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Against this uncertain backdrop, so called ‘Industry 4.0’ technologies such as artificial intelligence (AI), the Internet of Things and machine learning are changing industry and the workplace but are yet to be fully realised across tertiary education. Education needs to take advantage of technology to provide a capable workforce and a flexible, lifelong learning experience that benefits future decades of learners.

I am passionate about Jisc’s role in enabling our universities and colleges to make this change and make the most of advanced technology for two reasons: one, so they can help equip students of now and the future with the richness of skills that the developing workplace demands; and two, to transform teaching, learning and the overall education experience for a better, flexible and more accessible lifelong learning sector.

This is part of our vision for an Education 4.0 (https://ji.sc/SHF-Education-4) — but to get there, we must address what major challenges really hold us back. We also need to ask the question, what technologies should we focus on now to benefit our students, staff and institutions for decades to come?

That is why we have launched Horizons — a bi-annual initiative that brings together national sector bodies and government, together with universities and colleges and our own innovators, technology experts and designers, to predict and rise to the challenges that lie decades ahead and tackle them using the power of technologies and the innovation it enables.

With a core group of 30 representing all parts of the UK education and research ecosystem, we have researched, workshoped, tested and mapped out the challenges that impact institutions the most and predicted their significance as far as 2030. Against this, we have looked at key emerging and existing technologies from 5G to blockchain, to ascertain which could and should have the most effective change on education.

The findings outlined in this first Horizons report will directly influence our collaborative research and development ‘co-design’ programme to ensure that whatever innovation comes next, it has been developed for education and by education. Future issues will focus on research more strongly and we are starting work to define that now. The initiative also takes a deeper dive into specific critical
challenges that impact students, staff and institutions, and looks at the potential for technology to be applied to new or improving innovations that can help tackle them.

This first report centres on the critical challenge of mental health and wellbeing in tertiary education. In 2017 the Institute for Public Policy Research (IPPR) reported [https://ji.sc/IPPR_not_by_degrees](https://ji.sc/IPPR_not_by_degrees) that there had been a fivefold increase in the number of students who had disclosed a mental health condition to their college or university over the past decade. This is an issue that needs constant attention and coordinated effort across the education sector and government to make change. Through our own collaboration under Horizons, we uncover new recommendations to improve the wellbeing of students and staff, including responsible sharing of relevant data which is crucial to understanding students’ behaviours and needs, and to addressing them.

While you might not associate Jisc with dealing directly with mental health and wellbeing issues, it is vital that everyone who is touched by what we do can benefit from our ability to use data and technology to help people. This is ultimately what Horizons is about: looking to the future, understanding the needs of education and the next generation of learners and the role technology can play to support the delivery of positive change for the future.
Introduction to the Horizons report

The purpose of this report is to monitor and assess how the technologies associated with the fourth industrial revolution (in which emerging technologies such as artificial intelligence and the Internet of Things blur the lines between the physical, digital and biological spheres) are developing and to help institutional leaders and practitioners decide which of the technologies will prove most useful to them in addressing the major strategic challenges they face.

We are working with a diverse group of sector experts to produce a report every six months so that we can track the evolution of the technologies over time and establish which ones offer the most promise for education and research. Each report will also include a deeper dive into a challenge or technology that is attracting particular interest in the sector, to provide more detailed analysis and recommendations for universities, colleges and skills providers. For this report we have chosen to take a closer look at the mental health and wellbeing challenge that is facing all educational institutions.

The report is split into two sections. The first section focuses on summarising the major strategic challenges the sector is facing, analysing the current state of the most relevant emerging technologies and then mapping where the emerging technologies could help with the strategic challenges. The second section consists of a horizon scan of mental health and wellbeing. In that section we attempt to predict how the challenge may develop in the near future and make a series of suggestions for actions that should be taken now and how we can begin to shape a more comprehensive response for the future.

The Horizons group also plays a key role in helping to steer and focus Jisc’s R&D effort. We are running two co-design labs as a result of the discussions that led to this report. One will explore the development of a data trust or data cooperative. This will allow multiple different stakeholders to share and analyse data relevant to wellbeing in order to produce insights and services that are useful to staff and students in a way that ensures their consent has been sought and they have trust in the use of their data. The second will explore the notion of developing a bundle of trusted, high quality resources and services that colleges and universities can easily adopt or purchase to enhance their wellbeing services for students and staff.

If you are interested in the work of the Horizons group or any of the topics in this report, please get in touch at innovation@jisc.ac.uk.
Horizons group members

The following people formed the Horizons group which developed and refined the content for this report. We would like to thank them for their time and expert insight.

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• Michelle Pauli
• Jo Robotham
# Mapping strategic challenges to emerging technologies

This table summarises how emerging technologies may help with the strategic challenges the education sector faces. More detail on the challenges and technologies can be found in the sections that follow.

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The knock-on effect of Brexit is uncertainty around the UK government and possible policy impacts. Labour have made it clear that, if it were to gain power, tuition fees would be scrapped while the Conservatives have hinted at the reintroduction of maintenance grants. Universities are already facing a financial shake-up with the conclusions of the Augar Review due to be published this year. Meanwhile, colleges have seen the impact of changes to apprenticeships funding and face the introduction of T Levels. While financial policies are currently the most clearly articulated party policies, a potential change of government, or even just a general election, could have far reaching implications for universities and colleges alike.

Strategic challenges for education and research

The academic year 2018-2019 is shaping up to be a tumultuous one for universities and colleges. With a backdrop of increasing globalisation, a resurgence of identity politics and populism, Brexit (and the associated confusion in British politics) and the increase in the privatisation and marketisation of education, both the FE and HE sectors have a lot to contend with.
### 1. Education and research finance

While this report highlights a number of challenges to the education sector, education finance is acknowledged to be the most significant for all education sectors across the UK and looks set to remain so for the foreseeable future.

There are numerous challenges to the way higher and further education is funded. The current Augar review of student tuition fees ([https://ji.sc/tuition_fees](https://ji.sc/tuition_fees)) could result in changes which have a significant impact on HE. While most are anticipating a *drop in fees* ([https://ji.sc/drop_in_fees](https://ji.sc/drop_in_fees)), until the report is released it is hard to plan or consider the consequences. There may also be a reduction in income from foreign students due to Brexit. Alongside this, universities are under increasing pressure to *spend more* ([https://ji.sc/spend_more](https://ji.sc/spend_more)) in order to protect existing pension arrangements.

Research funding is increasingly becoming more directed by the government. While research and innovation funding is increasing, and the government aims to *increase spending as a percentage of GDP to 2.4%* ([https://ji.sc/no_deal_brexit](https://ji.sc/no_deal_brexit)) by 2027, the number of researchers applying for funds is also increasing, leading to researchers spending a greater proportion of their time applying for funds, and higher failure rates.

There is much uncertainty regarding the UK’s access to EU research funding ([https://ji.sc/impact_on_horizon](https://ji.sc/impact_on_horizon)) and reports suggest we are already seeing a *reduced amount of EU funds to UK-based institutions* ([https://ji.sc/reduced_eu_funds](https://ji.sc/reduced_eu_funds)). The uncertainty itself makes planning *future research* ([https://ji.sc/future_research](https://ji.sc/future_research)) problematic.

With the near universal support for open science from research funders, institutions now have to work out how best to comply with these requirements, such as those from the Plan S founding coalition, which includes UKRI, Wellcome Trust and the Gates Foundation as members. Funders and funding programmes, such as EPSRC and Horizon 2020 ([data.cam.ac.uk/funders](http://data.cam.ac.uk/funders)), have mandates for depositing and sharing research data. These requirements dictate the need for institutional, national and international infrastructure to enable and monitor compliance, costs and benefits.

Technology could support the decisions and refining of proposals to help reduce the time spent on unsuccessful applications. For example, a range of data sources, AI-based infrastructure and tools could assist in preparing proposals and analysing funding opportunities.

FE colleges continue to operate under a challenging *budgetary environment* ([https://ji.sc/budget_environment](https://ji.sc/budget_environment)), with the Institute for Fiscal Studies stating that funding for sixth forms and FE has been *"cut much more sharply than any other area of education"* ([https://ji.sc/cut_more_sharply](https://ji.sc/cut_more_sharply)). At the same time the cost of delivering education is *rising, not falling* ([https://ji.sc/rise_not_fall](https://ji.sc/rise_not_fall)).

Universities and colleges are going have to look for more *efficient ways* ([https://ji.sc/efficient_ways](https://ji.sc/efficient_ways)) to deliver services while reaching and teaching a greater diversity of learners.

Part of the response by universities and colleges is to provide more cost effective learning by competing in the *online space* ([conted.ox.ac.uk/about/online-courses](http://conted.ox.ac.uk/about/online-courses)). Initiatives such as smart and intelligent campuses ([jisc.ac.uk/rd/projects/intelligent-campus](http://jisc.ac.uk/rd/projects/intelligent-campus)) can use technology to identify where efficiencies can be made in the physical space and ensure resources are being fully used. The University of Glasgow, for example, has collaborated with the wider Smart City initiative to create a *smart campus* it believes ([gla.ac.uk/explore/future](http://gla.ac.uk/explore/future)) “heralds one of the most significant expansions and developments of a UK university city campus for over a century”.

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Universities and colleges are facing competition from an increasing range of sources (https://ji.sc/range_of_sources). The regulated HE system is expanding, with more providers entering the arena.

