University and College Union
Scotland

The Automatic University

A review of datafication and automation in higher education

UNIVERSITY AND COLLEGE UNION

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Foreword

The University and College Union (UCU) is the largest trade union in the post-16 education sector in the UK, representing over 125,000 academic and related members across the UK, and is the largest union in the higher education sector in Scotland.

As the response to the 2020 Covid-19 crisis and rush to online learning shows, increasing use of technology in the education process is promoted by institutions and by policy makers as being largely if not wholly positive. Anyone seeking to offer a counter view or question the trajectory risks being labelled Luddite or accused of standing in the way of progress.

Beyond the obvious examples driven by the 2020 crisis, the full impact of wider automation and learning technologies is becoming increasingly common and visible to workers in universities in Scotland and elsewhere. From the very obvious daily experience for staff of being asked to record lectures so that they are available to students, automation in university libraries, through to plagiarism detection, there are obvious and easily understood impacts on university workers in their day to day lives. It is the case too that there are less immediately obvious areas of impact, and that they are becoming increasingly prevalent but that they are not commonly recognised. Nor is the impact on students. From the use of data analytics, machine learning algorithms, and artificial intelligence to automated digital technologies; the impact of automation in higher education is wide ranging and touches on almost every aspect of university life.

Many areas of automation will indeed be positive but there are others that need to be treated with caution. Do students appreciate the impact of aspects of learning analytics, including who holds data on them and what decisions are made about them and by whom? There are also concerns about the increased number of private, global companies seeking profit and data harvesting from universities, potentially impacting on the nature of universities themselves and their purpose. Universities are not commercial entities and their focus should always be on delivering a public good through education and research foremost rather than an enabler for private sector profit.

In early 2019 UCU decided to review the extent and impact of automation in the higher education sector and to seek to begin to draw together a set of recommendations for trade unions and like-minded bodies. We commissioned the research which comprises the bulk of this report from Dr Ben Williamson from the Centre for Research in Digital Education at the University of Edinburgh, and who has written and researched extensively on the issue. We asked him to review the current reach of automation into higher education and begin to consider what an appropriate response might be. The nature of automation is such that it is constantly evolving and much of what this report details will be outdated in the not too distant future.

Indeed, while this report looked at the role of automation on universities the Covid-19 crisis, that erupted after this report was first drafted, has highlighted the significance of

remote working and the phenomena of 'Working From Home' in the automated university. Most starkly the gendered nature of this development with predominantly women trying both to maintain work activities whilst retaining primary responsibilities as carers brings equality issues to the fore in any discussion around technology and the university. It is important that trade unions representing workers on our campuses and other interested groups are on top of what is occurring and are giving consideration to an appropriate approach. This report and accompanying recommendations seek to play a role in developing this thinking.

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1. Introduction: datafication, automation and higher education

Data analytics and machine learning algorithms, automated digital technologies and artificial intelligence are becoming increasingly common across higher education. From student recruitment and digital learning through to graduate employment, technologies that can process data play a significant role across the sector. The process of 'datafication' means that many functions, practices and tasks of HE are being rendered 'machine-readable' as digital information. Added to that, datafication is ushering in increased automation, as the processing of digital information by advanced or 'smart' computational technologies, at high speed, great scope and fine-grained detail, makes it possible to automate tasks normally undertaken by humans.[1]

In some sectors, automated technologies are perceived as a significant potential threat to human labour. Although automated robotics have already transformed many technical production and manufacturing processes, it has been predicted that 'increasingly capable systems' will also begin to transform a wider range of occupations, including professions such as health, law, management and education.[2] The risk of widespread 'technological unemployment' among academic higher education professionals is significantly lower than in many other manual, administrative and service occupations.[3] Automated systems and artificial intelligence technologies powered by data analytics and machine learning may, however, bring significant changes to the working lives of academic educators, management, and professional service staff, as automation augments or encroaches into their labour, and their skills and expertise are redeployed to different kinds of tasks in years to come.

For the purposes of brevity, this review refers to 'automated systems' to cover a variety of different technologies that employ forms of datafication – algorithms, data analytics, machine learning or artificial intelligence – to fully or partly automate different functions of higher education. Algorithms are the underlying mathematical rules and mechanical sequences for transforming data inputs into outputs. In data analytics, algorithms are used to process, classify, sort, arrange, and translate data into well- organised information. Although data analytics requires highly sophisticated data practices undertaken by human professionals, as evidenced by the increased influence of 'data science' as a discipline and profession, many analytics processes are increasingly automated. Machine learning refers to computer programs that can learn and then adapt their behaviours automatically to better match the requirements of their task.[4]

As datasets have become bigger and more complex, machine learning is required to learn the algorithms for processing them automatically in order to turn the data into knowledge. Most machine learning requires the use of extensive 'example data' to 'train' the analytic algorithm, which can then search for, identify or infer any hidden patterns or models in data collected 'in the wild', and even make predictions based on those results. Insights from the data may even be 'actionable' where they highlight particular actions

to be taken to achieve specific desired outcomes. Different forms and techniques of machine learning underpin current interests in artificial intelligence. AI means the practical application of machine learning and in some cases, it can take action based on data for itself, automatically and autonomously of human oversight. The combined powers of algorithms, data analytics and machine learning have all fed into contemporary enthusiasms and concerns about automation. Algorithms, analytics and AI make automated systems possible, such as the return of web search results, driverless cars, large-scale text analysis, facial recognition and so on.[5]

These automated technologies have been implicated in a range of controversies in recent years, such as the threat of workplace automation, social media misinformation, online targeting, surveillance, algorithmic bias and discrimination, and widespread exploitation of personal data.[6] Algorithmic and automated systems are already making controversial decisions in the UK public sector, raising questions about how data analytics are being used to categorise citizens, allocate services, and predict behaviour automatically.[7] The technologies are not neutral but reflect the intentions of their originators and designers, which may include in-built assumptions, policy aims, business models, biases or imagined visions of the future.[8]

In the field of education, algorithms, analytics, AI and automation are now the focus for a lively body of research, both from a development and application perspective and from more cautious and critical angles. Automated, AI-based educational systems are also the subjects of considerable hype, market forecasting, and commercial marketing.[9] Academic groups have already begun to question the expansion of the 'data university' and to push for a restatement of the social, economic and political good of higher education as a public institution.[10]

This briefing paper provides a snapshot review of current developments in datafication and automation in higher education, outlining potential implications for workers in UK universities. The focus is on technologies that affect the teaching and learning functions of universities rather than research.[11] Many of the major developments in data analytics and AI in HE at the current time are focused on issues of measuring and improving learning, assessing and advancing educator performance, and evaluating and enhancing the overall 'student experience'. The review does not speculate on the loss or replacement of parts of the HE workforce, but rather on key changes brought by increasing datafication and automation in higher education.

2. The higher education policy and data environment

Growing interests in the use of digital data-processing technologies and automated systems are part of a longer recent history of HE policy which has seen the sector experience increasing performance comparison, competitive rankings, privatisation, and market-based reform. In practice, in many countries this means that the cost of HE has shifted from the state to the individual student or consumer; education has been redefined as a search for the highest income stream after graduation; scholarly research has been turned into an individualised form of competition (grant income, number of publications, publisher metrics); national and global competitions among universities have been instituted, often attached to funding incentives; and new managers and administrators have been recruited with enhanced powers to pursue competitive objectives, set targets and measure progress and outcomes.[12]

These changes have made practices and techniques of measurement and rating integral to the sector, as metrics and rankings have become a source of 'quantified control of the academy',[13] and institutions have become 'data universities' characterised by performance metrics, audit and evaluation procedures, and competitive market processes.[14] Rankings and metrics have become proxies for 'quality' in assessments of research and teaching, as well as indicators of 'student satisfaction', well-being, and the 'student experience', as HE has become increasingly focused on efficiencies, value-for-money ratings, target-setting, benchmarking and internal and external accountabilities.[15]

It is in this context of intensive measurement of HE that algorithmic forms of data analytics, automated systems, and even artificial intelligence based on machine learning have been put forward as technologies of sector-wide improvement and reform.[16] Across the UK HE sector widely, HE policy has become increasingly data-driven or even data-led over the last decade, assisted in part by buoyant projections by think tanks, consultancies and sector agencies.[17] Since the 2011 publication of the HE White Paper 'Students at the Heart of the System' and then the 2016 'Success as a Knowledge Economy', significant policies have been developed to ensure HE data are more publicly available and accessible, to link existing and new datasets, and to use data for purposes of regulation and accountability.[18] The Department for Education 2019 'edtech strategy', 'Realising the potential of technology in education', has firmly established governmental support for the education technology industry,[19] twinned with firm commitment to establishing and growing the market for online learning and artificial intelligence in education.[20] These policy ambitions have laid the foundations for an expansion of technologies of datafication and automation across HE in the UK.

