



Internet of Things (IoT) in Enhancing Onsite and Online Educational Development—*An Era for Digital Education Promotion*

P.K. Paul

Executive Director (MCIS), Head/Coordinator & Asst. Professor, Dept. of CIS, Raiganj University, West Bengal, India

Corresponding author: pkpaul.infotech@gmail.com

Received: 13 Sept., 2022

Revised: 27 Nov., 2022

Accepted: 05 Dec., 2022

ABSTRACT

Educational systems are changing rapidly throughout the world and among the aspects latest technologies are widely changing. Today education not only meant for textbooks rather it is an interaction way of getting knowledge in a scientific knowledge and environmental systems. Technological systems has radically changed entire systems of education and teaching learning. Once only in offices of educational institutions being considered as main stakeholder in educational technologies and computing but gradually in other educational activities as well Educational Technologies being highly deputed and started in using. Today quality and quantity both can be managed significantly using ICT. Among the latest Information Technology components most important and emerging are Cloud Computing, Big Data, Internet of Things (IoT), Blockchain, Cyber Physical Systems (CPS), Edge Computing and even emerging components of Edge Computing. As far as Internet of Thing (IoT) is concerned it is lies on internet technologies and systems and deeply with connectivity to the physical devices and objects. Today IoT developer and designer are being engaged in developing IoT enable educational systems including teaching learning, educational management, research and training, and so on. Therefore in teaching-learning and other educational activities as well IoT and allied technologies being considered as worthy for students, teachers, officers and other stakeholders. This paper is on latest aspects on IoT in Educational Systems and management including foundation, applications and emergence. Paper also discussed about the issues and challenges related to the IoT applications in Digital Education promotion viz. onsite and online education.

Keywords: Education Technology, E-Learning, Digital Education, Online Education, Knowledge Management

How to cite this article: Paul, P.K. (2022). Internet of Things (IoT) in Enhancing Onsite and Online Educational Development—*An Era for Digital Education Promotion*. *Learning Community*, 13(02): 123-136.

Source of Support: None; **Conflict of Interest:** None



Internet of Things (IoT) is dedicated internet technology based systems and one of the emerging in Information Technology. This is basically works closely with computing devices, machines and other digital objects and systems. An IoT ecosystem basically consist with various smart devices like processors, sensors, various kind of communication hardware for collecting and selecting data in an intelligent environment. IoT devices and equipments basically collect and share sensor related data by an advanced IoT gateway and using cloud such data must be sent to the cloud and analyzed locally^{[1],[5]}. Operating and using such devices needs less human involvement or simply absence of human environment. Therefore such system should be considered as worthy and important in all the settings. IoT is changing rapidly and various areas too, and education and training segment is not an exception in such context. IoT is dynamically applicable in education field and here implementation of digital tools changing traditional educational systems and operations significantly. More efficient and inclusive education is actively possible with IoT based educational systems. Today smartphones are being used in almost all the sectors and areas in education and all kind of students group are also being used such devices powered by IoT. Digital classrooms become a trend not only in traditional education but also in coaching, and tuitions. Different complex process with virtual reality and augmented reality become easily possible with IoT based systems. Therefore it may offer better understanding and empowerment in different sorts^{[4],[10],[19]}. In such AR & VR systems partially IoT based systems may be considered as significant. Using IoT based systems educational institutions and organizations are being involved in more technology enhancement and here there is a role of different IT components. Most of the online educational platforms are offered with facilities such as live classes, recorded (pre) classes, symposium environment using latest software and platform and here IoT based systems are significant. IoT solutions is offer more and more quantity support by managing large number of students specially in online education and partially in onsite/on-campus education. As far as quality is concerned IoT also support more enhanced education and this is become reality all over the world. Internet of Thing is also being used in many schools in many developed countries but this phase is slowly growing due to issues of finance, proper technological implementation and investment. Internet of Thing offers a bunch of benefits and advantages over traditional and onsite educational systems to the teachers, students and other academic community^{[3],[18],[34]}. Ultimately Internet of Thing will offer fast, easy to use and safe educational experiences using other latest technologies of IT & Computing.

Objective of the Work

The work entitled ‘Internet of Things (IoT) in Enhancing Onsite and Online Educational Development—*An Era for Digital Education Promotion*’ is carried with following objective (but not limited to)—

- To learn about the basics of Internet of Things (IoT) with foundations, concepts and development of IoT for modern educational organization and development.
- To know about Internet of Things (IoT) applications in basic educational operations and management.

- To learn about the emerging and latest places and sector in education for growing Internet of Things (IoT) applications.
- To know about the onsite/ on-campus educational developing using Internet of Things (IoT) and allied technologies.
- To gather about the way and specific sector for the promotion of Internet of Things (IoT) in various online and digital education.
- To find out common and alarming challenges in Internet of Things (IoT) in educational and other knowledge related facets.

