

Imminent Challenges of Adoption of Big Data in Educational Systems in Sub-Saharan Africa Nations



Chinecherem Umezuruike, Habiba Njeri Ngugi

Abstract - Exponential technological development as seen in the 21st century has led to the generation of the very large volume of data in different formats and at a very high speed, such that traditional processing methods cannot be used to process these data. With the evolution of big data and its processing techniques, useful information has been derived from these volumes of data that has been useful in decision making in various domains, education inclusive. In the developed economy land stride has been made in the use of big data analytics especially academic and learning analytics, but such cannot be said in the developing economy like sub-Saharan Africa. Researchers have done thorough work on the benefits and challenges of big data as a trend and in extension big data analytics in education. This work systematically reviewed works in big data, academic analytics, learning analytics, identifying generalized challenges of big data and it extends to identifying salient factors that are hindering adoption of big data in education in sub-Saharan Africa in line with the 4th sustainable development goal 2030 Development Agenda of the United Nations; using online sources as it bulk of data collection. These issues that formed the gap are addressed in the different sections of the article.

Keywords: Academic Analytics; Big Data; Learning Analytics; Sustainable Development Goals.

I. INTRODUCTION

The 21st century has seen exponential development of technology and emerging trends which has shaped data generation, analysis, and management for meaningful and sustainable business growth. Volumes of data are generated at high speed, different structures, and the inability to use traditional processing tools that characterizes big data [3]. Big Data has benefitted organizations and enhanced organizational growth with learned patterns that improve decision making, policy-making, and client management [1], [2].

These benefits are seen in the health sector, business sector, financial sector but much cannot be said about the educational sector in sub-Saharan Africa. United Nations draw out 17 sustainable development goals for its member states. United Nations as an organization recognizes the importance of quality education, hence, they gave it a place in the SDG. Member countries adopted the SDG in 2015 and aligned it with their different developmental goals. Hence, this work looked at Big Data in education, its challenges and identified factors that have hindered the adoption of these technological trends in sub-Saharan Africa in line with the sustainable development goal of 2030.

II. LITERATURE REVIEW

A. Big Data

Big data as defined by International Telecommunication Union (ITU) is a standard for enabling the collection, storage, management, analysis, and visualization, potentially under real-time constraints, of extensive data sets with heterogeneous characteristics [3]. The defining characteristics of big data are volume, velocity, variability, and veracity [4] which in context is associated with data generated on a day to day bases from different educational institutions. Assessing/collection of data, analysis, and deployment are the three stages that big data goes through to become useful. Analysis of data is a critical stage of generating meaningful and useful information for decision making. [5] identified benefits of big data analytics to have increased cross collaborations, Improved knowledge flow, learning effectiveness, cost reduction, and reduction in learning and academic risk and complexity. In the education sector, big data is catching up fast as tremendous data is generated on a daily bases by students and teachers as seen in other sectors. Transparency, accountability has become the paramount expectation of the public about generated data and in achieving this, big data analytics has become handy. Tracking of Student academic and behavioral progress is simplified by implementing big data analytics, also an important aspect of this is the improvement of faculty visibility [6]. On the part of the teachers, it has helped in monitoring student online activities, results, and response time to online tests and examinations [5] [7]. This, in turn, improves the ability of the teachers in understanding the individual behavior of students. Also, personalized learning is enhanced leading to a better learning environment and learner participation. To fully harvest these benefits, there are important analytical procedures used to access these huge data in educational organizations; these are academic analytics and learner analytics [5] [8].

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B. Academic Analytics (AA)

Education today has a lot of increased competition, assessment, collaborations and regulation sectors across the globe. With technological development, these parameters have become more with the daily creation of large data, hence, the need for a tool(s) to harvest information from a pull of heterogeneous and homogeneous data that leads to accurate decision making by top management of the educational sector. In the context of educational big data, the level of intelligence is required in data analysis and development of predictive models. According to [9], AA is defined as the process of evaluating and analyzing organizational data received from educational systems for reporting and decision making. This area of technological advancement has started yielding a result that enhances curriculum development, Course redesign, enhancement of course assessments and instructors line of communication with students [10]. The educational sector creates tremendous data using technology, hence academic institutional data are so big that traditional tools will not be able to process them. With this knowledge, more needs to be done to enhance teaching and learning, not just prediction and decision making. With the output from academic analysis, systems and applications can be developed to enhance teaching and learning of complex topics and courses. Deep learning a subset of AI with the capability of learning with or without supervision could be ideal when deployed to data from educational institutions within a given period to understudy patterns used for forecasting and decision making. In Africa with many institutions of learning and much data and less technological benefit, academic analytics can be used to harness generated data for growth, research, and innovation to mention but few.

