focus on foresight that might be of greatest interest to Higher Education, particularly Science, Technology, Engineering, Arts and Maths (STEAM) and all the professions (Fisk, 2018). My interest is in curricula and skills, (especially those that could be scattered throughout the whole learning portfolio) and also the importance of the modes of learning that are most likely to prepare graduates regardless of discipline or profession. Ehlers and Kellermann, (2019) tell us that change is happening quickly and that there will be significant differences by 2022; so, we need to start now.

If you would like a quick idea of what jobs your students might be doing by 2030 look at these: http://careers2030.cst.org/jobs/. More lists come in here. They include deeper relationship building, flexible and innovative thinking, social and emotional intelligence, collaborating virtually, design mind-sets, new media competencies, 'thinking like a data-scientist' and interdisciplinarity (Ramge & Schwochow, 2018). *Currently* machines are unable to replicate judgement, empathy, persuasion, the ability to collaborate and communicate, and be flexible, adaptable and resilient (Letellier, 2018), though more AI change is coming (Heaven, 2017). Some creative arts, such as text and movies, generate possibilities from science facts. Science fiction often extrapolates from a known base and explores imagined scenarios (for example, take a look at McEwan, 2019).

If you'd like to look back for looking forward, take a good peep at Heather McGowans' work (www.heathermcgowan.com/writing). You can also explore the Future Skills report (Ehlers & Kellermann, 2019, see, particularly, pp. 23, 27, 28). To note, a key suggestion is students' ability to deal with uncertainty and act in unknown, complex futures. In 2018, JISC in the UK surveyed 22,000 university students and, while 81.5% of them felt that digital skills will be important for their chosen career, only half believed that their courses were preparing them well for the digital workplace. What impact do these all of these predictions have for your 'Graduate Attributes' and middle-term curriculum plans?

The Nesta research report (Bakhshi et al., 2017) tells us that around one-tenth of the current workforce are in occupations that are likely to increase as a result of Industry 4.0. Areas mentioned include healthcare, sports and fitness and therapy. Around one-fifth of jobs will reduce since they will no longer be required. So that leaves the rest, i.e., around 70% of the current jobs where the research is unsure! However, they point to the likelihood of production occupations requiring a combination of electrical, mechanical, hydraulic, pneumatic and computer technologies. A first reminder for the absolute necessity of saying goodbye to disciplinary silos in universities. Other areas suggested are some professional occupations and some jobs in service industries. They also favour creative, digital, design and engineering occupations that are likely to be complemented by digital technology. And they point to architectural occupations with the increasing expansion of cities and greater interest in environmental sustainability. There must be some clues in there for Education 4.0 curriculum planners! In addition, they have anticipated new occupations. Fellow educators may be delighted to know that education and training professionals are in one of the growth areas. My guess is there'll be plenty of education and development in the future, but not as we know it now.

This report (Bakhshi et al., 2017) is one of the few pieces I have discovered that at least nods towards the importance of changes to the modes of learning as well as listing skills of the future. It suggests interpersonal skills, higher order cognitive development and preparing to work in globalised contexts. They also note the important role of 'Active Learning' in order for students to be able to rapidly assimilate and work with change, problem solving, judgement and decision making. My interpretation is that they mean not just 'active' but also 'authentic'. They also use the term 'fluency of ideas', i.e., to enabling learning creatively and across traditional boundaries. And there are many mentions of design concepts and systems thinking. My view is these may even be the supreme skills for Higher Education— to appreciate and work with intersections—between infrastructures and human behaviour, humans and technology and to undertake complex measurements and analyses. These are all aspects that have a dependency on how students learn. They apply to all of the predicted employments and to creating those that are yet undefined. From my work with futures and programme design, called Carpe Diem, (Salmon, 2013), I am aware that many university staff are keen to embrace these ideas, but their actionable uptake and wider diffusion is disappointingly slow (Ehlers & Kellermann, 2019).