The Office for Students (OfS), the new HE regulator in England, specifically has put data at the centre of its regulatory strategy, with the Higher Education Statistics Agency (HESA)—the official statistics body for the sector—as its 'Designated Data Body'.[21] The OfS 3-year data strategy published in 2018 emphasised its government mandate

to utilise performance data and comparative, real-time and historical analysis in order to accelerate data-led decision-making across the sector, with an emphasis on using data to achieve efficiency, success, effectiveness, impact, outcomes, actionable evidence, and continuous improvement.[22]

In Scotland, the Quality Assurance Agency (QAA) Scotland—the independent body that checks on HE standards and quality—has led an Enhancement Theme on 'Evidence for Enhancement' that includes a focus on big data, learning analytics and other forms of evidence. Emphasising 'the information (or evidence) used to identify, prioritise, evaluate and report' on student satisfaction, its priorities are:

- Optimising the use of existing evidence: supporting staff and students to use and interpret data and identifying data that will help the sector to understand its strengths and challenges better
- Student engagement: understanding and using the student voice, and considering concepts where there is no readily available data, such as student community, identity and belonging
- Student demographics, retention and attainment: using learning analytics to support student success, and supporting institutions to understand the links between changing demographics, retention, progression and attainment including the ways these are reported

The Evidence Enhancement program is unfolding collaboratively across all Scottish HE providers and is intended to result in sector-wide improvements in data use related to student satisfaction.[23]

Across the sector as a whole, HE policy faces two ways at once: towards a 'student-empowering' future where students and staff have enhanced access to data to make informed choices, before, during and at completion of their studies; and towards a 'metrics-powered' future where universities, processes, staff and students are intensively measured and compared in terms of quantifiable performance, improvement targets, benchmarks and outcomes. More mundanely, as HE becomes more focused on the demands and uses of data and digital materials, technologies such as 'robotic process automation' will become necessary to handle the huge administrative burden of storage and processing.[24]

A further context is the so-called 'unbundling' of the university into discrete components that can be outsourced to external suppliers for 'rebundling' as new services.[25] Unbundling the HE sector has opened up market opportunities for software outsourcing companies. The new 'HE data services solutions' industry includes 'business intelligence' and 'data dashboard' providers offering services to management centres, as well as multinational suppliers of digital learning, resources and library services, and far more.[26] Mass data collection in higher education has become a source of commercial advantage,

with potentially every activity of staff and students tracked and analysed in the search for efficiency, cost containment and improved outcomes.[27] These companies are now involved in the longstanding project of educational modernisation, albeit reconceived in specifically privatised and technologised terms, whereby HE institutions are being transformed into 'platform universities' that depend on commercial platform technologies for their everyday operations.[28]

The large and rapidly expanding market of commercial data services vendors and platform suppliers has amplified the uses of data in HE, while also increasing attention to the potential of even more advanced forms of data analytics, machine learning algorithms and artificial intelligence as sources of insight[29]. Data-enhanced policy is now being accomplished by external private vendors, as many of the key tasks of measuring the HE sector have been outsourced to the private sector. As such, unbundling and rebundling are key aspects of HE 'marketisation' – the process of making the sector look and behave more like a market – whereby private companies have developed strategies to penetrate the HE sector to establish markets for their products, and universities have become 'buyers' of their services.[30]

The combination of data-enhanced HE policy with commercial platform providers shifts control of the field of judgement from educators to data analysts, advanced administrators, vendors, and, in some cases, to automated systems that participate in decision-making. This represents a shift to 'automated management' where computational programs that are fuelled by data and driven by software take part in the organisation, arrangement and running of many tasks and systems, automatically and autonomously of human oversight.[31] In sum, three key trends lie behind the expansion of automated management in HE:

1) The empowerment of students as informed users of data and as recipients of data-enhanced improvements to teaching, learning and student experience.

2) The measurement of the sector at all levels, including quantified measures of teaching, learning, research, and student experience, for purposes of performance comparison, efficiency, regulation and accountability.

3) The commercialisation and marketisation of HE as services are outsourced to an expanding market of external technology suppliers and platform vendors.

The following sections review many practical instantiations of automated management in higher education, which together mark out an emerging shift from the 'data university' characterised by metrics and evaluations to the 'automatic university' of datafication and automation.

3. Large-scale data infrastructures

Large-scale data infrastructures are the networks of hardware technologies and software services that enable data to be collected, connected together into datasets, analysed, and then communicated and presented for consumption and use by different audiences.[32] Within HE, data infrastructures are the underlying systems necessary for the production of information and knowledge about the various functions of the sector. In the research environment, demands such as national research evaluation (the Research Excellence Framework) have made it important for universities to invest in sophisticated research management infrastructures. Pure, owned by the multinational publishing company Elsevier, for example, is a centralised system that automatically aggregates research information from internal and external databases. As a research data infrastructure, Pure is designed to enable organisations to identify research outputs, build reports, carry out performance assessments, manage researcher profiles, and coordinate networks for funding proposals in ways that are supported by automation.[33] Data infrastructures are also important in the collection and analysis of student data.

DATA FUTURES

National-level data infrastructure refers to systems that coordinate the flow of information from institutions across the country. The Higher Education Statistics Agency (HESA) is currently leading the 'Data Futures' program to deliver a new national data infrastructure for recording and reporting information about students in UK HE institutions.[34] Designated the official statistics and data body for HE since 1993, HESA compiles huge quantities of data about students, staff and institutions, departments, courses and finances, as well as performance indicators used to evaluate and compare providers. It maintains the data infrastructure for HE recording and reporting first established in its current form in 1994.[35] Data Futures is HESA's flagship data infrastructure upgrade program, which it initiated as part of its corporate strategy in 2016, in response to government demands, and plans to operationalise fully by 2020.

Funded with £7.5million from the HE funding councils, Data Futures is intended to enhance HE data quality, reduce duplication, and make data more useful and useable by members of the public, policymakers, providers, and the media. In the Data Futures infrastructure, HESA is positioned as a central 'data warehouse' for all HE data collection and access. Rather than once-a-year reporting, under Data Futures all HE providers will be required to conduct 'in-year' reporting during specified 'reference periods'. This will speed up the flow of data between institutions and HESA, and enable HESA to produce analyses and make them available to the public, media and policymakers more swiftly. It will also make individual-level data in the 'student record' much more available for up-to-date analysis and reporting.

DATA DASHBOARDS

At the core of Data Futures is a new 'data platform' for data collection, and new 'data dashboards' and visualisation technologies to analyse the data and communicate results. The data platform is being built by the software outsourcing company Civica Digital,

while data dashboard development to communicate findings from the data platform is being undertaken through a collaboration between HESA itself and Jisc (the HE digital learning agency) as part of their 'business intelligence shared service.'[36] This 'Analytics Labs' collaboration provides an agile data processing environment using 'advanced education data analytics' in order 'to rapidly produce analyses, visualisations and dashboards for a wide variety of stakeholders to aid with decision making.' It emphasises 'cutting-edge data manipulation and analysis,' access to current and historic data for time series analysis of the sector, and competitor benchmarking, using the Heidi Plus software platform provided by the commercial software supplier Tableau Server.[37]

As the Designated Data Body of the Office for Students in England, HESA's Data Futures and its dashboards will play a significant role in the measurement and comparison of institution performance. Already, HESA – together with Jisc and the QAA – release 'community dashboards' on Tableau Server for institutional performance comparison and benchmarking. One is the Provider Healthcheck incorporating metrics from the TEF and NSS as well as league table information, degree classifications, graduate employment data, learning enhancement and improvement scores, and other key performance indicators (KPIs). The Provider Healthcheck dashboards 'show KPIs for quality managers at any UK HE institution to demonstrate that academic standards are being maintained, and to identify any issues, at a glance, for further investigation'.[38]

HESA also signed an agreement with both The Guardian and The Times newspapers to use Heidi Plus to produce interactive HE dashboards of rankings and measures based on their league tables. This, claimed HESA, would 'enable universities to accurately and rapidly compare and analyse competitor information at provider and subject level, changes in rank year on year,' and 'the highest climbers and the biggest "fallers."' It also noted that the dissemination and presentation of league table data help shape public opinion about different providers.[39]

The data platform built by Civica, twinned with dashboards produced using Heidi Plus, are interfaces to the data infrastructure being built by HESA and accessible portals to comparative performance data. Together, these software platforms enable student data to be collected, analysed, visualised and circulated to the public, the press, providers themselves, and policymakers and politicians, and in so doing, to shape opinion and influence decision-making. By prioritising the visualisation of comparative performance information, data dashboards 'bring about a new "ambience of performance", whereby members of staff or the public become more attuned to how whatever is measured is performing'.[40]

BUILDING A DIGITAL HE SECTOR

New large-scale data infrastructure programs such as Data Futures will bring significant changes to the ways data about students are collected, analysed and used. Already, HEIs are recruiting for experts in data analytics to handle the new demands for data placed on the sector by such large-scale system changes, with implications for the work of professional and administrative services staff. These infrastructural changes also

open up the HE sector to further expansion of data systems and automated management. As the chief executive of HESA has argued, Data Futures establishes the foundations for a digital HE sector where universities would routinely use data drawn from many sources and devices to design and deliver their services, allocate resources, and monitor their performance; policymakers would be able to pool data from multiple sources for monitoring progress comparatively across the sector; and students and staff would be able to access real-time data on their own progress and feedback on how to improve.[41]

SUMMARY

- Large-scale HE data infrastructure programs such as Data Futures are making it possible to gather and analyse data about students and institutional performances in increasing detail and at faster speeds.

- Administrative and professional services capacity is being upgraded to cope with the new demands of very large data collections and analyses, with automated systems playing an increasing role in the production of HE intelligence.

- Data dashboards act as portals to the information that flow through data infrastructures, and attune their users to indicators of 'performance' and ranking by prioritising comparative data visualisations.

- Large-scale infrastructure projects such as Data Futures are laying the foundations for building a digital HE sector of data-driven universities operating within a smart, connected environment and at least partly organised through techniques of automated management.

4. Student recruitment and admissions

Pressures on universities to increase enrolment, expanding student numbers, and requirements such as widening access and participation have led to significant sector-wide activity around recruitment, enrolment and admissions.[42] Digital technology has come to play a major role in attracting and recruiting students, with data and analytics a key area of ongoing development.

