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The Role of Big Data Management and Analytics in Higher Education

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Abstract: Higher education institutions now a days are operating in an increasingly complex and competitive environment. The application of innovation is a must for sustaining its competitive advantage. Institution leaders are using data management and analytics to question the status quo and develop effective solutions. Achieving these insights and information requires not a single report from a single system, but rather the ability to access, share, and explore institution-wide data that can be transformed into meaningful insights at every level of the institution. Consequently, institutions are facing problems in providing necessary information technology support for fulfilling excellence in performance. More specifically, the best practices of big data management and analytics need to be considered within higher education institutions. Therefore, the study aimed at investigating big data and analytics, in terms of: (1) definition; (2) its most important principles; (3) models; and (4) benefits of its use to fulfill performance excellence in higher education institutions. This involves shedding light on big data and analytics models and the possibility of its use in higher education institutions, and exploring the effect of using big data and analytics in achieving performance excellence. To reach these objectives, the researcher employed a qualitative research methodology for collecting and analyzing data. The study concluded the most important result, that there is a significant relationship between big data and analytics and excellence of performance as big data management and analytics mainly aims at achieving tasks quickly with the least effort and cost. These positive results support the use of big data and analytics in institutions and improving knowledge in this field and providing a practical guide adaptable to the institution structure. This paper also identifies the role of big data and analytics in institutions of higher education worldwide and outlines the implementation challenges and opportunities in the education industry.

Keywords: Big data; Analytics; Data management; Performance excellence; Higher education.

1. Introduction

The generation of today's era is called big data. Technology users enjoys the benefit of collecting data which is not only simple data but meaningful and intelligent data. The term 'Big Data' describes innovative techniques and technologies to capture, store, distribute, manage and analyze petabyte- or larger-sized datasets with high-velocity and different structures. Big data can be structured, unstructured or semi-structured, resulting in incapability of conventional data management methods. Data is generated from various different sources and can arrive in the system at various rates. In order to process these large amounts of data in an inexpensive and efficient way, parallelism is used. Big Data is a data whose scale, diversity, and complexity require new architecture, techniques, algorithms, and analytics to manage it and extract value and hidden knowledge from it (Alamri and Qureshi, 2015). The education industry gains the advantages especially for gaining institutional achievement. "Big data and analytics go together because analytic methods help user organizations get value from big data (which is otherwise a cost center) in the form of more numerous and accurate business insights (Anirban, 2014)." Similarly, reflecting their student populations, universities have long been bastions of oodles of consumer technology. We are awash in mobile phones, laptops, tablets, gaming consoles, and the like. If one combines mobile consumer technology with Big Data analytics, one gets a host of new possibilities ranging from new ways of providing students with basic support to new ways of getting students to learn what the faculty needs them to learn. If we can get the right information flowing through the minds of students, perhaps we can improve their success. We can potentially help transform the classroom from the 19th century to the 21st (Bhosale and Gadekar, 2014).Furthermore, the rapid advancement of big data analytics makesit necessary for any organization to coincide it with their management and measurement

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processes. While considering the education sector it is now becoming essential to analyze data for the development of both learning and academic activities. So, the analytics in education sector can be divided into two broader categories: learning analytics (LA) and academic analytics (Bichsel, 2012).With the evolution of technology, the number of services which migrate from traditional form to the online form grows as well. Accordingly, the universities must perform changes in order to be service oriented and in order to fulfill excellence in performance, and this will not be achieved unless higher education institutions do their best to apply modern trends in IT services, such as cloud computing (Bienkowski *et al.*, 2012).This paper will review the types of big data analytics and management that canbe used in the higher education sector and also the needs, opportunities and challenges in case of implementing big data analytics in this sector.

