

Clicks and mortarboards: how can higher education make the most of digital technology?

Geoff Mulgan and Reema Joshi

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Introduction: higher education and technology

This paper looks at the potential uses of digital technologies in higher education. It shows the extraordinary range of innovation taking place:

- Making content more freely available
- Transforming collaboration between students, for example through the use of AI
- Making assessment more systematic, and more real-time
- Making teaching more open and collective in nature
- Allowing learning to adapt to students' individual needs through adaptive tools

The paper examines which innovations are working and which ones aren't (but also asks why more isn't being done to find out, and why there is a dearth of serious analysis and measurement).

It suggests how these tools could evolve and suggests how the UK, and the EU, could improve their chances of getting the best from digital technologies and strengthening the global position of existing and new universities. It links to research now underway at Nesta (with Pearson) to map [future skills needs](#) and the mismatch with current educational provision. It builds on past papers looking at the lack of an [innovation system in higher education](#), and [challenge-driven universities](#).

For the UK higher education has become a hugely important source not just of knowledge, but also of jobs and wealth. Of the top ten universities worldwide, the UK accounts for four, and has sixteen in the top hundred, and has reason to care about ensuring it sustains its position through a period of potential transformation¹. In many cities, universities have become primary engines of regeneration.

But at every level of government, from cities, to regions and nations, to the UK as a whole, there is nothing resembling an industrial strategy for higher education, let alone a serious strategy for R&D to make the most of these emerging technologies. There are fantastic current examples of innovation – like Futurelearn, which now has over four million students – but these are succeeding despite, not because of, any broader strategy.

The UK has great strengths in digital and great strengths in higher education – but doesn't succeed so well in combining the two. History suggests that the big advances – like the creation of the Open University - depend on the combination of political will and bringing in outsiders, rather than depending on existing universities which have been better at incremental innovation.

One reason for the absence of radical innovation in recent years is the intense pressure that comes from current measurements on research and teaching,

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which seems to squeeze out future readiness. Policy has mainly focused on reforming funding models, and more recently, introducing inspections into teaching. Accountability frameworks – which are uniquely powerful and demanding in the UK – appear to have greatly reduced the scope for serious strategic innovation. The European Union also lacks any systematic approach to R&D despite having arguably invented the university (in Bologna and Paris) and providing the base for hundreds of famous universities.

Higher education is not an industry. But it is a major source of employment, earnings and opportunity. So the lack of serious support is a striking contrast with other industries, like aerospace, digital and genomics, which have had generous public subsidy; recognition that long-term investment pays off; and constant efforts to align law and regulation with innovation funding. Part of the reason is that when Higher Education does have the chance to lobby ministers universities generally argue for their own particular interests, or for greater freedoms in the present (eg on charging), rather than seeking support for future innovation.

Looking back in a few decades that may be seen as a serious failure of leadership and vision, both within HE and within government. The combined challenges of Brexit, declining numbers of overseas students (eg China) and new competition from online courses heighten the urgency of change. This paper suggests what needs to be done.

Background

Universities have long used emerging communications technologies to improve their work.

The radio was used to broadcast lectures even before 1920. The Open University, launched in the late 1960s, and its emulators in countries like India and China (the Indira Gandhi National Open University (IGNOU) and Open University of China) used television as well as radio and video to reach tens of millions of students.



The Open
University

More recently the arrival of the Internet has opened up many new ways to share content, to connect students and teachers, and to organise assessment.

The most visible recent innovations in digital higher education have mainly come from the US where large sums have been invested in [EdX](#), [Coursera](#), [Udacity](#) and other Massive Online Open Courses (MOOCs). Europe has a few examples of its own, of which the most successful has been [Futurelearn](#), set up in 2012 as an offshoot of the Open University.

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Evidence on what works is scarce – we simply don't know if universities have made as many mistakes as other parts of education, where heavy investment in [technology often had no effect on performance](#). But huge investments are being made; exciting new methods and tools are spreading fast; and few can be in any doubt that much of the work of universities will continue to be transformed.

Current trends in technology in Higher Education

In 2014/2015, 2.27 million students were taught in the UK higher education sectorⁱⁱ, a sector with income of some £33 billionⁱⁱⁱ. There are no figures on how much is spent on digital technology though it can't be much less than the £900m spent each year by schools^{iv}. Here we briefly outline some of the main technology trends and their implications.

MOOCs

MOOCs are online courses which are directed at unrestricted participation and open access via the web^v. The Open University was providing online courses from the 1990s, but the more recent US-based MOOCs mainly date to the late 2000s. MOOCs provide traditional course materials such as lectures, readings and problem sets, as well as interactive user forums for communication among students and professors.