MARKETING AUTOMATION

Automated marketing technologies are increasingly being developed and implemented for the recruitment of students. One example, SmartHub, includes automated chatbot communication technology to answer queries from prospective students with personalised messages, as well as automated lead management to prioritise prospects for follow-up.[43] Other services provide automated lead scoring, where automatically updated scores are assigned to certain activities and behaviours that indicate interest in application by prospective students, while some HE marketing automation software also includes social media management and monitoring tools allowing recruitment and marketing departments to create and schedule posts across sites like Facebook, Twitter, and Instagram.[44]

Along similar lines, The Universities and Colleges Admissions Service (UCAS) has developed and established a suite of data analytics-based services through its UCAS Media subsidiary. A marketing branch of UCAS that supports education providers in 'recruitment, brand-awareness and acquisition challenges', it also offers commercial brands and employers access to verified data on future customers and employees. UCAS Media claims it supports universities to 'Precision-plan smarter acquisition and recruitment activity with our data-led products and services', which include data-driven targeted communications, direct contact services, an application and decision tracker, data matching, competitor tracking, and, amongst many more, a service called STROBE that enables individual-level tracking of prospective students from application to acceptance.[45]

UCAS services such as STROBE indicate how aspects of datafication and marketing automation are already active in the processes through which prospective students are attracted to UK universities. This trend is likely to develop further as UK institutions fresh face pressures for both international and domestic recruitment.[46] The UK-based company Quacquarelli Symonds, for example, has created the product MoveIN to enable institutions to automate the management of prospects, online applications, and student recruitment.[47]

STUDENT RECRUITMENT SERVICES

New platform and app services have also been launched to support prospective candidates to make choices about providers and degree courses based on matching data from providers with students' data. In 2018 the Department for Education opened up the longitudinal educational outcomes dataset (LEO)[48] to software companies, enabling them to present longitudinal outcomes and career earnings data collected from graduates

as a way of shaping future students' application choices. Such automated systems work like dating apps, enabling students to 'swipe' and 'like' potential HE destinations that are presented to them based on their own past performance and profiles. When then Universities Minister Sam Gyimah announced the initiative he claimed the competition would allow tech companies to use graduate earnings data to 'create a MoneySuper-Market for students, giving them real power to make the right choice'. The prototypes awarded funding included a 'web-based compatibility checker' to assist applicants in making HE choices; a smartphone app using machine learning and AI techniques to recommend effective matches between potential applicants and courses, with users presented with projected possible earnings based on averages for particular courses; and a web service providing access to details such as which universities the student could choose based on their school exam grades, and how long it would take them to pay back their student loan based on a projected graduate salary.[49]

The official launch of the new web-based Discover Uni service in 2019 replaced UniStats as the authoritative UK-wide source of information and guidance for prospective students.[50] Discover Uni is jointly owned by the Office for Students, the Department for the Economy Northern Ireland, the Higher Education Funding Council for Wales and the Scottish Funding Council. Discover Uni links together and mobilises datasets including the HESA student record, student views from the National Student Survey (NSS) results, the Destinations of Leavers from Higher Education data (DLHE, now replaced by the Graduate Outcomes Survey), and LEO data on employment and earnings, as well as information on professional accreditations, the number of students who continue on the course and entry qualifications held by previous entrants, and links to detailed information on providers' course pages about course content and delivery, and fees and funding. The presentation of these data on Discover Uni is designed to inform applicants' selection of courses and institutions, based on the understanding that prospective students require improved guidance in making choices that might lead to better long-term outcomes.[51]

These choice-shaping apps and services introduce the idea that student choice can be influenced (or 'nudged') through the interactive presentation of data on apps, price-comparison websites, and social media-style services that indicate the quality of a provider's performance. With their enhanced focus on future income stream, they treat students as consumers, investing in HE with the expectation of ROI in the shape of graduate outcomes and earnings, thereby potentially pressuring institutions to focus on labour market outcomes as the main purpose of HE[52]. They also encourage prospective students to see and think about HE in primarily quantitative and evaluative terms, as represented in metrics and market-like performance rankings and ratings.

ALGORITHMIC ADMISSIONS

Significant claims are also being made about the potential of AI in computer-supported admissions systems and enrolment management practices at universities, especially in the US context. Automated AI-based solutions might be used in two ways: to further support prospective students in their choice of application, by helping to match them to courses and institutions, or by automatically sorting applications in the institutional admissions office.[53]

Algorithmic admissions systems may help to identify promising students and widen access for disadvantaged groups, but also run the risk of further entrenching disadvantage by automatically screening certain sociodemographic groups out of the admissions process at highly competitive institutions. An early experiment in algorithmic admissions at a medical school in London in the 1980s ended in controversy after it was found to unfairly discriminate against female applicants and applicants with 'non-European' names.[54] Persistent problems with AI bias ever since, even in cases where algorithms have been employed specifically to tackle disadvantage, continue to raise questions about the fairness of employing automated systems in high-stakes processes such as educational admissions processes.[55]

SUMMARY

- Student recruitment is increasingly approached through techniques of datafication and automation, with detailed data profiles of candidates matched to institutions and courses, and prospects being tracked and monitored throughout the admissions process.

- Degree choice apps and platforms prioritise educational outcomes data such as graduate employability and earnings as a key basis for decision-making by prospective students, and 'nudge' students to discriminate between institutions on the basis of comparative quantitative performance data rather than other qualitative merits.

- Algorithmic admissions systems are being developed to automate the process of student selection and recruitment, but are vulnerable to bias owing to discriminatory assumptions in the historical data used to train the algorithms.

5. Learning management systems

Learning management systems (LMS) provide the digital backbone to many university courses. An LMS (sometimes alternatively known as a Virtual Learning Environment, or VLE) enables institutions to manage administration, tracking, reporting and delivering of courses, lessons and tests. The global LMS market is estimated to grow to US$18-22billion by 2025, in what has become one of the most lucrative segments of the e-learning sector.[56]

Major LMS vendors with strong presence in HE in the UK include Moodle, Canvas, and Blackboard. These and other LMSs enable educators to create and deliver content, monitor student participation, and assess student performance within a single digital environment. LMSs also automatically collect data about the students using them. Because they are so widespread across HE globally, LMS providers have amassed some of the world's largest educational datasets. This has opened up opportunities for large-scale 'educational data mining' both by the commercial operators of the systems and by staff at participating institutions, as insights are sought from near real-time data aggregation and analysis.

EDUCATIONAL DATA MINING LMS DATA IN INSTITUTIONS

For educational data analysts based in institutions, LMS data can be analysed to provide intelligence for decision-making. An example is the use of LMS data to generate 'early warning' indicators of students at risk of dropping out or non-completion as a way of intervening to ensure improved retention. Early warning systems combine measures of performance, based on points earned on the course; effort and behaviour, as assessed by interaction with the LMS compared with other students; prior academic history, including previous course grades and school results; and other recorded student characteristics or background variables. Weighted together, these data are then processed by predictive algorithms to assess the probability of students being successful or struggling on a given course, thereby highlighting any additional need for assistance, feedback or intervention.[57]

A prominent example of the use of LMS data for early-warnings alerts in UK HE is the Nottingham Trent University Student Dashboard project, which measures students' engagement with their courses. Its engagement scores are calculated from LMS access as well as library usage, card swipes and assignment submissions, which NTU reports as being more accurate predictors of student success than background or demographic information. Working with the data analytics vendor Solutionpath and its proprietory analytics model since 2014, NTU has fully implemented the Student Dashboard across the entire university. When a low engagement score is calculated for a student, automated email message alerts are sent to tutors to initiate conversation as a first-stage intervention. Evaluation of the Student Dashboard by NTU has reported positive results in terms of retention and building relationships between staff and students.[58]

As these reports indicate, HE institutions are already locating positive value in the use of educational data mining and analytics to process and generate intelligence from learning management system data. The potential availability of tens of millions of data points means analysts can generate insights both into general usage and into individual engagement.

COMMERCIAL LMS DATA MINING

For commercial LMS providers the value of collecting huge quantities of student data is to develop new data-driven services which might assist further sales or other monetisation strategies. Having established long-term positions across the sector, LMS vendors have access to vast troves of historical and real-time data from institutions and individuals' uses, which they are actively utilising to develop new services, upgrades and add-ons.

One of the most widely used LMSs, Blackboard, recently launched its Blackboard Data service to provide customers with 'reporting stack' functionality to build visualised performance reports from their LMS data. Its Blackboard Learn service also offers granular analysis of the performance of courses, programs or even whole schools, provides feedback on 'evidence of what works', and includes 'student-facing dashboards' to enable students to access visualisations of their personal academic performance. Alongside these services, Blackboard Intelligence provides a 'complete student information system data warehouse' with reporting functionality to support enrolment management, retention, financial aid, strategic finance, human resources, and advancement decisions.[59]

Going further, the company Instructure, which provides the successful Canvas LMS, has recently revealed it has amassed a huge global database of student data that it may use to train machine learning algorithms in order to make automated recommendations for staff and students. The new Canvas add-on, with the working name Dig, is due for launch in 2020, with three key aims: to help customers identify and engage at-risk students; improve online instruction; and measure the impact of teaching with technology.[60] The chief executive of Instructure has claimed:

> *We have the most comprehensive database on the educational experience on the globe. So given that information that we have, no one else has those data assets at their fingertips to be able to develop those algorithms and predictive models. ... [W]e can take that information, correlate it across all sorts of universities, curricula, etc, and we can start making recommendations and suggestions to the student or instructor in how they can be more successful. ... Our DIG initiative, it is first and foremost a platform for ML and AI, and we will deliver and monetize it by offering different functional domains of predictive algorithms and insights. Maybe things like student success, retention, coaching and advising, career pathing, as well as a number of the other metrics that will help improve the value of an institution or connectivity across institutions.*[61]

Late in 2019, Instructure announced it had agreed an acquisition deal by the private equity firm Thoma Bravo for almost US$2billion, opening up opportunities for the company to further invest in the development of its Canvas LMS, produce new functionality, and engage in its own acquisitions as a private company.[62]

EMERGING LMS DEVELOPMENTS

The move of LMS companies towards enhance automation has already been anticipated in the commercial training and enterprise learning and development arena, where LMSs are being replaced by so-called Learning Experience Platforms (LXPs).[63] LXPs are marketed

as next-stage instantiations of LMSs, with a particular emphasis on being cloud-hosted and dedicated to 'personalised' learning experiences based on highly individualised learner profiling. The key feature of an LXP is that it is designed to automate the 'intelligent discovery' and 'recommendation' of relevant learning content. Whereas conventional LMSs are based on searchable course catalogues, an LXP is organised more like YouTube or Netflix as a content management platform with in-built recommendation technologies. Rather than hosting all its content within the LMS, an LXP can access learning materials wherever they are available on the web.

An LXP also collects continuous data from learners' behaviour, learning and performance, as well as linking with existing employer datasets, making it possible to track how learning influences employee performance, and to predict what each learner needs based on patterns identified in the data. Automated recommendations can be based on skills profiles, where individuals users are recommended learning content based on skills assessments, skills inferences, and skills-based learning paths; on popular usage of particular content (this follows the logic of Google search or Facebook newsfeed); or on AI-based content analysis. In this last category, AI is said to be able to read or 'ingest' content, automatically figure out what it is trying to teach through 'pedagogical analysis', and then 'create' bespoke content, learning resources and assessments based on 'hyper-personalised' profiling of the user's further learning and development needs.[64]

Although LXPs at present remain confined to the enterprise learning sector, these examples indicate that the next stage in LMS design is toward further automation through predictive algorithms, individualised student profiling, and personalised curriculum, coaching and other advisory functions. The LMS has expanded its functionality from reporting of student engagement to be the dominant source of institutional analysis and intelligence. As LMS providers begin to mobilise techniques of machine learning to enable systems to 'learn' about their users and adapt to them, LMSs have the potential to become a far more automated management technology that may be involved in decisions about programs and courses, as well as curriculum development, teaching, and personalised learning.