Another report (Navitas, 2017) surveyed 10,000 people across the world, 70% of whom want to work for organisations with 'social consciousness'. That's an interesting one for curriculum development and preparation. But their respondents' views of their own skills vary widely: 54% of the individuals surveyed felt that they 'have all the skills they need for the rest of their career'. Just over half of people globally believe they already have STEM skills (science, technology, engineering and maths). People from India and China, and Millennials, have a higher level of confidence in their skills. Are they right? Will that view continue as Industry 4.0 takes a hold? (Williams, 2017). Fortunately, the thousands of respondents surveyed were willing to 'retrain'. Three-quarters of people said they were 'Ready to learn new skills or completely re-train in order to remain employable in the future'. Older workers with less years left in the workforce, were not quite so ready to think about a whole new set of skills—but 59% of Baby Boomers globally (aged between 53 and 71 at the time of the study) said they would do so 'if necessary'. It will be necessary! It seems that the dominance of young people entering university is about to end, with multiple employments during a lifetime and the need to constantly re-educate.

When presented with a range of emerging technologies, the survey respondents considered AI to have the greatest potential impact on Higher Education. This was followed by the Internet of Things and virtual/augmented reality, with chatbots and blockchain having less impact. It is not clear to me how the people they surveyed could know this. Sixty-five percent of people believed that technology developments would improve their job prospects. Three-quarters of people— with a strong consensus around the world and across demographics—believe that 'Technology will never replace the human mind' in a work context. And eight in ten agree that 'Human skills will always be in demand' (Navitas, 2017). Of course, that may be what they wish for. What does your foresight tell you?

University leaders were also surveyed. They prioritised digital transformation, above all, as a means of improving the student experience with 94% citing this as a key outcome. One of the top transformation priorities for university leaders was digitising marketing and admissions to drive enrolment growth, with 72% saying this is very important. US universities rated this item as the highest priority in their digital transformation efforts (Navitas, 2017). In my view, whilst I can see that

efficiency objectives are worthwhile, I strongly feel the main investment should go towards curriculum and mode of learning transformation to make the biggest difference to graduates' employability.

Responses from students in the survey echoed the need to improve some of the 'basics' of their experience, with digitisation of administrative processes, improved 'user experiences' and digital curriculum featuring high on their 'Wishlist'. Students called on their universities to adopt an integrated digital approach, and to involve them in technology decisions. I would answer we must improve experience and efficiency. But the change does need to be much more radical to prepare students for what they don't yet know they will encounter.

Most universities said that that they're 'looking' at what others are doing without any clear solutions yet for full transformation of their own. I think we need some heroes and leaders in that scenario. Only, 17% of university leaders were planning to launch at least one digital business outside their core operations, to experiment with new business models. This approach could help to protect and support breakthrough ideas (Navitas, 2017). It does not feel sufficient, soon enough or fast enough for Education 4.0, to me. As Gallagher says, "Simply adding digital skills to a traditional education is not enough to succeed in the digital economy. Learning has to be re-imagined for the emerging futures of work" (2019).

A deeper dive into the survey findings identifies some interesting trends and differences between countries and demographic groups in people's attitudes to the future of work and how it will impact them, and some scenarios which are worth exploring before deciding on new curricula (PWC, 2019b). Best to look at your region in the report and then undertake a long, hard review of your curriculum.

Achieving Constructive Digitalization

Artificial Intelligence and machine learning are fundamentally about making decisions based on data—and that describes much of education. At present there are experiments going on across Higher Education's value chain. These are mainly boutique and crafted. They include search tools for scientific research, powering chatbots, connecting learners with appropriate universities, matching students with career coaches and optimising student health and fitness facilities. They typically exploit improving connectivity of student devices to campus infrastructure and cloud services and often aim to enable personalised experiences. With wider-spread adoption, significantly more data would be available for analysis (see a few examples at JISC, 2019c).

There is work going on to bring emerging technologies into educational experiences. We can point to experiments, pilots and prototypes but on the whole, they are small scale, with no guarantee, or often funding, for scaling up. Virtual Reality is being used to bring science to life, transport classes on virtual trips, and market universities to potential future students (see, for example, the *2019 IEEE conference: Transactions on visualization and computer graphics;* IFTF, 2019a). These build on the earlier stages of research in immersive technologies for education (Salmon, 2009). Augmented reality (AR) is a bit more accessible and it has already appeared on campus to support wayfinding and orientation and in the classroom to enhance knowledge in the medical, engineering and science disciplines (see, for example, Barrow et al., 2019). There are also Chatbots (software programs that simulate conversing with a human) that are making some progress to answer students queries online to deal with

admissions or for online tutoring. Efforts continue to make the bot more responsive to humans (see, for example, Ciechanowski et al., 2019). Robotics are becoming more widespread in engineering teaching but less so in other disciplines (Bakhshi, 2017; Ameen, 2019).

