not enter early would have performed worse if they had taken two or more GCSEs early. Further research could also estimate the average treatment effect for the treated in the case of two treatment groups, to see if taking two or more GCSEs early is beneficial to these students or not.

Finally, it will be interesting to see the impact of GCSE reforms on the amount of early entry. Students will still be able to sit GCSEs in Year 10, but changes to accountability measures mean that only the result from the first sitting of a GCSE will count in performance tables. This is likely to lead to a fall in early entry because schools may want to wait until students are ready to achieve their best possible grade, rather than getting them to sit GCSEs early and then re-sit if they underperform.

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Big data and social media analytics

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Introduction

'Big data' is fast becoming an area of great importance for businesses in many areas, including education. In simple terms it refers to the combination of data from various sources and understanding patterns in the data which can be used for various purposes such as improving market intelligence and educational research. Businesses, large and small, are implementing (or planning to implement) big data strategies. Apart from market intelligence, it is being applied in diverse areas such as healthcare and other scientific research, complex manufacturing industries such as aviation and heavy machinery, improving public utilities and traffic management, oil and gas exploration, telecoms, retail, banking and insurance, defence and security.

In this article we give an introduction to big data and some of its applications in various fields, including education. We also describe the use of big data for the monitoring of social media (for instance LinkedIn, Facebook and Twitter) for market growth and brand management. Some training courses in big data offered by various universities are mentioned in the article.

Applications in the education industry mentioned in this article include the combination of various sources of information about pupils such as test records, behaviour patterns, and teacher observations over a period of time for providing more accurate and timely interventions. In addition to this, we discuss new forms of assessment such as e-assessment and adaptive testing which will provide new streams of data which could be tapped for studying the performance of test takers in more detail and for monitoring and evaluation of tests.

Big data

Technological advances in recent years have led to a significant amount of data which is now generated in everyday life, such as shopping, travelling, banking, manufacturing and trading, public utilities, state and governance, sports, entertainment, science, education and health. Commercial organisations, research bodies and governments have started to realise the importance of using this data for their growth. As a result, the study of big data has gained prominence among scholars in different areas of research (Einav & Levin, 2013; Mayer-Schönberger & Cukier, 2013) as well as generating interest from the non-academic world (BBC, 2013; Lohr, 2012).

The concept of big data encompasses the collection of data, the combination of the data collected from various sources, processing it and using the results so obtained. Specifically, big data is a term used for large databases requiring complex processing and visualisation which cannot be efficiently handled by traditional data processing software (Wikipedia, 2014a). According to the McKinsey Global Institute, "Big data refers to datasets whose size is beyond the ability of typical database software tools to capture, store, manage, and analyze" (Manyika *et al*., 2011). A well-known model (known as 3V's model) of big data attributed to Gartner Inc. defines it as "Big data is high volume, high velocity, and/or high variety information assets that require new forms of processing to enable enhanced decision making, insight discovery and process optimization" (Beyer & Laney, 2012). The term 'volume' here indicates the complexity of datasets and not necessarily their size. 'Variety' refers to the different type of structured or unstructured data such as text and

numeric, video and audio and log files. 'Velocity' refers to the speed with which data can be made available for analysis. Sometimes other V's such as 'Veracity' (aiming at data integrity and the ability of the organisation to confidently use the data) or 'Value' (does new data enable an organisation to get more value?) are highlighted as well (Swoyer, 2012; Villanova University, 2014).

The rising potential of big data has led to the funding of several new initiatives by governments in recent years. The European Union has recently launched the Big Data Public Private Forum (called the BIG Project) to engage with academics, companies and other stakeholders to formulate a clear strategy for research and innovation in big data. The outcomes of the project will be used as input for Horizon2020 – an initiative aimed at securing Europe's global competitiveness and creating new growth and jobs in Europe (BIG, 2014; European Commission, 2014). The US Government announced funding of $200 million for the "Big Data Research and Development Initiative" in 2012 which aims to gain insights from large and complex collections of data in the fields of science and engineering, national security and teaching and learning (Kalil, 2012). The United States National Security agency is constructing a data centre in Utah to handle information they collect over the internet. There may be some concerns over privacy related to this development because it might result in the collection of personal data of individuals, such as internet access history, private communications, credit card usage and health records, etc.

