A Survey on Role of Internet of Things in Education

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Abstract
Internet of Things (IoT) is a rapidly growing network of a variety of different 'connected things.' Use of IoT in academics is like a new wave of change that has brought new opportunities and possibilities for the improvement of both teaching-learning process and educational institutions' infrastructure. This paper discusses the usefulness and applications of IoT in the field of education. Moreover, it tries to present the recent research works, challenges and impact of IoT in future education.

Keywords:
IoT; Smart Classroom; Internet; Connected devices; Education

1. Introduction

The concept of connected devices or things has given a new rise of the Internet, anything, anywhere can get connected with the Internet and becomes 'Smart.' Connected devices can communicate with each other and share information which can then further be processed to take some decisions. This whole concept is named as 'Internet of Things.'
According to Mark Weiser, "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it" [1]. Kevin Ashton first used the term Internet of Things in 1999. Since the beginning of *Internet of Things* (IoT) many researchers have tried to define IoT in various ways like *Internet of Everything*, *Internet of Anything*, *Internet of People*, *Internet of Signs*, *Internet of Services*, *Internet of Data* or *Internet of Processes* [2]. According to [3], IoT represents '*anything at all, depending on requirements.'* Cisco defines IoT as a network of connected physical objects. Cisco also uses the term *Internet of Everything* for both physical and virtual objects. Cisco states that *"IoE brings together people, process, data, and things to make networked connections more relevant and valuable than ever before—turning information into actions that create new capabilities, richer experiences, and unprecedented economic opportunities for businesses, individuals, and countries*"[4].

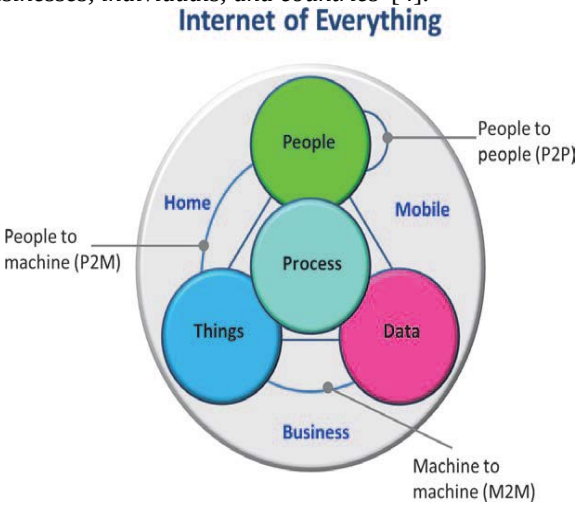

Fig. 1 Internet of Everything (source: Cisco)

The IoT network connects different types of devices like personal computers, laptops, tablets, smartphones, PDAs and other hand-held embedded devices. Others include devices to measure blood pressure, heart rate, devices like biochip bracelets for pets or farm animals, devices to call emergency services, robots, autonomous vehicles, home appliances, etc. These devices gather useful information with a variety of sensors and data collection technology, then transmits it to other processing devices for interpretation and decision-making [2].

The number of connected devices is increasing enormously, and many predictions have been made with this regard. According to Gartner's forecast, 20.8 billion new things will be connected by 2020 [1]. According to Machina Research, the growth of IoT connections is wonderful: from 6 billion in 2015 to 27 billion in 2025. The number of cellular IoT connections will be 2.2 billion, and 45% of these will be in connected cars. The revenue forecast of IoT in 2025 is 3 trillion US$. IoT will also generate over two

[1] http://www.gartner.com/newsroom/id/3165317

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zettabytes of data, generally from consumer electronic devices [5].

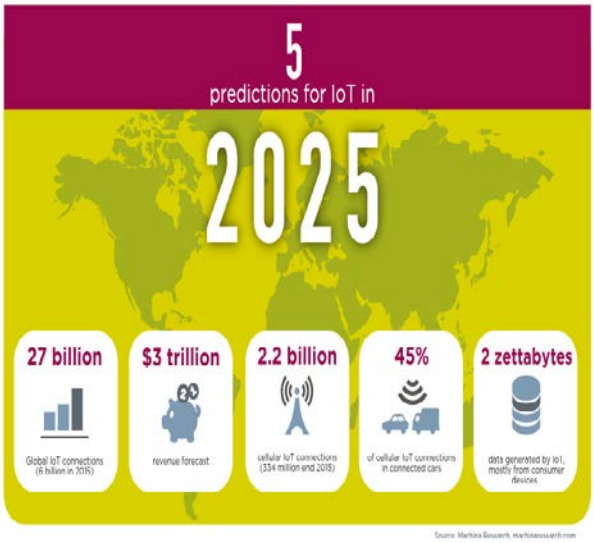

Fig. 2 Five Predictions for IoT in 2025 [5]