Early US MOOCs came from the open educational resources movement, such as the 'Connectivism and Connective Knowledge' course, led by George Siemens of Athabasca University and Stephen Downes of the National Research Council^{vi}. The course had 25 students who paid tuition fees and over 2200 students online who paid nothing. Course content

was available through RSS feeds and online students were able to participate through collaborative tools, such as blog posts and threaded discussions. Other E-learning platforms include [Khan Academy](#) and [Peer-to-Peer University](#), which are similar to MOOCs and involve work outside the university and self-paced lessons.

MOOCs have grown rapidly since 2012. Many universities and more established online education providers such as Blackboard Inc decided to join in during the rise in 2012. There are several non-profit and for-profit providers. For-profit providers include [Coursera](#) and [Udacity](#), and non-profit providers include [Bill & Melinda Gates Foundation](#) and the [American Council on Education](#).

Several universities including Stanford, Harvard and MIT have invested in MOOCs, as well as companies such as Google and Pearson PLC.

The use and provision of MOOCs has grown immensely; with 18 million students, 1849 courses and 142 university partners in twenty countries, Coursera is the largest MOOC provider. Other major companies include Udacity which offers more than 120 courses, and edX. In addition, a range of courses have emerged; courses in psychology and philosophy are among Coursera's most popular, and student feedback and completion rates suggest that they are as successful as math and science courses^{vii}.

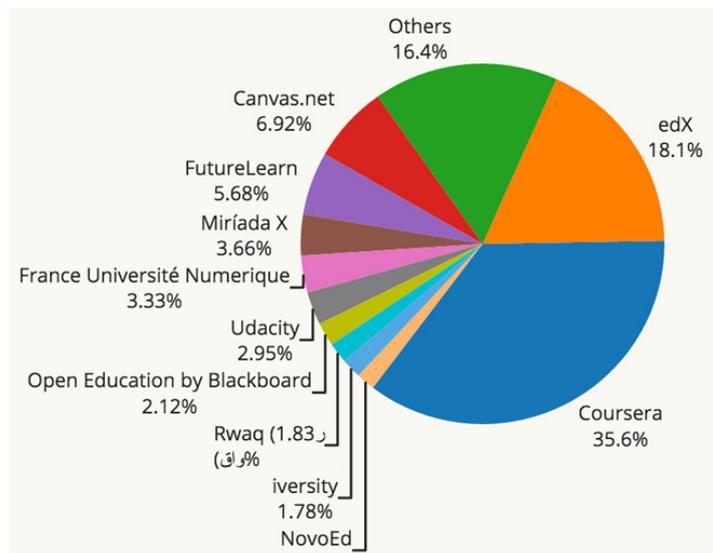


Figure 1 Provider market share by courses offered in 2015

MOOCs are seen as a substantial part of a disruptive innovation taking place in higher education, with both advantages and disadvantages. The MOOC guide^{viii} indicates five potential challenges: relying on user-generated content can create a chaotic learning environment, digital literacy is required, the time and effort required may be more than what students are prepared to commit, content will be reshaped and reinterpreted by the student body which makes the course trajectory difficult to control, and participants must self-regulate and set their own goals. Nonetheless, MOOCs have many advantages and benefits which may supersede the challenges; they are free or nearly free for students, they provide a solution to overcrowding in universities, they allow professors to create an archive and offer interesting business opportunities as several new companies, such as edX, Coursera and Udacity, have formed as a result of this technology.

As MOOCs have grown, two distinct types have evolved: ones that are similar to more traditional courses (xMOOCs) and others that emphasise collaboration (cMOOCs), and a greater emphasis on collaboration and peer support^{ix}.

MOOC Statistics

In 2015, there were 35 million students who signed up for at least one MOOC, a rapid increase from the 17 million students in 2014^x. Out of the number of students who have enrolled onto a course, completion rates have been found to approach 40 per cent, the current average completion rate for MOOCs is approximately 15 per cent^{xi}. Satisfaction rates appear to be quite high. In 2014, 91 per cent of students taking a MOOC offered by the University of London International Programmes rated them as "excellent", "very good" or "good"^{xii}. Survey data from Coursera showed that 26 per cent of students who completed

their courses reported that it helped them in finding a new job, and 43 per cent stated that it increased their candidacy for a new job^{xiii}.

FutureLearn students on the first eight courses found that 94 per cent would recommend the experience to a friend, and 87 per cent described their course as "very good" or "excellent"^{xiv}. The cost of developing MOOCs for FutureLearn has varied widely among some institutions. Loughborough University produced two courses for £10,000 each, whereas the University of Dundee allocated £130,000 to a programme that has produced one course. The University of Edinburgh, the first university in the UK to produce a MOOC, had three FutureLearn MOOCs come to a total of £150,000. The average cost per MOOC, based on information on 20 courses from nine institutions that provided both total costs including staffing and a definitive number of courses developed, was £29,356^{xv}.