Methods Adopted

The work entitled ‘Internet of Things (IoT) in Enhancing Onsite and Online Educational Development—*An Era for Digital Education Promotion*’ is a conceptual and theoretical work and mainly concentrated on review of literature related to the Digital Education emphasizing Internet of Things (IoT) utilizations in different educational process and systems. Therefore the work is entirely theoretical with a strategy of finding trends and ways of Internet of Things (IoT) in education, training and research.

Internet of Things (IoT): Basics

This is also offer unique identifiers and responsible for data exchange and sharing. IoT has the ability in sharing data over a network even without requirement of human to human or computing systems to human. In Internet of Things the word ‘Things’ refers to any kind of object having internet and sensor connectivity. And this may be an animal of a farm integrated with biochip or an intelligent car embedded with sensor or some other objects like intelligent care-takers with built in sensors^{[2],[8],[9]}. Such systems basically connected with Internet Protocols (IP) and transfer data over a network. Today apart from profit making organizations lot of other categories of organizations involved in IoT based product development, and services and this trend is rising rapidly. Effective operations, improved and sophisticated decision-making become possible with IoT enable systems and procedure. Internet of Things is a kind of complex wireless network in which numerous devices and e-gadgets may be connected together for the sharing, collecting, creating and receiving different kind of data and information. As far as types of such devices are concerned it could be biochips or mobile phones and other systems that can be monitored using ICT^{[31],[40]}. Some of the allied technologies such as AI and machine learning, Augmented reality and virtual reality, Big Data and Analytics, Cloud Computing and Virtualizations and so on. IoT applications in addition to other allied technologies therefore increasing in diverse fields (Refer Fig. 1).

IoT in Educational Development

Internet of Things (IoT) is enhancing education sector impressively in different sphere and sectors such as in adopting and effective teaching-learning process, educational management and governance,

better and healthy collaboration, interactive educational process. Internet of Things (IoT) is offer most reliable access for getting educational resources in different platforms.

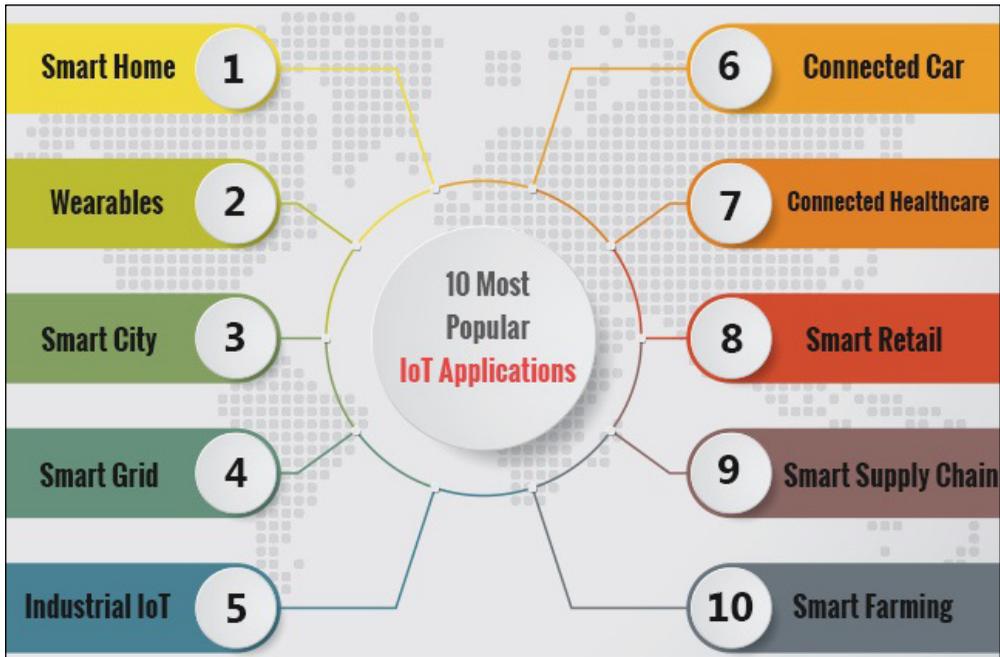


Fig. 1: Diverse applications of IoT in different sector

The educational sector is enhancing using Internet of Things (IoT) based products and services for different kind of opportunities such as good ability in understanding of the teaching/ thoughts, measuring students progression in learning, real-time data collection, and so on. Internet of Things (IoT) has significantly enables opportunities in advanced virtual learning and helps in managing proper teaching learning process in ICT based Onsite education or Traditional Education^{[3],[11],[35]}. Internet of Things (IoT) helps in advancing traditional teaching methodology towards digital one, and therefore it has increased efficiency (Refer Fig. 2).