C. Learning Analytics

Learning analytics is an analytical procedure used to mine the online behavior of learners, progress, and results. According to [11], learning analytics is defined as the measurement, collection, analysis, and reporting of information about learners and their contexts for understanding and optimizing learning. This procedure provides institutions of learning, the possibility of focusing on student success and design instructional materials that consider individual differences of the learners. The potential of learning informatics ranges from the transformation of student learning to understanding of how they learn. This is achieved by giving continual formative feedback as they progress through their studies [12]. It also enables them to compare themselves to peers, thereby, adding a competitive element (an important motivator for many students) and a check that they are keeping up with the progress of successful students in previous [12] [13]. Meanwhile, some universities provide analytics-based systems to help students select future modules, building on data about their career choices, aptitudes and grades for previous modules to provide optimum pathways through their studies. The objectives of learning analytics are: supporting informed decision making, improved student retention, understanding students' learning behavior, cost-effectiveness, arranging personalized assistance to students, and timely feedback and intervention which are key to learning progress. Learning Analytics is a useful tool in analyzing educational big data and this has improved in many learning outcomes, improvement in the result and student performance.

III. III. CHALLENGES OF BIG DATA IN EDUCATION

A. Data collection

Collecting data for analytics is a big challenge as quality, database access, and data formatting play key roles in accessing data for quality analytics. With technological advancement in terms of hardware and software, there arises the issue of integration of technologies and database which in turn affects data collection.

B. Data quality

The quality is determined by the users of such data. Does it enhance decision making? does it lead to a creative decision that enhances competitive advantage? If this happened, then data is said to have high quality. Determining the quality of data is one of the challenges of big data in every domain, education inclusive. Lack of standard across board has also made data quality unmeasurable [14].

C. Data integration

Understanding that big data comes in different formats (structured, semi-structured and unstructured). With data in repositories with different architectural and storage structures, there arises the need for integration to reduce the loss of important data which comes from mostly data cleaning during integration.

D. Ethical and privacy concerns

The challenge of who takes the responsibility of the data, who accesses the data and what level of data can be accessed without infringing on individual privacy has become a concern. As data is generated in different formats and sources, and across borders using the internet as a transporting means, individual privacy level becomes an issue. Ethical issues as relates to data usages and sharing cannot be monitored as responsibilities cannot be determined by instructions.

IV. IV.SUSTAINABLE DEVELOPMENT GOAL OF 2030 AGENDA

The global agenda, adopted by united nations member countries in 2015, with a vision of ending poverty, protecting the planet and ensuring that all people enjoy peace and prosperity has 17 goals referred to as the sustainable development goals. This applies to both developed, developing and underdeveloped nations. The 17 goals are itemized in Table 1, with the descriptive definition of each goal

Table 1: Sustainable Development Goals of 2030 Development Agenda

Goal	Definition
1	No Poverty
2	Zero hunger
3	Good Health and Wellbeing
4	Quality Education
5	Gender Equality
6	Clean Water and Sanitation
7	Affordable and Clean Energy



- 8 Decent Work and Economic Growth
- 9 Industry, innovation, and infrastructure
- 10 Reduced inequality
- 11 Sustainable cities and communities
- 12 Responsible Consumption and Production
- 13 Climate Action
- 14 Life Below Water
- 15 Life on land
- 16 Peace and Justice Strong Institutions
- 17 Partnerships to achieve the goals

Source:[15]

In this work, the 4th goal which is quality of education is the focus. The terms of reference of this goal are to ensure that there will be zero dropouts of citizens at the primary school level, train youths and adults in relevant skills and vocation that helps them to fit into the developmental structure of their respective nations. Also important is bridging the gap of educational Based on these premises, most nations have drawn plans as milestones to achieving this goal. In the sub-Saharan nations, much has been archived in the area of primary education but there is little progress in the training of primary school teachers in sub-Saharan Africa, [16], but much needs to be done in the area of skill acquisitions. To bridge these gap especially in the technological domain, many technological hubs have sprung up to develop technical skills and vocational acquisition. Technological hubs are informal technological communities that encourage innovations for technological startups companies space to share facilities. They also train youth on technological skills to meet up with the skill requirements of a technological company's example is Silicon Valley. Figure 1 highlights the number of technological hubs by country in Africa as of 2019.