MOOC Business Models

In terms of business models, three of the most frequently cited business motivations for offering MOOCs include^{xvi} (a) charging for certificates, (b) linking students with potential employers, and (c) charging for supplementary services. Analysis by Moody's Investors Service acknowledged several revenue opportunities for MOOCs^{xvii}: charging fees for certificates, courses, degrees, licensing, or advertisement; improved operating efficiencies due to lower cost of course delivery on a per student basis; increased global brand recognition and decreased geographic campus-based barriers to attracting students and staff; an enhanced residential campus experience for students at traditional universities; longer-term potential to create new networks of much larger scale across the sector, enabling more universities to specialise and reduce operating costs; and new competitive pressure on institutions that fail to align with growing high-reputation networks or find a niche.

Coursera has three revenue-generating strategies^{xviii}: 1) fee-based courses which require students to pay a fee to gain access to graded assignments, 2) specialisations, a sequence of courses with a Capstone project, and 3) Course certificates (formerly known as Signature Tract), which is Coursera's first significant revenue-generating strategy; students are required to pay a fee in exchange for the opportunity to earn a verified certificate. Recently, the name has changed to Course Certificate and requires a flat fee of \$49. Revenue estimates suggest Certificates generated between \$8 and \$12 million in 2014. Specialisations feature a sequence of courses where students apply the skills learned in order to gain a certificate, with fees ranging from \$300 to \$600. Participants on Capstone projects work on a topic set by companies that Coursera have entered into a partnership with, for example, to create a new app for Google as part of a 'Mobile Cloud Computing' specialisation, or to create a new social experience for Instagram under the 'Interaction Design' programme.

Coursera argues that the partnerships will benefit both course participants and partnering companies. There is the potential that firms may be interested in



hiring participants upon completion of their Capstone projects. In addition, partnering firms benefit from being part of a new movement to popularise new forms of qualifications and diplomas.

Coursera's strategies are similar to those offered at iVersity, a German MOOC provider. iVersity offer a Business Communication Programme which is targeted at working professionals looking to improve skills in business communication and marketing. Its regular price is \$1704 and an extended programme, which includes an expert training session, is \$2611. Udacity introduced Nanodegrees, which are similar to specialisations, and raised \$105 million. Udacity recently formed a partnership with AT&T, along with Georgia Tech, to offer a master's degree in computer science. Course materials at Udacity are free but students pay \$7000 in tuition fees. EdX's business model involves selling its MOOC technology to universities to create their own MOOC offerings and to make actually attending university more appealing, by enhancing existing teaching. It is evident that the major MOOCs are now finding ways to generate revenue.

SPOCs

Recently, several courses at Harvard have experimented with a simple solution to the disadvantages of MOOCs by scaling down, not up^{xix}. Known as SPOCs (Small Private Online Courses), they allow professors to engage fully with a targeted group of learners, who gain from a thorough and intimate course environment. By using technology to bring together lessons of campus education with the advantages of massive learning, SPOCs may be the most promising and relevant disruptive technology produced by the MOOC boom.

SPOCs involve using MOOC video lectures and additional online resources as course materials in real, normal-sized classes. Lectures are assigned as homework and actual class time is spent answering questions from students, understanding what they have learnt and have not learnt, and working with students on projects and assignments. Additionally, MOOC-style online assessments and automated grading features are used. SPOCs allow professors to adapt the curriculum, pace and grading system to their own and students' needs. This is similar to the flipped classroom approach used in schools.

Some of the results are encouraging. In 2012, edX formed a SPOC partnership with San Jose State University (SJSU). During SJSU's 2012 *EE98 Introduction to Circuits Analysis* course, SJSU Lecturer Khosrow Ghadiri used the *MITx 6.002x Circuits and Electronics* materials on the edX platform. Students were required to view the MITx video lectures and complete the problem sets at home. Class time was spent answering questions students had and working in groups to solve problems together. Findings showed that students were sceptical at first, but as the module progressed, they were found to consistently perform better than their peers in the non-flipped classroom. In the end, 91 per cent of students passed the course, a 36 per cent increase in the pass rate from the previous 7

years. It seems that SPOCs may hold more promise than MOOCs with regards to providing students with a well-rounded educational experience.

Learning Analytics

Another recent trend is learning analytics, which refers to measuring, collecting, analysing and reporting data about learners and their contexts, for the purpose of comprehending and enhancing learning and the environments in which learning takes place^{xx}. Nottingham Trent University (NTU) has implemented a learning analytics initiative^{xxi}. The University has had three main aims for the project: improving retention, improving the sense of belonging and engagement, and improving attainment. The practical application of learning analytics includes the use of the NTU student Dashboard, which integrates biographical data such as students' enrolment status and evidence of their engagement from door swipes, library loans, VLE use and assessment submissions. Student engagement is rated as high, good, satisfactory or low, and a student's week by week engagement rating compared with the cohort can also be viewed and commented on. For students who are at risk, alerts can be made.