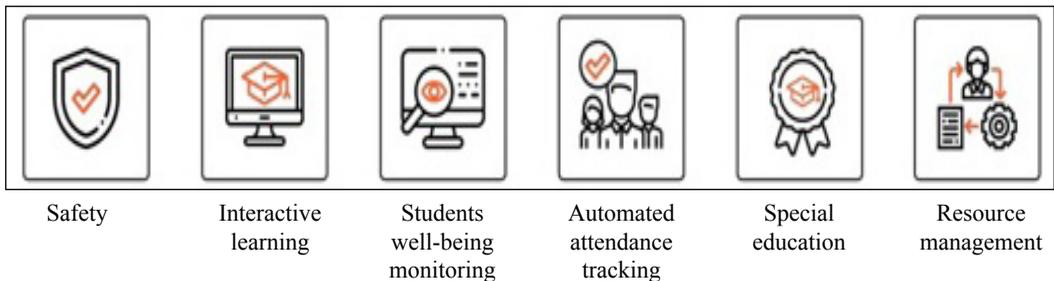


Fig. 2: Growing trends and future potentiality of EIoT

In smart attendance systems, smart boards and digital display systems, alarm integrated teaching-learning process, evaluation and checking tools, in intelligent camera operations and management, automated and intelligent document management, and so on^{[6],[17],[34]}. Virtually Internet of Things (IoT) is helping in different modes of education viz.—

- Onsite/ Campus based/ Traditional Education
- Online Education
- ICT based Education
- Distance, Open and Flexible Education
- Corporate and Continuing Education, and so on.

As far as the sectors are concerned following are considered important regarding Internet of Things (IoT) and allied technological applications in education, teaching and learning. The applications of Internet of Things (IoT) has classified into following.

Evolving Methodologies

As far as Internet of Things (IoT) is concerned it has role and implications in different educational strategies and systems. In modern day educational platforms are equipped with different gadgets and devices. Days are shifted from blackboard to smart and intelligent boards with multimedia support. E-devices become common in modern educational systems and can be connected and be able in controlling and monitoring syllabus and topic specific categorization of the students. Additionally voice command based techniques are able in educational activities for the teachers, students, staffs and other stakeholders. Internet of Things (IoT) is also helpful in enhancing smart security cameras including tracking of GPS of educations institutions vehicles. Regarding electronic devices such as alarms of the disasters systems, intelligent tables and smartphones are also helpful in getting data from the sensors. And all these ultimately helpful for different educational stakeholders, therefore as a whole Internet of Things (IoT) is helping in enhancing and rejuvenating teaching methodologies^{[12],[13],[33]}. A better learning is perfectly possible in different contexts using 3D enable and animated systems powered by IoT and allied intelligent systems^{[32],[41]}.

In Smart Classroom

As far as Smart classroom is concerned it is also empowered and enhanced by the Internet of Things (IoT) enable systems for intelligent smart classrooms and this can be fruitful in different activities such as writing the projection, enhancing practical based concepts like life sciences, and so on^[29]. Internet of Things (IoT) is therefore advancing Augmented Reality enable education systems and helpful in teaching biology and Animal Science as well. With AI based smart classroom supported by IoT can be effective in student's idea enhancement and developing voice command systems and some other electronic gadgets like speech to text note tracking devices. Further smartphone based virtual applications are effective in smart virtual classroom development and management. Classroom based education can be enhanced

with smart apps and useful in support of remote education or while students out of their educational institutions, physically^{[14],[15],[22]}. Self learning can be enhanced with Internet of Things enable systems by scanning the codes on the books and helps in digital version of the same.

In Automated and Intelligent Record Management

Internet of Things (IoT) is highly applicable in planning, executing and bringing automated and intelligent record management systems. And this is become beneficial in students progress and management as far as traditional day to day task is concerned. Internet of Things (IoT) is helping in student attendance and recording the same for further assistance. In every specific, daily, weekly, monthly and semester wise student data and their attendance can be effectively calculated using Internet of Things (IoT). Existing biometric attendance and barcode based attendance can be effectively managed using Internet of Things (IoT) enable systems. Therefore chances for discrepancy and storage are manageable using IoT. As teachers are having lot of works in addition to the teaching such as educational planning and management, administrative activities and governance therefore uses of IoT in record management significantly managed the timing of the teacher concerned. Moreover such Internet of Things (IoT) enable record management can be a worthy deal for the parents too for the information of their children regarding attendance in classrooms, events, lab sessions, and so on. Internet of Things (IoT) thus helps in students monitoring, and can be uses in various governance including in accreditation process and inclusion. In almost all the institutions students attendance considered as worthy and in calculating attendance IoT devices can be effectively useful. A punctual report therefore helps to the administrators of the Higher Educational Institutions as well^{[9],[23],[24]}. Such systems can be useful in hostel and accommodation place management too.

