International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-9 Issue-2, July 2020

IoT and Big Data Technologies: Opportunities and Challenges for Higher Learning

Ruth Chweya, Samuel-Soma M. Ajibade, Abba Kyari Buba, Moveh Samuel

Abstract*: *Internet of Things (IoT) and Big data have been speculated to result in various opportunities and challenges to higher learning. The two mentioned technologies inclusive of cloud computing, pervasive learning and 3D printer can improve teaching and learning beyond classrooms. Furthermore, the above-mentioned technologies have led to enhancements and valuable living in many sectors like education, medicine, agriculture, and even security. Taking into consideration the predictions made for IoT and Big Data, it is beneficial to provision for confidence in this current world. IoT and Big Data have therefore emerged as innovations to change the education sector for quality training, education, and research. However, there have been challenges accruing to the mentioned technologies. This study gave an approach of how both IoT and Big Data could play similar beneficial roles to higher learning. This paper suggests that IoT and Big data can be incorporated in learning as they complement each other in supporting intelligent connections. The outcome is an enriched learner with effective and efficient study surrounding. Further, from the study, both technologies also share similar issues like security, transparency, and huge gathered information. Hence, this paper concentrates on the relationship between IoT and Big Data, examines their opportunities in education and mentions their challenges to improve the education sector.

Keywords:* *Big Data, Education, Higher Learning, Internet of Things.

I. INTRODUCTION

Internet of things and Big Data have brought much contribution to digital transformation with the development of several innovative implementations in every sector of organizations and society [1], [2]. Research also argue that, the expansion of innovation and the internet have furnished the learning sector with different kinds of teaching, learning, and evaluation techniques that are possible on/off campus, within the classroom or virtualized surrounding [3]. Hence, there is greater rise in the volume of data reproduced by companies due to increase in data in social media, Internet of Things (IoT), multimedia that is either structured or unstructured [5]. Digital innovation and social media have also brought the possibility of accessibility in both online and distance study universally and extensively with minimal cost [3]. The expansion of data acquired from IoT has had a significant contribution on the big data landscape [1]. According to [1], this expansion of IoT has resulted in challenges in big data analytics due to processing and gathering of information via various sensors in the IoT surrounding. From research, IoT and Big data have a two-sided link [4]. That is, on one side, IoT is the key producer of big data, while on another side it is significant for big data analytics for IoT process and service enhancement. From [5], big data is the great amount of data that necessitates current innovations for analyzing to facilitate extraction of meaningful details. Equally, IoT is an internet gadget that entails linking various gadgets via some intelligent connections for sharing information. Based on surveys, the big data market would reach over US$125billion by 2019 [1] . Further, IoT ‘s prediction was at a growth rate of 20% compound annual growth rate of up to 7.1 trillion dollars in 2020 [6], while sensory gadgets expected to reach 190.6 billion by 2021 [7], [8]. As the number of sensors will reach a trillion, IoT data will be the supplier of Big Data’s most significant data, as this entails heterogeneity, variety, unstructured among others [9]. Because IoT aims to connect sensors and other gadgets to the Internet, it will further provide context data which is a challenge for Big Data [10], [11]. Further, the merge of Big data and IoT means Big Data supporting IoT data processing and this creates new IoT solutions. According to research, Big Data in IoT possess the following elements: many terminals generating huge amounts of data, the details generated are semi-structured and unstructured, and the details are significant after analysis. IoT is furnishing a better method of accessing the internet, and any gadget has the possibility of communicating with other gadgets anywhere, while provisioning the server to the user at any time. Meanwhile, the current explosion of big data has caused rapid digital change in the society while traversing the world with several profitable implementations [2]. But, IoT and big data have brought much contribution to digital transformation with the development of several innovative implementations in every sector of organizations and society [1], [2].