The dashboard is being used across the institution and the majority of tutors are using it. A significant correlation between engagement and success has been found; a first year student with high engagement is three times more likely to progress to second year than a low engagement student. A student with high engagement in final year is twice as likely to achieve a good degree as students with low engagement. Tutors have reported having better information on students and tutor groups, which allows them to target interventions better. More than 25 per cent of students said the dashboard has changed their behaviour; increasing their attendance, taking out more books, accessing the VLE more and trying to improve their engagement ratings.

Assessment and Feedback Tools



Technology has also been applied to creating assessment and feedback tools for learners. One tool is known as GradeMark which allows instructors to grade students' written work and non-written work.

Comments can be added to papers, grammar and punctuation can be assessed, performance within a class can be assessed and a grade can be entered which is automatically saved into GradeBook. Student feedback to this tool is positive; students like the fact that comments are personalised and that they can compare their performance with the rest of the class.



Other tools include Nomoremarking.com which provides a free web tool for teachers to implement and run assessment of a variety of student work. [Digital Assess](#) offer a tool for student and peer formative assessment using comparative judgement, where two pieces of work are assessed side by side as opposed to against a set criteria. Evidence suggests that people are more competent at comparative judgement than judging against criteria.

Another tool is the Intelligent Assessment Technology (IAT) engine created by the Open University which is designed to deliver students instant feedback on constructed response items, help students monitor their progress and encourage communication with tutors. The feedback is tailored specifically and in detail to allow each student to improve their responses.

The importance of self-assessment is also recognised and there are tools to assist in this. An example is the [WebPA](#) tool developed at Loughborough University which gives students the opportunity to individually enter scores for themselves and their peers against prescribed assessment criteria.

The [Khan Academy](#), an E-learning platform, also provides assessment and feedback by delivering abundant data on learners' performance, including which videos they have watched, how much they have watched, and how their performance on various mathematics exercises have changed over time. Showing learners these metrics give them an opportunity to track their progress.

In addition to self-assessment and the assessment of individual students, tools can be used to monitor engagement and progress at the course level. Learning analytics allow instructors to identify at-risk students, measure student engagement and participation, and offer ways to see which activities seem to be producing the best results. Although this tool is very informative, there are questions remaining about what use students and instructors will make of this information. Another question concerns how much support will be provided to manage the intervention required for students identified as at risk.

A new test has been created to assess students' collaborative problem-solving abilities by [PISA](#). The new test involves 15-year-olds taking part in computer-based tasks which entail a chat function with computer-generated virtual collaborators to help solve problems^{xxii}. The measurement focuses on the way a student engages with others, instead of focusing only on the correct answer. Andreas Schleicher, the Division Head and coordinator of PISA, states that the results will be beneficial as employers are increasingly looking for teamwork and communication skills in addition to the usual maths, reading and science skills.

More recently, a new algorithm has been developed by researchers at Stanford University and Google in California which analyses students' performance on past practice problems, recognises where they tend to go wrong and creates a picture of students' complete knowledge^{xxiii}. This new algorithm is based on deep learning, where machines learn by digesting substantial amounts of data. More



than 1.4 million student answers to maths problems set on Khan Academy and the scores were fed to the system, and a neural network to sort questions by type was trained. Using this information, the system began to learn each student's abilities on each question type. The model was found to predict with 85 per cent accuracy whether a student would answer a new exercise correctly or not by looking at other questions the student had already answered. This algorithm is an important advance because it didn't need human input to annotate training data or create models of expertise. The researchers want to create a model that can predict what a student will get wrong and also understand why. The application of such a system, which assesses students while they learn, could reduce the need for the stop-and-test approach that characterises the majority of present assessments. Rather than traditional tests that explore small samples of what a student has been taught, assessments driven by AI would be incorporated into learning activities and would assess all of the learning and teaching that takes place, as it happens.

Platforms for Collaboration

With the rise in technology, there has been an increase in the development of platforms that enable collaboration and communication for both teachers and students. Software companies are creating user-friendly applications that are an asset to business and educational settings. The first-generation Web tools, such as email, chat rooms and discussion boards have been useful, but it is the second-generation Web tools, such as blogs, wikis, and podcasts, and applications such as Imeem, Writeboard and Instacoll, that have been extremely beneficial^{xxiv}.