The government has made it “much easier for private providers” (https://ji.sc/private_providers), both for-profit and not-for-profit, to obtain degree-granting powers and the right for their students to be eligible for publicly-backed loans. Large technology corporations are moving aggressively into the lifelong learning space. Corporations are exploring new ways to train existing and potential employees (https://ji.sc/potential_employees).

Universities are maximising their incomes by increasing student numbers (https://ji.sc/private_providers) with the removal of caps on students. The Teaching Excellence Framework, or TEF (opt-in only in Wales), rates universities based on student outcomes, whether graduate-level employment or further study (https://ji.sc/what_is_tef). So universities find themselves in an ever-more saturated market being measured by increasingly commercial metrics. In England, the most overtly marketised of the home nations, the HE regulator (OfS) recognises that it needs special powers and advisory duty in widening participation and fair access, as this cannot be left to market pressures.

The landscape has been no less tumultuous for FE, which has also seen a raft of changes and reforms (https://ji.sc/change_and_reform), many brought about with a view to increasing choice and competition. Since 2015, following the government’s post-16 area review programme, many college mergers have taken place (https://ji.sc/college_mergers). Meanwhile funding continues to decline while marketisation and competition pressures increase (https://ji.sc/pressures_increase).

An additional tension for FE is its perceived role in ‘social good’. The health and wellbeing of individuals, social mobility and supporting local communities are all integral to FE colleges’ missions (https://ji.sc/missions). The argument is made (https://ji.sc/pressures_increase) that increased marketisation of FE will “mean colleges pursuing students who had the best chance of success and neglecting those whose needs were greatest”. Indeed research (https://ji.sc/tandfonline) published in 2017 found an “inherent tension between professional integrity and funding requirements apparently directly opposing ‘good’ practice”.

From a technology perspective the rise of online learning is helping colleges and universities to reach further than ever before, whether by supporting apprentices on site or expanding international markets. These developments can only enhance institutions’ ability to work collaboratively with other institutions and with business to create the hybrid market model providing education for the workforce of the future.

What cannot be predicted yet is the disruption of the current and future edtech startups. While the initial concerns around MOOCs (bbc.co.uk/news/education-23069542) seem to have subsided for the time being (and important lessons were learned (https://ji.sc/lessons_learned) through the development of MOOCs), there is no room for complacency when it comes to edtech developments (https://ji.sc/edtech_developments). With the rising personal costs of education there is a lot of appeal to a low cost technological solution (https://ji.sc/low_cost_solution) to continuing education. Colleges and universities must be cautious about dismissing edtech startups as a passing fad and instead should aim to learn from their successes (holoniq.com/edtech-unicorns) and consider their own ways of being more agile and responsive to ensure they are not ‘out-innovated’ by new suppliers (https://ji.sc/edtech_anatomy) in the market.
Yet student expectations of the nature of university teaching are still largely unformed and they can be unprepared (https://ji.sc/undergrad_expectations) for the demands on them.

Universities are wrestling with the changes required to meet student expectations and provide a strong sense of value (https://ji.sc/sense_of_value). This is not helped by the move from some major companies such as Google, IBM and Apple to no longer require a degree education by default. However, according to the 2018 HEPI / Advance HE Student Academic Experience Survey (https://ji.sc/academic_exp_survey), students do feel that value for money in HE is improving, with 38% of students in the UK perceiving 'good or very good' value from their course.

While the FE sector is not impacted by the tuition fees issue, full student funding is dependent on positive student destinations (ie a job or further study) and FE does share many of the same expectations from students around quality, employability and overall appeal. Incoming students have technological expectations, given their experiences of edtech and resources in schools, and these have cost and infrastructure impacts (https://ji.sc/cost_and_impact) on colleges and universities. Similarly, they expect that their studies will include the skills that are required in ‘real world environments’ with a call to “design courses in partnership with major employers or building internships and work placements into degrees as standard practice” (https://ji.sc/uni_expectations2).

AI may help. With Bolton College’s chatbot, Ada, able to give instant answers to high numbers of ‘mundane’ enquiries, such as ‘what is my timetable’, ‘which room am I in’ and ‘who is my tutor’, the college has seen a decrease in the number of dropouts in the critical first 42 days of term, with retention increasing from 93.1% in 17/18 to 96.1% in 18/19.

Across UK society, problems with mental health and wellbeing are on the increase, and universities and colleges are no exception to this with more students needing support and more effort required to identify problems early. This challenge is covered in more depth later in the report.
4. Skills gap

Not enough of the graduates from universities and colleges have the skills that employers need. Staff in universities and colleges also need to be equipped for a changing digital environment.

This broad challenge covers the digital skills of students and specific skills required by certain trades or industries as well as softer employability skills such as problem solving, communication and collaboration. It also encompasses concerns, from colleges in particular, that the qualifications system in the UK is too inflexible and slow to respond to changes in the skills required. A syllabus can be out of date within a year but qualifications boards do not have the pace to react accordingly. Staff digital capabilities also need to be addressed.

There are skills shortages across the whole of the UK with London being hardest hit followed by the northwest. Exacerbating the problem is the fact that the number of adults in training is at an all time low. A study commissioned by the Department for Education concluded that “changing economic circumstances, new technologies and potentially changing migration patterns will all affect demand from employers for different skills which workers will need to learn.” In addition, a study carried out by City and Guilds found that a majority of employers felt Brexit would worsen the situation. Interestingly, many employers are expressing greater frustration with the lack of softer skills, than the lack of technical skills which they are happier to provide training for.” In addition, a study carried out by City and Guilds found that a majority of employers felt Brexit would worsen the situation. Interestingly, many employers are expressing greater frustration with the lack of softer skills, than the lack of technical skills which they are happier to provide training for.

It is important to distinguish digital skills from technical skills required for those wishing to work in an IT environment. Digital skills apply to almost any career. The UK government digital skills framework broadly defines them as: digital foundation skills, communicating, handling information and content, transacting, problem-solving, being safe and legal online. A recent report suggests that the digital skills gap could cost the UK £141bn in GDP growth. Yet the latest Jisc digital experience insights survey reveals that only 41% of students feel prepared for the digital workplace.

The survey also finds that both FE and HE staff want more time and training to improve their own digital skills, so they can use technology more effectively to benefit students. It finds that 38% of HE teaching staff rate their university’s support for developing digital aspects of their role as better than average and 26% rate it below average. Demanding workloads are also impacting opportunities teachers have to improve their digital skills. Yet finding this time is critical, not only in order to learn about specific technologies but also to play an active role in the reimagining of professions that is taking place as a result of technology, from library and information professionals to teachers.

Universities and colleges are making inroads into improving learners’ employability skills, particularly in relation to technical and digital skills. Edinburgh and Heriot-Watt Universities are collaborating to tackle the digital skills shortage while City of Glasgow college has an initiative to tackle the skills gap in the construction industry. There have also been innovative uses of technology to address this challenge. For example, the engineering department at Swansea University is making extensive use of AR/VR technology to enable students to ‘visit’ an excavation site before and after building work was carried out. The University of Keele’s School of Pharmacy is doing pioneering work with AR apps and virtual patients.
However, universities and colleges are increasingly facing fierce competition from the private sector with provision such as Google Digital Garage (https://ji.sc/digital_garage) and even from less obviously digitally-focused industries such as the banking industry, with examples like Barclays Digital Confidence initiative (barclays.co.uk/digital-confidence). Many of these initiatives focus on fundamental, foundational digital skills, such as setting up a website for a small business, but there are also a number of more ambitious initiatives such as Udacity’s self-driving car engineer ‘nanodegree’, devised in partnership with industry rather than academia, which covers postgraduate-level topics around AI techniques for building the code that will operate autonomous vehicles.
5. Bricks and clicks: the physical, virtual and data estates

For universities and colleges, managing estates is increasingly complex and requires balancing the requirements and opportunities of the physical, virtual and data estate.

One of the largest expenses for universities and colleges is their campus (https://ji.sc/their_campus) and demand for on-campus education remains high (https://ji.sc/engineering_students). Online and blended learning (https://ji.sc/online_and_blended) remain important tools for face-to-face education as well as distance learning. Universities and colleges need to ensure they get the most out of the investment in the campus (https://ji.sc/all_together_now) while still providing a compelling online offer. Changes in technology as well as changes in the way people want to study, such as increasing numbers of commuter students, mean that universities and colleges need to innovate in the way they deliver education using technology while, in the longer term, considering fundamental changes to existing course structures (https://ji.sc/online_and_blended).

With an increase in private provision of education, particularly within the online space, universities and colleges need their campuses to be enticing (the sticky campus (thestickycampus.com) — see, for example, the University of Leicester’s digital reading room (https://youtu.be/MjgH_zL5pQ) ) — and offer a genuinely life-enhancing experience without disadvantaging those rarely physically present. Universities and colleges need to create a truly blended approach (https://ji.sc/truly_blended), bringing the digital and physical worlds together and recognising that the physical world has a digital footprint.

Pragmatically, universities and colleges need to do what they can to maximise student numbers, and virtual learning plays an integral part in this. With the Higher Education Policy Institute (HEPI) predicting student numbers will increase by 300,000 by 2030 (https://ji.sc/set_to_soar) in England alone, providing consistent physical infrastructure could prove an insurmountable challenge to already overstretched campus footprints. Equally, they must consider the impact of such an increase on local infrastructure and relationships and on student life.