Safety Management of the Educational Institutions and HEIs

As far as safety of educational institution is concerned Internet of Things (IoT) is helpful in different academic activities such as in fire safety and management IoT enable systems are worthy and effective. From different incident and accident Internet of Things (IoT) based sensor therefore worthy deal in educational management. Normally such IoT enable camera play important role in real-time data gathering, transferring to the concerned authority/ person and in further decision making. Further if anyone in process of unfair means such as deactivate camera or tries to break lock of the door of the educational institutions can be solved effectively and easily.

Internet of Things (IoT) is able in finding different other safety related issues and tasks and therefore universities and other educational institutions are engaged in gathering different benefits from the IoT enable systems. Among the benefits few important are finding, analyzing and recording of sexual abuse and harassment, crime of different kinds etc. In case of finding and managing disaster management, and emergency institution management IoT considered as impactful and necessity^{[7],[25]}. Therefore such occurrences are helpful not only educational management but also proper and effective administration. Like HEIs schools may also use IoT and other allied technologies for detecting, abusing, theft management

including other crimes. In library premises and lab management also IoT is worthy and effective. Fire outbreaks can be effectively and smoothly possible with Internet of Things (IoT) applications in educational systems. Researchers are doing activities in creating, managing customized machinery and devices for better safety management and crisis management^{[8],[26]}.

In enhancing AR and AI enabled Intelligent Learning

As far as Augmented Reality and Virtual Reality is concerned it is effective and important in advanced education, teaching and learning in different context. As Augmented Reality is helpful in creating real life more advanced and realistic using intelligent devices therefore same can be applied in education, teaching and learning as well. IoT enable and integrated devices in AR can enhance the services effectively with proper markings. Here students can study just using barcode and able in reading with graphics and sound combined software systems. Anatomy of human being can be easily understand with IoT and AR based systems because it do better understanding using animated contents^{[13],[27]}. Similarly AI supported IoT systems can also helpful in 3D based software systems with enhanced detailing, working of the human digestive systems.

In Close Monitoring and Care

As far as close monitoring is concerned Internet of Things is useful and effective in different activities such as creative website to gather data of different situation. Web portals are being used in getting data when students are on-campus or out of campus using ICT. Students interest, perception study is effectively possible with proper IoT enable web portal management^{[38],[42]}. In further learning process, finding proper assessment, getting score and progress tracking smoothly possible with such systems. In preventing misuse of the smart devices, students activities, better wifi management also Internet of Things is impactful. Parental controlling and management is effectively possible in such intelligent systems and the same also useful to the teachers as well. IoT devices are able in getting data regarding pupils and helps in personalized learning plan^{[43],[46]}. Students assignment, their interest and status can be easily and intelligently possible with such systems and therefore it as a whole helps in complete and sustainable development.

Productivity Improvement and Engagements

Internet of Things and other allied emerging technologies of IT is highly required for the purpose of education and research related institutions in modern age. Among the allied technologies few important are Big Data, Cloud Computing, Artificial Intelligence and Machine Learning, Robotics etc. partially^{[37],[39]}. As far as Internet of Things is concerned it is helpful in enhancing productivity of the institutions (of the teachers, students and official staffs) and advancement of the overall educational process. Computerization and Information Technology infrastructure is helpful in advancing teaching-learning process, and mobile applications also in this regard playing a big role^{[20],[33]}. Here with IoT support students can simultaneously able in accessing textbooks and graphics including 3D visualization. With 3D based systems students are also able in solving the issues and problems and helps in immersive learning for complete group assignments and activeness.

In Special Education Promotion and Development

All the activities related to the special education can be highly enhanced using Internet of Things based systems. This is considered as worthy in planning, executing and developing special education students. Though, it is important to note that some of the additional technologies are also be useful in overall process. As far as IoT is concerned it is impactful in verbal speech to sign language and also vice versa. Here it should be taken into consideration that both students and teachers can be physically challenged, and here IoT enable sensor gloves are helpful in several educational assistance and support^{[44],[45]}. The Internet of Things supported tools and smart devices are helpful in modifying general classroom environment assisted by sound and light-sensitive matters for catering needs of the students and other stakeholders.

In Online, Distance and E Learning

As far as Online and emerging educational models are concerned the uses and role of Internet of Things is significant. Using specific website and portal one can able in sign-in and uses the resources and as supported by the Internet of Things it is helpful in students data gathering including topic, hours and time spent. Internet of Things based systems also helpful in calculating students locations as in online programs students basically joined from different places^{[10],[28]}. Mobility is one of the important feature in online education and it is worthy support of IoT to promote and excel concerned objective. As far new age educational modes are concerned it is helpful in following—

- Live/ on-streaming classes.
- Pre recorded classes
- Blended education
- Timer and location based educational management
- Time spent tracking etc.