SUMMARY

- Learning management system companies have generated some of the most extensive educational datasets on the planet, which have become valuable sources for generating commercial advantage by vendors

- LMSs are used as sources of institutional analytics and performance measurement by universities, as well as 'early warning' indicator systems that are intended to target underperforming students for interventions based on metrics such as 'engagement scores' calculated from their interactions with the systems.

- Developers of LMSs are building increasingly sophisticated machine learning/AI-based functionality to automate the analysis of student data, in some cases leading to proposals to offer automated recommendations to students that might support their studies.

6. Library systems

While digital online library catalogues have been commonplace in HE for many years, library system providers are rapidly extending their services to digitised online resource lists and various analytics services. Digital library platforms increasingly deploy analytics algorithms to examine student engagement and use of library resources, and are even becoming interoperable with existing learning management systems, learning analytics and other student engagement metrics. Library companies claim they can automatically detect and report students' engagement with texts and are working on services that will automatically recommend library resources based on large-scale analysis of patterns of student resources use.

AUTOMATED LIBRARIES

Talis is a well-established library software company originally known as The Automated Library And Information System (owned by Sage since 2018), and the most commonly used resource list management system in HE in the UK. It offers two key products. Aspire is its established library back-end and resource list management software, and Elevate its newer product for data analysis of library resource usage and in-resource collaboration.[65] Talis Aspire reading lists can be embedded in learning management systems and integrated with library catalogues, discovery services, student registry, citation tools and bookstores, while the Talis Aspire Reading List dashboard enables course leaders to perform 'regular list health checks' based on analytics of usage, and modify their course content and resource lists in response.[66]

Behind the scenes, Talis uses analytics to construct 'education graphs' of links between students, teachers, courses, subjects, topics, texts, authors and other objects, which can then be used for making automated resource recommendations, and potentially to generate data about the 'most used' (highest-performing) academic texts.[67] Talis Elevate provides institutions with 'granular' insights into how cohorts or individual students are using assigned content, including documents, textbooks, video, audio or YouTube video, and shows how students are utilising these resources, page by page or section by section, alongside timeline information. This enables educators or administrators to track an individual student's engagement across a module with 'easy to digest analytics', see how students are interacting with content and course design, identify potential retention issues early, and monitor trends in learner behaviour. Elevate also allows students to annotate resources digitally, engage in peer review, reflection, discussion, debate, and critique of content, and to interact and collaborate through 'in-resource discussion activity'.[68]

RELEVANCY AND RECOMMENDER ALGORITHMS

Ex Libris is another long-established library software company, owned since 2015 by ProQuest, itself part of the Cambridge Information Group, a private global investment group focused on information systems.[69] Its products include Alma, a cloud-based unified library services platform, which is designed to allow universities to manage all print, electronic, and digital materials in a single interface. Alma Analytics also allow customers to transform 'library data into actionable reports and identifiable trends, for data-driven

decision-making', and includes usage, cost-per-use, overlap analysis and collaborative benchmark analytics. Alma Analytics even comes packaged with a virtual Data Analysis Recommendation Assistant (DARA), which is intended to provide institutional users with 'smart recommendations'.[70]

Ex Libris's 'discovery' product, Primo, uses a 'sophisticated relevancy algorithm' to support searching of library resources, and enables 'automated article recommendations' based on analytics of user behaviours. The relevance ranking technology is an algorithm called Primo ScholarRank that ranks search results based on criteria such as the degree to which an item matches a query, a value score representing an item's academic significance, and the publication date of an item.[71] The Leganto resource list product also integrates with Ex Libris Alma as well as learning management systems, library discovery services, mobile apps, citation tools, and other systems. It provides 'automated workflows for provisioning course materials' and, as with Alma, analytics and reports to provide an overview of the materials students use and their usage patterns.[72] A key automated technology underpinning the Ex Libris suite of tools is the bX Article Recommender, which is integrated into its Primo discovery service and its Leganto resource list product. bX captures anonymous usage information from millions of researchers around the world, using the data to provide relevant recommendations for articles and ebooks for the same topic.[73]

DATA LIBRARIES

As both Talis and Ex Libris indicate, library systems are becoming increasingly automated with relevancy and recommender algorithms. Based on techniques of machine learning, these algorithms are trained on vast datasets of library users' engagement and interaction with resources. Through their creation of online resource lists, academic teaching staff are providing library companies with well-curated sets of recommended readings, which can then be used for further automated recommendations to other students studying similar topics and courses.

These developments are part of a broader reconfiguration of the academic library industry as it has been integrated into the wider business activities of major publishing and media companies:

> *The new information economy is drastically changing vendors' and libraries' information acquisition, sales, and purchasing norms ... as the companies transition their services from traditional publishing to become 'information analytics' companies. These corporations are no longer the publishers that librarians are used to dealing with, the kind that focus on particular data types (academic journals, scientific data, government records, and other staples of academic, public, and specialized libraries). Instead, the companies are data barons, sweeping up broad swaths of data to repackage and sell. Libraries have observed drastic changes in vendor services over the last decade.*[74]

With the big library systems now integrated into the data-driven business models of their commercial owners, it has become possible not only to link data for more powerful analytics insights, but also to sell those data for profit.

SUMMARY

- Library technologies are becoming increasingly automated, especially through the development of automated article recommendation services that are based on long-term data mining of library users' engagement with resources.

- Library software is owned by global media businesses and private companies that are seeking competitive advantage from the collection of behavioural data from library users and resource list creators.

- Academic resource lists uploaded to library systems are used as source material for relevancy algorithms that automate article recommendations, while analytics of resource list usage are becoming sources of insight into students' engagement with tests that academic educators are expected to consult to design more engaging courses.

- Librarians' roles are being reconfigured as they are incited to become data users, whose tasks are increasingly circumscribed by data-driven commercial platforms and publishers.

7. Learning analytics

Learning analytics is a term used to describe three interrelated strands of activity: a field of academic research and development; the practical application of data analytics to assess learning within courses; and a fast-growing industry of commercial analytics tools. Many learning management systems (LMS) feature learning analytics functionality. As an academic field, learning analytics has become increasingly synonymous with objectives to apply artificial intelligence to education (AIed), especially as machine learning techniques have been developed to make educational platforms 'adaptive' and suited to 'personalised' learning.[75]

LEARNING ANALYTICS TECHNIQUES

Learning analytics is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs.[76] It is associated with the analysis of big data in education, particularly the data gathered from learning processes and contexts, with the objective of locating patterns and trends in the data, and creating computational models of learning processes, in order to develop effective approaches to teaching and learning. Unlike data mining LMS data for overall trends and patterns (sometimes referred to as academic analytics or institutional analytics based on 'business intelligence' techniques), learning analytics is more concerned with individual learner profiling and with making predictions about student progress, often using aspects of psychological and cognitive learning science to analyse the data.[77]

Three key techniques are involved in many learning analytics applications. The first, analysing 'actor-actor network structures', involves social network analysis to plot ties between actors (and artefacts), which can therefore be represented as connected nodes in social network graphs. The second emphasises analysing sequences of tasks and activities in order to detect the occurrence of certain patterns that indicate task progress, collaborative interaction, knowledge-building and so on. Finally, the third set of methods involves computational artefact analysis and text mining to extract semantic information from learner-created artefacts, which can then be used to measure student knowledge, understanding and comprehension.[78]

COMMERCIAL LEARNING ANALYTICS SOLUTIONS

Learning analytics has become a significant commercial interest. Major vendors include Civitas Learning, LearnSprout, Brightbytes, Panorama Education, and Learnmetrics, while learning analytics are also integrated into many LMS products including Blackboard, Canvas and Moodle. Solutionpath is one of the leading learning analytics providers in HE in the UK, with institutional customers in Scotland and England. Its Student Retention, Engagement, Attainment and Monitoring platform (StREAM) automatically generates a near real-time 'engagement score' for each individual enrolled at participating institutions. It does this by collecting data from a range of 'electronic proxies' that represent students' participation in their course, including building access card swipes, LMS data, software logins, library loans, attendance and assignment submissions. These transactional data are then

automatically analysed and presented on dashboards that provide information on engagement scores and engagements over time. If patterns in student behaviour change over time, alerts are triggered within the StREAM platform to facilitate staff intervention.[79]

NATIONAL LEARNING ANALYTICS INITIATIVES

Besides commercial learning analytics, large-scale efforts are underway across the UK to embed learning analytics in institutions and courses. The HE sector's national digital learning agency, Jisc, launched a national learning analytics architecture and tools in 2018 to allow universities to track and visualise student performance, and even use predictive data modelling for forecasting problems and planning pre-emptive interventions.[80] The learning analytics service 'uses real time and existing data to track student performance and activities':

> *From libraries to laboratories, learning analytics can monitor where, when and how students learn. This means that both students and their university or college can ensure they are making the most of their learning experience. ... This AI approach brings existing data together in one place to support academic staff in their efforts to enhance student success, wellbeing and retention.*

The service itself consists of a number of interrelated parts. It includes cloud-based storage through Amazon Web Services so individual providers do not need to invest in commercial or in-house solutions, and 'data explorer' functionality 'that brings together the data from your various sources and provides quick, flexible visualisations of VLE usage, attendance and assessment – for cohorts and individual students. ... The information will help you to plan effective personal interventions with students and to identify under-performing areas of the curriculum'. A third aspect of the service is the 'learning analytics predictor' that helps teaching and support staff to use 'predictive data modelling to identify students who might have problems' and 'to plan interventions that support students'.

The final part of the service is a student app called Study Goal, which is available for student download from major app stores. As it is described on the Google Play app store, 'Study Goal borrows ideas from fitness apps, allowing students to see their learning activity, set targets, record their own activity amongst other things'. In addition, it encourages students to benchmark themselves against peers, and can be used to monitor attendance at lectures.