2. Definition

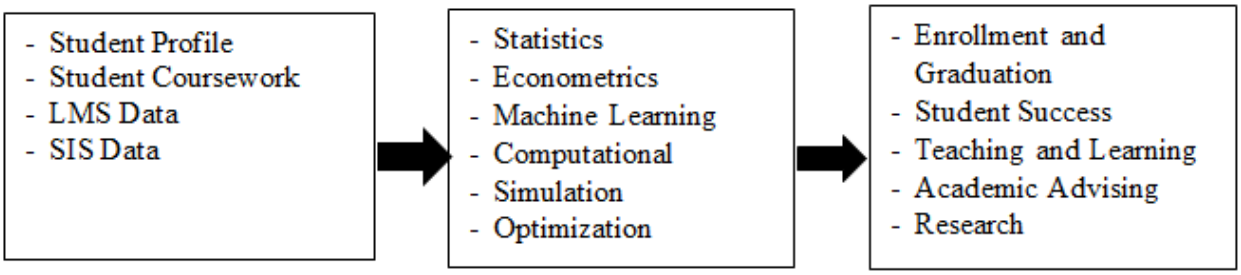
Higher education was acknowledged in timeas one of the pillars of society development.Academic analytics is concerned with the improvement of resources, processes and workflowsof the academic institution through the use of learner, academic, and institutional data (Cisco). Academic analytics, akin to business analytics, are concerned with improving organizational effectiveness (Dahlgaard-Park, 2003). The adoption of academic analytics in higher education is expectant because of increased competition, accreditation, assessment and regulation. Although there are lots of essential data in the institutions of higher learning but the collected data is not being analyzed. Consequently, higher education leadership is bound to make critical and vital decisions based on inadequate information while that could be achieved by appropriately utilizing and analyzing the available data (Daniel, 2014). Some other analytics like predictive analytics, business analytics or action analytics can also be taken as consideration for the big data analytics in the education sector. But form all of these analytics learning analytics in the academic domain is focused specifically on learners, learning processes and their learning behaviors (Darus *et al.*, 2015).UK's higher education commission recently reported that that learning analytics is a powerful way for their institutions to achieve strategic goals as well as providing huge benefits for their students, and that all HEIs should consider introducing an appropriate learning analytics system to improve student support / performance at their institution (Desai *et al.*, 2016).Tools such as Moodle (Open-source learning platform), Blackboard Analytics (Packaged self- service analytics applications), GISMO (Interactive tracking system built for Moodle that displays data through a graphical interface) and Meerkat-ED (Web tool that analyzes participants and their interactions in discussion forums) are some of the examples of types of Learning Analytics Resources (Dyckhoff *et al.*, 2012). For higher education to develop its analytics capacity, institutions will need to view funding for analytics as an investment in future outcomes, increase the amount of funding for analytics and invest in hiring an appropriate number of analysts to institute and develop an analytics program.Big data analytic is an interest or a major priority for most universities and it can significantly advance an institution in strategic areas such as resource allocation, student success, and finance (Economist Report, 2008). While, big data management is where data management disciplines, tools, and platforms (both old and new) are applied to the management of big data.Traditional data and new big data can be quite different in terms of content, structure, and intended use, and each category has many variations within it. To accommodate this diversity, softwaresolutions for BDM tend to include multiple types of data management tools and platforms, as well asdiverse user skills and practices (Russom, 2013).

3. Principles

Big data analytics is now becoming a great challenge for the educationalist. People are now concerned about the intelligent outcome of institution to know students learning and academic progresses. But it is becoming hard for the management of the institution to just drive for the big data analytics without knowing its aspects.Theeducational (learning and academic) analytics from three aspects: Needs, Opportunities and Challenges. Strategic aims of educational analytics includes Helping Learners, Helping Mentors, Developing Curriculum and Learning Process and Helping Administrators (Eduventures, 2013). Institutions began to change their approach to management and began to focus on what Lawler (1988) (Hussein and Mohamed, 2015) has labeled "High Involvement Systems." In these new systems employees were expected to assume the responsibility for performing tasks which traditionally had been considered management tasks— planning, decision making, and quality control, for example. Consequently, the number of middle level managers was reduced and many tasks which had traditionally been considered managerial tasks were delegated to employees. In addition, in order to maintain high levels of intrinsic motivation on the part of employees, the managers that remained were asked to abandon the traditional role of supervisor and assume the role of mentor. Instead of doing the planning, decision making and controlling themselves, managers were now expected to help their employees perform these tasks by acting as facilitators, coaches, and trainers (Bienkowski *et al.*, 2012). The key principles for using analytics includes responsibility, transparency and consent, privacy, validity, access, minimizing adverse impacts, stewardship of data (Desai *et al.*, 2016).