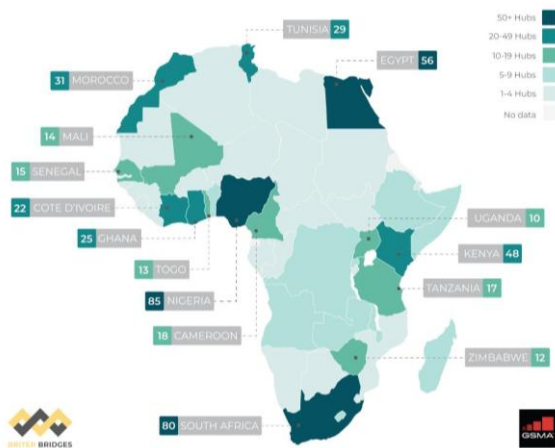


Figure 1. Technological Hubs in Africa

Source: [17]

V. RESEARCH APPROACH

Research approach is a plan that details the method of data collection and analysis. In this paper, the qualitative research approach was adopted and convenience sampling method used in choosing the samples for the research.

A. Data Collection

Data was collected using a 5 point likert scale questionnaire. the questionnaire was in four sections which are:

- Educational goal
- Technological expertise

- Human interference and
- Big data in educational institutions.

Data collected was supported by information from journals and online resources to draw a conclusion on the impeding factors.

B. Responses by respondents

One thousand questionnaire were distributed and the 600 were used for the analysis. This is tabulated Table 1.

Table 1 Analysis of distributed questionnaire

S/N	Item	Number
1.	Distributed Questionnaire	1000
2.	Returned Questionnaire	700
3.	Incomplete	100
4.	Completed	600

The result was drawn based on the completed questionnaire represented in Tables 2 to tables 5. The acronyms used in the table are as explained.

SA: Strongly Agree

A: Agree

N: Neutral

D: Disagree

SD: Strongly disagree

Table 2 shows the responses on African educational goals, Table 3 shows responses for technical expertise, Table 4 represents responses for human interference and Table 5 represents the responses for understanding of big data in education.

Table 2: Responses on goals of educationSub-Saharan Africa

Items	SA	A	N	D	S D
Classroom expansion	332	165	43	50	10
Increase Student Enrolment	250	165	70	80	30
Constant review of Curriculum	150	150	70	30	200
Insufficient number of institution compared to the population	320	95	65	50	70

Table 3: Responses on the level of technical expertise

Items	SA	A	N	D	S D
Adequate government financing	120	80	20	20	360
Adequate technological infrastructure	120	80	20	120	260
Equal female to male ration in technical education	120	100	56	44	280
Adequate number of educators	140	80	60	160	160

Table 4: Responses on the level of Human Interference

Items	SA	A	N	D	S D
Easy acceptance of new technology	150	90	53	57	250
Better understanding of new technological trends	130	80	40	150	200
Management support for change in teaching and learning system	100	100	100	170	130
Adequate training for appropriate state that will implement the new technology	200	70	60	142	128

Table 4: Responses on the level of understanding of big data in education

Items	SA	A	N	D	S D
Online student interaction	110	90	200	80	120
Online video tutorials	130	70	150	50	200
Online test/examinations	130	70	150	50	200
Student enrolment records	200	0	200	200	0

VI. RESULTS AND DISCUSSION

Conclusions were drawn from data collected from the field and from literature. These conclusions are the factors impeding adoption of big data analytics in in sub-Saharan Africa.

A. African Educational System Goal

Education is key to development and innovations. No particular economy develops more than its educational

system. The educational system in most developing nations mostly sub-Saharan Africa has educational expansion as its main goal thereby leaving off skill acquisition [18]. With the increasing number in the population, the existing educational institutions are seen not to be enough to cater for the growing population. Figure 1, indictate that classroom expansion, student enrolment, and building of more education facilities are the key goals that drive educational systems in Africa.