Learning analytics is a major focus of the QAA Scotland Enhancement Theme on 'Evidence for Enhancement'. Under this initiative, universities in Scotland are actively implementing LA systems, for example to provide automated feedback and well-being advice to students.[81] Part of the project involved consultation with students to gather their perceptions of benefits and risks. Perceived benefits included:

- the expectation of learning analytics providing reflective tools to improve student performance through a hybrid of personalised, automated feedback and individual face-to-face support

- the suggestion of using past student cohort experiences to develop and enhance current/future student experiences; and to provide staff accountability
- the desire for learning analytics to identify and support academically-struggling students and mitigate the risk of them dropping out
- learning analytics being desired to advance higher education institutions' performance with regard to student wellbeing and students' professional development

However, student participants in the consultation also reported:

- a need for transparent use of learning analytics and continuous conversation with the student body about the regulation and expectation of how learning analytics are used to enhance student experiences
- growing concern of the misuse of student data to support other agendas beyond the sole purpose of enhancing the student experience
- the probable disapproval of learning analytics if used unethically, from the student's perspective

In its final year, the theme activity is expected to produce sector-wide policy, guidance, and best practice documents to support institutions implementing learning analytics across Scotland.

ADAPTIVE PLATFORMS

Methods have also been devised for predictive analytics and modelling, which are used to make inferences about uncertain future events such as student academic success, skill acquisition, or the impact of a given pedagogy or teacher. The predictive technical capacity of learning analytics has led to the emergence of adaptive learning platforms that generate an adaptive response or feedback, so changing the actual course of a student's learning pathway in ways that have been calculated by the system to best match that student's future needs. Predictive analytics is therefore reported to be an 'enabler for the development and introduction of adaptive learning,' otherwise known as 'personalised learning', whereby students are directed to learning materials on the basis of their previous interactions with, and understanding of, related content and tasks.[82]

Predictive analytics may even be accompanied by 'prescriptive analytics' where the system makes an automated decision about the relevant learning content that each individual student receives, based on predictions about their likely progress from traces of their past activity. The logic of adaptive, personalised learning is congruent with emerging aspirations to create 'robot teachers' or 'AI classroom assistants' that could help teachers generate new lessons by autonomously navigating online teaching resources to find relevant resources based on the details of the students and the school's specific curriculum.[83] While the whole-sale replacement of teaching by automated systems seems unlikely

and undesirable, enthusiasm is growing among many academic developers of learning analytics and AI-education applications, as well as among commercial ed-tceh supplier, for using adaptive platforms to augment certain capacities of the teacher, or take on certain tasks such as locating relevant resources.[84]

SUMMARY

- Learning analytics emerged as an academic field of research and development and has quickly been applied in many universities around the world as a means of measuring students' engagement with courses and their processes of learning.

- A large industry of learning analytics vendors provide for-profit services to universities, offering increasingly automated ways of tracking students, making predictions about their progress, and offering 'actionable insights' for intervention by interventions by institutions and staff.

- In the case of adaptive personalised learning platforms, 'prescriptive analytics' may even recommend course content and resources to students, anticipating the possibility of 'robot teachers' that might work alongside human educators or replace their authority on certain tasks.

8. Automated assessment and detection

Technologies such as learning analytics and adaptive platforms have been associated with plans to reimagine the ways assessment is conducted. As students produce trace data from their interactions with learning systems, it may be possible to generate both summative scores and automated feedback directly within the interface itself.[85] A recent report from Jisc identified 'appropriate automation' in assessment as a key target in HE assessment practice in coming years, and also endorsed the use of new assessment technologies including automated real-time feedback, learning analytics, natural language processing of student writing, keystroke dynamics, and educational data forensics for cheat detection.[86]

COMPUTER ADAPTIVE TESTING

Already, technologies such as computer adaptive testing (or 'tailored testing') have been developed that can monitor an individual's interaction with a test, and adapt the questions or challenges automatically to match the inferred ability of the student.[87] The benefits of CAT are reported to include reduction of time spent grading by educators, lower costs, accelerated return of assessment results, increased feedback, the provision of more detailed, granular data, and high accuracy from the use of artificial intelligence techniques. CAT applies discriminatory power to eliminate redundant questions and questions that are too easy or too difficult, by identifying a student's performance range and automatically tailoring the test based on their performance data[88]

ROBO-GRADING

Automated essay scoring, or 'robo-grading' is a longstanding goal of the educational assessment industry, and has recently received a boost in support in the UK as one of the priorities of the Department for Education's 'edtech strategy' and its plan to support growth of the edtech industry.[89] The reported benefits of automated essay scoring include saving time for educators, reducing human bias in grading, and increasing accuracy. Although automated essay scoring has a relatively long history, recent developments have begun to use machine learning to algorithmically imitate the judgment of educators evaluating the quality of student writing. Such systems require the selection of content for use in a robo-grading system, selection of student samples for training sets, and annotation to define the labels for training sets.[90]

Automated essay scoring has been criticised for several reasons. One line of criticism challenges the claim that automated scoring reduces bias, since software, including 'Artificial Intelligence, is an encoded version of human biases. This is particularly true for programming that scores something as subjective as writing. You cannot write the program without first making your own judgment about what constitutes good writing'. Another key criticism is that automated robo-grading simply cannot distinguish between meaningful writing and 'gibberish' that has been structured effectively.[91]

PLAGIARISM DETECTION

The first stage of assessment for many HE students is plagiarism detection, as huge quantities of student assignments are automatically screened for similarity with existing

sources. Plagiarism detection has a long history in HE as an automated way of identifying cheating in student assignments. These automated systems are now common in higher education as a way of assessing the originality of students' assignments.

The most well-known plagiarism detection software service is Turnitin.[92] The 'world's largest comparison database' of student writing, it consists of 600+ million student papers, 155,000+ published works and 60+ billion web pages. Its plagiarism detection algorithm, called the 'similarity score', is constantly fine-tuned as millions of essays are added, analysed and cross-checked against each other and other sources. Students can even pay to upload their essays prior to submission to Turnitin's WriteCheck service, in order to check for similar sentences and phrases, missing or inaccurate citations, and spelling or grammatical inaccuracies. Although Turnitin is closing the WriteCheck service in 2020, students will still be able to receive automated feedback through the Feedback Studio.[93] Nonetheless, studies have repeatedly shown its plagiarism detection software is inaccurate, both mistakenly branding some students as cheats while completely missing other clear instances of plagiarism.[94]

In 2019 Google announced the launch of a new 'originality reports' service. Originality reports compare student work against hundreds of billions of web pages and tens of millions of books that the Google web search service has scanned. The reports highlight missing citations, ineffective paraphrasing, or unintended plagiarism due to high similarity and link to the external source, allowing students to run originality reports before submitting in order to save educators time on grading.[95]

GHOSTWRITER IDENTIFICATION

Turnitin also expanded its service to 'ghostwriter detection' as an automated way of tackling 'contract cheating' (when a student pays an 'essay mill' to produce an original assignment) following its $1.74bn acquisition in 2019. The new Authorship Investigate service extends Turnitin from the analysis of plagiarism to students' writing ability, using students' past assignments, document metadata, forensic linguistic analysis, machine learning algorithms and Natural Language Processing to identify if a student has submitted work written by someone else.[96] Universities and HE policymakers are collectively beginning to address the rise of online 'essay mills' and their erosion of 'academic integrity', with the UK government advocating increased use of detection software such as Turnitin's new ghostwriter service.

Plagiarism detection services are the subject of significant controversy regarding the commercial exploitation of student assignments and influence on the ways students approach academic writing. One claim is that Turnitin has monetised students' intellectual property for its own commercial advantage. Another is that it encourages students to treat 'good' writing as that which is undetectable by the similarity score algorithm, and to see their assignments first and foremost as products for algorithmic scoring rather than as intellectual practices of personal development and learning.[97]

SUMMARY

- Automated assessment is currently a high political priority and a growing industry, focused on efficiency-savings by removing the assessment burden from educators.

- Computer-adaptive testing represents a new model of assessment that utilises data analytics to automatically modify an assessment task or question to meet the inferred ability level of the test-taker.

- Plagiarism detection and authorship identification software acts as an automated first-stage of assessment for millions of students worldwide, with hundreds of millions of student papers translated into machine-readable data used by commercial vendors to train detection systems.

- Key criticisms of automated forms of assessment, including plagiarism detection, is that it displaces educator judgment from the process of marking, grading and feedback, encodes biases about what constitutes good writing, and is prone to inaccuracy.

9. Online learning platforms

Online learning has become a major priority among universities as a vehicle for extending recruitment and widening participation, particularly in the context of demands for internationalisation and increasing numbers of fee-paying students. A very wide variety of online learning provision exists, from small, enclosed courses to public courses open to very large numbers of students, as well as online learning extensions to existing programs and other 'hybrid', 'blended' or 'flipped' approaches.[98]

MOOCS

Massive open online courses (MOOCs) are low-cost ways for wider groups of students to access HE. Typically, MOOCs consist of pre-recorded video lectures accompanied by other learning resources and collaborative discussion boards which are intended to guide the enrolled learner to specified learning outcomes. Some MOOCs offer official certification upon completion of a course, often for an additional fee. A perceived benefit of MOOCs is that they encourage students to become more self-directed rather than led by the teacher, which fits with philosophies of education that prioritise student-centred learning. However, they also open up the possibility of streamlining higher education around pre-designed courses that encourage 'anywhere, anytime' learning rather than presence on campus or in-person attendance in lectures and seminars. For this latter reason they may be considered threatening to existing models of HE.

MOOCs are also extremely lucrative for platform providers, some of which are valued as billion-dollar businesses and have attracted significant business investment. To a significant extent, MOOCs are automated teaching and learning systems that have established a market for HE-based online learning platforms. This raises the risk that MOOC providers might become affordable alternatives to attending university. These providers might have very different organisational aims and guiding assumptions about the purposes of education. For example, in 2019 both the UK-based Futurelearn platform and the US Coursera business were part-acquired by the SEEK group, an Australia-based online jobs platform committed to 'upskilling' and 'reskilling' workers for the labour market.[99] MOOCs have normalised ideas about unbundling HE services to commercial technology providers such as Coursera, edX and Futurelearn, many of which have now begun to extend their offerings from MOOCs to other online learning models.