Manuscript received on May 25, 2020.
Revised Manuscript received on June 29, 2020.
Manuscript published on July 30, 2020.
***** Correspondence Author
***[1]Ruth Chweya,** Department of Information Systems, Faculty of Engineering, Universiti Teknologi Malaysia, Johor, Malaysia. Email: rchweya@kisiiuniversity.ac.ke
Samuel-Soma M. Ajibade, Department of Computer Science, Faculty of Engineering, Universiti Teknologi Malaysia, Johor, Malaysia. Email: samuel.soma@yahoo.com
Abba Kyari Buba, Department of Information Systems, Faculty of Engineering, Universiti Teknologi Malaysia, Johor, Malaysia.
Moveh Samuel, department of Mechanical Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, Johor, Malaysia. Email: smoveh@yahoo.com

Blending Big Data and IoT technologies creates vast opportunities for not only smart cities but opens innovation opportunities for academia too [10]. Several researches have been conducted on big data [12], [13], [14], [15] and similarly of IoT technologies [16], [17], [18], [19], [20].

According to study, implementing IoT and Big data integration solutions have the possibility of addressing problems on storage, processing, data analytics, and visualization tools [1], [11]. Research from [3] point out that this will help in forecasting the student performance among other educational uses. The advantage of this advancements is real-time automated collection, processing, caching, and evaluation of the huge volumes of data. However, learning establishments are burdened with the difficulty of controlling and evaluating the produced information from education materials in an effective and efficient manner [2]. Also, the amount of data present is big whereas the olden procedures are restricted to processing the conventional data applications [3]. This resulted in the utilization of big data applications for processing their educational data. This paper examines the opportunities and challenges brought about by IoT and Big Data for higher learning institutions. The organization of this paper is as below. Part II introduces IoT and Big Data. Part II explores the significance of IoT and Bid Data to education. In Part IV, the challenges of IoT and Big data in education are highlighted. Part V mentions the conclusion.

II. OVERVIEW OF IoT AND BIG DATA

This section provides an introduction of the IoT and Big Data

A. Internet of Things

IoT provisions organizations with a ground for sensory gadgets and devices to seamlessly link and permits information passage conveniently across environments [1]. According to study, IoT can permit self-configuration with regards to standards and protocols [21], [22]. Most of the communication gadgets in IoT are liked into the sensor gadgets in the real environment [1], [23] Hence, IoT is furnishing into the surrounding, an improvement in the present innovations with several devices [24. It is the assent intelligence that gives institutions the capability to arrive at informed judgement to enhance learners study experiences, operational effectiveness, and institutions safety [25]. IoT is therefore offering continuous help in higher learning which is allowing new opportunities from ubiquitous computing and technologies [18].

B. Big Data

This means large voluminous data that is either structured or unstructured [25]. The data is designed and analyzed to fit in institutions. In education, big data has a significant impact on teachers, school structures, learners, and curricula [23]. Moreover, evaluating big data can help in identification of students at risk, check that learners are making required progress, and offers support for implementing a better system to evaluate and assist instructors and heads of schools.

III. BENEFITS OF INTEGRATING IOT AND BIG DATA IN EDUCATION

Intelligent technologies for instance learning analytics, big data, cloud computing and IoT among others boost the materialization of smart education [26]. Study explains that IoT data are distinct from universal big data [4]. The benefits offered by IoT and big data for education are discussed subsequently. IoT and Big Data among other technologies will perform a major role in education because many learners have expectation to have personalized curriculum delivered to their desks [9]. According to study, the data resulting from IoT and Big data have a link with each other [5]. This is because IoT on smart gadgets entails data and further, the generated details from the IoT sensors must undergo evaluation via big data analytics [5]. Big data itself necessitates different type of analytics for improvement of the different procedures of IoT gadgets. Hence, merging IoT with big data will enhance the activities in different areas for instance current education structures, intelligent transportation, protection of the surrounding, agriculture, among others. The aim of the education sector is enhancement of the learner experience, enhancing efficiency, and provision of necessary, effective, and efficient teaching and learning environment as per the student needs [3]. Big data technology can facilitate this through provisioning the communication and availability for students, educators, and administrators. This is possible, according to [3], through data mining algorithms for model development. The models will further create adaptive learning structures that utilize the model's forecasting which have the possibility of altering the learner's experience or offer recommendations to management for learner support. Similarly, IoT has the possibility to improve the learner experience [26], [27]. IoT is an enhancer of system effectiveness, greater flexibility and further creation business opportunities and revenue stream [28]. For instance, a study in Columbia showed learner improvement through IoT incorporation [29]. More so, IoT also eases and enhances the quality of education [26], [30], [31], [32]. Hence, IoT can boost, supports, and stimulates lifelong study [33].