Teachers and students use blogs, which are collections of writings, to enhance the learning experience. Information can be shared amongst readers and writers, and comments can be made to communicate. The broadcasting of audio or video files over a podcast allows distance educators to deliver instruction and students to engage in learning. Although podcasting does not allow direct communication, it provides students with information that helps them feel connected to the learning community. Students can also create their own podcasts and share them with classmates. Another tool is wikis. A wiki is a collection of Web pages that are linked and reflect the collaborative works of many authors. As authors collaborate on a project, edits are recorded and logged and changes are finalised when others approve. An example of the use of a wiki in education was documented at Bowdoin College (USA) where students initiated their own collaborative wiki to share their love of romantic literature and poetry. In addition, the "collaborative icebreaker" wiki at Deakin University was created to promote student interaction, allowing students to socialise and get acquainted virtually.

Other technologies such as Imeem, InstaColl and Writeboard encourage real-time collaboration between learners. The Imeem social networking software provides invitation-only secure and encrypted access where instructors can form



a private network and invite students. Members can create blogs, photo albums, instant messaging, file sharing and discussion groups. [InstaColl](#) supports collaboration using Microsoft Office applications. Participants can edit documents, presentations, conduct live meetings or chats, with each participant assigned a colour to identify individual edits. Writeboard combines wiki and blogging as it allows archiving each revised version. These emerging technology tools make it much easier for students to interact in distance education, and for instructors to see exactly who has contributed what on group written products.

Recently, AI techniques have been investigated for their contribution to collaborative learning^{xxv}. One approach, 'adaptive group formation', uses AI techniques and information about individual students to create a group best suited for a specific collaborative task. It could bring together students with similar cognitive abilities and interests, or students with but complementary knowledge and skills. Another approach uses intelligent virtual agents as part of the collaborative process to mediate online student interaction or contribute to dialogues by behaving as an expert participant, an artificial student who can introduce novel ideas or an artificial student that makes deliberate mistakes or provides alternative points of views that participants may be required to teach.

An important role is already being played by platforms for collaboration and communication between educators. [TES](#), long the leading newspaper for teachers, is now also a platform for teachers and the world's largest online community of teachers which helps to support, guide and inspire educators around the world by helping them to find the tools and technology they need to excel. A dynamic global marketplace is hosted where teaching materials can be discovered, shared and sold. [Blendspace](#) is a lesson-building product where the resources hosted on the global marketplace can be integrated and implemented, and [Wikispaces](#), an open classroom-management platform supports communication and collaboration between students and teachers.

Today's learner requires educational opportunities not constrained by time or place, yet allow interaction with instructors and peers. Many tools, such as those discussed, enable interaction and collaboration, fostering a sense of connectedness between the members of a group. Research on these technologies in educational settings is limited, yet research that exists demonstrates their usefulness and versatility.

Technology-enabled learning

The University of Leeds has several IT systems to support student learning^{xxvi}. The university's strategy is to promote the use of technology to enhance face to face teaching and to support student learning. Both a blended learning strategy and a digital strategy are used. Blended learning approaches have been applied to all stages of learning and teaching, including curriculum design, delivery and assessment. The blended learning strategy involves the use of event capture systems in central teaching spaces, multimedia management systems , video-



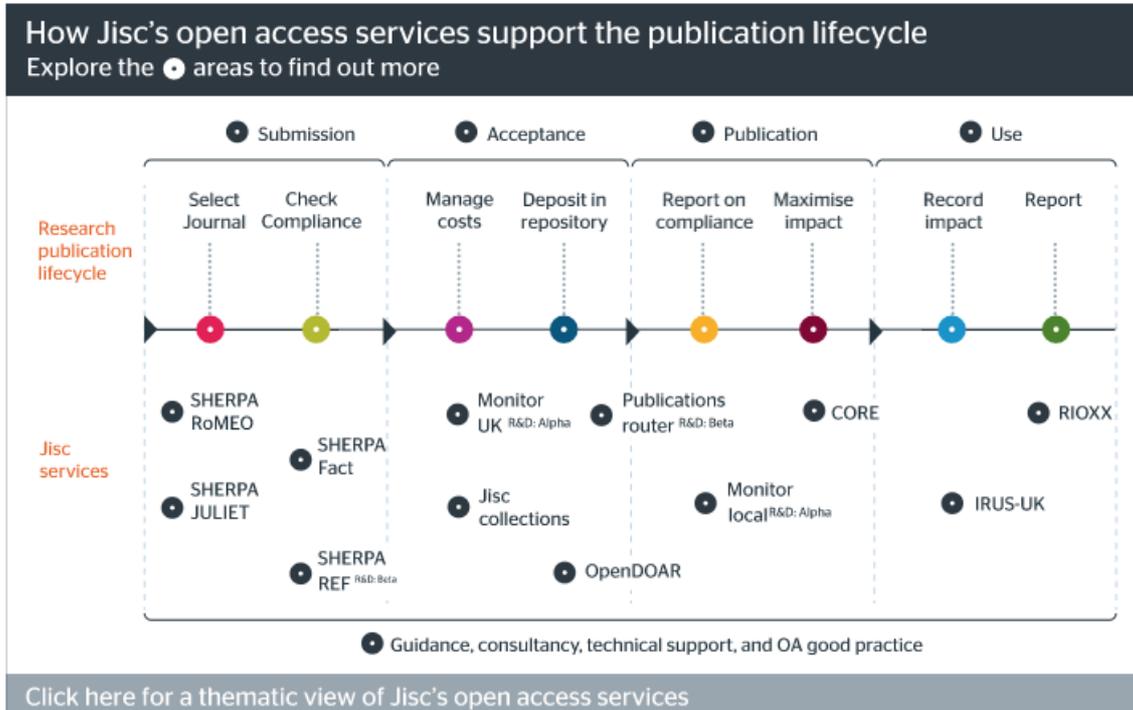
conferencing and interactive classroom facilities for collaboration, external digital learning channels such as iTunesU, and computing facilities and software packages. The digital strategy entails investing in institution-wide digital technologies and services for student education, and in infrastructure which allows use of mobile devices to access internet based services, and training for staff and students to help them make the most effective use of digital tools and services.