Colleges are collaborating both within a local area (eg to ensure good local coverage of minority A-Level subjects) and across large distances, within a disparate college group. School multi-academy trusts also want to enable excellent teachers in one place to support teachers and learners in other places, whether sharing their resources or expertise.

Universities are very much focused on this challenge with long-term planning being put in place for new campuses, including those overseas. International branch campuses and partnerships will be increasingly important to mitigate against threats to freedom of movement of staff and students, and climate change. There are also initiatives such as Bristol University’s new development that are explicitly about joining up different aspects of the university mission and designing spaces that work for teaching, research, innovation and knowledge transfer, and the university’s role in wider local and regional society. Changes are also taking place within existing infrastructures - for example at Abertay University where the concept of a sticky campus has been built into its estates strategy (https://ji.sc/estates_strategy).

Colleges are looking to ‘future-proof’ their campuses in respect of job skills: Richmond College’s new campus, due to be completed at the end of 2019, is set to incorporate a range of innovative technologies including a digital golf studio and a 3D prototyping ‘FabLab’.

The term ‘data estate’ (https://ji.sc/modern_data_estate) has not yet made it into education vocabulary in the way it has in technology-focused organisations. Currently colleges and institutions are focusing on
specific areas of data such as student data or estates data and there are few examples of institution-wide approaches to the consolidation and use of data.

A 2016 report (From Bricks to Clicks (https://ji.sc/bricks_to_clicks)) into HE data focused largely on student ‘data footprints’ and the role of learning analytics. The use of data to support student retention and achievement under the learning analytics banner is becoming more common across colleges and universities with an increasing interest in expanding its use to support student wellbeing (https://ji.sc/student_wellbeing) (discussed in the in-depth topic section of this report). Currently 26 institutions have subscribed to the Jisc learning analytics service, the world’s first national learning analytics service.

A fully integrated data estate can enhance security and compliance, cost savings and analytics capabilities (https://ji.sc/enhance_security). It can ensure the more effective and efficient use of the physical estate, from room use to energy consumption. As colleges and universities increase the value of this data by combining datasets and employing technology to respond to it in ways that maximise the use of the campus and reduce costs we see the movement from the ‘smart’ campus to the ‘intelligent’ (https://ji.sc/what_makes_ic) campus.
In light of the finance, marketisation and student expectation pressures on the sector, institutions are seeking to innovate in order to reach more learners, give a better experience to those they have and deliver on their own distinctive educational missions.

Active learning, peer-to-peer learning and increased interaction in learning are increasingly in evidence and seen as a way of ensuring that students are actively engaging in their subject and in the interpretation of material and construction of learning, designed to help them get the most learning benefit from their class attendance and study time. The University of Northampton is taking this a step further by transforming learning spaces (https://ji.sc/transform_spaces) to create learning environments that support its own brand of active blended learning. Northampton’s approach is to expose students to a rich blend of learning experiences, including face-to-face teaching, online learning and active student engagement with course content.

Personalised, adaptive learning has long been a goal in both colleges and universities — as evidenced by a very high incidence of ‘personalised’ learning examples in TEF submissions — but it is currently used broadly, from students choosing their own combination of modules to carrying out student-defined assessments. In FE, the implementation of T levels will see a 50% increase in the number of guided learning hours compared to a standard study programme and it is expected they will lead to an increase in quality blended learning content. At the University of Leeds, researchers are looking into the Unbundled University (https://unbundleduni.com) intersection of increasingly disaggregated curricula and services.

"There is currently a lot of interest and activity in the area of unbundling, both as a research topic, and in practice. Unbundling has increased sharply with the innovations taking place on online course platforms, and is beginning to impact on campus-based education."

Professor Neil Morris, dean of digital education, University of Leeds

Lifelong — and ‘just in time’ — learning is increasingly needed in order to enable people to up- and re-skill throughout their lives and careers, meeting the needs of both the UK economy and individuals increasing their career opportunities and satisfaction. It is vastly enabled by online learning, once learners have the digital and learning skills and confidence to study in this way. The introduction of the government’s National Retraining Scheme, which is designed to up-skill current employees whose jobs are at risk due to automation, will see a move to micro-credentialing, enabling employees to gain credits for short, sharp acquisitions of knowledge/skills. How these micro-credits are recorded and aggregated is going to be a challenge for the sector.

Assessment needs to change for a digital age — both the use of technology to support formative assessment and rapid feedback, and a rethinking of what kinds of assessment tasks are meaningful and possible with digital technology. Students at the University of Edinburgh are editing Wikipedia pages (https://ji.sc/edit_wiki_pages) as part of their assessed work, while the University of Leeds’ digital education master’s programme is pioneering online group work and the creation of useful, public joint artefacts as a form of assessment. Student as Producer (https://ji.sc/student-producer), adopted by institutions such as the University...
of Lincoln, includes learning by undertaking real research projects, connecting teaching with research and developing collaboration.

Technology can be used to support digital skills development and employment-relevant activities in a variety of ways, from technology-enhanced authentic and simulated learning experiences (including cohorts of students collaborating on real-world or employer-relevant tasks, or the use of online simulations or virtual reality to provide valuable practice in simulated employment-like environments) to digital communications and engagements with employers. Technology can support the planning, reflection and managing of learning, such as through e-portfolio or reflective blogs, and enable feedback from key stakeholders such as employers.
Successful submissions to these are critical for funding, reputation and recruitment, which places a heavy burden on staff and leadership to provide the evidence and adapt the organisation in response to the results.

Yet there is a risk that these metrics and rankings lead simply to a focus on improving specific metrics rather than underlying services and quality of teaching and research. In addition, league tables and the pressure for universities to perform, particularly to support the recruitment of students, have been linked to negative impacts on the mental wellbeing of staff (https://ji.sc/mental_wellbeing) and grade inflation (https://ji.sc/grade_inflation).

For FE, the challenge is to respond to multiple requests for statistical collection and reporting, and nation-level inspections, with increasingly tight resources.

Improvements to the way that metrics are collected and managed could lead to significant efficiencies for universities and colleges. As importantly, improvements may open up the metrics themselves, and their effects, to wider scrutiny. How can technology support the collection, analysis and decisions for submitting the evidence and helping to make organisational changes that will lead to successful outcomes? Jisc is exploring the research metrics and analytics space (https://ji.sc/scholarly_comms) and there have been calls, in Hefce’s Metric Tide report (https://ji.sc/metric_tide), for an ‘open data infrastructure’ to underpin research indicators.
Institutions’ reputations rely on their staff. Recruiting and retaining high quality researchers and lecturers is frequently listed as one of the critical issues facing UK universities.

How do UK universities attract top-quality academics when they are competing with universities around the world as well as industry? How do colleges attract tutors with the right skills in a competitive market? When advanced digital and computational skills are in such high demand in the well-paid commercial sector, how can universities and colleges develop career structures that will nurture and retain staff with those skills?

For research in particular, Brexit has become a major contributing factor: 17% of staff in UK HEIs are from non-UK EU countries (https://ji.sc/he_and_brexit). The New Scientist reports (https://ji.sc/newscientist_brexit) that “almost two-thirds of managers who recruit scientists and engineers in the UK believe Brexit will affect their ability to attract top talent from within the European Union”. Universities are reporting a 9% fall in non-British EU students starting postgraduate research courses in 2017-18 (https://ji.sc/non_brit_eustudents).

In FE it is estimated (https://ji.sc/FE_estimate) that, driven by the age profile, 582,000 staff will be needed over the next ten years. In addition, more than 24,000 teaching staff have been lost from the sector (https://ji.sc/sector_loss) since 2009, and 90% of colleges report difficulties in attracting the staff they need. Recent changes to FE have led to requirements for different and updated skillsets, including STEM and technology subjects which have traditionally been difficult to recruit. There are also concerns in the FE sector (https://ji.sc/FE_sector_concerns) in recruiting at the principal level.

How could digital technology incentivise researchers and teachers to work at our institutions and how can it enable HEIs to make informed decisions in finding, recruiting, retaining and utilising key talent? A PWC report into university recruitment (https://ji.sc/PWC_report) noted “emerging technologies including artificial intelligence, virtual reality and gamification are improving the applicant experience in most sectors, however, higher education appears to be lagging behind”.

Other factors include lower pay (https://ji.sc/lower_pay) compared to countries such as the US and competing jobs in the private sector, huge investment by countries such as China in their research infrastructure (https://ji.sc/huge_investment), and the UK being perceived as difficult to migrate to for work (https://ji.sc/migrate_work).
9. Open science and research infrastructure

UK academic research has never had greater impact and connection to society. Nor, thanks to digitalisation and open access, has it ever been more widely available.

However, this has also led to greater scrutiny and exposure of questionable research practices, which can be seized upon in a heightened political environment of ‘fake news’ and misleading narratives.

Research integrity, plus inadequate reporting of the data, software, methodology and inputs, has led to questions being raised about how reliable research is, especially experimental research, and claims of a ‘reproducibility crisis’ (nature.com/collections/prbfkwmwvz). Demands on researchers, including metrics and institutional performance methods, can create incentives which can lead to undesirable results, including false citations, rushed research and exaggeration of results (https://ji.sc/false_citations). Universities risk serious damage to the reputation of their research (https://ji.sc/climatic_research) and to their status as curators of academic values. They also risk losing opportunities to collaborate with other academics and with industry.