But these are minor compared to the needs, and many universities are struggling with the challenges to achieve effective upgrades to Education 2.0 technologies such as VLEs, and the associated education transformations. Very few yet have Education 3.0 policies, such as mobile-first or data analytics reports for students. The 2019 Horizon report lists more technologies, such as, mixed reality, blockchain and virtual assistants with time scales, but also usefully confronts issues of adoption and implementation (Alexander, et al., 2019). There is simultaneously a growth in working with commercial companies, particularly for student recruitment, technology platforms or for achieving online learning at scale to future-proof, and provide access to new data and ways of operating (Salmon, 2019).

To summarise, the future for work will be more diverse, demanding, flexible and in many ways. There will be more entrepreneurs and more people working in small and medium size enterprises. And people will work longer in life, change their jobs more often and have less security. The half-life of skills acquired is getting shorter while working lives are lengthening (Gallagher, 2019). There will be increased numbers of knowledge workers, service workers and specialists. Just looking at that list surely makes us think differently about how we prepare people through Higher Education? Much discussion about Industry 4.0 is around employability and STEM. However, there's a growing movement suggesting that the most valuable skills of all will be in strong systems and design thinking, human- creativity, critical thought, effective communication, collaboration and problem solving (McGregor & Hamilton, 2019).

Achieving Higher Education 4.0

It takes a while to map a university's strengths to accommodate the future, and then at least three years for graduates to appear 4.0-ready. I suggest one way of looking at it would be to ensure that the next generation of students throughout the Higher Education system will wish to be equipped to tackle the world's biggest challenges, and alongside that, to ensure their personal employability and contribution in the new Industry 4.0 world. So, we should start today.

- **Curricula:** We can use data and extrapolate where students are likely to sign up in large numbers, using jobs and skills of the future information. As a start, note that working entirely digitally means that potential students do not have to be enticed to come to campus and hence their numbers could be hundreds of times larger than now. Second, we can focus on the 'Flagship' aspects of our university and its research and specialness but deliver this in a way that our reputation is enhanced. And third, we must 'future-proof' as far as we can, by identifying brand new programmes that are likely to prepare students preparing for Industry 4.0 to have worthwhile sustainable, multiple careers and to become contributing citizens of globalization 4.0, during their long lives. By building curriculum portfolios, we can share resources across faculties and programmes and promote the essential 'Medici effect' that the future requires (Johansson, 2017). Every student will need to become a systems and design thinker and achiever; that's the least of our responsibility. We need to engage students, too, in understanding the important impact of

their focusing on studying for the future (Bates et al., 2019). It should be a win-win-win; better student recruitment, reputation enhancing, happier and more successful onwards destinations.

- **Modes of Learning**: We need to rethink how we deliver to optimise students' experience for the future, within limited funding. This will involve building into our teaching and learning the very best of threshold concepts (Land et al., 2016) enabling students to understand how they are learning and preparing for the future. We need to optimise the use of digital technology for what it has to offer, for efficiency, effectiveness, engagement and communication but most of all for authentic and valued educational experiences (Admiraal et al., 2019). There are many prototypes and plenty of new models of learning to choose from. We need to mirror symbiosis—the best of technology with the best of human teaching. Of course, we know that in education major changes take a very long time. Many discussions around Industry and Education 4.0 are couched around the technologies themselves. We already know there's a little paradox here—that the most valuable skills of all in the future will be those intrinsically blatantly human: creativity, critical thinking, responsive communication and out-and-out human collaboration. Therein lie our clues. The way we are teaching students needs to be collaboratively designed (not assumed) with a strong future vision (Dobozy & Cameron, 2018). Assessment and credentialing must be changed to be fully authentic, meaningful and reflective of the new goals of Education 4.0 (Alexander et al., 2019).
- **Rethinking ways of achieving:** The ways in which universities conduct their business has grown up throughout centuries based on Education 1, 2 and a bit of 3.0. Most universities are cautious of disruption, suspicious of transformation, and risk-averse—pointing to reputation worries and looking for certainty. A way of confronting this challenge is to understand universities as 'hybrid' organisations in systems terms (Jongbloed, 2015). Although universities are influenced by their complex external environments and buffeted by constant changes in country and global trends, government policy and funding regimes, internally they are subject to isolation and insulation engineered by their many layers of institutional autonomy and stratified governance (Salmon & Asgari, 2019). Universities need to open their doors, their visions and their ways of education to embrace 4.0.