The university also encourages the use of and publication of Open Educational Resources, and has been offering MOOCs in partnership with FutureLearn as part of its commitment to technology-enhanced learning and openness.

Other technology-enabled learning involves the use of patient simulator training facilities used by health professionals. A Simulation and Interactive Learning (SaIL) Centre has been built at St Thomas' Hospital which hosts a mock GP consulting room, a six-bay ward/clinical skills training space, an operating theatre/two-bay intensive care unit ward, a home environment and a surgical simulation room^{xxvii}. Sophisticated life-size manikins, known as human patient simulators, are used to train healthcare professionals in the non-technical skills associated with patient safety, such as leadership, teamwork, communication etc. The human patient simulators are able to breathe, talk, respond to drugs, and have measurable blood pressure and pulse rates. The centre allows users to be put into real-life situations, including intensive care and resuscitation, and also practice their roles, and reflect on how they deal with emergency situations by viewing videos of their scenarios. This innovative advance in training has been found to enhance patient safety, improve patient management skills and allow users to practise dealing with errors.

Open Access for Journals

Jisc was set up as a shared infrastructure to help UK universities, providing broadband access and a range of other services, including ones aimed at supporting open access. These enable the automation of workflows, compliance, sharing of good practice, benchmarking and influencing third parties such as publishers and funders, to simplify the transition to open access. Agreements have been reached with several publishers to develop offset models to reduce the cost faced by higher education institutions in maintaining subscriptions to hybrid journals whilst also paying article processing charges for open access publication. Jisc's open access services support the full publication lifecycle from journal selection to publication and use^{xxviii}.



Emergent models

Some growing technologies in education include adaptive learning, crowd teaching and the application of blockchain.

Adaptive learning

Adaptive learning is a computer-based or online educational system that modifies the presentation of material in response to performance^{xxix}. Systems capture data and use learning analytics to enable tailoring of responses. Instructional content and methods are customised to students to enable learning and the mastering of new concepts. It is able to track progress as it teaches and adjust its instruction accordingly. Adaptive learning brings together features from computer science, education, psychology and brain science.

These systems attempt to transform the learner from being a passive receptor of information to being a collaborator in the educational process. Adaptive learning systems are primarily utilised in education but also in business training. They exist as desktop computer applications, web applications, and are at present being introduced into overall curricula.

Adaptive learning systems began gaining popularity in the 1970s. Then the main barrier of application was the cost and the size of the computers, which made application impractical. In addition, another challenge was that the user interfaces were crude.

These barriers have been largely overcome and more recently, adaptive learning systems have been implemented on the internet for use in distance learning and group collaboration. The most recent distance learning systems account for students' answers and familiarise themselves to the students' cognitive abilities

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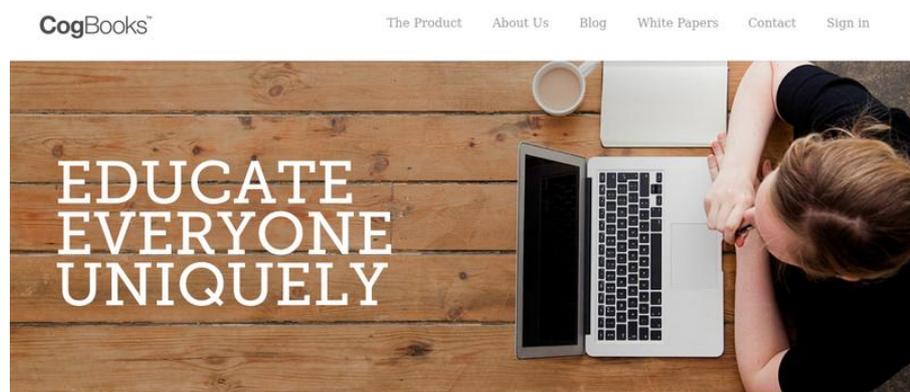
using a concept called Cognitive Scaffolding, which refers to the ability of an automated learning system to create a cognitive path of assessment from lowest to highest based on demonstrated cognitive abilities. An example of an implementation is the Maple engine of [WebLearn](#) by RMIT University, which has the capability to assess answers to questions that have no single answer^{xxx}. Adaptive learning systems are also used to support group collaboration in distance learning environments, where they can automatically categorise users with the same interests and personalise links to information sources based on the user's interests and surfing habits.