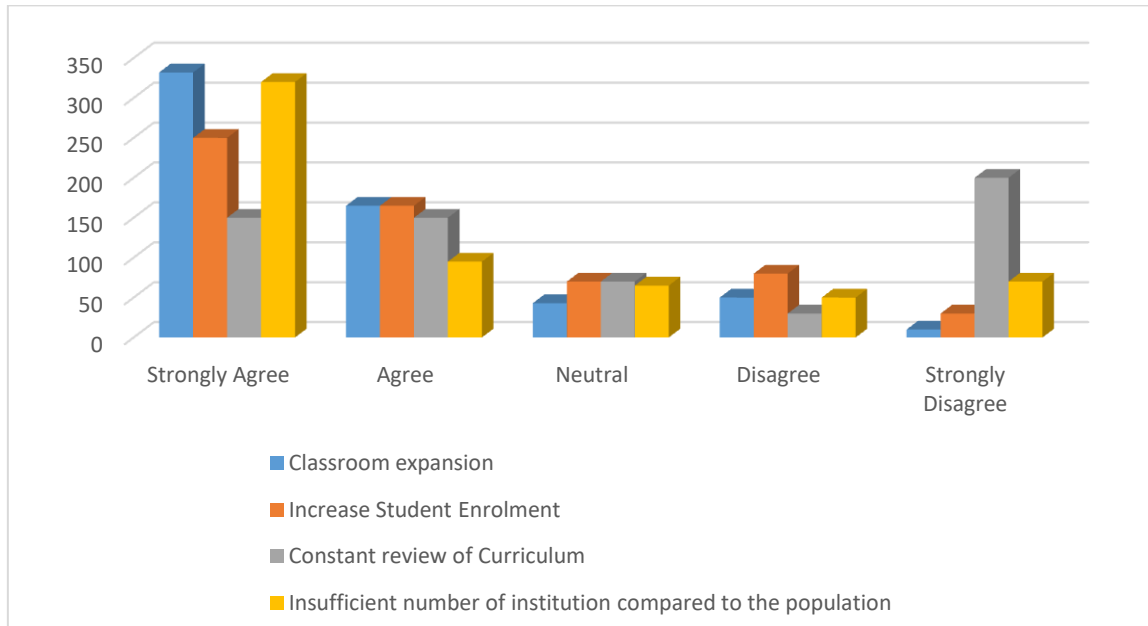


Figure 1: African Educational Systems Goal

B. Insufficient technological expertise

With the policy of expansion, public and private educational agencies have worked tremendously to increase the number of institutions and the number of students attending school but using the old curriculum that plays down on skills acquisition [19]. Insufficient technological experts are triggered by challenges of low and inequitable access to

education, poor learning outcomes, inadequate political commitment, financing, and weak education system capacity [20]. Figure two indictate that respondents strongly disagree with the items in the questionnaire, which agrees with the work done by authors in [20] as the factors that determines the level of skills acquisition.

With the growth in technology, complex educational tasks and environmental pressure on the educational organization for productivity, technological expertise becomes the

driving force behind development and innovation. Therefore, without experts, driving these technological trends to fruition becomes unachievable

