Towards Smart Education through the Internet of Things: A Review

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IoT is a fundamental enabling technology for creating smart spaces, which can assist the effective face-to-face and online education systems. The transition to smart education (integrating IoT and AI into the education system) is appealing, which has a concrete impact on learners' engagement, motivation, attendance, and deep learning. Traditional education faces many challenges, including administration, pedagogy, assessment, and classroom supervision. Recent developments in ICT (e.g., IoT, AI and 5G, etc.) have yielded lots of smart solutions for various aspects of life; however, smart solutions are not well integrated into the education system. In particular, the COVID-19 pandemic situation had further emphasized the adoption of new smart solutions in education. This study reviews the related studies and addresses the (i) problems in the traditional education system with possible solutions, (ii) the transition towards smart education, and (iii) research challenges in the transition to smart education (i.e, computational and social resistance). Considering these studies, smart solutions (e.g., smart pedagogy, smart assessment, smart classroom, smart administration, etc.) are introduced to the problems of the traditional system. This exploratory study opens new trends for scholars and the market to integrate ICT, IoT, and AI into smart education.

Additional Key Words and Phrases: Internet of Things (IoT), Education System, Smart Education, E-Learning, Flipped Classrooms

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1 INTRODUCTION

Smart education (also referred to as education 4.0) is a teaching, learning, and managing paradigm, where smart technologies (e.g.

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IoT, Artificial Intelligence (AI), and 5G) are applied to make it more effective and attractive [53, 110, 111]. Smart education provides a digital environment to facilitate learners, parents, teachers, and administrators to enhance learner engagement and motivation [199]. For smart education, different terminologies are used, such as smart university, smart learning, smart classroom, smart learning environment, etc [127, 181]. The word "smart" refers to intelligence in decisions, penalization (in learning and teaching), transparency, and adaptivity in smart education. With the recent development in smart technologies, *educational institutions* need to be transformed into smart institutions rather than continue with the traditional methods [64, 110]. Table 1 differentiates smart and traditional education.

It is estimated that around 75 billion smart devices will be connected to the internet by 2025 [81]. This is a revolutionary hypothesis about the future. Moreover, the launch of the 5G mobile network introduces real-time communication [93]. These large number of devices and super-fast connectivity show that everyone will have a smartphone to communicate in real-time in the near future. These smartphones and smart devices can be used for smart teaching and learning [105]. The Internet of Educational Things (IoET) is proposed for the devices used in smart education, which is missed in the literature [12].

Three essential pillars of the educational management system are; i) administrators, ii) teachers, and iii) parents. All these stakeholders' active involvement and productive decisions are crucial for learner development. Smart devices help administrators, teachers, and parents to involve learners in learning activities, and to monitor the teaching and learning process in real-time [145, 162]. Fig. 1 shows the possible structure of smart education. In this structure, smart devices are used to connect students, teachers, parents, and administrators.

In the vast majority of institutions, the Standard Operating Procedures (SOPs) are not followed due to a lack of resources, which declines the quality of education. Furthermore, learners are not creatively engaged in producing a creative generation. IoT may play a big role in these issues as it has been playing smart tasks in various fields. Unfortunately, it has not been properly integrated into the educational system. Furthermore, smart education is still not properly included in the IoT platform (e.g, smart cities, smart agriculture, and smart health care, etc); therefore, there must be a term "smart education". As per our research, this article is the first

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Table 1. Analysis of smart and traditional education

Smart Education	Traditional Education
Flexibility is an influential advantage of smart education. It allows students to learn in their own space. Teachers can listen repeatedly [92].	Compared with smart education, traditional education is not so flexible. Students must go to classes [131].
Smart education is not location and time-dependent. Students can watch lectures anywhere and anytime [179].	Concerning smart education, traditional education is location and time-dependent and has very firm policies.
Operational cost is a big issue for institutions and learners. Smart education minimizes this cost in many ways; for example, paper- less work minimizes the expenditure of travelling, examination and administration, etc.	Traditional education needs more operational costs than smart edu- cation in terms of paperwork, travelling expenditure, examinations, administration, etc.
Smart education allows teachers to teach worldwide; therefore, a large number of courses can be offered[51].	Traditional education does not follow this case. It needs the physical presence of teachers. Therefore, it cannot offer every type of course.
There are a number of channels (Zoom [173], Google meet [168], Skype [170] etc), which are used for communication and collabora- tion.	In the case of traditional education, physical presence is needed, and no other options are available. Especially in the meeting, a massive budget is consumed in daily and travelling allowances.
The major lack of smart education is social interaction. Learners stay home or remain busy with gadgets, etc., which badly affects their social and communication skills [155].	One of the major benefits of traditional education is social learning Students get together and participate in face-to-face discussions, which increases their social skills [131].
The other issue with smart education is that it does not have ex- tracurricular activities.	Instead of smart education, traditional education provides extracur- ricular activities. This prepares the learners for further study [48].
Although smart education minimizes operational costs, it needs a massive capital cost to install a smart system.	The overall cost of traditional education remains on the high side.