Adaptive learning systems allow students to work at different paces and use resources when educators aren't available. In addition, educators have access to students' performance and progress, allowing them to gain insight and alter their methods for each student.

An example of an adaptive learning system is [CogBooks](#), a cloud-based online learning system, which plugs into existing systems. The platform collects and interprets data on every learner

interaction, keeping the educator updated through real-time reports and dashboards, allowing educators to direct help to where it is needed.

To assess learner experience and efficacy of the platform, two courses were piloted in 2015 at Arizona State University^{xxxi}. An introductory biology course used a flipped classroom approach while a course in US history since 1865 was delivered completely online. An online student survey and focus group were conducted and performance results were compared. It was found that over 80 per cent of students wanted [CogBooks](#) to be used in other modules they were studying. Students in the focus group indicated that [CogBooks](#) would be useful across a range of subjects. The majority of students were extremely satisfied with [CogBooks](#) and confirmed that it was an easy and effective way to study, indicating that there may be a place for the use of [CogBooks](#) and other adaptive learning systems across other fields in higher education.



Our advanced adaptive learning personalizes to each individual and enhances the interaction between instructors and students. The CogBooks platform plugs into your existing systems to deliver an instant upgrade to your online learning.

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Crowdteaching

Another technological development in higher education is crowdteaching: educators working together to create, share and adapt curricula and classroom activities online, using their peers' work to serve the needs of students^{xxxii}.

A good example is the #Phonar (photography and narrative) course run by Jonathan Worth and Matt Johnston. #Phonar is a free, online undergraduate curriculum which is entirely open. In addition to 28 attending students, thousands of students join in via the internet from around the



world. The class' RSS feeds hosting audio-recorded lectures, class assignments and discussions attracts over 10000 visitors from 1632 cities in 107 countries. The class gives access to famous and talented photographers, and students benefit from the input of internationally acclaimed critics, directors and designers. Using the hashtag #PhonarEd, instructors can share experiences, and students can share notes with others from all over the world, enabling individuals to partake in open collaboration. Attending this course then helps students find work with famous photographers.

Blockchain

The technology which underpins the bitcoin digital currency, blockchain, has potential applications in higher education. A blockchain is a data structure that enables the creation of a digital ledger of transactions and the sharing of it among a distributed network of computers^{xxxiii}. Cryptography is used to allow each network participant to manipulate the ledger securely without needing a central authority. Once information is entered, it cannot be erased, and it can only be changed once there is a shared consensus among all participants.

Sony is planning to develop an educational assessment and testing platform powered by blockchain technology^{xxxiv}. The Sony Global Education division has developed technology that uses the blockchain to store educational data that can be shared securely with other services and third parties, acting as a central system for candidates and their test results, similar to a universal education ID. Sony sees potential for its platform in attracting educational institutions to add more to this concept. Having educational institutions participate would mean that school records could be accessible to third parties when applying for jobs or further education.

Holberton School in San Francisco has used blockchain to authenticate degrees, allowing employers a simpler method of verifying candidates' credentials^{xxxv}. By



offering academic certificates for graduates that are secure and publicly accessible through the blockchain, employers can verify credentials and graduates have clear proof about where they attended and what qualifications they gained. The aim is to discourage counterfeit academic certificates and lying on CVs.

The Textbook and Open Educational Resources

Another trend at the moment is associated with the textbook. At present, the textbook appears to be undergoing evolution; its traditional form as a book is disappearing. This is due to the decline in the purchase of textbooks, which is driven by their increasing costs. The nominal price of textbooks has increased more than fifteenfold since 1970, three times the rate of inflation, according to the Bureau of Labour Statistics^{xxxvi}. This has led to students and instructors to find alternatives. The ECAR 2013 student study found that 71 per cent of students used Open Educational Resources (OER) in 2013, a 46 per cent increase from 2010, and that 54 per cent of students said that open resources are extremely important^{xxxvii}. Furthermore, the growing amount of additional content relevant to education, for example, iTunes U and MOOCs, enables students to avoid buying textbooks and instead search for basic explanations of content from these open resources.