In addition to these Internet of Things is applicable in other educational platforms and models to enhance online and online education more and more effective and useful. As far as COVID-19 pandemic is concerned all the educational institutions moved into the online and during the time Internet of Things and similar/ allied technologies played leading role for educational promotion and development^{[16],[21]}. Apart from online education in open booklet based assessment also it plays leading role for different activities such as open booklet based assessment, pre-recorded class management, current users with location tracking etc. It is worthy to note that Internet of Things based systems helpful in storing and distributing data for various specially designed applications. Internet of Things is further helpful in managing digital learning or blended learning with specially designed software management. Today students can learn from reputed universities to reach their desired goal. Here students can get the benefits of live and pre-recorded classes including online timer based assessment and automated checking for the assignments.

EoIT Emergence and Future: Remarks

Internet of Things and its applications leads the development of the new age educational model and also helps in rejuvenating existing and traditional educational systems. And as a result new mode of education has been developed and new concepts and version of Internet of Things i.e. Educational of Internet of Things (EIoT). It is simply the education opportunities using IoT and an intelligent teaching-learning process using Internet of Things and other allied technologies. EIoT is simply applications of internet systems and cyber physical system enable education systems for the purpose of teaching, educational management, administration, examination and library management, and so on. The increasing and growing Internet of Things applications in educational areas are becoming helps in educational area as ‘Education Sector’ or ‘Educational Industry’. It is offering ‘smartening’ in educational systems and process for complete development^{[20],[29]}. Today most of the modern educational institutions and organizations highly adopting technologies and among these EIoT is important one for different purposes viz. smart boards, wireless door locks, emergency fire management systems, online attendance systems, educational transportation management, emergency indicator, and so on. It is worthy to note that EIoT is also called as IoET in certain places and the market share is growing rapidly not only in western countries but also in developing countries. A Data of verified market share estimated that this sector may reach at 19.5 Billion USD within 2027 and as far as CAGR is concerned it would be 17.74 percentage in 2027 (from 2020), refer Fig. 3.

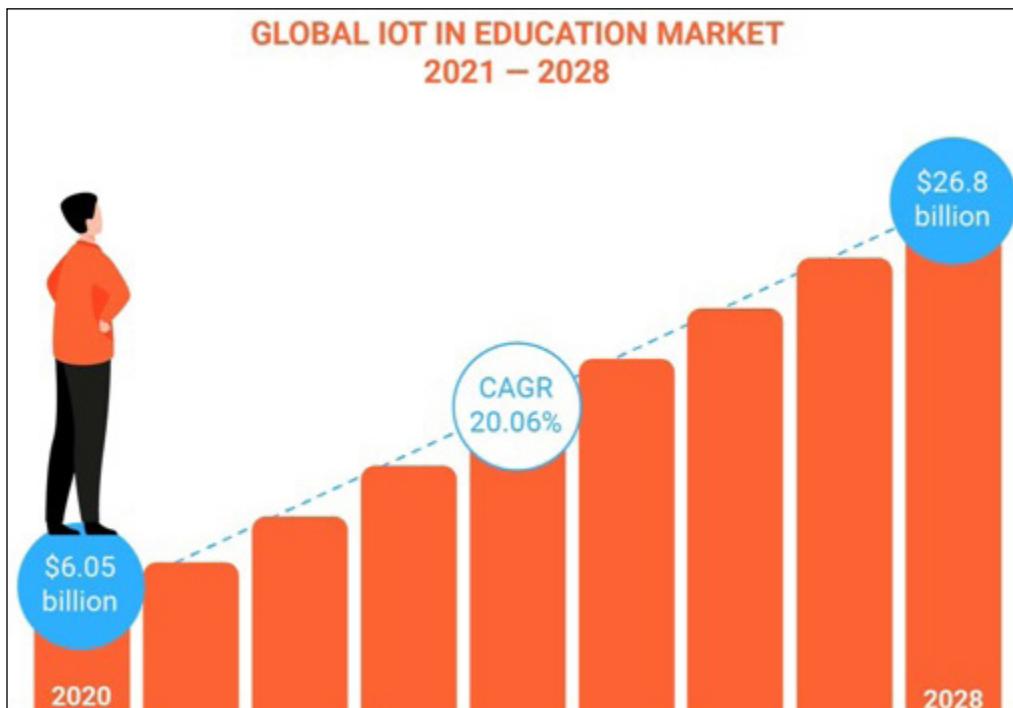


Fig. 3: Future prospects of IoT in Education segment

Finds, Issues and Challenges of IoT in Digital and ICT Enable Education

Educational of Internet of Things (EIoT) has significantly enhanced in recent past and different top areas have been indentified in recent past, it is enhancing educational systems drastically into advanced, intelligent education and more flexibility in online education. There are opportunities for all the stakeholders such as—

- Students
- Researchers
- Teachers
- Administrators and officers
- Staff and HRs and so on.