Higher learning is experiencing increased levels of competition, accreditation, evaluations, and regulations [3]. Also, educational institutions are utilizing new digital learning structures to assist in discovery of the learner behavior [34]. Therefore, decision makers are necessitated to arrive at resolutions depending on relevant details produced from investigated data. The outcome is to establish student's achievement rates, patterns, and difficulties, apart from academic progression. Hence, big data technologies deal with massive educational data utilized for evaluating and tracing students' past information, store time stamped input and behaviors during the learning process. But also, smart gadgets have chances of being significant in teaching and learning to improve the learning process [27], [34]. This further enables the management to choose necessary practices and streamline the learning procedures [3], [34].

Hence, Big Data can improve teaching and learning and further help an institution attain academic achievement [35]. Hence, this study concludes that both big data and IoT had great significance in learning and teaching. Successful institutions need to trace and establish their achievement rate, weaknesses and strengths, and status as compared to other institutions [3]. Big data technologies enable analysis of the business situation, academic accreditation and further help them plan and manage their strategy.

As per study, utilization of Big Data provisions for unprecedented visualization to stakeholders of higher education institutions for smooth management and encouraging outcomes [35]. This provides evidence of achievement rates and establish improvement areas for improved proactiveness. IoT also provisions educational institutions to gather information easily from sensory and wearable gadgets and perform as per gathered information [36]. For instance, the incorporation of quick response codes, radio frequency chips and feedback can assist in tracing leaners [37]. However, according to [35], most of the gathered information in higher education is not fully utilized as there lacks proper technologies to change the unstructured information to meaningful details. Hence, with Big data, data analytics is provisioned to uncover this process for further development of an institution. According to [3], big data technologies provisions decision makers with knowledge for detection, comprehension, analysis and forecasting of the learner behavior, instructor progresses and course outcomes. This helps instructors to examine students' knowledge and the best methods effective for every learner [38]. In this way, it provisions the instructors with chances to learn current methods and procedures related to their teaching activity. In the end, study agrees that big data enhances the decision-making capability [39]. Equally with IoT, many activities can be done like tracing learners, gathering information to know which students need extra attention and further assist instructors alter designs and procedures for future classes [33], [40]. According to study, this includes discovering the learner behavior and achievements to assist in providing materials when required [34]. This explains why both Big Data and IoT are significant in higher education.

Through big data technologies, educators can acquire instant purposeful opinion to examine the layout of their course and the efficiency of their instruction and assessment procedures and techniques [3], [41]. The monitoring of the procedures helps in onset detection of student weak areas and failure risks as per learner ability and knowledge level. This means, big data can provide further deeper detection of study requirements or difficulties of learners [42]. Similarly, according to research by [26], IoT just like Big Data allows efficient and diligent management of every gadget utilized. This is because stakeholders believe that the desired outcome of learners is possible through correct tracking of students, staff and resources which is possible through the implementation of IoT. Accordingly, knowledge of their environment will help provide necessary information when required for further improvement of the learning process [27], [42]. Institutions are evaluating methods to enhance numbers at a cheaper yet affordable cost [39]. As per research, big data can not only help in enhancing the overall achievement of a learner but also can lower the overall institution and learner costs [42]. It is indicated that big data offers a cost-effective expectation for enhancement of decision making [39]. Similarly, IoT has been mentioned to be a cost saver for institutions [17], [36]. Research by [36] echo that IoT positively affects educational models using sensors which further lowers the cost of learning.

IV. CHALLENGES OF IOT AND BIG DATA APPLICATION IN EDUCATION

Despite several higher education institutions beginning to offer data science programs at different stages, big data innovations are a bit current in old disciplines curricula. According to [2], the issues include how to seamlessly merger big data revolution into data science learning, education learners on creation of tools, information from big data through utilization of data science skills, the method of expanding the curriculum to current areas like intelligent augmentation and cognitive computing, and incorporation of data management areas into the curriculum. IoT, Big data and even cloud computing suffer security challenges as the security procedures like disaster recovery schemes, strong password approaches, firewalls, encoding, and antivirus software fail to be adequate in securing hi-tech innovations [3]. Furthermore, educational institutions require enough policies to control and oversee the intellectual property and access to information apart from securing the storage, transfer, and processing the massive different instructional data types. Security of IoT as a challenge is also underscored by researchers [36], [43], [44]. For instance, a study by [45] reveals security as a risk in IoT in higher education.