The UK House of Commons Science and Technology Committee undertook an inquiry (https://ji.sc/research_integrity) into research integrity and a follow-up report is expected. A manifesto for reproducible science (nature.com/articles/s41562-016-0021) was published in 2017.

Open science practices, such as the pre-registration of study protocols and analysis plans and the publication of data alongside articles, are a very positive development. For research to be truly ‘open’, both the findings and the data behind these results need to findable, accessible, interoperable and reusable (FAIR). These approaches require policies, infrastructure and platforms (such as Jisc’s open research hub (jisc.ac.uk/open-research-hub)). Technology has a role to play in making good research data management easier and better integrated into research workflows.

The building blocks already exist in part. How could we build on these to develop the required relationships, structure and metadata to create reusable research packages and pipelines, and the infrastructure to exploit them? Can text mining and AI help identify questionable citations and research?
10. Cybersecurity

Institutions’ reputations rely on their staff. Recruiting and retaining high quality researchers and lecturers is frequently listed as one of the critical issues facing UK universities.

Universities and colleges rely on their reputation and credibility to attract students and funding, and deliver impact. Yet the data they hold on their students and staff, as well as their cutting-edge research, makes them popular targets (https://ji.sc/popular_targets) for cyber-security attacks. All students should expect a basic level of IT and network infrastructure to be in place that meets robust, requisite security standards and protects their data.

There are 400,000 new malware attacks everyday (ucisa.ac.uk/publications/cyber_guide). In a recent survey (https://ji.sc/cyber_security_posture), only 15% of IT and security staff in HE scored their institution 8+ or above, when asked how well protected their institutions are. The government’s 2016 National Security Strategy reaffirmed cyber threats as one of the most significant risks to UK interests.

In FE, there were 12 distributed denial of service (DDoS) attacks (https://ji.sc/ddos_attacks) on average per week in 2017, a quarter of all colleges, with the number rising annually.

Institutions are investing in staff and, at the national level, Jisc has also invested in increasing the level of centralised Janet security for both staff and technology. The sector needs to attract and train experts and invest in new technologies to help protect their valuable data and ensure staff and students are equipped with the necessary skills to avoid falling for phishing and other security threats.

Cyber security brings opportunities as well as challenges. The National Security Strategy (https://ji.sc/national_security_strat) commits £860m for education and research to provide knowledge and skills in cyber security for the future workforce. The government has recently published a policy paper (https://ji.sc/policy_paper) outlining an initial national security skills strategy which describes the support the government will offer to help equip the current and future workforce — as well as upskilling existing workers — with the required skills and digital capability to combat cybersecurity.
This section of the report analyses the technologies associated with the fourth industrial revolution and assesses their relevance to education and research. We have given each technology a rating to help institutional managers decide how they should be approaching it. Our ratings are:

**Watch** — continue to pay attention to the technology but be wary about significant investment at this stage

**Explore** — the technology is mature and promising enough to start experimenting with it. A full roll-out is not advised but focused experiments can help develop understanding of whether and how the technology could solve institutional problems

**Implement** — the technology is mature and there are already examples of how it is being used to solve education and research challenges. It should be possible to procure or develop the technology and use it to enhance the institutional offer
Overview

5G stands for fifth generation and is the next generation of mobile networks. While we have heard a lot about 5G in the media, the standardisation process only concluded in March 2018 and vendors are still fine-tuning their products for launch. 5G is expected to be 10 - 1000 times faster (https://5g.co.uk/guides/how-fast-is-5g) than our current 4G networks — perhaps exceeding ten gigabits per second. At that speed it would be possible to download a high definition film in less than a second. On top of this, 5G networks will be able to cope with connecting a much greater number of devices. This will help with the adoption and development of Internet of Things technology (https://ji.sc/adopt_and_develop) as far more devices and objects will be able to be connected to the network and greater speeds will enable new use cases to be explored (https://ji.sc/bbc_use_cases). The first 5G-ready phones and devices are expected to hit the market in 2019 (wired.co.uk/article/what-is-5g-vs-4g) but it is likely to be longer than that before 5G networks are widely available. There is certainly a lot of hype around 5G and not everyone is convinced (https://ji.sc/not_convinced) that 5G will end up being all it is cracked up to be or that it is required for technologies like the Internet of Things (IoT) to flourish. This is not helped by some mobile phone service providers using 5G branding for enhanced 4G services (https://ji.sc/5g_brand_use).

Relevance to research and education

5G is likely to have a secondary impact on education and research in that it could support the development and adoption of technologies (https://ji.sc/verizon_innovative_learning) that will have a direct impact such as virtual reality, artificial intelligence and IoT. It may also support the development of new technologies that could impact education and research such as the tactile internet (https://sociable.co/technology/iot-tactile-internet) and holograms (https://ji.sc/surrey_5g_tech). Some universities and colleges are already involved in working with 5G. The University of Surrey has its 5G innovation centre and the University of Worcester and Heart of Worcester College are creating new courses as part of the 5G testbed in Worcestershire.

Horizons group rating

Watch 2019 is likely to be an interesting year for 5G with new devices released and trials getting started in the UK (https://ji.sc/bbc_use_cases). Opportunities to get involved will be limited to the geographic regions that are experimenting with 5G but eligible universities and colleges should be keeping a close eye on these developments and be looking for opportunities to get involved in any trials. Having said that, it is also important to take the 5G hype with a pinch of salt as there are plenty of reasons for companies to be talking up the impact and benefit of 5G and it is not guaranteed that all those benefits will be realised.
2. Artificial Intelligence

Overview

Artificial intelligence (AI) is a broad concept that is used to refer to a range of technologies (https://ji.sc/ai_revolution_science). The bulk of recent developments in AI have taken place using advances in machine learning or a subset of machine learning called deep learning. Both approaches can use neural networks which are simplified models of the human brain. These neural networks are fed data and examples, and use these to find patterns in the data to achieve a set goal such as develop a way for bipeds to walk (https://ji.sc/biped_walking) or find compounds that may be active against a drug target (https://ji.sc/find_compounds). The vast majority of applications at present are around recognition and classification of input data, such as teaching a self-driving car what a pedestrian looks like, but there is a whole new class of generative AI coming onstream that specialises in creating new digital objects, including ‘deep fakes’ (https://ji.sc/deep_fakes).

We use the outputs of machine learning everyday as companies like Amazon, Google, Facebook and Apple use it in many of their products, and as computing power has improved so has the ability for machine learning to be applied to more and more sophisticated tasks. It is this increasing sophistication that is leading many experts to predict that AI will have a massive impact on many professions (https://ji.sc/pwc_massive_impact).

The UK government is taking steps to ensure the UK is at the forefront of AI. In 2018 a sector deal for AI (https://ji.sc/Al_sector_deal) was launched that includes funding for 1000 AI PhDs and support for start-ups. This is in addition to the founding of the Turing Institute (turing.ac.uk) as a national centre of expertise for data science and AI.

Relevance to research and education

AI is already used in research; for example, a neural network was used in discovering the Higgs boson (https://ji.sc/discover_higgs_boson). As machine learning and other techniques become more widespread and affordable we can expect the use of AI to increase. This will also be helped as more data from research gets published on the web. We are also starting to see some tools emerge that help with the research process (nature.com/articles/d41586-018-06617-5). A good example is Iris.ai (https://iris.ai) which aims to help researchers discover content relevant to their research problem from outside their discipline. AI will also bring new problems to research; for example, how can we ensure new insights from AI can be trusted when it may not be possible for humans to track the derivation of the insight (https://ji.sc/open_the_black_box). New research (https://ji.sc/new_research) offers some hope this particular problem can be overcome.

Many people are predicting that AI will transform teaching (https://ji.sc/transform_teaching). Most predictions focus on AI taking over the administrative parts of teaching leaving humans to focus their effort on the essential interpersonal elements. While much of this promise lies in the future, we are starting to see some early adopters making use of machine learning to help with education. Leeds Beckett (https://ji.sc/becky_the_bot) and Bolton College (https://ji.sc/bolton_college_chatbot) have both been experimenting with chatbot technology, commercial learning apps such as Duolingo have been investing in AI research (https://ai.duolingo.com) and some AI learning tools such as MATHiaU (https://ji.sc/MATHiaU), CenturyTech (century.tech) and Squirrel (https://ji.sc/squirrel) are starting to emerge.
Future possibilities

There is a lot of speculation about how AI could change teaching and research. Some of the most interesting opportunities are:

• Automated marking — AI can manage simple marking tasks already but there is still a lot of work to do to ensure AI can mark written assignments to a high standard ([https://ji.sc/automated_marking](https://ji.sc/automated_marking))

• Personal learning assistants — there are quite a few chatbot-based learning assistant tools available now; examples include Cognii ([cognii.com](http://cognii.com)) and Otto ([https://ji.sc/otto](https://ji.sc/otto)). However, this area is still in its infancy and we are likely to see increasingly sophisticated tools over the next few years

• Adaptive learning environments and differentiated learning — we are already seeing tools emerge in this area such as Squirrel and CenturyTech, mentioned above, and there seems to be a lot of room to develop new tools that focus on helping teachers plan and deliver teaching ([https://ji.sc/teachers_plan](https://ji.sc/teachers_plan)) or new types of virtual learning environments such as the University of Southern California’s CVIT project ([https://ji.sc/cvit_project](https://ji.sc/cvit_project))