The amount of data which is expected to be processed (not stored) at the facility in Utah is likely to be in 'yottabytes' – the largest unit prefix in the International System of Units (SI) and which was added in 1991. One yottabyte (prefixed as YB) is equivalent to 10^{24} bytes. Table 1 gives the data storage units in use. Gigabyte is still the most commonly used measure for the capacity of hard disk, however terabyte and petabyte have started to be used as well. Today a 1-terabyte disk drive (about 2.5 inches wide) can fit within a laptop. It is fascinating to note that, according to one estimate, storing a yottabyte on terabyte sized drives would require a million city block size data-centres, as big as the US states of Delaware and Rhode Island (Wikipedia 2014c; 2014d; Diaz, 2010).

Table 1: Data storage units (Wikipedia, 2014d).

Metric prefixes (multiples of bytes)

Decimal		*Binary*		
Value	*Metric*	*Value*	*JEDEC*[1]	*IEC*[2]
1000	kB Kilobyte	1024	KB Kilobyte	KiB kikibyte
1000^2	MB megabyte	10242	MB Megabyte	MiB mebibyte
1000^3	GB gigabyte	10243	GB Gigabyte	GiB gibibyte
1000^4	TB terabyte	10244	TB Terabyte	TiB tebibyte
1000^5	PB petabyte	10245		PiB pepibyte
1000^6	EB Exabyte	10246		EiB exbibyte
1000^7	ZB zettabyte	10247		ZiB zebibyte
1000^8	YB yottabyte	10248		YiB yobibyte

1. Joint Electron Device Engineering Council memory standards
2. International Electrotechnical Commission units

This gives an idea of how much traffic is likely to flow through the internet in the coming years, and the investment being made by governments (and private organisations) realising the potential impact of this data revolution (Wikipedia, 2014a).

According to CompTia (The Computing Technology Industry Association), in 2013, 28% of UK companies were using big data, 36% were planning a big data initiative that year and 95% see data as crucial to success over the next two years (Raconteur Media, 2013). They also report that there was a 5% annual global growth in IT spending in 2013 compared to a 40% growth in data. There has been a phenomenal explosion of data available from online usage in recent years. According to some estimates (IBM, 2013):

- 1.43 billion people worldwide visited a social networking site in 2012;
- nearly one in eight people worldwide have their own Facebook page;
- one million new accounts were added to Twitter every day in 2012;
- three million new blogs come online every month;
- 65% of social media users say they use it to learn more about brands, products and services.

The amount of data collected in organisations is expected to grow in the coming years. This could be due to an increase in the efficiency and declining cost of data storage and processing capabilities, the spread of digital technologies, and volume of data available from internet and digital devices and sophistication of algorithms for processing. A significant amount of this data would be generated online which would require substantial investment in data storage facilities. It has been recently reported that Facebook is currently building a data centre in Sweden the size of 11 football fields, along with two others in America, to collect and process their data (Bradbury, 2013).

There is a considerable amount of interest in educational organisations in exploiting the applications of big data and analytics, which is expected to rise in the near future. However, in order to make the most of big data, organisations should be clear about what exactly they want to investigate and how they plan to use the information. We believe that businesses need to consider the following questions while implementing big data/ social media policies:

1. Are we future ready?
2. Is it hype or necessity?
3. Are there any simpler and/or more economical ways of getting similar results?
4. Is it better to develop in-house capability or hire external resource?
5. Would our customers/stakeholders be comfortable with such monitoring?
6. Do we need to disseminate our policy to the stakeholders? If yes, have we done that?
7. What is the state of preparedness of our competitors?
8. Are we adhering to the data privacy laws?
9. How much value can be placed on the online behaviour of people?
10. Are we also using traditional sources of information (such as interviews and focus groups) to complement online metrics?
11. Are we also relying on human judgement for interpreting the data (and not only on software-generated results)?
12. Are we working with other departments within the organisation to develop a comprehensive policy?