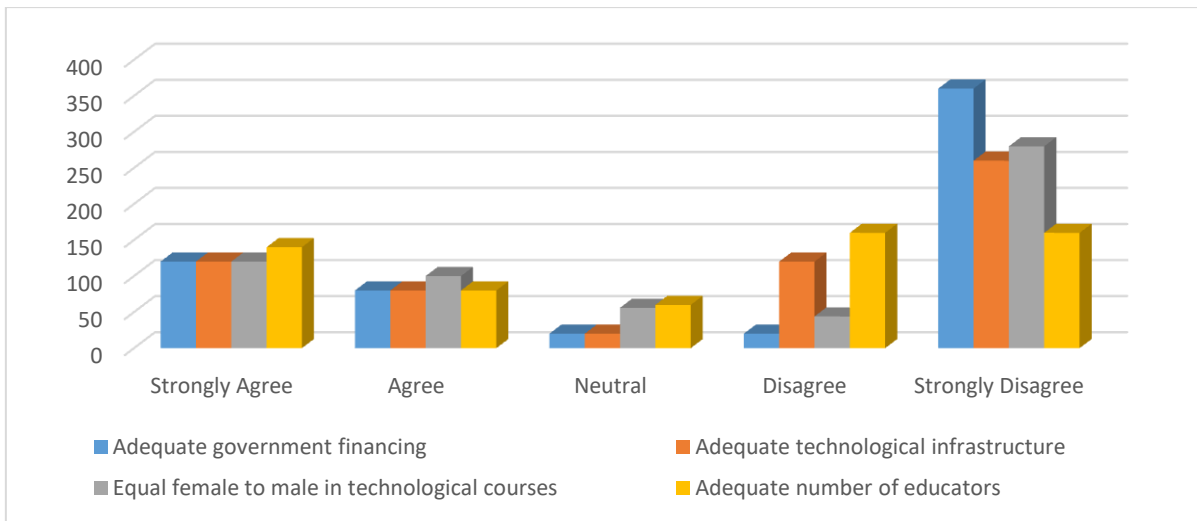


Figure 2: Insufficient technological expertise

C. Political Instability

Political uncertainties exist in most African countries, thereby, obstructing the free running of the educational system in such countries and regions. In Nigerian North East, there has been insurgency and obstruction of activities by the Boko Haram group, In Liberia, they have also seen a decade of civil war, Rwanda has its fair share of disruption, Sudan, Congo, to mention but few. During these periods, educational activities remain stagnate and little or nothing is achieved in terms of training, learning, and teaching. Also, political instability comes with the non-implementation of policies. Focus is shifted from policy implementation to restoration of peace, hence, the educational policies are left without been implemented. In the course of change of

government, the new government comes with new policies that will need time to be understood and implemented.

D. Human Interference

Human interference is another great factor that has hindered the adoption of most technological trends in Sub Saharan Africa. The misconception of technology as a fast track to losing jobs and unemployment in most organizations has bred resistance to the adoption of trending technologies. The factors indicated in the Figure 3 and its corresponding responses indicate that acceptance, understanding of technological trends, management support for new innovations and training plays important role in determining the level to which human interference hinder adoption of big data in education

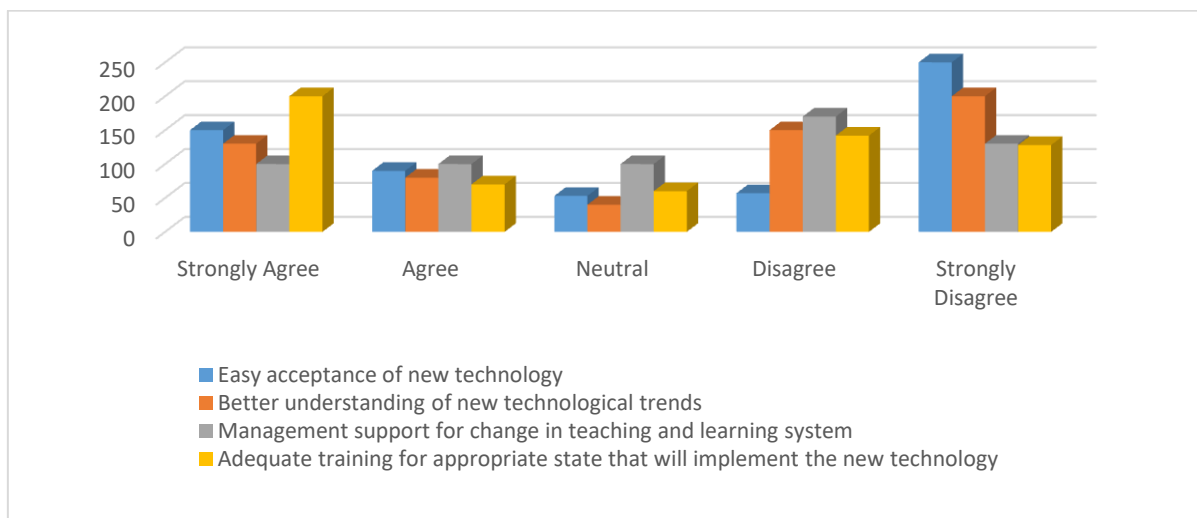


Figure 3: Human Interference

E. What data forms big data in Educational System?

Data is generated on a daily basis on the educational platform in structured or unstructured form. Irrespective of this fact, questions are raised whether there are big data in educational system.

Though voluminous online student and teacher transaction happens on daily bases in educational system within Africa, it is not clear what data can be said to be big data in education. Figure 4,

explicitly shows that majority of the respondent are neutral indicating that they have little or no knowledge about what data form big data in education. Without good understanding of a concept such as big data and big data analytics, adopting it becomes difficult. Hence, this is a

hindering factor. This is shown in Figure 4 with the number of respondent picking the different options against corresponding scales.