• Feedback — some tools are emerging that use AI to deliver feedback to students; for example hubert.ai ([https://hubert.ai](https://hubert.ai))

• Administrative tasks — there are already tools that automatically schedule meetings on someone’s behalf and the same technology could be used to address a range of administrative tasks ([https://ji.sc/5companies_using_ai](https://ji.sc/5companies_using_ai)) for researchers and teachers

• Some experts predict ([https://ji.sc/experts_predict](https://ji.sc/experts_predict)) that AI could completely replace teachers as soon as 2027 but others disagree with this prediction ([https://ji.sc/robot_disagreement](https://ji.sc/robot_disagreement))

• A number of start-ups are exploring how AI can help researchers ([yewno.com](http://yewno.com)) by automating the knowledge discovery process ([https://quartolio.com](https://quartolio.com))

• With open access publishing and open research data becoming the norm in more and more disciplines, text and data mining using AI could fundamentally transform key aspects of the research process with innovations such as AI-assisted search engines and literature reviews ([https://ji.sc/literature_reviews](https://ji.sc/literature_reviews))

Horizons group rating

Explore

The major software vendors are all investing heavily in artificial intelligence so colleges and universities will start to benefit from AI even if they do nothing. However, it is also worth looking out for specific areas where AI could be used to help address strategic needs, as there is now a handful of innovative new AI tools that are mature and affordable enough to make experimentation relatively low risk. Our recommendation is that institutional managers should actively look for opportunities where AI can be used — for example, to reduce admin overhead, improve student and staff experience or support innovative approaches to teaching and learning. Chatbots in particular are worth investigating and may even warrant an implement rating as a number of universities and colleges have benefited from using them.
Overview

Blockchain is the technology (https://ji.sc/blockchain) behind cryptocurrencies, the most famous of which is Bitcoin. Blockchain is an algorithm and distributed data structure (https://ji.sc/blockchain_algorithm) designed to keep track of digital transactions. It works in a decentralised way so that every computer on the chain has a complete record of all transactions rather than relying on one central organisation to own and control the record. Investment in blockchain start-ups is continuing to grow (https://ji.sc/continue_to_grow) and reports suggest IBM has 1,000 people working on blockchain projects (coindesk.com/ibm-blockchain-iot-office). These are strong indications that many experts see blockchain as a technology that is going to expand far beyond the world of cryptocurrencies.

Relevance to research and education

There is plenty of speculation about how blockchain could be relevant to education (https://ji.sc/blockchain_and_education), which ranges from qualification validation (https://ji.sc/qualification_validation) all the way to a blockchain-based university (https://woolf.university). All the examples we have found are at a very early stage.

Researchers are also exploring the potential offered by blockchain (blockchainforscience.com). Potential opportunities may include applications (https://ji.sc/bitcoin_science) in keeping a record of research activities or in managing peer review (blockchainpeerreview.org) and other aspects of scholarly communication but again all the examples we have found are at a very early stage.

Like all technologies on this list, blockchain is subject to a large amount of hype but for blockchain it is especially difficult to look past the hype to see what value it truly offers to education and research. There are many people who are positive about blockchain (https://ji.sc/positive_blockchain) but just as many are sceptical (https://ji.sc/blockchain_sceptics), noting that many proposed blockchain applications could be created more quickly and cheaply using conventional database technologies.

Horizons group rating

Watch

Blockchain is a fascinating technology that seems to have plenty of potential for education and research. However, our recommendation is to wait and see how the early experiments develop before committing to experimenting or investing heavily with blockchain projects. At the moment it is far from clear which of the many possible uses of blockchain will turn out to be affordable, scalable and practical, and to offer significant benefits to education and research over other technical approaches (https://ji.sc/other_approaches). It is worth ensuring a few people in the organisation understand and are keeping up with the latest developments in blockchain.
Overview

Data and analytics cover a huge area of technology; in this report we will focus on analysis and visualisation tools and prediction modelling. They can also include nudge technologies that try to change user behaviour based on results of data analysis. Many of the technologies associated with the fourth industrial revolution rely upon large amounts of data and need expertise in analytics to exploit them properly. But data and analytics cannot really be described as an emerging technology since all universities and colleges are already using data and analytics in some form. However, it is important to note that there is still an enormous amount of work to do before the full range and potential of analytics are exploited in education and research. The education sector lags behind other industries in using analytics and we need to do more to ensure we develop a comprehensive data estate that allows us to work across data silos. This is particularly important when considering adopting some of the other emerging technologies discussed in this report since, big data and analytics are the foundational infrastructure on which many of these technologies are built.

Relevance to research and education

There are many aspects of data and analytics in education and research including:

- **Business intelligence** — all colleges and universities have individuals or teams responsible for analysing data about the running and strategy of the institution.
- **Metrics for research** (https://ji.sc/metrics) and education — universities and colleges are accustomed to monitoring key metrics that are used to assess them for Ofsted, the research excellence framework or the teaching excellence framework. It is possible that new forms of analytics may offer new insights that can help with these assessments, or in some cases, that entirely new metrics may become available.
- **Learning analytics** (https://ji.sc/la_he) — analytics used to monitor student’s progress and make predictions on which students need support. Many universities and colleges are making use of learning analytics now
- **Wellbeing analytics** (https://ji.sc/wellbeing) — this is emerging as an area of serious interest for schools, colleges and universities, as analytics may prove to be a useful tool in combating the serious mental health challenge facing the education sector. We look at this again in the in-depth section of this report.
- **Curriculum analytics** (https://ji.sc/cur_analytic) — it is likely that analytics can scrutinise which parts of a curriculum are working well and which parts may need improvement, but this area is only starting to be explored.
- **Intelligent campus** (https://ji.sc/intel) — data about the estate and its usage can provide a more efficient campus and, if analytics are real-time, could even enable a more fluid campus that responds to user needs.

Individually these analytics are useful but if they can be joined up then they could offer deep insight and compelling new tools that could enrich the student experience and provide a more personalised approach to education.

**Horizons group rating**

**Implement**

All universities and colleges will have implemented data and analytics already. But the surface has only been scratched and few colleges or universities would confidently assert that they have full control over their entire data estate and are exploiting all the opportunities it offers (https://ji.sc/exploit). This is potentially a huge task since it involves a vast array of educational, research, estate and administrative data, some of which may be controlled by third parties responsible for software or delivering services. Despite the scale and difficulty of the task, it is likely to be essential to realise the full potential on offer from analytics and is also a requirement for realising benefits from other technologies such as artificial intelligence and the Internet of Things. So the recommendation here is to implement a strategy for a data estate that manages existing data flows and joins up data where appropriate and desirable, and collects new forms of data wherever possible. This will need to be accompanied by efforts to improve staff skills and an informed and transparent approach to ethics and privacy, and more of a focus on informed consent and education to improve data literacy.
5. Immersive technologies

Overview

Augmented, mixed and virtual reality are technologies designed to deliver an immersive experience. The difference between them is how immersive they are. Augmented reality overlays digital objects on the real world (zappar.com) via a phone or other device. Mixed reality takes things a step further by using a headset but still having the user interact with the real world (https://ji.sc/hololens).

Virtual reality fully immerses the user in a digital world via a headset and other devices required to interact with the digital world, such as gloves (https://ji.sc/vr_gloves) or treadmills (virtuix.com). Apps like Pokémon Go have taken augmented reality firmly into the mainstream but virtual reality is a bit further behind. Devices such as Playstation VR are gaining in popularity but they remain expensive and have not had any of the must-have content that drives adoption.

Relevance to research and education

AR and VR offer the promise of richer learning experiences for students and interesting possibilities for remote learning, whether that is for students learning away from a campus or for students on campus exploring other places and cultures. There are many exciting examples of AR and VR being used in education such as Parisian immersion in language teaching at Harvard (https://ji.sc/examples_from_the_field), teaching surgeons (https://ji.sc/teaching_surgeons), learning from Pixar animators (https://ji.sc/learning_from_pixar) and Keele University’s virtual patient (https://ji.sc/virtual_patient), which is used to teach pharmacy students. There are also a number of interesting start-ups in this space such as WondaVR (wondavr.com), a content creation platform that Jisc has invested in, and Unimersiv (https://unimersiv.com), a VR learning app.

The usefulness of AR and VR for research is less clear. Some early adopters are using the technology to visualise objects (https://ji.sc/visualise_objects), data or concepts but widespread adoption seems some way off. Some companies and products bridge the gap between education and research, such as Labster’s virtual labs (labster.com) which can be used to help induct junior researchers before they are let loose on expensive equipment such as mass spectrometers or DNA sequencers.

Future possibilities

Even though these technologies are close to the mainstream they still have a long way to travel before they reach their full potential. Low-end approaches such as Google Cardboard (https://vr.google.com/cardboard) and Oculus Go (oculus.com/go) have made VR affordable, as mass production has led to commodification, but the results are not comparable with what can be achieved using high-end headsets such as HTC Vive (vive.com/uk), which are typically driven by a workstation class PC.

Advances in other technologies such as computing power, 5G and AI will lead to better and better VR experiences. The quality and quantity of content is likely to increase over the next few years as technology companies (https://ji.sc/ar_vr_corporates) and education institutions (https://ji.sc/ar_vr_education) are investing heavily in VR and AR. If the technology gets more affordable at the same time as more and better-quality content emerges, the use of VR and AR in education is likely to soar.