Applications of big data

There are many examples of how big data is being used in various fields. Whilst these are not directly associated with the field of education, they give us a picture of the impact of data in our day-to-day lives (Raconteur media, 2013). Examples include:

- **IBM's Deep Thunder weather analytics package:** helps farmers know when to irrigate their crops;
- **SAS:** uses big data to identify fraud in the insurance sector;
- **British Airways' Know Me Programme:** uses the data collected to get a better insight into personal preferences and buying patterns of its frequent fliers;
- **Transport for Greater Manchester:** uses real-time traffic information to avoid congestion on roads;
- **Bank of America Merrill Lynch:** creates practical and effective solutions for clients based on a more comprehensive and holistic understanding of their requirements;
- **East Kent Hospitals University NHS Foundation Trust:** staff given access to data to adapt to real-time changes such as re-allocation of doctors and nurses between sites based on changes in demand across sites;
- **Citi:** estimates targeted predictive analytics according to customer behaviour;
- **Public Health England:** creates highly targeted treatments according to how patients respond in real-time through recently announced national cancer database (the data contains 11 million historical records and 350,000 new entries added every year);
- **Ocado:** delivers groceries purchased online. It keeps track of vehicle location, driving styles and petrol consumption while delivering 1.1 million items every week;
- **Royal Dutch Shell:** spends £650 million a year compiling big data across a number of sites so that they can more accurately predict presence of hydrocarbon resources at a site – this may help save them drilling costs (which for a single offshore drilling can cost up to £65 million);
- **Accenture:** collects social media analytics for the purposes of sentiment analysis by using data and text mining, semantics, linguistics and syntax processing;
- **Facebook:** recently started to decode the content of photographs (identifying faces and objects) and video;
- **Apple:** granted a patent to collect data on body temperature and heart rate through audio buds;
- **Google:** tunes algorithms in language processing to be culturally relevant (for instance differentiating between American and British idioms) and also improving its speech recognition capabilities;
- **Temetra:** collates information on how people use gas and water in their homes and businesses, giving them data after every 15 minutes rather than an annual reading;
- **Modak Analytics:** mined about 18 terabytes of data of a 810 million electorate during the general elections in India held in April to May 2014 on various demographics such as gender, age, and economic status for their client, a political party (Kurmanath, 2014).

An interesting application of the use of big data in developing government policy is the Behavioural Insights Team (www.behaviouralinsights.co.uk) which is jointly owned by the UK Government and Nesta www.nesta.org.uk. This organisation brings together data from a range of inter-related academic disciplines (Behavioural Economics, Psychology, and Social Anthropology) to understand how individuals make decisions in practice and how they are likely to respond to options so as to enable the Government to design its policies or interventions accordingly.

Applications of big data in education

A large amount of data is being generated in schools and higher education. Big data in education could be used to:

- understand performance and behaviour patterns of students;
- keep track of student progress throughout their education, allowing timely intervention if any anomalies are noticed;
- develop personalised content and instructional methodologies for each student in order to provide remedial help without stigmatising or isolating students or embarrassing them in front of their peers;
- estimate how students will perform on standardised tests (i.e. predictive assessment);
- find out which instructional techniques work best for students and to provide customised teaching (i.e. diagnostic assessment);
- feedback in real-time to help improve student performance;
- conduct adaptive testing;
- merge systems such as learning management and curriculum management;
- integrate ICT devices used by students in classrooms and homes leading to a large amount of useful information about them under initiatives such as bring your own device (BYOD);
- combine various data sources such as course records, student attendance, class rosters, programme participation, degree attainment, discipline records and test scores which could enable more efficient management of student recruitment, administration and academic research; (Hoit, 2012; West, 2012).

In addition to the applications mentioned above, awarding bodies could use data for more comprehensive research in areas such as test development and marker monitoring. They could also make use of large amounts of data which is likely to be generated by the use of computerised assessment and through other IT-enabled initiatives such as computerised, interactive systems for producing questions.