The growing importance of Educational of Internet of Things (EIoT) into educational sector therefore moving towards worth USD 19.57 billion within 2027 (according to verified market research). And according to another market research agency MYTech Decisions it has reveals that the school safety has been enhanced about 55% using IoT and 65% of K-12 professionals believe that smart education is the only and emerging solution in enhancing education sector^{[21],[30]}. Educational sector as suffering with different issues and has many imperfections such as according to a study 70% of the students have negative feeling about studying and growing, and Internet of Things is treated as worthy in identifying such situations, psychological status and perception.

Educational of Internet of Things (EIoT) offer wide range of benefits in onsite and oncampus, both kind of educational initiative and process. It is further helps in other emerging and mixed mode of education, teaching segment^{[6],[36]}. Since IoT technologies are applicable in diverse areas of education therefore finally we can have a remarks on its wide range of applications in educational process and activities for different stakeholders (as depicted in Table 1).

Table 1: Growing trends and future potentiality of EIoT

Beneficiaries	Core Benefits	Devices can be used
Students/ Learners	Enhanced educational process	IoT enabled tables, smart devices, voice-to-text systems etc.
	Wide involvement in learning activities and process	Smart boards, smart markers, smart microphones, VR headsets etc.
	More optimized learning	Document camera and scanners with IoT enable features
Teachers/ Educators	In better attendance systems	RFID, ID Cards, E Bracelets
	Innovative and Interactive Teaching	Document Camera, Interactive Display, Scan Markers
	Utilization of more enhanced curriculum	Whiteboards, intelligent pen and recording systems.

Administrators/ Officers	Flexible and utilizable Resource Sharing	Smart trackers, smart meters etc.
	Robust Safety	Smart locks, Smart Door Management, RFID Tags, IoT enabled badges, intelligent sensor enable Cameras
Parents	Real time monitoring of their children	Smart wristbands, smart watches, wearable etc
	Location tracking system	Smart and IoT enable buses, GPS enabled sensors

Thus, Internet of Things offers opportunities to enhance traditional education more advanced, up-to-date and intelligent, and at the same time it offer better access and management in online education and e-learning. As a whole all kind of education model in contemporary era is using ICT for better Digital Education access and IoT and allied technologies playing a crucial role in this regard. With Internet of Things and allied systems people can have more experienced and new age, remote learning experience. It is worthy to note that issues such as *technology implementation* may be considered as important for many developing and undeveloped countries, and undeveloped countries. Similarly aspects of *finance* and *fund* can be considered as important in modern days IoT enable educational process. As far as *human resource* and skilled manpower is concerned the issues of availability of manpower is an alarming issue in developing and designing Internet of Things enable systems in education and teaching learning process.

CONCLUDING REMARKS

Internet of Things therefore helps in enhancing more interactive and enjoyable teaching-learning process. It is also beneficial in management of the universities, colleges and other educational institutions. Though it is important to take a note on preparing and developing Internet of Things enable systems due to lack of knowledge of teachers and educators, students and researchers, and administrators as well. Internet of Things must need support of different allied technologies and therefore such matters should be looked into. Augmented and Virtual reality is an emerging IT component and educational intuitions are widely using such technologies. Educational of Internet of Things (EIoT) or IoET segment is booming rapidly for complete higher educational development. Different educational technology companies are working in further development of educational process and educational uses. Many startups in the field of education technology and ICT have engaged in various educational uses and segment. Educational of Internet of Things (EIoT) are highly applicable in HEIs like universities and colleges and students can learn lot of things using IoT enable education systems.

REFERENCES

1. Abdel-Basset, M., Manogaran, G., Mohamed, M. and Rushdy, E. 2019. Internet of things in smart education environment: Supportive framework in the decision-making process. *Concurrency and Computation: Practice and Experience*, **31**(10): e4515.