IoT based systems communicate through wireless technologies like RFID (Radio-Frequency Identification), ZigBee, NFC(Near Field Communication), WSN (Wireless Sensor Network), WLAN (Wireless Local Area Network), DSL (Digital Subscriber Line), UMTS (Universal Mobile Telecommunications System), WiMax (Worldwide Interoperability for Microwave Access), GPRS (General Packet Radio Service), or LTE (Long-Term Evolution) [6].

The key challenges to IoT include security and privacy, availability, mobility, reliability, performance, interoperability, scalability, trust and management [7]. Most of the known challenges are stated in the surveys [8], [9], [10]. As far as applications of IoT are concerned, there are various useful IoT applications based on the needs of potential users like Smart Cities, Smart Energy and Smart Grid, Smart Transportation and Mobility, Smart Homes, Smart building and infrastructure, Smart factory and manufacturing, Smart health, Food and water tracking and security [11]. This paper discusses the role of IoT specifically in the field of education. Although there are many survey papers available on IoT, there is no survey on applications of IoT in education. In this article, we attempt to present recent research, challenges and future impact of IoT in education.

The rest of the paper is organized as follows: Section 2 presents background and overview of IoT in Education, Section 3 gives IoT-based Smart environment and its components, Section 4 discusses some of the challenges related to the integration of IoT in a setup, and Section 5 presents the conclusion.

2. IoT in Education

Technology in education has played a significant role in connecting and educating the students. IoT technology has an important impact on education field. IoT has not only changed the traditional teaching practices but has also brought changes in the infrastructure of educational institutions [12]. The term Internet of Things in Education is considered two faceted because of its use as a technological tool to enhance academic infrastructure and as a subject or course to teach fundamental concepts of computer science [13].

IoT technology is playing a likely role for the improvement of education at all levels including school, college and university teaching. From student to teacher, classroom to campus, everything can get benefited with this technology.

Another way to understand the impact of IoT on education is through the use of sensors. For example, Super Mechanical's Twine7 product—a small box described as "the simplest way to connect stuff to the Internet"—allows users to link almost any physical object to a local area network. Twine integrates sensors with a cloud-based service, allowing for easy setup. Just point Twine to a Wi-Fi network and sensors are immediately recognized by the web app, which reflects what the sensors see in real time. Even people with no knowledge of software coding can receive text and email updates on whatever items or environments the box is sensing [4].

IoT is being used as a teaching and research medium in education. According to [14] "*integrating IoT as a new actor in educational environments can facilitate the interaction of people (students and teachers) and (physical and virtual) objects in the academic environment*". As a subject, IoT is a highly exciting and stimulating topic to attract students and an ideal platform for teaching computer science concepts [15]. Realizing the importance of IoT as an active subject, in the UK, the Open University introduced a new course, My Digital Life, based on IoT concepts for undergraduate computer science students. My Digital Life assists students to use IoT as a tool to understand and question the world around them and know their role in understanding IoT[4]. An IoT-based interactive model is built to teach the English language. To correct the pronunciation and the shape of English learners' mouth, this model uses voice and visual sensors [16]. IoT is also used to teach fundamental concepts of Programming language to students [15]. Another system uses objects with tags and Learning Management System to collect data and analyze students' learning method using learning analytics techniques [17].

Using IoT as a tool to improve education and make educational life easier, some of the related works in this regard are presented here. A real attempt was made to use and implement IoT technology in University of Padova [17]. The primary focus of their study was to develop a Web Service Model for Wireless Sensor Network and to provide a framework that had been validated through a case study. These services were then implemented in the Information Engineering Department at the University of Padova. The work examines the use of Cloud Computing and IoT in incorporating the structure of education resources and provides an integration model. Another[18] study discusses the impact of four different technologies including IoT, Cloud Computing, Data Mining and Triple-Play on new distance education. The research work [19] describes the application of IoT and Cloud Computing in Education and also differentiates smart campus with the digital campus. An integrated architectural model was presented to develop IoT system in an academic setup [13]. Figure 3 shows a heat map of 2016 which highlights education in IoT as the hottest trend.