In education, big data and IoT require transparency to show the learner identification for informed decisions. Privacy is concerned with the learner's data [41], [46], [47]. However, in some situations the learners do not provide the data required [41], [48]. In Big Data there is possibility of a malicious person utilizing the learner details that are used during tracing of educational records, performance, among others [3]. This could violate a learner's privacy when such information is needed for predicting academic performance and future outcomes. There is a possibility of educational breaches as this has happened earlier where 14.8 million records of educational institutions were compromised. Privacy is an issue that has not been handled in IoT as well. For instance, privacy is a challenge in adoption of emerging technologies like IoT [43]. Also, another study mentions that there is benefit in utilizing IoT in education as it enhances learning despite privacy issues [36]. Educational institutions lack formal ethical review processes [3]. This brings ethical challenges like identification of techniques for preservation of private data, personal consent, data ownership, and transparency [3], [36]. The utilization of various gadgets and techniques for data gathering and analysis of educational details likewise brings ethical challenges of authenticity.

With the utilization of big data and IoT application, there is generation of huge amounts of data in the educational sector. For instance, the use of Learning management systems, online cache, instructional digital repository, students' information structures, social media, personal gadgets, and administrative structures possess data on curriculum and program completion estimates and study channels. This results in the issue of data processing, caching, and interoperability.

V. CONCLUSIONS

The education sector is perceived to be an efficient environment for utilization of IoT and Big data. The main aim of this paper is explaining the utilization of IoT and Big Data applications in higher learning. It also highlights the difficulties linked with utilizing the two technologies. Several researches have examined the need to incorporate IoT and Big data as this will enhance and alter the learning environment to improve teaching and learning. Even with utilization of various IoT technologies and Big data in education, adoption of the mentioned technologies and potential utilization is still limited, more so in developing nations. From the study, it was realized that IoT and Big Data can enhance personalized learning for learners, improve the study environment, provision for dissemination of content widely, enhance academic attainment for institutions, assist stakeholders in smooth administration, help to monitor and trace learners, and enhance decision resolutions. Among the challenges mentioned, the study realized that educational institutes fail to have formal ethical review procedures which is a shortcoming to preservation of individual details and transparency. This paper gives a recommendation that higher education should establish a full trust in IoT and Big Data technologies and reconsider utilization of the innovations to help institutions. Further, through the examined studies, there is need to evaluate the significance of IoT and Big data to the learner's achievement. Also, there is need to understand factors influencing utilization of IoT and Big data in higher learning in developing nations. This will result in a positive significance on utilization of IoT and Big Data in higher learning.