There are some interesting developments happening with haptic interfaces such as Ultrahaptics (ultrahaptics.com) and these interfaces could open new possibilities for teaching and research. Another key development has been the creation of standardised approaches to augmented reality on Apple and Android devices, via the ARKit (https://developer.apple.com/arkit) and ARCore (https://developers.google.com/ar) software development kits (SDKs). ARKit is the more mature of the two and we have seen a large number of AR applications released that simply use the phone or tablet camera and do not require a headset — building on the legacy of Pokemon Go (pokemongo.com/en-gb).

As always with new technologies, we need to be wary of hype and some experts believe AR and VR will be a useful tool in some disciplines but will not have a transformative impact on education (https://ji.sc/non_transformative).
Horizons group rating

Explore

Immersive technology is becoming more mature and tools are becoming available to create your own high-quality content, building on other technologies such as cheap 360-degree cameras. There are myriad use cases for education and some interesting possibilities for research. These factors push this technology very close to an implement rating. However, the cost involved, the limited amount of high-quality educational content and the lack of widespread skills in universities and colleges make it difficult to recommend fully committing to investing in AR or VR just yet. We recommend identifying targeted and limited opportunities to embed AR and VR into education, starting with disciplines which teach practical skills or which need to practice responding to specific situations. These experiments can be used as case studies to assess a full roll-out of the technology. We also recommend dedicating time and effort to increasing staff knowledge and skills to ensure they are familiar with AR and VR, and confident using it.
6. Internet of Things

Overview

At its simplest, the Internet of Things (IoT) is about connecting a wider range of objects to the internet (https://ji.sc/wider_iot). Cisco estimates there could be as many as 50 billion devices connected to the internet by 2020 (https://ji.sc/50billion_devices). These devices could be sensors that collect information and then send it to the internet, devices that receive information and act on it and devices that can do both. These three categories cover a dizzying array of devices from learning environment sensors (http://rubble.heppell.net/learnometer) to meditation aids (https://chosemuse.io). This array makes IoT a huge concept that has applications in many industries (https://ji.sc/internet_of_everything). We are already seeing IoT impact our lives on a daily basis through examples such as fitness trackers and smart home systems but we are just at the start of innovation in this area. The Chinese government, in particular, has invested heavily in IoT and is expected to exceed the growth ambitions they set in 2010 (https://ji.sc/growth_ambitions) to reach a market worth $230 billion.

Relevance to research and education

The most obvious application for IoT in universities and colleges is in buildings and facilities management where significant savings can be made from more efficient maintenance (https://ji.sc/iot_to_save_money) and better use of space (https://ji.sc/better_use_of_space). But the promise of IoT extends far beyond a more efficient estate. At Jisc we have been exploring the possibilities for IoT in education and research as part of our intelligent campus project (https://ji.sc/intelligent_campus) and we have identified 23 different use cases (https://ji.sc/use_cases). The relevance of IoT does not stop at the campus boundary; developments in smart cities (https://ji.sc/smart_city_dev) are relevant to universities and colleges and there are a number of interesting examples of universities and councils (https://ji.sc/smart_city_examples) collaborating on IoT-driven smart city projects.

IoT also offers benefits for research (https://ji.sc/benefits_for_research). Researchers have been deploying remote sensor networks for decades and as IoT technology improves we can expect more research equipment to be connected to the internet (https://ji.sc/iot_in_the_lab). The principal benefit from connected equipment is the new opportunities it offers for data collection and new experiments (https://ji.sc/benefits_for_research) but there are ancillary benefits such as automated collection of environmental data during an experiment, more efficient maintenance and remote operation of equipment. However, institutions’ existing wireless networks may not reach all of the locations where people would like to use IoT devices, and the power requirements for wifi networking can be prohibitive for battery-powered embedded devices such as microcontrollers tracking chair occupancy or room environmentals. To fully exploit the potential of IoT, institutions may find they need to explore low power wireless technologies such as LoRaWAN (https://ji.sc/intelligent_campus_data).

IoT technologies offer the ability to track and monitor people, sometimes anonymously, sometimes in a way that allows individuals to be identified. In both cases there are serious ethical issues to be considered to ensure students and staff are comfortable with how the technology is being used. Some universities have already experienced backlash around the use of desk occupancy monitors (https://ji.sc/desk_occupancy).
Horizons group rating

Implement

Many universities and colleges are already engaged in Internet of Things initiatives, particularly when planning new buildings or refurbishments, and libraries have made use of RFID tags for years. However, the full promise will only start to be realised when isolated IoT experiments begin to be joined up into a coherent whole, so that data from a wide range of sensors and software can be analysed together to grant deeper insights and offer compelling new experiences to students and staff. This is not an easy task; it requires a detailed strategy, engagement of many stakeholders, a sophisticated approach to managing data and a thorough consideration of ethical issues involved in monitoring and tracking students. However, the efficiency savings and improvements in student and staff experience appear to warrant investing in an institution-wide approach to IoT as long as consent and privacy are addressed transparently to ensure students and staff trust that their data is being used appropriately.
7. Robotics

Overview

Much like AI, the term robot is used to refer to a range of specific technologies from basic automation all the way to intelligent, humanoid machines. There is some disagreement over the definition of the term robot but most definitions tend to agree that a robot is a physical manifestation of an artificial intelligence agent (wired.com/story/what-is-a-robot). We have covered AI in its own section so we will focus on the physical manifestation aspect in this section.

Relevance to research and education

Robots have three potential roles in education: tool, peer and tutor (https://ji.sc/tool_peer_tutor). Robots used as tools are uncontroversial. Robots are used throughout education (https://ji.sc/bbc_news_robots) as an engaging tool to teach students about robotics and related concepts like coding, or to stand in as proxies for humans (https://ji.sc/proxies_for_humans) in disciplines such as medicine. Robots can also be used as tools for education delivery and there are a few examples of telepresence robots being used to help people who find it difficult to attend education institutions (edudemic.com/robots-education-whats-coming).

There are some interesting examples of robots being used as peers in school education. For example, Kaspar the robot (herts.ac.uk/kaspar) helps children with autism spectrum disorder to improve their social skills, and some research has indicated that young children are happy to accept robots as part of their learning (https://ji.sc/robots_partof_learning). Examples of application in the later stages of education are harder to find. It is the role of robot as tutor that attracts the greatest scepticism (https://ji.sc/robots_in_classrooms) and it remains to be seen whether we will find robots taking over any teaching roles in the future.

For research, the situation is less ambiguous: robots are already being used to carry out research. Eve, the robot scientist at Cambridge, automatically develops hypotheses and carries out experiments to test them, and this year discovered that a compound found in toothpaste could be used to fight drug-resistant malaria (https://ji.sc/find_compounds). Companies such as Universal Robots (https://ji.sc/universal_robots) are promoting their services to research teams who are looking to use robots to augment their research, and start-ups such as Cytera Cellworks (https://cytera.bio) are exploring basic, affordable automation for labour-intensive research. For some disciplines such as engineering, the use of robots is already commonplace.

Future possibilities

It is difficult to predict the future for robots in education. Many articles that talk about robots taking over the classroom are primarily focused on AI rather than on any physical manifestation of AI and, while it seems clear that AI could have a significant impact on education, a substantive role for physical robots seems less likely (https://ji.sc/me_myself_and_ai).

Research is different. Science is likely to become increasingly reliant on robots if they become more affordable. While many of the special purpose devices used by STEM researchers could arguably be described as ‘robots’, they do not typically embody any facets of AI at present. Other disciplines may not rely on robots so much but there is likely to be an increase in research into how humanity and robots interact and the impact of robots on society.

Robots may be useful in the running of the campus. Some universities and tech companies have experimented with security robots (https://ji.sc/security_robots). The library is likely to be a place where robots could prove helpful (https://ji.sc/robot_librarian). Predictions of humans on campus being replaced by robots still seem unlikely, not least because of high profile failures (https://ji.sc/robot_failures).
Horizons group rating

Watch
While robots are very relevant to research and are already widely used in some disciplines, individual research teams are best placed to explore these possibilities in concert with funding organisations. It may be worth keeping an eye on the possibility of using robots on the campus or in teaching but we do not believe the technology promises enough value right now to justify widespread exploration. However, this may change quickly so opportunities for exploration are worth looking out for.
There are other emerging technologies that could have an impact on society. We considered the technologies below but decided that, for now, they should not be included in this report.

**3D printing**

3D printing is widely used in a range of research disciplines and is essential for the teaching of certain disciplines. However, it is hard to see how 3D printing will transform education and research. It seems far more likely that it will move from being a useful tool to an essential one for certain disciplines or subjects.

**Autonomous vehicles**

This area will undoubtedly have an impact on education, not least in the demand for training people to work in the autonomous vehicle industry and in retraining people whose jobs have been changed by autonomous vehicles. But this is not a technology we predict many institutional leaders and practitioners will need to work with directly.

**Biotechnology**

At the moment it is not clear whether this will have a significant impact on education and research apart from in the research disciplines studying it. One notable exception is DNA-based data storage (https://ji.sc/DNA_data_storage), invented in the UK by scientists at EMBL-EBI, which could enable the storage of vast amounts of data in just a few grams of bio-engineered genetic material.

**Nanotechnology**

It is not clear that nanotechnology will have a direct transformational impact on education and research although it may be instrumental in the development of other technologies that do directly impact education and research.