4. Models

Figure-1. Big data analytics in higher education



Learning analytics is concerned with the measurement, collection, and analysis and reporting ofdata about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs (Hussein and Mohamed, 2015). More broadly, learning analytics software and techniques are commonly used for improving processes and workflows, measuring academic and institutional data and generally improving organisational effectiveness (Ibe-Ariwa and Ariwa, 2015; Jain and Pandey, 2013).

Corporate–academic partnerships are increasing (Jones, 2012); however, toattract and sustain these partnerships, corporations require institutions of higher education to demonstrate a commitment to the utilisation and development of advanced technologies that are likely to support applied research outputs and potentials for knowledge transfer and commercialization (Kellen *et al.*, 2013).

At the same time, these global changes are mounting on the institutions of higher education; new technologies continue to have a significant impact on academic careers as research and teaching become more reliant on these technologies (Leydesdorff and Etzkowitz, 2001). Over the last decades, a digital revolution associated with developments in new technologies such as ubiquitous computing devices, flexible class room design and Massive Open Online Courses is radically reshaping the mode and accessibility of learning and teaching. In addition, many institutions are embracing new class formats and technologies designed to meet either evolving student needs or as mechanisms to reduce operational costs.

5. Challenges

According to Long and Siemen (2011), various challenges have been identified in achieving successful analytics such as affordability and resources which incorporates training and tools, misuse or inaccurate data, culture and individuals privacy rights, lack of expertise, insufficient ROI and data standardization.

Vulnerability to security breaches are the biggest obstacles to cloud computing adoption in higher education, according to recent surveys of IT leaders in higher education (Machii and Kyalo, 2016; Manohar *et al.*, 2016). The most important of these security risks includes the loss of governance, lock-in issues, isolation failure, compliance risks, management interface compromise, data protection, incomplete or insecure data deletion and malicious insiders (Mariani and Thompson, 2014). In addition, concerns regarding privacy, data integrity, intellectual property management, regulation issues and audit trails are significant barriers to adoption of cloud-based solutions (Mircea and Andreescu, 2011). However to help mitigate these risks for higher education institutions, several organizations have emerged in the last few years.

In spite of having lots of necessity andopportunities educationalist must have face some challenges to implement big data analytics. Some of these challenges are: 1. Ensuring data flow: acquiring data for analysis is a great challenge for the implementation of educational analytics. It is difficult to access required data from poorly integrated database system and it will also be hard develop data warehouse for all the institutions. Besides, poor quality and incorrectly formatted data from less accessible database system can cause significant problems. 2. Training practitioners: To develop better understanding of the practitioners about the system will be time consuming. It would be difficult for the learners and educators to present information in an accessible and informative way and therefore would be inflexible to collaborate with the system. 3. Transforming thinking into actions: Just implementing the analytical systemis not overcoming all the challenges. Finally, to make the practitioners becomeused to with the system and to groweagerness to cooperate would not beeasy. As a result all efforts will be go invain if the effective use of the analyticalsystem could not be ensured (Eduventures, 2013).

6. Benefits

1) Improved retention and graduation rates

Big data analytics involves making sense of large and complex datasets. Institutions must embark on various types of analytics, such as discovery, iteration, flexible capacity, mining and predicting and decision management (Economist Report, 2008). Take the example of student engagement. The process of discovery involves exploring and connecting different engagement points of data, such as class attendance, VLE activities, digital library, university email etc. For emerging patterns to emerge, such as student retention risk factors, it is necessary to go through an iterative process,learn from each iteration and gradually move

on to the next level of analytics, such as further data mining and predictive analytics in order to generate concrete insights on student engagement and retention. Big data analytics can also be processed automatically for specific decision to be taken. For example, academic staff will automatically receive an alert on disengaged students who are at risks of dropping-out.