Fig. 3 Heat Map of Key IoT Opportunities varies by Industry and Applications [21]

3. IoT-based Smart Environment

Mark Weiser's idea about smart environments is that smart devices and smart environments will be available everywhere, for everyone to perform routine tasks [1]. Smart environments can be smart homes, smart offices, smart classrooms and other smart places [22]. The primary purpose of IoT-based smart environments is to provide ease in everyday routine tasks. For example, when we drive cars, we want to know about the road conditions, best route, traffic jams or want to change the radio stations, etc. By using sensors, actuators and smart devices, one can get all this information only with his /her voice[23].

Three primary objectives in the Smart environment are learning, reasoning and predicting. In other words, creative environments must learn or understand how the environment works and thinks and must able to react according to the action or situation. A smart environment can be expressed "as one that can acquire and apply knowledge about the environment and its inhabitants to improve their experience in that environment"[24].

3.1 IoT-based Smart Campus

In general, almost all university campuses are connected to the Internet, and on each campus, there are multiple objects like windows, doors, projectors, printers, classrooms, labs, parking, and building, etc. Using sensors, RFID, NFC, QR tags and such other IoT technologies, these objects can be converted to Smart objects [25]. A Smart Campus can be a collection of multiple smart things in a single system. An intelligent campus may include following

- Smart E-learning Application with IoT
- Smart IoT-based Classroom
- Smart IoT-based LAB Room
- IoT Sensors for Notes Sharing
- IoT Sensors for Mobiles Devices
- IoT-enabled Hotspot for Campus [12]

In addition to above, a smart campus may have many other smart features like smart parking, smart inventory, smart lighting, and smart tracking of students, goods and equipment using RFID technology [25]. The smart education institute has smart classrooms, smart corridors with infoboards and datacenters for processing all types of data [26].

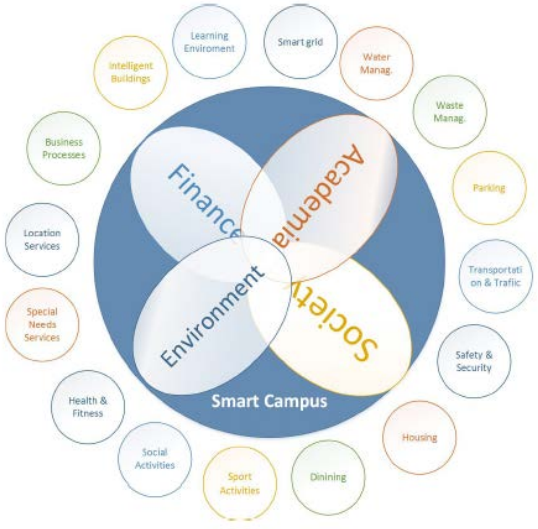

Fig.4 Smart Campus and its applications [31]

Another study was conducted to establish an intelligent campus using crowdsourcing and other technologies. The

purpose of the study was to collect data from the crowd, analyze them and to provide a view of value-added services [27].

3.1.1 IoT-based Smart Classroom

Smart classrooms concept means an intellectual environment equipped with advanced learning aids based on latest technology or smart things. These smart things can be cameras, microphones and many other sensors, which can be used to measure student satisfaction regarding learning or many other related things. The smart object provides ease and comfort for class management. Use of IoT in a classroom may help to provide a better learning and teaching environment.

1) Smart Classroom Management: The term "classroom management" means a way or approach a teacher uses to control/manage his/her classroom. Smart devices have made it possible for a teacher to decide when he should speak louder when students are losing interest, or their concentration level is decreasing [28].

The use of IoT devices for teaching and learning purposes is a hot trend among institutions across the world which provides a new and innovative approach to education and classroom management. Such tools are already being utilized. Some of the commonly used IoT devices in the classroom are:

- Interactive Whiteboards
- Tablets and Mobile devices
- 3-D Printers
- eBooks
- Student ID Cards
- Temperature Sensors
- Security Cameras and Video
- Room Temperature Sensors
- Electric Lighting and Maintenance
- Smart HVAC systems
- Attendance Tracking Systems
- Wireless door locks[1]

Smart classrooms allow teachers to know what students want to learn and the way they want to learn which is beneficial both for faculty and students. Moreover, smart classrooms help students to understand the real purpose of using technology which also makes the learning process easier [29],[30]. The advancement in the field of technology in education has facilitated educators to design classrooms which are productive, useful, and collaborative and managed through IoT.