**Quantum computing**

Quantum computing could have a massive impact on research and on AI, which will in turn impact education, but our assessment is that it is too far in the future to review in this issue of the report. However, companies such as Amazon, IBM and Microsoft are working on quantum computing and the US government recently announced significant investment in developing quantum computing science and skills (https://ji.sc/quantum_computing_now). So this is likely to become an area that we need to cover in more depth in future issues of the Horizons report.
In-depth topic: The mental health and wellbeing challenge in FE and HE

The rise in mental health disorders is one of the greatest health challenges facing society today and it is one that is affecting the education sector particularly acutely, with a steep increase in the number of young people experiencing mental health difficulties.

These manifest across a broad continuum, from mild anxiety or discomfort that may be a natural response to a challenging event through to extreme mental illness. Mental health forms part of a more general wellbeing and resilience challenge that the education sector needs to address.
An overview of the challenge we face

In a 2015 survey (https://ji.sc/mental_health_survey) by the National Union of Students, 78% of students said they had experienced mental health issues in the last year and 33% said they had had suicidal thoughts.

In 2017 the Institute for Public Policy Research (IPPR) reported (https://ji.sc/not_by_degrees) that there had been a fivefold increase in the number of students who had disclosed a mental health condition to their college or university over the past decade. In the 2015/16 academic year, 15,395 UK first-year university students in Britain reported a mental health condition.

Student suicides have fluctuated (https://ji.sc/suicide_fluctuation) with a steady increase from 108 in 2001 to 134 in 2015 but a 15-year low in 2007 of 75 and 95 recorded suicides in 2017 (which is lower than for the general population of similar ages). The figures do not include suicides among learners at further education colleges.

The mental health of college and university staff is also coming under the spotlight due to increased workload, funding cuts in FE and the constant pressure to do more with less. As student numbers and expectations grow (including around mental health support), so do pressures on staff and the corresponding implications for their mental health and wellbeing. The extent of workplace bullying, harassment and intimidation is also emerging, especially in science research groups and institutes. A 2018 investigation by the Guardian revealed that nearly 300 academics across the UK, including senior professors and laboratory directors, had been reported for bullying in the last few years (https://ji.sc/bullying_reports).

Association of College (AoC) surveys (https://ji.sc/aoc_surveys) of colleges in 2014 and 2016 found that 66% said that the number of FE students experiencing mental health difficulties had ‘significantly increased’ in the past three years while 75% felt there were significant numbers of students who had undeclared mental health difficulties.
What might be causing it?

There are several possible reasons behind the current mental health challenge in further and higher education.

Changing demographics (https://ji.sc/changing_demographics) may be a factor, with more young people in education for longer. 64% of the university student population (and 83% of the undergraduate population) are between 16 and 24 years old, an age group that is particularly vulnerable to mental health issues, with 75% of mental health problems established by the age of 25. In addition, the number of young people from disadvantaged backgrounds in higher education has increased over the last five years. While mental health issues can affect people in all socio-economic groups, being from a more socially disadvantaged background is associated with a substantially higher risk of experiencing mental health challenges. This is particularly pertinent for further education, which educates two-thirds of 16-18 year olds and recruits disproportionately from disadvantaged areas.

Looking at the pipeline from schools into colleges and universities, increasing numbers of children and young people under the age of 19 are reporting mental health disorders. One in eight people aged under 19 in England have a mental health disorder, according to recent NHS statistics (https://ji.sc/nhs_statistics). Social and family context emerges as a clear risk factor, particularly parental mental illness, family separation or financial difficulties.

Once they have made the transition to higher education (which in itself can be disorientating and can cause students to slip through gaps in the health system), debt accumulation and financial concerns play a role, with 78% of students worrying about making ends meet and 46% saying that their mental health suffers as a result, according to a 2018 Student Money survey (https://ji.sc/student_money_survey). Money worries have an impact on their social life, with 68% saying that they can’t afford to go out, increasing the risk of isolation. It also affects students’ diet, with 50% saying that they do not eat as often, as much or as healthily as they would like. Juggling part-time jobs with study adds to the stress.

Life after university or college is also a source of anxiety, with 53% of undergraduates not confident about finding work after graduation.

The use of social media — which represents a significant new factor for this generation — is widely blamed anecdotally for increased feelings of inadequacy in the face of pressure to be seen to be popular and socially successful. It also comes with a loss of a sense of privacy. Certainly, according to the NHS statistics, 29.4% of those aged 11 to 19 with a disorder spent more than four hours a day on social media, whereas just 12% of those displaying no symptoms did the same thing. In addition, those who have a disorder were much more likely to compare themselves with others on social media and to say that “likes, comments and shares impact my mood”. However, more nuanced studies also look at the positive role (bbc.co.uk/news/uk-46115932) social media can play in offering support networks and reducing isolation.

Finally, students who may previously have been reluctant to talk about mental health problems, or access support in dealing with them, may now be more likely to do so due to greater awareness of the issue and reduced stigma in talking about mental health and wellbeing.
What impact is it having?

For the young people concerned, mental health issues are deeply distressing and impact every aspect of their life, from feelings of social isolation to academic failure.

The Unite Students Insight Report 2016 ([https://ji.sc/unite_students](https://ji.sc/unite_students)) found that nearly a third of students (29%) had sometimes considered leaving university, with 10% reporting that they had strongly considered doing so. In 2015, 2,050 students with mental health problems dropped out of university. As mentioned above, student suicide continues to be a concern.

For colleges and universities, there is increasing pressure on institutional counselling services and a need to place more resources into mental health support. IPPR research ([https://ji.sc/not_by_degrees](https://ji.sc/not_by_degrees)) found that over the past five years 94% of universities have experienced a sharp increase in the number of people trying to access support services, with some institutions noticing a threefold increase. At some universities, one in four students were using, or waiting to use, counselling services. In addition to the need to fund more support services, there are also financial and reputational implications ([https://ji.sc/reputational_implications](https://ji.sc/reputational_implications)) for institutions if support services are criticised as inadequate and increasing numbers of students drop out of courses.

For FE the financial pressure is particularly acute, with 43% reporting ([https://ji.sc/aoc_surveys](https://ji.sc/aoc_surveys)) no full-time counsellor in college and 55% reporting cutbacks in this area.
What is being done?

At a national policy level, UUK’s 2018 Minding our Future report (universitiesuk.ac.uk/minding-our-future) called for urgent action involving a partnership of national and local government, schools, colleges, the NHS and universities, to work together to “join up” mental health care services.

This follows its 2017 #StepChange framework (universitiesuk.ac.uk/stepchange), encouraging leaders across the higher education sector to take a whole university approach in response to student mental health. Its recent Suicide Safer Universities guidance (https://ji.sc/suicide_guidance) offers advice on developing a strategy focused specifically on suicide prevention.

Student Minds, the student mental health charity, has identified ‘10 grand challenges’ (https://ji.sc/grand_challenges) to highlight where efforts to improve the state of student mental health might be directed.

The AoC has a mental health policy group and has also created a package of resources including a college self-assessment tool which supports the development of a whole college strategy on mental health.

At a local, institutional level, colleges and universities have introduced their own initiatives to tackle the issue. For example, many universities now have mental health advisers who work collaboratively, within their academic departments, with students who have mental health issues. Wolverhampton University has trained 450 staff — including security guards, caretakers and cleaners who have regular out-of-hours contact with students — to recognise early warning signs in at-risk students and how to follow up in a compassionate way.

In FE, East Coast College has created a wellbeing programme focused on developing resilience, which is incorporated into all aspects of college life; staff wellbeing is also covered. Truro and Penwith College has introduced a wellbeing and sport service to reduce social anxiety and depression, including specific one-to-one sessions for safeguarding and mental health referrals.

Schools are also taking steps to support students’ overall mental health and wellbeing; one example is the use of specific technology in boarding schools (https://ji.sc/boarding_school_tech).
The government perspective

The government has acknowledged the mental health challenge in society and pledged to tackle it, including by putting mental health on an equal footing with physical health by 2020.

However, there remains “a gap between rhetoric and reality”, according to the Kingdom’s Fund (https://ji.sc/kingsfund), arguably partly attributable to funding gaps and the time-sapping demands of Brexit.

Recent developments include the launch of the first loneliness strategy (https://ji.sc/loneliness_strategy), led by then-sports minister Tracey Crouch. In February of this year, at the Office for Students launch conference, the then-universities minister Sam Gyimah described (https://ji.sc/accountability_revolution) the ‘challenge’ for universities as “to be there for students offering all the support they need to get the most from their time on campus”, particularly in the area of mental health. His use of the words “in loco parentis” in relation to universities was more controversial (https://ji.sc/loco_parentis).

On 7 March 2019 (University Mental health Day), the government announced a new taskforce to look at how students moving from sixth-form or college to university can be better supported in their crucial first year. Known as the Education Transitions Network, the group will include UCAS, the National Union of Students, Student Minds, Universities UK, the Association of Colleges and the Office for Students. It is tasked with developing measures to help students maintain good mental health.
What role can technology play?

Learning analytics

Big data and analytics is an area being seriously explored for its potential in tackling student disengagement. Identifying those at risk and enabling early intervention is crucial and, with the right metrics (https://ji.sc/student_minds), it becomes possible to identify patterns of disengagement. These may give early warning of mental health concerns, allowing timely responses. Jisc’s Learning Analytics Service went live in August 2018 and is now being rolled out to institutions. Student wellbeing and mental health is one of the research areas (https://ji.sc/la_research) that will be explicitly explored in the next phase of development. Some universities are already moving into that area. For example, Nottingham Trent University has a dashboard for staff and students that generates an alert after 14 days of lack of engagement, allowing tutors to follow up. The University of Greenwich is also expanding its learning analytics system to cover mental wellbeing.