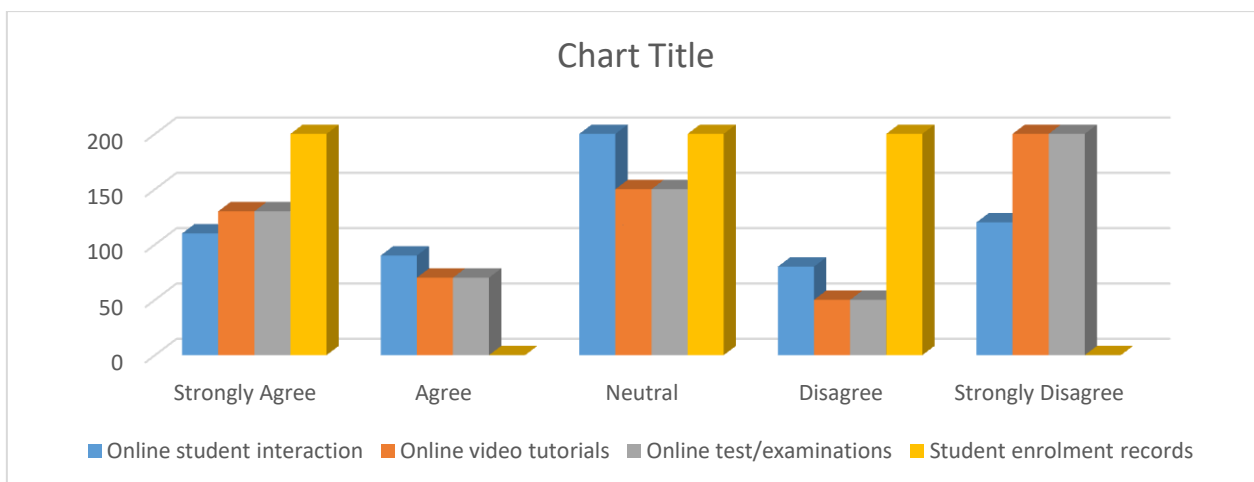


Figure 4: What data forms big data in Educational System?

VII. THE FUTURE

Educational systems in Africa is witnessing growth and embrace of technological trends. To harness the benefits of big data much needs to be done in the area of prediction, curriculum enhancement, and institutional collaboration. To achieve this feat, the following recommendations are made to enhance the adoption of these trends:

- Full Implementation of the 4th goal of the 2030 Development Agenda by reviewing of the African goal of educational growth and expansion to technological skill acquisition.
- Increase funding by government and promulgate funding policies for technological trend startups and academic institutions.
- Curriculum review to promote personalized learning and skill acquisition
- Encourage collaboration among educational institutions of developed and developing economies
- Applying big data analytics to existing educational data to predict and improve learning.

VIII. CONCLUSION

Big data a technological trend of the 21st century, has carved a niche for many organizations in management and business growth. Various data patterns have been learned and utilized to give a competitive advantage for various organizations healthcare, business, education. Learning analytics and academic analytics have been used in the developed nations and these benefits cannot be said of the developing economy like Africa where the main educational goal is growth and expansion leaving off technological skill acquisition. This work identified the core analytics associated with educational big data and the techniques of artificial intelligence that would be beneficial to Africa. It further

identified salient challenges of adopting these trends irrespective of their benefits to education.