REFERENCES

1. M. Marjani, F. Nasaruddin, A. Gani, A.Karim, I. A. T. Hashem, A. Siddiqa & I. Yaqoob (2017). Big IoT data analytics: architecture, opportunities, and open research challenges. *IEEE Access*, *5*, 5247-5261.
2. I.Y. Song & Y. Zhu (2017). Big data and data science: opportunities and challenges of iSchools. *Journal of Data and Information Science*, *2*(3), 1-18.
3. M. A. BAMIAH, S. N. BROHI & B. B. RAD (2018). Big data technology in education: advantages, implementations, and challenges. *Journal of Engineering Science and Technology Special Issue on ICCSIT*, 229-241.
4. M. Mohammadi, A. Al-Fuqaha, S. Sorour & M. Guizani (2018). Deep learning for IoT big data and streaming analytics: A survey. *IEEE Communications Surveys & Tutorials*, *20*(4), 2923-2960.
5. H. Kaur, & A. S. Kushwaha, (2018). A review on integration of big data and IoT. In *2018 4th International Conference on Computing Sciences (ICCS)* (pp. 200-203). IEEE.
6. M. B. Abbasy & , E. V. Quesada (2017). Predictable influence of IoT (Internet of Things) in the higher education. *International Journal of Information and Education Technology*, *7*(12), 914-920.
7. T. Saarikko, U. H. Westergren, &T. Blomquist (2017). The Internet of Things: Are you ready for what's coming? *Business Horizons*, *60*(5), 667-676.
8. O. B. Sezer, E. Dogdu & A. M. Ozbayoglu, (2017). Context-aware computing, learning, and big data in internet of things: a survey. *IEEE Internet of Things Journal*, *5*(1), 1-27.
9. F. Moreira, M. J. Ferreira & A. Cardoso (2017, July). Higher education disruption through IoT and Big Data: A conceptual approach. In *International Conference on Learning and Collaboration Technologies* (pp. 389-405). Springer, Cham.
10. M. Ge, H. Bangui & B. Buhnova (2018). Big data for internet of things: A survey. *Future generation computer systems*, *87*, 601-614.
11. S. S. Ajibade, & A. Adediran (2016). An overview of big data visualization techniques in data mining. *International Journal of Computer Science and Information Technology Research*, *4*(3), 105-113.
12. F Bajaber, R. Elshawi,O. Batarfi, A. Altalhi, A. Barnawi & S. Sakr (2016). Big data 2.0 processing systems: taxonomy and open challenges. *Journal of Grid Computing*, *14*(3), 379-405.
13. M. Chen, S. Mao & Y. Liu (2014). Big data: A survey. *Mobile networks and applications*, *19*(2), 171-209.
14. D. Sinanc & S. Sagiroglu (2013, November). A review on cloud security. In *Proceedings of the 6th International Conference on Security of Information and Networks* (pp. 321-325).
15. C. W. Tsai, C. F Lai, H. C. Chao & A. V. Vasilakos (2015). Big data analytics: a survey. *Journal of Big data*, *2*(1), 1-32.
16. L. Atzoria, G. IeraAuthor Vitae, G. Morabito "The Internet of Things: A survey".
17. .S. Chen, H. Xu, D. Liu, B. Hu, & H. Wang (2014). A vision of IoT: Applications, challenges, and opportunities with china perspective. *IEEE Internet of Things journal*, *1*(4), 349-359.
18. R. Chweya, O. Ibrahim & M. Nilashi (2019). IoT in Higher Learning Institutions: Opportunities and Challenges. *Journal of Soft Computing and Decision Support Systems*, *6*(6), 1-8.
19. D. Miorandi, S. Sicari, F. De Pellegrini & I. Chlamtac (2012). Ad hoc networks internet of ings: vision, applications and research. *Ad Hoc Networks*, *10*(7), 1497-1516.
20. A. Ouaddah, H. Mousannif, A. Abou Elkalam & A.A. Ouahman (2017). Access control in the Internet of Things: Big challenges and new opportunities. *Computer Networks*, *112*, 237-262.
21. L. Da Xu, W. He& S. Li (2014). Internet of things in industries: A survey. *IEEE Transactions on industrial informatics*, *10*(4), 2233-2243.
22. A. Uzelac, N. Gligoric & S. Krco (2015). A comprehensive study of parameters in physical environment that impact students' focus during lecture using Internet of Things. *Computers in Human Behavior*, *53*, 427-434.
23. W. Villegas-Ch, X. Palacios-Pacheco & S. Luján-Mora (2019). Application of a smart city model to a traditional university campus with a big data architecture: A sustainable smart campus. *Sustainability*, *11*(10), 2857.
24. A. Whitmore, A. Agarwal & L. Da Xu, (2015). The Internet of Things—A survey of topics and trends. *Information systems frontiers*, *17*(2), 261-274.
25. S. Kusuma & D. K. Viswanath (2018). IOT and big data analytics in e-learning: A technological perspective and review. *Int. J. of Eng. & Tech*, *7*, 164-167.
26. S.S. Pai (2017). IOT Application in Education. *International Journal for Advance Research and Development*, *2*(6), 20-24.
27. J. Marquez, J. Villanueva, Z. Solarte & A. Garcia (2016). IoT in education: Integration of objects with virtual academic communities. In *New Advances in Information Systems and Technologies* (pp. 201-212). Springer, Cham.
28. D. Niyato, D.T. Hoang, N. C. Luong, P. Wang, D.I. Kim & Z. Han (2016). Smart data pricing models for the internet of things: a bundling strategy approach. *IEEE Network*, *30*(2), 18-25.
29. J. Gómez, J.F. Huete, O. Hoyos, L. Perez & D. Grigori (2013). Interaction system based on internet of things as support for education. *Procedia Computer Science*, *21*, 132-139.
30. S. S. M. Ajibade, N. B. Ahmad & S. M. Shamsuddin (2018). *A Study of Online and Face to Face Tutors and Learners" Practices in Collaborative Blended Learning*. UTM Computing Proceedings: Innovations in Computing Technology and Applications.