ONLINE PROGRAM MANAGEMENT

Online program management (OPM) refers to infrastructure services provided by vendors to enable universities to deliver online and distance education courses. Currently growing rapidly in the US and UK, OPM service providers also provide extensive data analytics in their platforms, offering convenient ways to automate student tracking and monitoring. OPM companies include 2U, Noodle Partners and Academic Partnerships, big education publishers, including Wiley and Pearson, as well as MOOC providers that have diversified into the OPM market. As a result, the OPM market is saturated with suppliers, with commentators expecting consolidation around a fewer number of large-scale successful businesses.[100]

A key aspect of the success of OPMs is that the companies usually cover the up-front costs of setting up an online degree program, and provide the technical infrastructure for university partners to build their courses on. This model saves universities having to front the costs or building the technical platform. The companies then take 50-60% of the student fees as a return on their up-front investment.

One of the most successful providers, 2U, provides the OPM platform 2UOS (2U Operating System).[101] 2UOS consists of an online teaching and learning platform, a suite of data analytics for generating information about students, technical support, and targeted, program-specific digital marketing campaigns using machine learning and AI.[102] Pearson also offers an OPM platform, with several UK universities entering into long-term 10-year deals with the company to deliver courses (at present these include King's College London, Leeds, Manchester Metropolitan, and Sussex). Through its 'full-service approach to creating online degree programs or individual learning solutions', Pearson's online learning services are presented as streamlined technical systems and standardised program management packages for universities to purchase in order to 'help you expand access, reach each student, and improve achievement'.[103]

STREAMING LEARNING SERVICES

An emerging model for commercial vendors of digital online learning technologies is to market products direct to the consumer as streaming content. The multinational education business Pearson recently announced a Global Learning Platform as a key part of its market expansion into HE digital services. The platform offers students 'pay-to-access' streaming content as a substitute for purchasing expansive print textbooks, thereby reframing HE as a Netflix-style streaming service.[104] The platform also makes student engagement with resources increasingly traceable by automated data analytics, enabling it to generate personalised recommendations to students. Notably, the global learning platform and Pearson's OPM offering are among its leading business priorities as the company has pivoted from publishing textbooks to being a 'digital-first' education company.[105]

SUMMARY

- Online learning is based on a philosophy of student-directed learning that is challenging to the historical arrangement of HE through on-campus teaching.
- Online learning platforms represent a highly successful business model based on ideals of disrupting existing modes of HE provision, particularly by replacing lectures with video content and establishing new models of 'networked' learning that take place across the web.
- Online providers are opening up access to educational opportunities, but some are guided by ideals of 'upskilling' and 'reskilling' people for labour markets, while the shift to online learning models such as MOOCs and 'streaming' services treats the student as a self-directed consumer of education, paying fees to commercial providers for access and resources.

10. Graduate analytics

Employability has become a major policy demand in HE, and with it an industry of technological employability and graduate analytics services has emerged.

PREDICTING EMPLOYABILITY

One key way in which data analytics technologies are being used to match graduates to labour markets is through advanced analyses and predictions of changing employment landscapes. The world's largest education business, Pearson, produced a collaborative research project with the innovation charity Nesta and the Oxford Martin School on 'the future of skills' required by students for employment in 2030.[106] The research produced extensive predictions about future labour markets and structural changes to the economy using a combination of machine learning, trend analysis, foresight methods, and 'employment microdata' to rank the future demand for occupations. The project involved training' a machine-learning classifier to generate predictions for all occupations, making use of a detailed data set of 120 skills, abilities and knowledge features', with different occupations then 'selected by the algorithm itself' in order to determine 'which skills, abilities and knowledge features were most associated ... with rising or declining occupations'.[107] In this way, the project constructed an algorithmic prediction of labour markets, which Pearson has subsequently sought to make 'actionable' by producing products for 'career-driven learning' and employability.

Subsequently building upon its predictive project, the practical task of aligning HE to labour markets has become a core strategy of Pearson. It has committed to both designing products for, and evaluating impact on, a wider range of outcomes including skills to support learners' career readiness and employability prospects. To deliver this ambition, it has assembled an entire 'career readiness and employability' strand of services, thought leadership, research, white papers and products dedicated to redefining the relationship between education and the workplace.[108] In another report on 'demand-driven education' and 'merging work and learning', Pearson advanced the idea of using AI-based talent analytics to automatically match graduates to career destinations.[109]

TALENT-MATCHING ANALYTICS

Graduate talent analytics enable graduates to create a personal profile, take psychometric tests, and upload their qualifications in order to receive automated push notifications and recommendations about potential employers and jobs. Some even promise to short-circuit the application process by automatically matching graduates to employers based on automated identification of their fit to job descriptions. Multinational companies are also actively moving into this market, offering new ways for graduates to present themselves to prospective employers while also providing learning resources to increase their employability.

Debut uses data provided by student users - including a psychometric competencies test – to match graduates to employer internships and graduate schemes.[110] It was recently awarded £5million in venture capital to train its AI-based recommendation algorithm to make better automated matches. Its entrepreneurial founder claims

Debut's 'cognitive psychometric intelligence' profiles are more useful to employers for matching graduates to jobs than 'irrelevant' degrees or academic grades.[111]

AUTOMATED JOB RECOMMENDERS

The US platform Handshake recently received US$40million venture capital from an investment team that included Facebook founder Mark Zuckerberg.[112] The Handshake platform itself works off a smartphone, providing students with automated push notifications and job recommendations that match their profile, and enabling them to apply direct from the platform. Handshake already claims 14 million student users, with uptake by over 700 university career centres and 300,000 employers. Its annual Campus to Career report details employment trends of over 9 million students who have used the platform, as Handshake positions itself as an authority on graduate employability.[113]

The platform for professionals, LinkedIn (owned by Microsoft) is rapidly expanding into HE through its student jobs portal, its advice to students on creating a profile and 'professional brand', and through its online suite of professional learning resources.[114] LinkedIn is creating an alternative credentialing platform to link graduates to employers, thereby 'building a global marketplace for skills to run in parallel to, or instead of university degrees'.[115] Like Handshake, LinkedIn has access to huge quantities of student data to deepen its penetration into HE employability services.

In combination with data analytics-driven predictions of future labour markets and employability demands, graduate talent analytics and automated job recommender services make employability the key purpose of HE. They propose increasing use of granular graduate profiling and predictive analytics as a way of part-automating the pipeline from university to the workplace, and are based on particular predictive analyses of future economic needs. They even, as the case of LinkedIn suggests, appear to be seeking to bypass the HE sector altogether by offering online learning, professional guidance and alternative accreditations that are matched to labour market demands and projections of future employment needs.

SUMMARY

- Employability has become a major measure of HE performance, at the same time as education companies and think tanks have begun to make dramatic predictions about future demand for occupations. This is putting pressure on universities to rethink how they prepare students for labour markets.

- Education companies are offering employability services and products to HE customers to support their students' career readiness. These include automated talent analytics and job recommender services that are based on 'matching' students to careers or making job recommendations based on students' professional graduate profile, in ways that are beginning to automate the 'pipeline' from degree to career.

- Some companies are beginning to seek to displace the monopoly of HE on qualifications and accreditation for employment by offering their own bespoke online learning, professional guidance services and qualifications to match projected labour market changes

11. Automated AI tutors

Many major technology and education companies are pursuing the development and implementation of automated artificial intelligence assistants for use in HE. Usually taking the form of 'chatbots' and modelled on AI assistants such as Amazon's Alexa, Apple's Siri, or Microsoft's Cortana, these assistants are said to 'learn' from their interaction with students in order to offer 'personalised' advice on academic, practical or personal matters.

INTELLIGENT TUTORING SYSTEMS

AI assistants have a long history in academic research and development. They include 'pedagogical agents' and 'intelligent tutoring systems' first conceived in the 1960s, and have progressed to systems that have some degree of capacity for sense-making and autonomous action based on analysis of what students know or what they can do can do. Contemporary pedagogical agents are based on advances in AI such as speech recognition, natural language processing, machine learning and computer vision to infer what students are thinking or feeling, to predict what they might do next, and then to engage in 'tutorial dialogue' and communication. Though they are in many ways sophisticated, critics suggest automated tutoring systems provide highly reduced versions of routine educational processes that are based around training and that assume teaching to be an individualised process of managing students' learning behaviours through the guidance of a machine.[116]

A notable example is the application of IBM's 'cognitive computing' system as a pedagogic chatbot at Georgia Tech University in the US. The IBM assistant is designed specifically to answer student queries during an online computer science course at the university. The chatbot, 'Jill Watson' is described as 'a graduate-level teaching assistant who can hold office hours 24/7/365 – because she's a literal teaching machine'.[117] It became well-known due to media coverage reporting that students were unaware that Jill Watson was an automated AI bot rather than a human teaching assistant when it was first introduced to the course in 2016.[118]

The education company Pearson has also partnered with IBM Watson on the development of AI-based tutoring apps. Pearson announced the launch of the first of its planned suite of AI learning assistants, named AIDA, for use in courses in 2019.[119] AIDA offers streaming video support, but more significantly provides real-time feedback and personalised recommendations to students, which are designed to become more accurate as the student interacts with the app.

STUDENT EXPERIENCE ASSISTANTS

Most current enthusiasm for AI assistants in HE tends to emphasise the enhancement of the 'student experience' rather than pedagogic guidance. Amazon, for example, has begun offering Echo devices for use in HE institutions as part of its corporate push of its Alexa assistant into the education sector, enabling Alexa to act as an enhancement of the student experience.[120] Lancaster University has incorporated Amazon web services,

Alexa and Echo smart speakers into its own voice and chatbot interface called Ask LU, which 'will act as a digital friend and companion for university students, with its own unique personality, allowing them to ask almost any question about their university experience, from student life, and welfare, to academic studies and more'.[121]

Next-stage iterations of student assistance chatbots feature voice and facial recognition. London South Bank University has announced the first voice-enabled and biometric facial recognition chatbot in Europe, developed through a partnership with the UK chatbot company ANS and built using Amazon Web Services cloud capacity. Dubbed 'Ellie', the chatbot can be accessed through digital screens placed around the campus. When Ellie detects movement toward the screen and identifies students through facial biometrics, it will share verbal information about lecture time and location, directions, and even offer catering pre-order opportunities, utilising in-built machine learning algorithms and predictive analytics to make suggestions and recommendations.[122] Ellie is a prototype for the potential transformation of the student experience through a blend of 3D virtual avatars, biometric identification, and automated predictive assistance.