Educational courses in big data

McKinsey reports that by 2018 the United States alone will face a shortage of up to 190,000 people with analytical expertise and 1.5 million managers and analysts with the skills to understand and make decisions based on the analysis of big data (Manyika *et al*., 2011). A recent report prepared by *e-skills UK*[3] for SAS suggests that over the next five-year period the average annual growth rate of demand for big data professionals in the UK is expected to be about 18% per annum (compared to 2.5% for IT staff). This would equate to the generation of approximately 28,000 job opportunities per annum (a total of 132,000) by 2017 (e-skills, 2013).

Various universities in the UK are offering MSc courses in big data/

3. The Sector Skills Council for Business and Information Technology based in the UK.

analytics/data science/business intelligence/marketing analytics. These include University College London (UCL), Imperial College, Royal Holloway, Sheffield Hallam University, University of Dundee, Warwick University, Aston University and the University of Westminster. Bournemouth University is offering an MSc in Applied Data Analytics in partnership with SAS. SAS has also launched the SAS student academy in collaboration with Birmingham City University to tackle the demand for big data specialists (Shah, 2012; Orater, 2013).

Internationally, universities offering similar courses are the National University of Singapore (in collaboration with IBM), George Washington University, Columbia University, the Big Data Institute – University of Virginia, University of San Francisco, and New York University. Online courses in this field are also being provided by various institutes and MOOC (Massive Open Online Course) providers such as the Stanford University, University of California, Berkeley School of Information, Big Data University, MIT, Coursera and Statistics.com (KDnuggets, 2014). Short term professional courses are being run by the University of Oxford and Harvard. Technology vendors such as IBM, SAS, SAP and Google are also running various academic programmes in this field (Nerney, 2013).

Big data and social media

Businesses thrive on understanding their customers to the greatest extent possible. The monitoring of people's online behaviour is therefore becoming important for their success. Organisations are investing in gathering such analytics using big data as a key component for monitoring social media activity, particularly on social networking websites such as Facebook, Twitter and LinkedIn.

Social media analytics are the synthesis of the behaviour of internet users. The availability of data on consumers' web browsing, online shopping behaviour, customers' feedback and marketing research on social networks allow organisations to gain timely and extensive insights into consumers. Therefore, organisations can focus their market intelligence strategies based on different objectives such as advertising and product launches; publicity and brand management; promoting customer loyalty; providing personalised services to customers; keeping a tab on market trends and competitors; minimising risk; saving cost and business expansion in general.

The big data phenomenon applied to social media is fuelling a new, growing area of study known as 'sentiment analysis'. Its aim is to be aware of what people say or share in their everyday life. Businesses mine this information to understand their customers and to improve their operations accordingly. Educational organisations could also 'listen' to students and gain further insights into their perceptions. Using students' activity on social networking websites, sentiment analysis provides a useful tool to gather information about their online behaviour and, most importantly, their feedback on different aspects of the educational system, such as the university admissions process, features of qualifications, examinations and their aspirations.

Organisations could feed this information into developing their marketing strategies. This could be done in a number of ways, such as targeting the countries/regions with lower than expected online activity from their students, monitoring their examination experiences based on discussions in online forums, understanding what their brand means to students and getting feedback on new products.

Tools and metrics

The availability of more sources and forms of online data has also led to the development of new tools to access information and produce metrics about visibility of websites. It is possible to gather metrics such as countries/cities where website visitors were based, the web browsers they were using, the keywords they had used to search for a website and the webpages they had visited before and after accessing a particular website. Some such metrics are presented below.

Website rankings

Websites can be ranked to get an estimate of a website's popularity relative to all other websites over a specified period of time (for instance, six months or one year). The ranks are provided by tools such as www.ranking.com and www.alexa.com. The lower the rank, the higher the popularity of the website (for instance, the rank of Google.com is 1 followed by Facebook.com and YouTube.com). The ranks could be used by organisations to estimate the popularity of their websites in general, as well as in comparison to their competitors. Figure 1 shows a comparison of the ranks of two websites www.education.gov.uk and www.parliament.uk from November 2013 to May 2014.