31. W. Tan, S. Chen, J. Li, L. Li, T. Wang & X. Hu (2014). A trust evaluation model for E-learning systems. *Systems Research and Behavioral Science*, *31*(3), 353-365.
32. P. Tan, H. Wu, P. Li & H. Xu (2018). Teaching management system with applications of RFID and IoT technology. *Education Sciences*, *8*(1), 26.
33. H. Aldowah, S.U. Rehman, S. Ghazal & I. N. Umar (2017, January). Internet of Things in higher education: a study on future learning. In *Journal of Physics: Conference Series* (Vol. 892, No. 1, p. 012017).
34. I. Bandara & F. Ioras (2016). The evolving challenges of internet of everything: enhancing student performance and employability in higher education. In *INTED2016 10th annual International Technology, Education and Development* (pp. 652-658).
35. A.Z. Bhat & I. Ahmed (2016, March). Big data for institutional planning, decision support and academic excellence. In *2016 3rd MEC International Conference on Big Data and Smart City (ICBDSC)* (pp. 1-5). IEEE.
36. M. Bagheri & S.H. Movahed (2016, November). The effect of the Internet of Things (IoT) on education business model. In *2016 12th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS)* (pp. 435-441). IEEE.
37. K. Mershad & P. Wakim (2018). A learning management system enhanced with internet of things applications. *Journal of Education and Learning*, *7*(3), 23-40.
38. A. S. Drigas & P. Leliopoulos (2014). The use of big data in education. *International Journal of Computer Science Issues (IJCSI)*, *11*(5), 58.
39. B. Daniel (2015). Big Data and analytics in higher education: Opportunities and challenges. *British journal of educational technology*, *46*(5), 904-920.
40. R. Chweya, S. M. Shamsuddin, S. S. M Ajibade & S. Moveh (2020). A Literature Review of Student Performance Prediction in E-Learning Environment. *Journal of Science, Engineering Technology and Management ISSN: 9989-7858*, *2*(1).
41. M. Vharkute & S. Wagh (2015, April). An architectural approach of internet of things in E-Learning. In *2015 International Conference on Communications and Signal Processing (ICCSP)* (pp. 1773-1776). IEEE.
42. M. A. Nazarenko & T. V. Khronusova (2017, September). Big data in modern higher education. Benefits and criticism. In *2017 International Conference" Quality Management, Transport and Information Security, Information Technologies"(IT&QM&IS)* (pp. 676-679). IEEE.
43. M. Farhan, S. Jabbar, M. Aslam, M. Hammoudeh, M. Ahmad, S. Khalid & K. Han (2018). IoT-based students interaction framework using attention-scoring assessment in eLearning. *Future Generation Computer Systems*, *79*, 909-919.
44. P. Isaias (2018). Model for the enhancement of learning in higher education through the deployment of emerging technologies. *Journal of Information, Communication and Ethics in Society*.
45. S.E. Lee, M. Choi & S. Kim (2017). How and what to study about IoT: Research trends and future directions from the perspective of social science. *Telecommunications Policy*, *41*(10), 1056-1067.
46. H. Shaikh, M.S. Khan, Z.A. Mahar, M. Anwar, A. Raza & A. Shah (2019, March). A Conceptual Framework for Determining Acceptance of Internet of Things (IoT) in Higher Education Institutions of Pakistan. In *2019 International Conference on Information Science and Communication Technology (ICISCT)* (pp. 1-5). IEEE.
47. O. Adetola, S. M. Shamsuddin, R. Chweya & S. S. M. Ajibade (2020). Social Communication of Students on Social Media Network Platform: A Statistical Analysis. *Journal of Science, Engineering, Technology and Management ISSN: 9989-7858*, *2*(2).
48. Y. Wang (2016). Big opportunities and big concerns of big data in education. *TechTrends*, *60*(4), 381-384.

AUTHORS PROFILE

Ruth Chweya is pursuing her doctorate degree (PhD) in information systems in Malaysia. Her areas of interest include Internet of Things, Big Data, E-learning and educational technologies.