Literature review shows that most of the recent studies propose different models for smart classrooms. Many advanced and innovative concepts are being proposed or introduced in education like introducing IoT technology with crowdsourcing in e-education can be useful for improving learning and teaching processes.

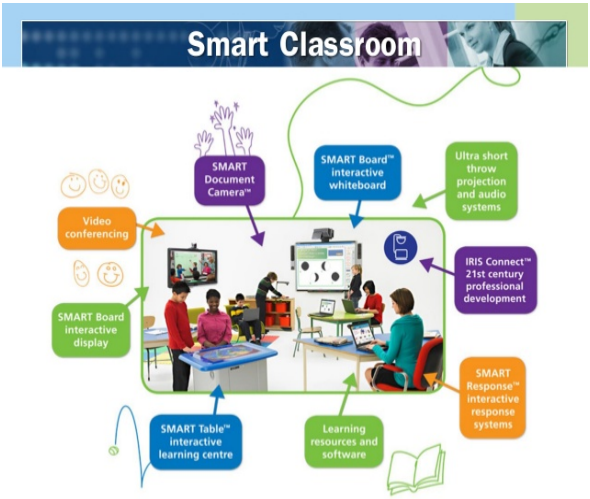

Fig. 5 Smart Classroom [36]

2) Smart Classroom Attendance System: Taking attendance of a class is a time-consuming task. Use of IoT can save time and effort both. A study proposed an efficient smart classroom roll caller system (SCRCS) using IoT architecture to collect or record student attendance after every period accurately and timely. RFID tags are attached to the Students' ID cards. The SCRCS can be installed in every classroom and read the students' identity card collectively. It shows not only the total attendance e on LED display at the beginning of any class but also shows the all identity card on multiple slots of SCRCS. The record of a student's attendance is also kept at the academic office [30]. Another study proposed a web based attendance system using NFC technology in Android smart phones. The student taps the matric card towards the NFC Android Smartphone, and the attendance will be saved on the server automatically. Teachers and students both can check the presence from their smart phones [31].

3) Real-Time Feedback on Lecture Quality: Students' understanding directly relates to the lecture quality. Students' feedback plays an essential role to improve lecture quality. A study proposes a creative environment

[1] http://aldridge.com/future-iot-in-the-classroom-education/

that can monitor and observe students' reactions to a lecture using sensing and monitoring technology. This IoT-based smart classroom provides real-time feedback on lecture quality which will help to improve the lecture quality [32].

3.1.2 IoT-based Smart Lab

It is said that the "*The college building (or campus) is the lab*." This thinking is part of a movement that began in the EU, called Living Labs. Research was conducted to combine several concepts together including IoT, the idea of living lab, i-*campus*, smart box design and Pervasive-interactive-Programming (PiP). The primary purpose of the study was to teach the necessary programming skills to novices using IoT and PiP together. Total 18 participants including staff and students participated in the evaluation of PiP. The results of the assessment showed that PiP helped and supported members of different backgrounds and age groups to understand and practice the programming skills effectively[15].

A study introduced a Lab development kit using a set of sensors with Zigbee, Raspberry Pi/Arduino boards which support to offer wireless communication in the lab. A module design method was adopted for the course labware. A survey was conducted to evaluate the Raspberry Pi based Lab kit, The results of the study showed positive feedback from students [33].

In their study, authors state that online virtual laboratories can also contribute to providing a qualitative and competitive edge to any education system. They present a case study where they use IoT and Arduino Platform with Xively web service for reading and showing data collected from a temperature sensor.

Fig. 6 IoT Lab [37]

4. Challenges with Integration of IoT in Education

For successful integration of IoT devices in a classroom environment, an education provider may have to face many difficulties like network bandwidth, reliable Wi-Fi Connection, web analytics, security, privacy, availability of devices for students, teacher training and cost of equipment, etc. Some of the challenges are discussed below.

4.1 Security and Privacy

Since in IoT-based environment, data is stored at an Internet-based network of connected devices, as devices start to measure and collect data from students, they put student's security and privacy at risk. Any security breach could disclose student's personal information related to an individual's medical record, family financial background or any other private information.

4.2 Reliable Wi-Fi Connection

There is a continuous need for new technologies for education, like high-speed wireless networks which provide the bandwidth for audio and video streaming of lessons.

4.3 Management

Some devices and applications are not compatible and can hinder the organization's ability to build an IoT setup that's both reliable and available to all users. For successful implementation of IoT, an educational institution must make sure that both its IT equipment and teaching approaches support the use of IoT in the classroom. Although risks and potential barriers are associated with technology, educational organizations may get advantages from exploring and experimenting with IoT options.