There also exist initiatives that enable students to create their own custom course content, mainly from OER. A company known as [Boundless](#) mimics the contents' table of a textbook and supplies OER alternatives for each chapter of the book. A [Pearson project](#) uses a specifically designed search engine, known as [Gooru](#), to allow anyone to find an appropriate OER.

These trends seem to suggest that the classic higher education textbook will one day vanish and be replaced by a range of resources, the most significant being the OER. This is established by the fact that textbook publishers, such as [Pearson](#), are shifting from the supply of educational materials to the provision of education services, such as testing, assessment, student information systems, and course management platforms. [Pearson](#) has also begun offering adaptive learning tools for various subjects, mostly in the sciences.

Conclusion

This overview provides a sense of how much is happening, and on how many fronts. So what more needs to be done?

There can be little doubt that digital technologies will continue to transform every aspect of higher education, from research and teaching to assessment. Predictions that the traditional university would be replaced wholesale have proven unfounded. But it would be surprising if much of the daily life of universities did not change profoundly.

As indicated at the beginning of this paper it's surprising that there are so few programmes of R&D and experimentation in higher education, particularly for

countries like the UK or Australia where HE is a very major industry, a major employer and source of export earnings.

There are several possible explanations. One is that the educational background of decision-makers may make them less interested in tools for reaching a mass audience. The very top universities have privileged access to political and official decision-makers, and have usually succeeded in protecting their interests (for example, ensuring a very heavy concentration of research funding).

Another factor may be that when universities get the chance to lobby governments these topics fall far down their list – they want better treatment for what they do now, not alternatives that will bear fruit in 20 years. They certainly do not want to encourage newcomers to disrupt things. Paradoxically, the problem was probably not helped by having both innovation and universities in the same department. The now restructured Department for Business, Innovation & Skills had strategies for other sectors but not for the one it was directly responsible for.

In Europe the partial explanation for the lack of support for digital experiments around higher education is that the European Union has no competence on education, and therefore no authority to promote change.

So what could be done? We advocate five main priorities for the UK as a whole.

Experiment

The first is more deliberate support for innovation and experiment. We need more conscious testing of different options – for teaching, research, assessment and collaboration, ideally set up in ways that allow conclusions to be drawn. These should push forwards the models described in this paper, testing out alternative variants. The [Innovation Growth Lab](#) provides a good model – pooling resources from many sources to fund rigorous experiments. Some should also focus on emerging technologies such as distributed ledgers.

Evidence

The second is more serious attention to evidence. Higher education needs better shared information about what works and why. No institution is playing this role at the moment, which is why it's hard to judge which of the many experiments described in this paper is working. In particular we need better understanding of hybrids of on and offline; how social interaction aids learning; how much adaptive tools can accelerate genuine understanding. This is one of many reasons why some kind of 'what works' capacity is so vital in HE. Primary and secondary education, and early years, are now both well served (by the EEF and EIF respectively). No institution takes responsibility for synthesising learning about HE and making it widely available, and universities have made no attempts to lobby for such an institution, perhaps because they are nervous about what it might uncover.



Investment

The third is encouraging investment. A lot of investment is going into educational technology, but there is a disconnect between the startups and scaling digital firms and the universities on their doorstep. Nesta invests in several edtech firms, including some which work in higher education: Cogbooks with adaptive learning; Third Space Learning; Digital Assess. But we see no serious attention to issues such as procurement that would make it easier for new firms to thrive.

Flagships

The fourth is backing flagships. Governments are wary of national champions and flagship initiatives. But the UK has done very well by backing a small number of public initiatives that concentrate talent. The BBC is one, and is of course a very major player in education. The Open University is another, and was one Prime Minister's proudest achievement. The British Council is a third institution that reaches very large numbers through providing educational services. There is now rather less of that confidence. A glaring example of both the potential and the problem is [Futurelearn](#). This is a highly successful project that is now working with over 60 universities, reaching millions of students and developing models that are in some respects superior to any others around the world. But it has few champions, and little visibility amongst the London elite. In this respect it mirrors the experience 15 years ago of [LearnDirect](#), which became the world's second most used educational institution, with strong levels of satisfaction, but again little visibility to decision-makers, and in the end it was privatised.

Fifth and finally we need **leadership**: leaders within higher education with the courage to make a forward looking case to the wider public and to government.

The UK now risks sitting on its laurels. Its universities are doing very well with today's tools and services. But as so many UK industries learned in the past, that's never enough. A more strategic and forward-looking stance is overdue, whether at the level of the UK, of individual countries or city regions – like London and Manchester – where universities play a particularly large role in the economy.

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info@nesta.org.uk [@nesta_uk](https://twitter.com/nesta_uk) www.facebook.com/nesta.uk www.nesta.org.uk

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November 2016