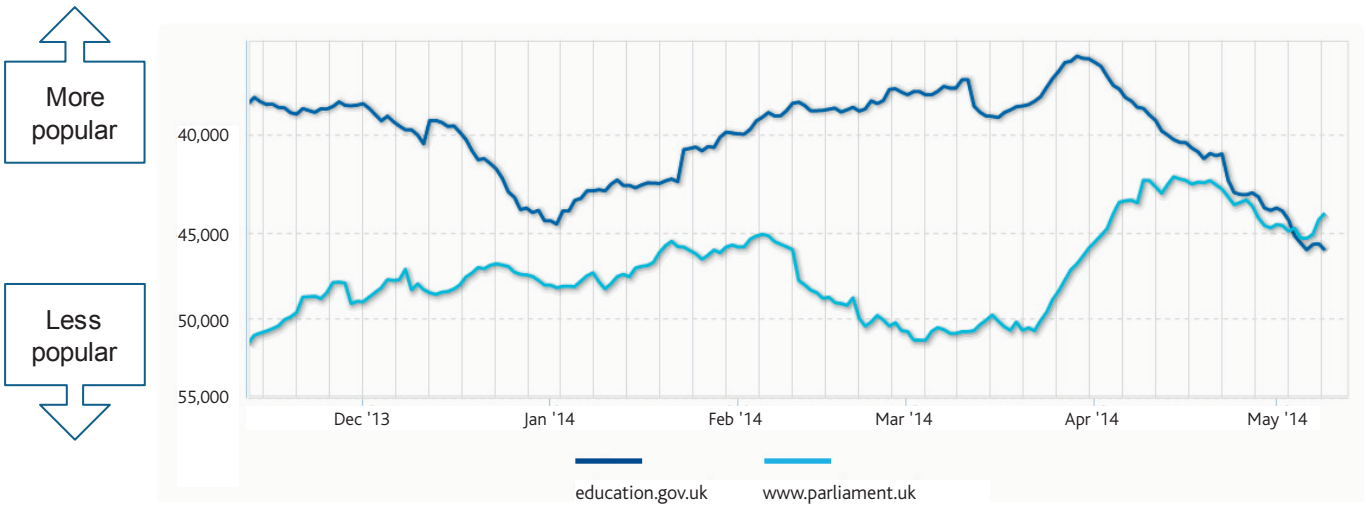

Figure 1: Historical traffic trends for the two websites from 12th November 2013 to 9th May 2014. Source: www.alexa.com (retrieved 12th May, 2014).

Online traffic analytics

Online tools such as Google Analytics and www.alexa.com provide traffic metrics of websites in the form of tables and interactive graphs which could be customised by the users. Some tools also provide the data collected in a spreadsheet, which can be used by organisations for producing graphs of their own. Some of the metrics provided are: the total number of visits to the website during a particular time period, the number of unique visitors, the total number of webpages viewed, the average number of webpages viewed in each visit, the average visit duration, and the bounce rate which is the percentage of single-page visits (i.e. visits in which a user left the website from the first page without continuing to view other pages within the site). Generally the lower the bounce rate the better the ability of the website to hold the interest of the visitors. A bounce rate of 50% is considered as an average value (Wikipedia, 2014b). All such metrics help organisations to get a more detailed understanding of the visitors to their websites which could be used for targeting their products and services. The metrics also allow the identification of those website sections which are popular with the visitors and those which are not, which in turn could help organisations improve their websites.

Social media monitoring

Organisations are able to be in regular touch with their customers through social media websites such as Facebook, Twitter, LinkedIn, YouTube and blogs. Organisations could also interact with their employees and other stakeholders (e.g. students, customers, external consultants) using tools such as Yammer, a private social network that aids collaboration across departments, locations and business applications.

Organisations can also monitor the news and find out who the key contributors are in online conversations about them. They can measure the results of their campaigns and monitor potential problems. Training providers can use such website monitoring tools to help them to understand and improve the reach of their training courses. Businesses can benefit from understanding the interconnections between their online users.