2) Better student success rates
IT staffs can help faculty to improve their technical skills in using various Web 2.0 tools (such as blogs or wikis) and can therefore help them to effectively integrate these collaborative tools in their courses in order to improve their students' learning experiences and performance (Mok, 2005).

3) Better teaching and learning techniques
Implementing the cloud computing technology enables a more efficient and efficient execution of external cooperation and collaboration processes in developing a modern concept of innovative university. Furthermore, new possibilities are created in the modes of connecting the entities of the Triple Helix concept, i.e. academia, industry and government, which should provide universities with a changed status and key role in connecting the learning and teaching process with the research process (Morgan, 2016).

4) Improved research scalability
Using smart machines to identify core themes and articles in academic research concerns with access and paywalls resulting to better results and more comprehensive use of scientific literature. The data analytics also managed the answer to the need of finding a scalable way to tag many research objects (Peters and Austin, 1985).

5) Improved Academic Advising
Improve academic advising through the use of dashboards, early-warning systems, and enhanced communication between advisors and students (Ong, 2016).

7. Opportunities

7.1. Cost reduction

According to Petkovics *et al.* (2014) summarizes benefits of cloud computing as unlimited scalability, reduced cost, increased storage, automation, flexibility and better mobility; moreover, pointed out reduction in cost, infrastructure flexibility, virtualization, ease monitoring and access of data, unrequired data backupand the availability increased. Therefore, the adoption and implementation within the Kenyan higher institution would greatly boost and improved education quality.

7.2. Increasing Functional Capabilities

According to (Russom, 2013), one of the benefits of cloud computing in higher education is the increased of functional capabilities, which is supported by Bienkowski *et al.* (2012) and Seke (2015). Another angle to data analytics in educational institutes that was explored in all the research literature was to do with machine learning algorithms. The C4.5 algorithm which is essentially a decision tree algorithm can be used to effectively design predictive models from the student data that has been accumulated over the years (Dyckhoff *et al.*, 2012).

7.3. Access to Application Anywhere

The potential users of Education cloud are students, staff or academicians. Each user has their own credentials to access the respective cloud services. Adopting SAAS of Education cloud, teaching staff can maintain the attendance, conduct online quiz and many more with the respective software packages .Adopting PAAS Institute can organize practical sessions as and when needed from Education Cloud. For e.g., developing projects like mobile apps, web apps, etc. Adopting IAAS Staff can upload their study materials or any related content on Education cloud and student can access these materials and content 24*7*365 (Shacklock, 2016).

7.4. Support for Teaching and Learning

Through the proper use of big data analytics the revolutionary development on the education sector could be achieved. Instead of some innate challenges, big data analytics can represents customized learning environments to the learners, can reduce potential dropouts and failure and can develop long term learning plans. All of these are possible through the effective development and use of big data analytics in the educational institutions which is also supported by Seke (2015); Shacklock (2016) and Bienkowski *et al.* (2012).

7.5. Increase Openness of Students to New Technologies

According to Daniel (2014), global changes are mounting on the institutions of higher education; newtechnologies continue to have a significant impact on academic careers as research and teaching become more reliant on these technologies. Over the last decades, a digital revolution associated with developments in new technologies such as ubiquitous computing devices, flexible class room design and Massive Open Online Courses is radically reshaping the mode and accessibility of learning and teaching. In addition, many institutions are embracing new class formats and technologies designed to meet either evolving student needs or as mechanisms to reduce operational costs which is also supported by Russom (2013); Seke (2015); Shacklock (2016) and Bienkowski *et al.* (2012).