2. Ahmed, E. and Rehmani, M.H. 2017. Mobile edge computing: opportunities, solutions, and challenges. *Future Generation Computer Systems*, **70**: 59-63.
3. Ahmed, E., Ahmed, A., Yaqoob, I., Shuja, J., Gani, A., Imran, M. and Shoaib, M. 2017. Bringing computation closer toward the user network: Is edge computing the solution?. *IEEE Communications Magazine*, **55**(11): 138-144.
4. Akiyama, K., Ishihara, M., Ohe, N. and Inoue, M. 2017. An education curriculum of IoT prototype construction system. In *2017 IEEE 6th Global Conference on Consumer Electronics (GCCE)* (pp. 1-5). IEEE.
5. Al-Emran, M., Malik, S.I. and Al-Kabi, M.N. 2020. A survey of Internet of Things (IoT) in education: Opportunities and challenges. *Toward social internet of things (SIoT): Enabling technologies, architectures and applications: Emerging technologies for connected and smart social objects*, pp. 197-209.
6. Al-Malah, D.K.A.R., Jinah, H.H.K. and ALRikabi, H.T.S. 2020. Enhancement of educational services by using the internet of things applications for talent and intelligent schools. *Periodicals of Engineering and Natural Sciences*, **8**(4): 2358-2366.
7. Banica, L., Burtescu, E. and Enescu, F. 2017. The impact of internet-of-things in higher education. *Scientific Bulletin-Economic Sciences*, **16**(1): 53-59.
8. Cao, K., Liu, Y., Meng, G. and Sun, Q. 2020. An overview on edge computing research. *IEEE Access*, **8**: 85714-85728.
9. Chen, J. and Ran, X. 2019. Deep learning with edge computing: A review. *Proceedings of the IEEE*, **107**(8): 1655-1674.
10. Corcoran, P. and Datta, S.K. 2016. Mobile-edge computing and the internet of things for consumers: Extending cloud computing and services to the edge of the network. *IEEE Consumer Electronics Magazine*, **5**(4): 73-74.
11. Deng, S., Zhao, H., Fang, W., Yin, J., Dustdar, S. and Zomaya, A.Y. 2020. Edge intelligence: The confluence of edge computing and artificial intelligence. *IEEE Internet of Things Journal*, **7**(8): 7457-7469.
12. Du, B., Chai, Y., Huangfu, W., Zhou, R. and Ning, H. 2021. Undergraduate university education in internet of things engineering in china: A survey. *Education Sciences*, **11**(5): 202.
13. Ferrer, A.J., Marquès, J.M. and Jorba, J. 2019. Towards the decentralised cloud: Survey on approaches and challenges for mobile, ad hoc, and edge computing. *ACM Computing Surveys (CSUR)*, **51**(6): 1-36.
14. Francisti, J., Balogh, Z., Reichel, J., Magdin, M., Koprda, Š. and Molnár, G. 2020. Application experiences using IoT devices in education. *Applied Sciences*, **10**(20): 7286.
15. Gul, S., Asif, M., Ahmad, S., Yasir, M., Majid, M., Malik, M.S.A. and Arshad, S. 2017. A survey on role of internet of things in education. *International Journal of Computer Science and Network Security*, **17**(5): 159-165.
16. Hassan, N., Gillani, S., Ahmed, E., Yaqoob, I. and Imran, M. 2018. The role of edge computing in internet of things. *IEEE Communications Magazine*, **56**(11): 110-115.
17. Hu, Y.C., Patel, M., Sabella, D., Sprecher, N. and Young, V. 2015. Mobile edge computing—A key technology towards 5G. *ETSI White Paper*, **11**(11): 1-16.
18. Ilieva, G. and Yankova, T. 2020. IoT in distance learning during the COVID-19 pandemic. *TEM Journal*, **9**(4): 1669-1674.
19. Kadhim, J.Q., Aljazeera, I. A. and Salim ALRikabi, H.T. 2023. Enhancement of Online Education in Engineering College Based on Mobile Wireless Communication Networks and IOT. *International Journal of Emerging Technologies in Learning*, **18**(1).