4.4 Cost

The whole setup of an IoT-based educational institution can be expensive. Therefore the cost of devices and equipment is another challenge.

5. Impact of IoT in Future Education

IoT will improve teaching and learning process in future. IoT will bring ease for both students and teachers. Students will learn better, and teachers will be able to perform their duties more efficiently. It can be predicted that IoT tools will provide a more appealing, flexible, engaging and quantifiable system of education that fulfills the different needs of a vast number of students.

The average American student uses 1025 hours/year in a classroom. Unfortunately, more than 308 of the 1025 hours are utilized in addressing expected disturbances like the distribution of class materials, transitions, or time spent at the beginning and ending a class. This data indicates that a student spends one out of every five minutes in the classroom on jobs that can easily be removed by using a network of IoT. Teachers would be able to spend less time on simple procedures and more time working with students to monitor their progress. They can also help them grasp difficult concepts in short span of time, attendance could be recorded automatically, neuro sensors could be used to determine learners' cognitive brain activity, and haptic vibrations could be sent to a student's wearable to warn them back on task discreetly. While a majority of schools have yet to adopt an IoT program, such a learning environment is not that far off [35].

6. Conclusion

Use of technology and especially IoT in the field of education has opened the doors for new and innovative ideas to bring ease and betterment in the lives of both students and teachers.

Research is being conducted in designing IoT-based teaching platforms including smart classrooms, smart labs and entire smart campuses. Studies have also been doing to investigate the usefulness of IoT-based smart learning applications and still much more is left to study regarding IoT in education. Though there are various advantages of IoT in education but may have to compromise privacy and security. In the future new techniques may be introduced that can resolve all these issues.

References

[1] M. Weiser, "The computer for the 21st century," *Sci. Am. (International Ed.*, vol. 265, no. 3, pp. 66–75, 1991.

[2] C. Cornel and D. Ph, "The Role of Internet of Things for a Continuous Improvement in Education," vol. 2, no. 2, pp. 24–31, 2015.

[3] E. Oriwoh and M. Conrad, "' Things ' in the Internet of Things : Towards a Definition," vol. 4, no. 1, pp. 1–5, 2015.

[4] S. Barakat, "Education and the internet of everything," *Int. Bus. Manag.*, vol. 10, no. 18, pp. 4301–4303, 2016.

[5] "Internet Of Things | IoT Market Analysts | Machina Research." [Online]. Available: https://machinaresearch.com/. [Accessed: 25-Mar-2017].

[6] G. Marques, N. Garcia, and N. Pombo, "Advances in Mobile Cloud Computing and Big Data in the 5G Era," vol. 22, pp. 115–130, 2017.

[7] A. Al-fuqaha, M. Guizani, M. Mohammadi, M. Aledhari, and M. Ayyash, "Internet of Things : A Survey on Enabling Technologies , Protocols and Applications," no. c, 2015.

[8] J. A. Stankovic and L. Fellow, "Research Directions for the Internet of Things," vol. 1, no. 1, pp. 3–9, 2014.

[9] S. Chen, H. Xu, D. Liu, B. Hu, and H. Wang, "A vision of IoT: Applications, challenges, and opportunities with China Perspective," *IEEE Internet Things J.*, vol. 1, no. 4, pp. 349–359, 2014.

[10] R. Khan, S. U. Khan, R. Zaheer, and S. Khan, "Future internet: The internet of things architecture, possible applications and key challenges," *Proc. - 10th Int. Conf. Front. Inf. Technol. FIT 2012*, pp. 257–260, 2012.

[11] N. Gershenfeld, R. Krikorian, and D. Cohen, *The Internet of things.*, vol. 291, no. 4. 2004.

[12] M. Mohanapriya, "IOT enabled Futurus Smart Campus with effective E-Learning : i-Campus," vol. 3, no. 4, pp. 81–87, 2016.

[13] H. F. Elyamany and A. H. Alkhairi, "IoT-academia architecture: A profound approach," *2015 IEEE/ACIS 16th Int. Conf. Softw. Eng. Artif. Intell. Netw. Parallel/Distributed Comput. SNPD 2015 - Proc.*, 2015.

[14] J. Marquez, J. Villanueva, Z. Solarte, and A. Garcia, "IoT in Education : Integration of Objects with Virtual Academic Communities," in *New Advances in Information Systems and Technologies*, no. 115, Springer International Publishing, 2016, pp. 201–212.