8. Discussion

The role of big data management and analytics is analyzed how analytics of big data in higher education institutions is managed. Different individual interviews and reviews of different existing studies and observations of different methods used for analytics has been used for data collection. According to Kellen *et al.* (2013), as learning technologies continue to penetrate all facets of higher education, a plethora of useful 'data traces' are generated. These data can be utilized to inform institutions of higher education to adapt better in response to changes happening within and outside their environmentswhich identifiesthe role of big data management and analytics in higher education.Once data have been rendered into a usable form, it has to be analyzed to generate actionableinformation. However, with the growing diversity in the nature of data, managing and analyzing diverse data set is becoming a very complex process. Analysis needs to include linking, connectingcorrelating different data sets to be able to grasp the information that is supposed to be conveyed by these data. This situation is, therefore, termed as the 'complexity' of Big Data.

The role of big data management and analytics in higher education has been categorized which includes institutional analytics refers to a variety of operational data that can be analyzed to help with effective decisions about making improvements at the institutional level. Institutional analytics include assessment policy analytics, instructional analytics, and structural analytics. Institutional analytics make use of reports, data warehouses and data dashboards that provide an institution with the capability to make timely data-driven decisions across all departments and divisions. In IT analytics, covers usage and performance data that helps with monitoring required for developing or deploying technology, developing data standards, tools, processes, organizational synergies and policies. IT analytics aim at integrating data from a variety of systems—student information, learning management and alumni systems, as well as systems managing learning experiences outside the classroom Kellen *et al.* (2013).

Academic analytics will be an essential component of the future. It encapsulates all the activities in higher education affecting administration, research, resource allocation and management (Tulasi, 2013). Academic analytics provides overall information about what is happening in a specific programme and how to address performance challenges. Academic analytics reflects the role of data analysis at an institutional level, whereas learning analytics centers on the learning process (which includes analyzing the relationship between learner, content, institution, and educator) (Hussein and Mohamed, 2015). Academic analytics combines large data sets with statistical techniques and predictive modelling to improve decision making. Academic analytics provide data that administrators can use to support the strategic decision-making process as well as a method for benchmarking in comparison with other institutions. The goal of an academic analytics programme is also to help those charged with strategic planning in a learning environment to measure, collect, interpret, report and share data in an effective manner so that operational activities related to academic programming and student strengths and weaknesses can be identified and appropriately rectified.

Higher education institutions are applying learning analytics to improve the services they provide and to improve visible and measurable targets such as grades and retention (Bienkowski *et al.*, 2012). Learning analytics is concerned with the measurement, collection, and analysis and reporting ofdata about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs (Hussein and Mohamed, 2015). More broadly, learning analytics software and techniques are commonly used for improving processes and workflows, measuring academic and institutional data and generally improving organizational effectiveness (Dyckhoff *et al.*, 2012; Jones, 2012).

9. Conclusion

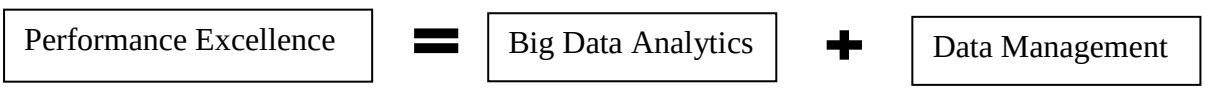
Proving the relationship of big data and analytics to excellence performance, the researcher has derived into a proposed model includes big data and analytics definition, important principles, models and benefits of its use to fulfill performance excellence in higher education institutions. The suggested philosophy for the proposed model is that big data and analytics and its management leads to achieve excellence of performance.

"4P"excellence model – is presented which has proven to be a goodframework model to be used when educational institutions are planning toattain excellence. The model is consisting of five components which are as follow; Products, Processes, Leadership, People and Partnership (Dahlgaard-Park, 2003).

In order to achieve excellence using big data and analytics in higher education, institution needs to develop key performanceindicators, metrics and methods for capturing, processing and visualising data. Also, there should set of diagnostic tools and an integrated technology-enhanced data analytic framework and a data warehouse.

In order to accomplish it the big data management strategies of the institution should include demand business value from big data, use big data to create new applications and extend old ones, Get training (and maybe new staff) for big data management, collaboration is key to all data management, especially when managing big data, beware the proliferation of siloed big data repositories and define places for big data in architectures for data warehousing and enterprise data management.

Figure-2. Implementation of big data analytics in higher education



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