SUMMARY

- AI-based tutors can provide tailored educational support or automated answers to student queries, but also raise questions about the reduction of teaching and learning to an individualised process of student management and guidance.

- Automated assistants rely on the private infrastructures of major multinational technology companies such as Amazon and IBM. They plug platforms such as Amazon Alexa into the core operating systems of the university, and are even beginning to utilise biometric forms of automated student identification alongside predictive analytics and automated recommendations.

- Although educators may not be replaced by 'robot teachers' one possibility is that teachers will become more 'robot-like' as they adapt and modify their pedagogies and curriculum design to accommodate or respond to automated technologies such as learning analytics and adaptive, personalised learning platforms.[123]

12. Recording and monitoring

The development of new hardware and software for recording the attendance, location, activities, tasks, and even emotional sentiments and critical views of staff and students has increased the possibilities of widespread monitoring in universities.

ATTENDANCE MONITORING

Attendance monitoring has become a key priority in HE, with institutions increasingly turning to technological solutions to record students' presence or absence at lectures, seminars and practical tutorials. Students on Tier 4 visas are a particular focus for attendance monitoring due to Home Office rules, although universities now routinely produce attendance monitoring policies to ensure they are meeting 'duty of care' requirements (in relation to identification of students with mental health or wellbeing needs) and regulatory reporting demands.

Many universities use smart cards to enable students to easily 'tap in' to lectures and classes. Increasingly, however, institutions are beginning to pilot and roll-out 'check-in apps' and other attendance monitoring devices based on smartphones and WiFi or Bluetooth signals. New vendors such as Spotter, for example, uses 'iBeacon' technology – which students install as an app on their own devices – to automatically detect when students enter a classroom, and checks that they remain in that location throughout the duration of a class.[124] These type of location-based automated attendance monitoring technologies have been criticised as 'surveillance machines'.[125]

LECTURE CAPTURE

Lecture capture software is widely used in HE for purposes of making teaching material accessible to students. There are benefits in terms of enabling students to review teaching materials, offering supplementary recorded lectures as part of courses or modules, and expanding access for off-campus students. However, lecture capture may also be used as a digital substitution for staff who are absent or participating in industrial action. Lecture capture is automated to some degree since it allows lectures to be provided during staff absence, raising concerns that lecture video recordings could be treated as longer-term teaching substitutes (as on online learning platforms such as MOOCs). It could also be used in the absence of adequate budgets for teaching staff. Lecture capture is seen by some academics as an impediment to critical discussion over sensitive issues, with implications for curriculum design and pedagogy, and is also perceived to disincentivise lecture attendance.[126]

STUDENT SOCIAL MEDIA MONITORING

Plans to monitor students' use of social media as ways of assessing their personal well-being or evaluating student satisfaction based on aggregated data have been developed both by individual institutions and national HE agencies. As part of a £14.5million fund managed by the Office for Students to improve student mental health, Northumbria University announced plans in 2019 to pilot an 'early alert tool' based on monitoring of students' social media posts and updates, combined with other educational analytics.[127]

The project will involve a number of other HE providers as well as technical partners, including Microsoft and learning analytics vendor Civitas Learning, to identify indicators of students experiencing mental health issues. The announcement of the project generated significant media coverage focusing on its surveillance of students' social media posts, conversations they have with individual members of staff and information held by their accommodation providers.[128]

At a national level, the Quality Assurance Agency undertook a 2018 study into student satisfaction using data scraped from social media, based on a large sample of over 200,000 student reviews of higher education provision posted on social media sites. In particular, the study involved collecting student reviews from Facebook, Whatuni.com and Studentcrowd.com, with Twitter data to be included in future research. The study authors found that 365 HE providers have Facebook pages with the 'reviews' function available, as well as many pages relating to departments, schools, institutes, faculties, students' unions, and career services. These data were compared with other sources such as TEF and NSS, and found to have a strong positive association. In contrast to retrospective sampled surveys, collecting 'unsolicited student feedback' from reviews on social media platforms is seen by the QAA as a way of 'securing timely, robust, low-burden and insightful data' about student experience. The scraping methodology generated 'collective judgment scores' for each provider on any given day, leading the study authors to conclude that 'the timely and reliable extraction of the student collective judgement is an important method to facilitate quality improvement in higher education'.[129]

SUMMARY

- The activities of students and staff in universities are the subjects of proliferating modes of recording and monitoring.
- Recording technologies such as lecture capture software appear to present benefits, but are also caught up in controversies regarding the potential for monitoring or replacement of staff.
- Increasingly pervasive modes of student monitoring through their uses of social media are already being trialled as ways of tracking student mental health and assessing student satisfaction. These initiatives have already raised concerns about the effects of continuous surveillance on staff and students.

13. The smart campus

The potential of big data analytics, algorithmic decision-making, artificial intelligence and increased automation has led some organisations to pursue the ideal of the 'smart campus' or the 'smart university'. Smart universities have been defined as 'institutions that can use the huge amounts of data they generate to improve the student learning experience, enhance the research enterprise, support effective community outreach, and advance the campus's infrastructure'.[130] Smart institutions would mobilise the combined resources of their datasets, analytics, cloud computing storage, enhanced wifi connectivity, large-scale indoor-positioning networks, and Internet-of-Things connected sensors and actuators to address challenges such as student experience, improved efficiencies, performance evaluation and energy consumption reductions.[131] The ideal of the smart campus is a prototypical 'automatic university' in which automated systems run constantly in the background of the institutions, automatically capturing data, linking datasets, making adjustments to systems, and providing feedback to staff and students.

INTELLIGENT CAMPUS

The HE digital learning agency Jisc runs an ongoing project on 'the intelligent campus', which seeks to produce smart solutions 'to improve the student experience by capturing and analysing the many kinds of data that can be collected across university and college campuses'. The intelligent campus would combine 'learning analytics' data from courses along with historical student data, as well as data gathered from systems that record and monitor space and equipment usage, timetabling and other activities, in order 'to make smarter, more effective use of learning spaces and other facilities across campus and to improve curriculum design and delivery'.[132]

Many UK universities are engaged in extensive smart campus developments. The University of Northampton has a new smart campus complex which enables tracking of student location on the campus and real-time online tracking of the use of software and websites by students and staff, and Manchester Metropolitan University has introduced engagement monitoring, digital wayfinding, lecture capture and cloud access. The University of Glasgow $1billion smart campus program is one of the largest urban infrastructure projects in Scotland, described by the university as a 'living laboratory' driven by smart building technologies.[133]

THE SENSORY CAMPUS

A significant controversy raised by smart campus plans is the degree to which they require continuous surveillance and monitoring to be conducted on the activities of staff and students. This can include using wifi connectivity data as proxies for physical location on campus, web analytics of access to websites, swipe card data to track building access and movement, as well as LMS logins, library system access, and learning analytics data. The smart campus is an environment designed for continuous automated sensing and feedback.

Multiple companies are now even developing facial vision systems for the automated capture of physical indicators of student attention, engagement and emotion data.

These are based on automated facial expression analysis, where student emotions are presumed to be 'machine-readable' from unconscious muscular movement in the face and eyes. Facial recognition technologies have already been developed and deployed for use on smart campuses in countries including France, the US, Australia and China.[134] Facial recognition and mood monitoring technologies raise concerns about surveillance and privacy, as the smart campus is treated as a 'data gathering laboratory' or a 'mini smart city' that collects masses of data on the activities of students and staff and relies on commercial vendors competing to provide smart systems to institutions.[135]

In the US, Carnegie Mellon University has developed an experimental system called EduSense for automated monitoring of teaching staff. Part of its AI-based approach to 'learning engineering', EduSense is a 'comprehensive real-time sensing system' designed to provide a 'continuous feedback loop' for the teacher by recording and analysing 'visual and audio features that correlate with effective instruction'. EduSense uses off the shelf camera and audio equipment to record students and teachers at the same time. It then automatically identifies information such as where students are looking, whether they smile, how often they raise their hands, whether teachers move through the space and how long they pause before calling on students, as well as sensing students' posture to determine their engagement. Machine learning and computer vision techniques in the EduSense system are designed to return these data to teachers as feedback to help them improve the ways they teach and engage students.[136] The developers of EduSense describe it as being like a FitBit for teaching, and a prototype for 'automated classroom analytics'.[137]

SURVEILLANCE CAPITALISM ON THE SMART CAMPUS

In addition, smart campus projects rely on the large-scale technical infrastructures of major multinational technology companies. The University of Northampton's smart campus program, for example, was built through a partnership with Cisco on networking, wifi, data storage, data analytics, dashboards and security. It includes:

- 'intent-based networking' and analytics with the capacity to anticipate actions, stop security threats, and continue 'to learn, adapt and evolve'
- the 'Cisco DNA CenterTM', a 'command and control center' derived from its 'smart cities' technology suite, that provides 'a clear view of everything and everyone on the network through a "single pane of glass", with insight and analytics into each user, device and application, regardless of where they are'
- 'Cisco Stealthwatch®' to 'provide the university with real-time analytics for all network flows traversing the campus'[138]

Less visibly, other technology vendors have expanded across universities through the provision of back-end technologies. Amazon Web Services is used widely by HE institutions for cloud storage, and Google's open source machine learning application TensorFlow is also used in some institutions for deriving insights and predictive models from student data.[139]

Smart campus projects are controversial because the technologies they rely on, such as smart city-style sensor networks, command and control centres, spatial monitoring, facial recognition, body movement sensors, and automated analytics are among the most contentious of contemporary AI-based surveillance technologies.[140] Companies such as Google, Amazon and Cisco are representative of 'surveillance capitalism,' a new logic of techno-capitalist expansion that relies on mass-scale data extraction, analysis and prediction, using that data as the basis for improving or creating new valuable products and services.[141] As such, smart university projects embed surveillance capitalism in the campus, and bring HE into its business logics and practices.