The use of some of the monitoring tools which offer basic metrics is free. However, most of the services that can actually help a business can be very costly ranging from a few hundred to several thousand pounds per month. It is therefore important for businesses to strategically plan their requirements and expectations from online monitoring tools. This might not be an easy task, because social media is a new and very fast changing area. In addition, the number of service providers in this area is growing rapidly and it might be difficult to find a reliable provider. The trialling of some tools might be required before selecting the most appropriate solution. Not all tools would fulfil the requirements of every organisation. The reports produced by the tools should be easy to interpret and worth the cost.

Tools for social media monitoring

Some popular tools for monitoring of social media are: Yomego, Ubervu, Hootsuite and Vocus. Other tools which social media managers may find useful are given in Table 2 and 3. Table 2 lists several web analytics reporting tools which can be used for producing insights from users' own websites. Data is visually presented using graphs and tables that can be customised through dashboards. Table 3 provides web-traffic estimation services which help gather how much traffic websites are receiving.

Table 2: Web analytics tools

Service	*Description*	*URL*
Google Analytics	Perhaps the most widely used website metrics service. It generates detailed metrics about a website's traffic. It's easy to use and is specifically designed for marketing research.	http://www.google.com/analytics/
AWStats	An open source web analytics reporting tool where users are encouraged to contribute to its development.	http://awstats.sourceforge.net/
Amung.us	Provides widgets to be included in the websites which show the number of live readers viewing a webpage and the location of current and previous visitors, in real time.	http://whos.amung.us/
WebSTAT	Its distinctive trait is the measure of visitors' behaviour once on the website. This includes their drivers and conversions; such as, the degree to which different landing pages are associated with online purchases.	http://www.webstat.com/

Table 3: Web traffic estimation tools

Service	*Description*	*URL*
Alexa	Provides an estimate of the percentage of internet users that may have visited a website during the last six months and allows comparisons with other websites.	http://www.alexa.com/
Compete	Helps to monitor online competition and to benchmark performance against the industry.	https://www.compete.com/
Website trafficspy	Makes use of data from a number of external sources to estimate traffic of a business' website or of their competitors.	http://websitetrafficspy.com/

Though this kind of data might not be completely accurate, it can be extremely useful to get an overall picture for marketing research.

Discussion

Data is changing our world – and fast. There is no denying this fact. What we buy, what we eat, how we communicate, how we are governed, how we live are all affected by the use of data. However, it should be noted that using data in day-to-day life is not a new concept. Ancient civilisations designed their calendars by predicting planetary movements based on data from prior recordings. More recently the advancement in digital and telecommunication technologies has led to an explosion of the amount of data available. The world has never been so interconnected. Each person who uses the internet, the telephone, or credit cards leaves a trail of information which can be used by organisations to predict their behaviour and adapt accordingly. The same is true of anyone who pays a utility bill, files a tax return or is registered

with government in some way (electoral registration office, health services, etc.). Big data is also being used in government initiatives as well as in all areas of research including health, economics, manufacturing, defence and security and education.

Organisations should plan their big data and social media policies carefully and with a long term view in mind. Due to the hype created in this area companies appear be in a rush to collect huge amounts of data, both text and non-text. However, not all of the data which they collect is necessarily meaningful or required. In essence, big data means combining data from various sources. There is a risk that accumulating very noisy data and making sense of it may require more resources than the returns it creates. Organisations also need to be aware of the increasingly high costs of hiring 'big data' scientists. It would therefore be advisable to carry out a cost-benefit analysis at the outset. The risk of data policies being unsuccessful can prove to be very costly for an organisation – both to its balance sheet as well as to its brand.

Schools and educational organisations hold huge amounts of data about students. This may include biographical information (such socio-economic status and ethnicity) and performance history (marks/grades/teacher observations) in summative or diagnostic assessments. Applications such as computer-based assessments allow more sources of data to be collected and analysed, such as the time spent by test takers on each question. This can help in the understanding of student performance more comprehensively which could be used at the classroom level to enable more targeted and timely interventions. Similarly, online marking of question papers makes available more (and certainly more accessible) data to awarding bodies for monitoring markers and evaluating their tests. Researchers and businesses may look forward to some new and innovative applications of data, as well as more refined statistical approaches to analysing complex data.

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