REFERENCES

1. International Telecommunication Union. (2015). ITU members agree with the international standard for Big Data. Retrieved September 1, 2019, from https://www.itu.int/net/pressoffice/press_releases/2015/66.aspx
2. Oza, H. (2018, April). Many Benefits of Big Data Analytics for Your Company. Retrieved September 20, 2019, from DATAVERSITY: <https://www.dataversity.net/many-benefits-big-data-company/>
3. Gutierrez, M., Ballejos, L. and Gramajo, G. (2018). Artificial Intelligence: pros and cons. Santa Fe, Argentina: International Telecommunication Union. Retrieved September 20, 2019, from https://www.itu.int/en/ITU-T/academia/kaleidoscope/2018/Documents/Presentations/K.2018_Presentation_CIDISI-TUTORIAL_final.pdf
4. Mauro, A; Greco, M. and Grimaldi, M. (2016). A formal definition of Big Data based on its essential features. Library Review, 65(3), 122-135. Retrieved September 2, 2019, from https://www.researchgate.net/publication/299379163_A_formal_definition_of_Big_Data_based_on_its_essential_features
5. Anirban, S. (2014). Big Data Analytics in the Education Sector: Needs, Opportunities and Challenges. International Journal of Research in Computer and Communication Technology, 3(11). Retrieved July 20, 2019, from <https://pdfs.semanticscholar.org/67a4/28c6764c7ece121dcd0c196f9541c7b2d9f2.pdf>
6. Lovett, M. C., and Wagner, E. (2012). Analytics for Teaching, Learning, and Student Success. EDUCAUSE Sprint.
7. Fry, S. (2019). Go Bid: data in education. Retrieved September 10, 2019, from <https://edtechnology.co.uk/Article/go-big-data-in-education/>
8. Vaitis, C., Hervatis, V and Zary, N. (2016). Introduction to Big Data in Education and Its Contribution to the Quality Improvement Process. DOI: 10.5772/63896
9. Campbell, J.P., DeBloise, P.B and Oblinger, D.G.(2007). Academic Analytics: A New Tool for a New Era. EDUCAUSE Review. Retrieved September 10, 2019, from <https://er.educause.edu/articles/2007/7/academic-analytics-a-new-tool-for-a-new-era>

10. Baepler, P and Murdoch, C.N. (2010). Academic Analytics and Data Mining in Higher Education. *International Journal for the Scholarship of Teaching and Learning*, 4(2). doi:<https://doi.org/10.20429/ijstl.2010.040217>
11. Khine, M. S. (2018). Learning Analytics for Student Success: Future of Education in the Digital Era. The 8th European Conference on Education. The International Academic Forum. Retrieved August 20, 2019, from http://25qt511nswfi49iayd31ch80-wpengine.netdna-ssl.com/wp-content/uploads/papers/ece2018/ECE2018_40028.pdf
12. Sclater, N; Peasgood, A and Mullan, J. (2016). Learning Analytics in Higher Education: A review of UK and International Practice. 2. Retrieved May 31, 2019, from https://www.jisc.ac.uk/sites/default/files/learning-analytics-in-he-v2_0.pdf
13. Lang, C., Wise, A., Siemens, G., and Gasevic, D. (2017). *Handbook of Learning Analytics*. (First, Ed.) Society for Learning Analytics Research. DOI:DOI: 10.18608/hla17
14. Daniel, B. K. (2015). Big Data and analytics in higher education: Opportunities and challenges. *British Journal of Educational Technology*. DOI:10.1111/bjet.12230
15. United Nations. *Envision 2030*. United Nations, Department of Economic and Social Affairs/Department of Economic and Social Affairs. United Nations. Retrieved December 10, 2019, from <https://www.un.org/development/desa/disabilities/envision2030.html>
16. United Nation. (2019). Report of the Secretary-General on SDG Progress 2019. Retrieved December 15, 2019, from https://sustainabledevelopment.un.org/content/documents/24978Report_of_the_SG_on_SDG_Progress_2019.pdf
17. Shapshak, T. (2019, July 11). Africa's Booming Tech Hubs Are "Backbone of Tech Ecosystem" Having Grown 40% This Year. Retrieved from *Forbes*: <https://www.forbes.com/sites/tobyshapshak/2019/07/11/africas-booming-tech-hubs-are-backbone-of-tech-ecosystem-having-grown-40-this-year/#324c1da24c24>
18. Gakusi, A. (2008). African Education Challenges and Policy Responses: Evaluation of the Effectiveness of. Third Annual African. Economic Conference on "Globalization, Institutions and Economic Development of Africa". Retrieved May 30, 2019, from <https://www.afdb.org/fileadmin/uploads/afdb/Documents/Knowledge/30768682-EN-1.3.4-GAKUSI.PDF>
19. Schwab, K. (2018). *The Global Competitiveness Report*. World Economic Forum. Retrieved October 1, 2019, from <http://www3.weforum.org/docs/GCR2018/05FullReport/TheGlobalCompetitivenessReport2018.pdf>
20. CBINIGHTS. (2019). *Research Brief*. Retrieved October 24, 2019, from <https://www.cbinsights.com/research/china-artificial-intelligence-investment-startups-tech/>
20. Gakusi, et.al. (2010, March). African Education Challenges and Policy Responses: Evaluation of the Effectiveness of the African Development Bank's Assistance. pp. 208-264. DOI:DOI: 10.1111/j.1467-8268.2009.00234

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