To be clear, the core mission of universities *does not* need to change (usually, research, teaching and civic and societal responsibilities) and each individual institution can and should keep their long-rehearsed values. But to achieve long-lasting constructive transformation, universities first need to disrupt themselves and allow themselves to think very differently about how new educational futures can be constructed. Looking back for looking forward is one way. But increasingly, to break the isolation, many universities are working across sectors—with commercial companies or employers so that no one organization bears a full burden of risk and benefits can be shared.

It is the moment in the long history of Higher Education to think differently and embrace rapid reactors and the permanent pace setters (Milligan, 2019). Milligan tells us to focus on building a 'brand' and then get it out there, not just to your external environment, but internally, too, and use that intelligent researched evidence base for new insights then build it into foresight. Brands are a shorthand for what your university stands for. Aspiring to be global and local, so common a mission for universities, just isn't enough for the future. Then, don't worry about time management (An

oxymoron anyway isn't it?) but focus on surrounding your institution with positive, challenging, constructive, critical friends and partners.

If you want to be there creating Education 4.0 forget SMART goals use FAST instead: Frequently discussed, Ambitious, Specific and Transparent. It's important to do things quickly and be open to challenge and change. This is how we create Education 4.0, rather than risk see it pass us by (Scharmer, 2018; Epstein, 2019).

Conclusions—And a Call to Action

Looking back over Education 1.0 to 3.0 it is a strong reminder to us that we must invest in change and focus on the most appropriate transitions to curriculum and education for our students and their future. Just as Web 1.0, 2.0 and 3.0 builds exponentially to Web 4.0, just as each Industrial Revolution created the conditions for the next, so we now need to take the best of the past and move to Education 4.0. In doing so we do not for one moment deny the value of education 1.0 to 3.0 but embrace them and then build them into the opportunities for Education 4.0.

This means that Industry 4.0 should be at the very centre of our strategies. As the Nesta report concludes (2017), we need to give absolute emphasis to the opportunities and innovations afforded to universities for Education 4.0. Now is the time to be willing to embrace risk and enable our Higher Education system to respond effectively and quickly. Despite political turmoil, there is recognition from politicians, in the UK at least, of the need for strong collaborations (McVitty, 2019). My suggestion is to start to apply strategic foresight to plan and design desired futures. It is essential to have a clear and distinctive vision and a way of achieving it without waiting for absolute 'truth'.

Through viewing Higher Education as a complex adaptive system of which time and the interaction with other systems is a major driver, I have a brought perspective on this. It is best to look back with understanding; to 'hold a mirror' up to the past in order to actively shape the future. Knowing is not the same as implementing. We need to identify much of the current growth opportunities and then extrapolate them to our students' rather changed needs and expectations and find a way forward. Universities *do not need* to change their core values and missions, but they do need to be very clear what their vision is, within an easy articulated and distinctive 'brand', for delivering them in the future.

Transformation is of course not easy. Transformation cannot be achieved by small-scale experimentation or 'change management'. I hope the more complex looking back with understanding with a complex view of Higher Education as an adaptive system will help. My approach to this is to combine foresight with design thinking, focussed on action to shape preferred and viable futures (Lewrick, et al., 2018, 212; Salmon, 2017; Vlachopoulos, 2018). When systems thinking addresses wickedly complex problems there is a good chance they can be solved, agility heightened, and constructive scaling achieved. It is my view that those who grasp this will be those surviving into the later decades of the 21st Century.

For me, The Institute for the Future sums it up:

> For the past century, we have thought of learning…to build an efficient workforce while affording learners the opportunity to grow their earning power…. Now we're shifting to a new kind of workforce focused less on predefined job categories and skill requirements and more on tapping the unique potential of billions of worker-learners for a rapidly evolving labor landscape.

> The next decade will not only challenge us to reinvent learning for this new kind of distributed, dynamic, and ultimately more creative workforce. It will also inspire us to re-envision the tools, practices, and standards of assessment for the infinity of pathways that tomorrow's learners and workers will pioneer to create their uniquely meaningful lives. (IFTF, 2019b, p. 1).

Yes. There we have it. May the Fourth be with you.

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