[15] J. Chin and V. Callaghan, "Educational living labs: A novel internet-of-things based approach to teaching and research," *Proc. - 9th Int. Conf. Intell. Environ. IE 2013*, pp. 92–99, 2013.

[16] Y. Wang, "English Interactive Teaching Model which based upon Internet of Things Keywords- Internet of things ; English ; Characteristics of," *Int. Conf. Comput. Appl. Syst. Model.*, vol. 13, pp. 587–590, 2010.

[17] H. Cheng and W. Liao, "Establishing an lifelong learning environment using IOT and learning analytics," in *Advanced Communication Technology*, 2012, pp. 1178–1183.

[18] A. P. Castellani, N. Bui, P. Casari, M. Rossi, Z. Shelby, and M. Zorzi, "Architecture and Protocols for the Internet of Things: A Case Study," *Pervasive Computing and Communications Workshops (PERCOM)*. 2010.

[19] Y. Chen and X. Dong, "The Development and Prospect of New Technology in Modern distance education," *Int. Conf. Inf. Sci. Comput. Appl.*, pp. 40–44, 2013.

[20] X. Nie, "Constructing Smart Campus Based on the Cloud Computing Platform and the Internet of Things," *Proc. 2nd Int. Conf. Comput. Sci. Electron. Eng. (ICCSEE 2013)*, no. Iccsee, pp. 1576–1578, 2013.

[21] M. Pelino and F. E. Gillett, "The Internet Of Things Heat Map , 2016," 2016.

[22] D. Lucke, C. Constantinescu, and E. Westkämper, "Smart Factory - A Step towards the Next Generation of Manufacturing," *41st CIRP Conf. Manuf. Syst.*, no. Sfb 627, pp. 115–118, 2008.

[23] S. Husnjak, D. Perakovic, and I. Jovovic, "Possibilities of Using Speech Recognition Systems of Smart Terminal Devices in Traffic Environment," *Procedia Eng.*, vol. 69, pp. 778–787, 2014.

[24] G. M. Youngblood, E. O. Heierman, L. B. Holder, and D. J. Cook, "Automation Intelligence for the Smart Environment."

[25] M. Cata, "Smart university, a new concept in the Internet of Things," in *2015 14th RoEduNet International Conference - Networking in Education and Research (RoEduNet NER)*, 2015, pp. 195–197.

[26] K. Simic, M. Despotovic-Zrakic, I. Đuric, A. Milic, and N. Bogdanovic, "A Model of Smart Environment for E-Learning Based on Crowdsourcing," *RUO. Rev. za Univerzalno Odlicnost*, vol. 4, no. 1, pp. A1–A10, 2015.
[27] A. Adamk, "A System Model and Applications for Intelligent Campuses," pp. 193–198, 2014.
[28] A. Rytivaara, "Collaborative classroom management in a co-taught primary school classroom," vol. 53, pp. 182–184, 2012.
[29] S. University, "Review Article Guidelines for Students on Rotation," no. 660, pp. 1–16.
[30] C. H. Chang, "Smart classroom roll caller system with IOT architecture," *Proc. - 2011 2nd Int. Conf. Innov. Bio-Inspired Comput. Appl. IBICA 2011*, pp. 356–360, 2011.
[31] A. Alghamdi and S. Shetty, "Survey toward a smart campus using the internet of things," in *Proceedings - 2016 IEEE 4th International Conference on Future Internet of Things and Cloud, FiCloud 2016*, 2016, pp. 235–239.
[32] C. B. Chew, "Sensors-Enabled Smart Attendance Systems Using Nfc and Rfid Technologies," *Int. J. New Comput. Archit. their Appl.*, vol. 5, no. 1, pp. 19–28, 2015.
[33] P. R. Temkar, M. Gupte, and S. Kalgaonkar, "Internet of Things for Smart Classrooms," pp. 203–207, 2016.
[34] J. He, Dan Chia-Tien Lo, Y. Xie, and J. Lartigue, "Integrating Internet of Things (IoT) into STEM undergraduate education: Case study of a modern technology infused courseware for embedded system course," *2016 IEEE Front. Educ. Conf.*, pp. 1–9, 2016.
[35] https://www.edsurge.com/news/2015-03-28-connecting-the-classroom-with-the-internet-of-things
[36] https://www.pinterest.com/pin/420453315183452859/
[37] http://udaipurtimes.com/rajasthans-first-iot-with-cloud-lab-in-ss-college-of-engineering/

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