SUMMARY

- Smart campus projects represent a high-tech ideal of the highly-networked and instrumented university being run on the basis of continuous monitoring and sensing technologies that, through automated feedback, constantly improve institutional processes and practices.

- Smart campus programs that are already in development show how universities could be redesigned as 'living laboratories' where various cloud-hosted datastreams captured from the uses of spaces, resources, and systems are linked and combined to produce advanced insights for improvement, and even, in some cases, automated adjustments to key processes and functions of higher education.

- Smart campus projects rely on the technical infrastructures of multinational technology companies for networking, cloud data storage, machine learning and AI applications, thereby bringing universities into the business practices of surveillance capitalism.

14. Conclusion and UCU Scotland recommendations:

The final section of this report identifies some of the most pressing issues regarding datafication and automation in HE in relation to the working lives of HE staff, and recommended next steps for unions. The 'automatic university' may bring significant benefits as a way of rethinking the future of HE. Yet the emerging technologies surveyed in this report, the imagined visions that have catalysed their development, and the kinds of data practices they enable also raise many critical tensions. If datafication and automation are already becoming a feature of university life, then they should be subject to vigorous debate and rigorous analysis to ensure that any benefits are appropriately harnessed and potential harms or risks are guarded against.

This section also makes a series of recommendations for actors in the higher education sector in Scotland including the Scottish Government, higher education institutions, trade unions and other sectoral bodies. The recommendations are broadly based on those identified in an earlier draft of Dr Williamson's work on automation but have been added to and amended by UCU Scotland. Before the recommendations there is an introductory narrative taken from the report.

LEGITIMISATION OF AUTOMATED MANAGEMENT OF HE

Government departments, HE agencies, think tanks and consultancies are highly engaged in legitimising ideas about the automation of higher education tasks and responsibilities through AI, analytics, machine learning and algorithms. What is being legitimised are ideals about increasing automated management of HE, covering the entire spectrum from automated administration to automated support for teaching, learning and assessment of students. These developments encourage the delegation of judgement to automated systems, as decisions normally taken by workers are deferred to advanced analytics and automation.

DE-/RE-PROFESSIONALISATION OF HE STAFF

Higher education teaching professionals are at low risk of technological unemployment through automation, but their professional roles and tasks are likely to be changed or redeployed by complex and capable digital technologies. A result of this is likely to be a requirement for re-skilling, with managers, administrators and educators alike forced to adapt to work alongside automated systems. In some cases the result could mean de-professionalisation as key tasks currently requiring professional expertise are displaced to automated machines, and the skills of workers are redeployed to different tasks.

PROFESSIONAL ANXIETY

In both the UK and elsewhere, it is reported that the culture of HE measurement induces significant anxieties. These anxieties are both institutional, in the form of continuous evaluation preparations, and personal, in stress and mental health problems among staff and students. As demands have increased on the academic workforce over concern

about university rankings and league tables, repeated research and teaching audits may have created 'a culture of workplace surveillance' in universities.[142] Digitally-enabled datafication could exacerbate these pressures as it potentially introduces 'real-time' performance measurement into working spaces including university offices and classrooms.

PRIVILEGING TECHNICAL MODELS OF TEACHING AND LEARNING

New data-based technologies for teaching and learning, such as learning analytics and adaptive platforms, privilege particular models of learning. In particular, learning analytics depends on increased student interaction with digital resources to gather continuous learning data. It also requires teachers to reconceive aspects of their courses for digital delivery. While learning analytics may offer benefits in terms of insights into and support for teaching and learning processes, it is based on particular assumptions about learning from the 'learning sciences' that are not always congruent with other pedagogical perspectives that see learning as rooted in relations and critical dialogue. Moreover, while academic learning analytics researchers remain committed to exploring how technology can support and enrich teaching and learning, other commercial suppliers are offering products under the banner of learning analytics that tend to privilege student tracking for purposes of performance measurement of courses and staff.

CONSUMERISATION OF STUDENT EXPERIENCE

In fee-paying contexts, students are increasingly perceived as consumers of a 'student experience' which universities are required to deliver in a way that has clear value for money. Even in non fee-paying contexts, such as Scotland, student experience is now a key metric of university performance, with the result that more and more techniques are being developed to measure student progress, identify indicators of emerging problems, and ensure students receive a high-value education (increasingly defined by employability in the labour market). More widely, the recent turn by education companies to adopt 'direct to consumer' business models, where they sell products or subscriptions directly to students, means that students are treated as customers of HE services. Students are represented by such companies as 'Gen Z' consumers with preferences for online learning. In these ways students are seen as consumers with desires and expectations of a high-quality, high-value degree that universities should deliver through modern, technologically-enhanced means. In turn, universities are also expected to deliver evidence of the increasing quality of their offering.

COMMERCIALISATION OF THE UNIVERSITY

The modernisation of the contemporary university through digital technologies, datafication and automation is being achieved through 'unbundling' services to outsourced commercial suppliers who can 'rebundle' those services as new products. In addition, multinational global technology companies have also become providers of back-end infrastructure and software services, networking, cloud storage, data analytics, and AI/machine learning functionality (e.g. Google, Amazon, Cisco and Microsoft), yet their role as back-end suppliers remains very little understood. Private sector outsourcing suppliers are now becoming key sources of expertise and authority in HE, and these companies are now 'plugged in' to the education sector. These developments raise the possibility of universities

becoming dependent upon, and locked-in to technical arrangements with transnational commercial organisations, with the further risk of 'function creep' as they take on more and more functions of institutions.

DATA AND AI ETHICS AND LEGALITIES

A huge range of ethical and legal issues are raised by the datafication and automation of HE. These include issues of privacy and data protection, as student data and data related to courses and staff are increasingly held in very large datasets, both within the sector itself and beyond in commercial servers and cloud storage facilities. Issues of discrimination are raised by the utilisation of machine learning and AI which may contain pre-existing biases. And a key issue of data ownership is raised by the concentration of commercial data companies in HE too. Beyond ethics issues, key legal questions will need to be addressed in a post-Brexit UK context, such as the legal basis for data processing, or the movement of data from the UK to other countries.

RECOGNISE THE CONTEXTS AND CONSEQUENCES OF HE DATA

Policy literature and vendor marketing for automated systems in HE tend to privilege the view that digital data-processing technologies present accurate, precise representations of higher education as it really is in the real world. Social research on data and metrics, however, makes two key points to challenge this straightforwardly 'realist' view. First, that data are never entirely 'innocent', 'neutral' or 'objective as they are said to be, because they are the products of social, institutional and political processes.[143] How the data are produced, and for what purposes, leaves an imprint on the results. Second, data and metrics also compel institutions and individuals to perform in ways that conform to the quantified criteria, by working towards measurable goals that are often set externally, or by 'reverse engineering' and manipulating their activities to ensure they 'count' in the metric, rather than in accordance with other purposes, values or aims.[144]

RECOMMENDATIONS

1. FOR THE SCOTTISH GOVERNMENT AND POLICY MAKERS

The Scottish government (as the key policy driver in Scotland and the provider of over £1bn annually to the sector in Scotland), higher education sectoral bodies and other policy makers should engage with UCU, NUS and other campus trade unions on the use of increasing use of automation in higher education. This should involve the establishment of a joint task group, including UCU, on the use of automation within Scotland's universities. This task group should include datafication and automation experts as well as educational experts to identify the benefits and drawbacks of the different ways of using automation in higher education.

2. FOR UNIVERSITY MANAGEMENT

a. University management should engage in meaningful dialogue with UCU representatives regarding the use of automation.

b. University management should accept that the potential effect of increased automation on academic related and professional service, and academic roles

is a form of organisational change and should be subject of formal consultation with the relevant trade unions through locally agreed arrangements.

3. FURTHER WORK WITHIN UCU

a. UCU should seek to establish an expert group of datafication, automation and educational experts from within its membership to:

- understand the implications for teaching and learning, specifically to identify the benefits and drawbacks of the different ways of teaching that learning analytics enables
- develop understanding of the roles that commercial outsourcing companies are playing in higher education, including through back-end networking, data storage and analytic solutions.
- investigate the wide-range issues resulting from the datafication and automation on higher education.
- develop recommendations on data and AI ethics to ensure that appropriate steps are taken to protect data about staff and students, and that oversight mechanisms are in place to safeguard against bias and discrimination emerging from automated systems.

b. UCU should continue to assess and address the effect of learning technologies and automation on academic, academic related and professional services roles, including conducting further research amongst the staff most affected.

c. UCU should seek to develop a strategy to pre-empt the adverse effects of automation on staff health and include in its members' surveys on workload and stress a question on the effect on their health (including their mental health) of the focus on metrics and automated management in higher education.

d. UCU should continue to argue against the consumerisation of the student experience by highlighting the role of universities as models for deliberation, democracy and social progress, rather than narrowly as value-for-money pipelines to career destinations and future earnings.

e. UCU should produce bargaining guidance for branches on automation and new technology in the workplace, allowing branches to engage effectively with employers and counter potentially negative impacts on staff in universities, while simultaneously using positive impacts to benefit our members. Given the increasing use of lecture capture technology in universities and the use of pre-recorded lectures in strike breaking, guidance should continue to include the issue of lecture capture and the ownership of the intellectual property being taught and the requirement for the consent of the staff member whose work is being recorded and held.

In addition to these recommendations UCU should aim to use its position as the largest union in higher education to, firstly, inform the debate around automation in the sector so that there is a recognition that the contexts, methodologies and purposes of data collection and production affect the result. Secondly, UCU should do so in order that there is a recognition that universities behaviour is changed as a result of the collection and use of data and metrics, leading them to adjust organisational behaviour to meet those demands and that such demands themselves may be predetermined by the goals of those who promote and build the systems.

For unions, treating data and automation as both contextually produced and socially consequential would mean taking a political view of these technologies as both the product of powerful groups and a way of exercising power over others. It would mean pushing back against depoliticised claims that data offer neutral and objective representations of an observable reality, or that automation provides innocent and efficient ways of changing and improving it.

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