“I see the technology as a human optimisation system, so the meaningful support people get ... comes from human beings. It’s that initial referral, realising that the people who need help are those who’re least likely to ask for it when they’re in a dark place, which the technology helps with.”

Phil Richards, chief innovation officer, Jisc

Apps and online mood diaries

Apps such as Calm Harm, online counselling (Kooth) and mood diaries (Blue Ice) are increasingly popular with young people seeking help with anxiety, depression and self-harm. Given that NHS England has endorsed (https://ji.sc/mental_health_endorse) a number of apps to help tackle mental ill-health, there may be potential for FE/HE-specific apps. Start-ups are moving into this area with keen interest.

Online support services

Big White Wall (https://ji.sc/big_white_wall), a 24/7 anonymous online peer support space overseen by qualified counsellors, is being used by an increasing number of institutions.

According to the head of student support at a Russell Group university:

“It’s been really interesting because students are using it in the evenings when our services don’t tend to be open and different sorts of students are using it. Specialist services tend to be accessed by white female students and you get more male students using the online space so it’s catering for a need out there - and [tackling] some of the stigma of saying out loud, as a 19-year-old fella, that you’re homesick.”

Chatbots

A handful of universities and colleges have started to explore AI-driven natural language text and voice — chatbots — as a communication channel with students. Examples include Becky (https://ji.sc/becky_the_bot) at Leeds Beckett University and Ada (aftabhussain.com/ada.html) at Bolton College. Could such uses of AI have a role to play in addressing student mental health challenges? Certainly, says Bolton College’s Aftab Hussain:

“Very early in the project we asked the college’s mental health team how the chatbot should respond if a student asked a question around their mental health. For example, if a student has been made homeless or is struggling with stress, or self-harm, the chatbot service will respond with links to appropriate online information and the contact details for the college’s mental health team. We are also improving the service so that our mental health unit is automatically notified when students are seeking further advice and support on these matters.”
What does the future hold?

It is clear that the mental health and wellbeing challenge facing universities is not going to diminish in the foreseeable future. Continuing societal and demographic changes are likely to increase the incidence of mental health disorders in young people while the increasing destigmatisation of the issues will open up more sophisticated conversations about the causes, and potential ways to alleviate, mental health distress. The following predictions offer an insight into how that conversation might unfold in the near future and the actions that might develop as a result.

Predictions: now to two years

Ever-increasing awareness and understanding of mental health and wellbeing
Students will arrive at university with better understanding of their own mental health and having experienced more personal development opportunities relating to mental health and resilience. This process has already started and will become more widespread. It will also increase students’ expectations of the support they will receive at university and their own role in that, including a greater level of agency. **Likely**

It’s not just about students
There will be wider recognition that a whole institution conversation about mental wellbeing is needed and that the mental health challenges faced by staff in increasingly time- and finance-pressured colleges and universities must also be recognised and addressed. **Likely**

Greater focus on transitions
Ways to ease the move from school or college into university will be examined, whether by taking a fresh look at overhauling the admissions system (https://ji.sc/overhaul_admissions) to bring in post-qualification admissions or better enabling of student communities to provide peer support at the start of term. Social media will also be more deliberately used in a positive way by institutions and students to provide enhanced peer support. **Likely**

Destigmatising the application process
Only 37% of those applying to university with pre-diagnosed mental health conditions disclose it in the UCAS process. The majority do not for fear it will jeopardise their application. More reassurance and destigmatisation will result in 100% UCAS disclosure. **Likely**

Greater flexibility
Courses will become more flexible and bite-sized to support students to learn in the way that suits them best, with multiple points of entry and more opportunities to take longer or take breaks in study. **Highly likely**

Data sharing
There will be increasing and better data sharing between different providers that touch on students’ lives, especially regarding health data. Universities may consider contracting private providers for mental health support, given pressures on the NHS. **Unlikely**

Apps and technology
A wider range of individual and personalised technological mental wellbeing support will be available as start-ups see the opportunities on offer in this field. **Highly likely**
Predictions: three to five years

Peer-to-peer support
As students become ever more aware of mental health issues, they will increasingly support each other in a more knowledgeable way as a student body, managed and tracked by institutions, rather than support always being provided through a top-down approach.
Likely

A pervasive, human-centred approach
The wellbeing of staff and students will become a fundamental value that must be considered in all the institution does. Every time a policy or system is designed, the mental health implications of it will be factored in, just as it currently is with disability, equality and other protected characteristics.
Likely

Systematic analytics
There will be an increasingly systematic approach to data sharing and to spotting changes in circumstances that feeds into an early alert or warning system.
Likely

Companion robots
Already trialled with children with autism spectrum disorder (ASD), robots will support students not only with personalised learning but also with social and emotional needs.
Possible

Predictions: 5 years+

Tracked from pre-school to post-grad
There will be a data flow from day one in school to university, with a significant number of data points around the individual educational journey of a student in order to identify outlier behaviour and raise a digital flag.
Possible

The rise of the neo-luddites
Young people will increasingly reject social media and absent themselves from technology due to its perceived negative impact on mental health.
Unlikely
What needs to happen to improve student wellbeing?

The Horizons group suggests a number of actions that can be taken as steps to address the mental health and wellbeing challenge, both now and further into the future.

• Offer schools and colleges better guidance in writing university references to ensure all relevant mental health information is included

• Provide more staff training and support around understanding mental distress and appropriate action to take

• Introduce or improve resilience education for all students, including learning how to learn, what a good work ethic looks like, reducing the stress of studying and avoiding the negative feedback loop of the glamour of the all-nighter

• Introduce mandatory on-enrolment modules on financial management and personal and life skills

• Extend equality, diversity and inclusion assessments of all policies and strategies to include mental health measures

• Improve metrics on mental health issues by incorporating the student voice in this area in a formalised way. This could be through broad focus groups of students on a quarterly basis and include a metric in the NSS or HEPI student survey

• Examine the potential for 24/7 support for mental health issues to match other 24/7 support services such as libraries

• Consider a Jisc Collections-style deal for self-help resources, enabling colleges and universities to better signpost, and make as accessible as possible, apps and other support

• Provide more guidance for mental health professionals and educators, and remove ambiguity around who can support young people with mental health issues, when and how

• Lobby government to facilitate ease of transfer between courses and institutions, and highlight where poor data flow has been a hindrance

• Explore a data trust approach (https://ji.sc/what_is_a_data_trust) for responsible sharing of relevant learner data and empowering students to manage their own data through a student data cooperative
Next steps

It is clear that the mental health and wellbeing challenge facing education is a complex problem. It will take time, a range of interventions and extensive collaboration to solve.

The extent of the problem shouldn’t deter us from acting; a problem as difficult as this will only be solved by many people taking action and exploring new ideas. Some of those actions and ideas can be taken individually by people working in universities and colleges but others require more coordinated action between a number of organisations or would benefit from a national approach.

The need for this coordinated approach has been recognised at a national level by the Office for Students, Higher Education Funding Council for Wales, the NHS and others, and many universities are responding to the need to provide an enhanced level of support for their students. Some key guidance has been published by UUK (https://ji.sc/some_key_guidance) to help universities with this and call them to action. There has also been a very high level of interest in the call for proposals, published by the Office for Students, to achieve a major step change in student mental health support; using analytics to support students will be a major element of this work.

At Jisc we will be working with organisations such as Universities UK and the Association of Colleges to continue to develop a joint vision for how we harness analytics to support mental health and wellbeing. As part of this, it is absolutely key that we continue the national conversation around mental health and wellbeing and we will be working with a range of partners to explore technology which could form part of the solution to the mental health challenge.

Specifically, Jisc will:

- As a result of the Horizons group meeting, convene co-design labs to explore two topics. A co-design lab is a short exploration of an idea carried out by a mixture of Jisc staff and experts from universities and colleges. Both labs will aim to develop some form of prototype output by June 2019. The topics we will explore are:
  
  a. A wellbeing data trust — can we use a data trust arrangement, like those being explored by the Open Data Institute, to enable a variety of organisations to share sensitive data related to student wellbeing? The data trust would need to be endorsed and trusted by students and focused on helping them rather than the organisations sharing the data
  
  b. A wellbeing bundle — can we produce a bundle of quality-assured resources that universities and colleges can purchase quickly and easily to enhance their wellbeing offer? The bundle would need to include e-books, wellbeing apps and services related to wellbeing
  
  • Work to extend our analytics code of practice (jisc.ac.uk/guides/code-of-practice-for-learning-analytics) to cover the legal and ethical issues involved in using analytics to support wellbeing services in universities and colleges
  
  • Identify and work with partners on multiple projects to develop the use of analytics to support the staff in institutions responsible for student wellbeing
  
  • Continue to explore wellbeing analytics through our learning analytics (jisc.ac.uk/learning-analytics) and analytics labs services (jisc.ac.uk/rd/projects/business-intelligence-project)
Next Horizons report

The Horizons group will reconvene in June 2019. We will refresh the information on the strategic challenges and the technologies as well as discussing a new in-depth topic. The next version of the Horizons report will follow that meeting and be released in autumn 2019.