20. Krestinskaya, O., James, A.P. and Chua, L.O. 2019. Neuromemristive circuits for edge computing: A review. *IEEE Transactions on Neural Networks and Learning Systems*, **31**(1): 4-23.
21. Liang, B., Wong, V.W.S., Schober, R., Ng, D.W.K. and Wang, L.C. 2017. Mobile edge computing. *Key technologies for 5G wireless systems*, **16**(3): 1397-1411.
22. Liu, F., Tang, G., Li, Y., Cai, Z., Zhang, X. and Zhou, T. 2019. A survey on edge computing systems and tools. *Proceedings of the IEEE*, **107**(8): 1537-1562.
23. Mach, P. and Becvar, Z. 2017. Mobile edge computing: A survey on architecture and computation offloading. *IEEE Communications Surveys & Tutorials*, **19**(3): 1628-1656.
24. Maksimović, M. 2018. IOT concept application in educational sector using collaboration. *Facta Universitatis, Series: Teaching, Learning and Teacher Education*, **1**(2): 137-150.
25. Mao, Y., You, C., Zhang, J., Huang, K. and Letaief, K.B. 2017. A survey on mobile edge computing: The communication perspective. *IEEE Communications Surveys & Tutorials*, **19**(4): 2322-2358.
26. Mishra, A.S., Karthikeyan, J., Barman, B. and Veetil, R.P. 2020. Review on IoT in enhancing efficiency among higher education institutions. *Journal of Critical Reviews*, **7**(1): 567-570.
27. Mohammed, A.H.K., Jebamikyous, H.H., Nawara, D. and Kashef, R. 2021. IoT text analytics in smart education and beyond. *Journal of Computing in Higher Education*, **33**(3): 779-806.
28. Moraiti, I., Fotoglou, A., Dona, K., Katsimperi, A., Tsonakas, K. and Drigas, A. 2022. IoT in special education. *Technium Soc. Sci. J.*, **30**: 55.
29. Ning, H. and Hu, S. 2012. Technology classification, industry, and education for Future Internet of Things. *International Journal of Communication Systems*, **25**(9): 1230-1241.
30. Pai, S.S. 2017. IOT application in education. *International Journal for Advance Research and Development*, **2**(6): 20-24.
31. Pan, J. and McElhannon, J. 2017. Future edge cloud and edge computing for internet of things applications. *IEEE Internet of Things Journal*, **5**(1): 439-449.
32. Paul, P.K. 2021. Digital Education: From the Discipline to Academic Opportunities and Possible Academic Innovations—International Context and Indian Strategies. In *Digital Education for the 21st Century* (pp. 255-281). Apple Academic Press.
33. Paul, P.K. and Dangwal, K.L. 2014. Cloud based educational systems and its challenges and opportunities and Issues. *Turkish Online Journal of Distance Education*, **15**(1): 89-98.
34. Paul, P.K., Karn, B. and Rajesh, R. 2015. Cloud computing and its deployment model: A short review. *International Journal of Applied Science and Engineering*, **3**(1): 29.
35. Paul, P.K. 2022. Digital Education: The Aspects and Growth in Socio-Economic Development—Towards sophisticated Education 4.0 Practice. *Econ. Aff.*, **67**(05): 971-980.
36. Porambage, P., Okwuibe, J., Liyanage, M., Ylianttila, M. and Taleb, T. 2018. Survey on multi-access edge computing for internet of things realization. *IEEE Communications Surveys & Tutorials*, **20**(4): 2961-2991.
37. Premsankar, G., Di Francesco, M. and Taleb, T. 2018. Edge computing for the Internet of Things: A case study. *IEEE Internet of Things Journal*, **5**(2): 1275-1284.

38. Ranaweera, P., Jurcut, A.D. and Liyanage, M. 2021. Survey on multi-access edge computing security and privacy. *IEEE Communications Surveys & Tutorials*, **23**(2): 1078-1124.
39. Sodhro, A.H., Pirbhulal, S. and De Albuquerque, V.H.C. 2019. Artificial intelligence-driven mechanism for edge computing-based industrial applications. *IEEE Transactions on Industrial Informatics*, **15**(7): 4235-4243.
40. Sonmez, C., Ozgovde, A. and Ersoy, C. 2018. Edgecloudsim: An environment for performance evaluation of edge computing systems. *Transactions on Emerging Telecommunications Technologies*, **29**(11): e3493.
41. Sun, X. and Ansari, N. 2016. EdgeIoT: Mobile edge computing for the Internet of Things. *IEEE Communications Magazine*, **54**(12): 22-29.
42. Wang, S., Zhao, Y., Xu, J., Yuan, J. and Hsu, C.H. 2019. Edge server placement in mobile edge computing. *Journal of Parallel and Distributed Computing*, **127**: 160-168.
43. Wang, X., Han, Y., Leung, V.C., Niyato, D., Yan, X. and Chen, X. 2020. Convergence of edge computing and deep learning: A comprehensive survey. *IEEE Communications Surveys & Tutorials*, **22**(2): 869-904.
44. Xiao, Y., Jia, Y., Liu, C., Cheng, X., Yu, J. and Lv, W. 2019. Edge computing security: State of the art and challenges. *Proceedings of the IEEE*, **107**(8): 1608-1631.
45. Xie, J. and Yang, Y. 2021. IoT-based model for intelligent innovation practice system in higher education institutions. *Journal of Intelligent & Fuzzy Systems*, **40**(2): 2861-2870.
46. Yang, R., Yu, F.R., Si, P., Yang, Z. and Zhang, Y. 2019. Integrated blockchain and edge computing systems: A survey, some research issues and challenges. *IEEE Communications Surveys & Tutorials*, **21**(2): 1508-1532.
47. Yu, W., Liang, F., He, X., Hatcher, W.G., Lu, C., Lin, J. and Yang, X. 2017. A survey on the edge computing for the Internet of Things. *IEEE Access*, **6**: 6900-6919.
48. Zeeshan, K., Hämäläinen, T. and Neittaanmäki, P. 2022. Internet of Things for sustainable smart education: An overview. *Sustainability*, **14**(7): 4293.