step toward exploring the possible uses of IoT in the education system. This explores all possible uses of IoT devices within the smart educational institution. IoT in education enhances the teacher's and learners' response, performance, and behaviour. Flourishing creativity is an essential goal of education; however, the current education system (usually in underdeveloped countries) is based on reading, watching, and listening, through which only 2 to 3 percent of information is retained in memory and the rest is forgotten [25]. Learning retention can be increased by up to 90% by engaging children in practical work, discussion, and teaching. Edgar Dale's research concluded that students retain 10% from reading, 20% from listening to a teacher, 30% from watching, 50% from watching and listening (at a time), 70% from participating in discussions and doing practical work and others, and up to 90% of information remains part of the memory from teaching to others [25, 121]. This is a brilliant idea; however, today's teaching methodology misses it. Smart devices can play a role in deploying this learning and understanding the idea [112].

Unfortunately, in most regions of the world [157], the traditional way of teaching and learning is followed, which prepares learners for *a manufacturing-based economy*. The teaching process is not the same as years ago. Everything has changed, including curriculum, pedagogy, assessment, and teachers and learners. The digital world is affecting all these terms very sharply. Therefore, it is the need of the day to find a smart system that works well for learners, parents, teachers, and administrators. It will empower parents, teachers, and administrators to develop a generation having high values and

global skills. Smart institutions not only save the cost but also make the classroom transparent and improve the quality of education [94, 101].

Therefore, the objectives of this research study are;

- To explore the challenges of the traditional education system and propose possible solutions in light of the recent Information and Communication Technology (ICT) trends (e.g, IoT, AI, and 5G).
- To investigate new directions to integrate the recent ICT trends with the educational system.
- To study the resistance and challenges (e.g., computational and social) to the implementation of smart education.

Smart education got very little attention; therefore, only a few review studies can be found in the literature. However, these studies have poor coverage, only looked at the related studies, and lack depth. Winanti et al. [190] and Dosheela and Binod [56] proposed smart solutions; however, they missed the smart education structure, smart solutions classification, and challenges with the smart system. Unlike the existing studies, this survey is covers all aspects of smart education system in depth. Along with a review of related studies, it addresses the challenges of the traditional education system, proposes possible solutions, and discusses potential challenges to smart education (e.g., social and IT challenges).

The general contributions of this article are listed as follows:

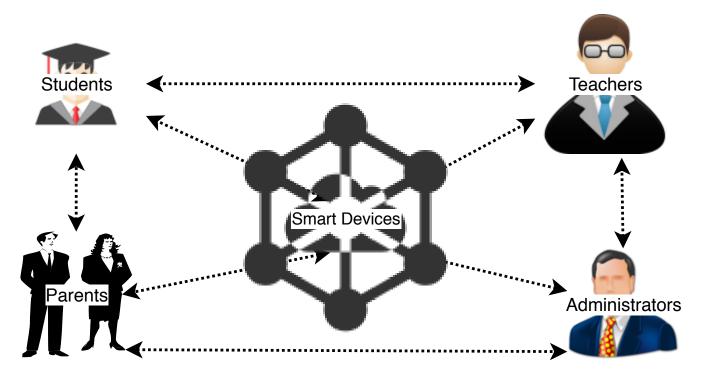


Fig. 1. Possible structure of IoT devices in smart educational institutions

- *Reviewed* the important investigations, projects, and frameworks of IoT, AI, and 5G in the context of smart education by explaining their motivations, challenges, and opportunities.
- Explored the *challenges* in traditional educational system in terms of teaching, learning, and management; and *possible smart solutions* to the challenges, e.g., smart classes, smart pedagogy, smart assessment, smart monitoring, and portfolio etc.
- Proposed a Smart Human Resource Model for educational institutions enabling integration of smart devices to manage institutions smartly and possible use of IoT, AI, 5G technology, and smart devices in educational institutions to make their activities smart.
- Explored the possible *challenges and resistance* from employees, parents, society, and customers along with the possible solutions to handle these challenges and hurdles. Furthermore, it discusses the possible future directions of smart education.
- Provided Comparative analysis of the proposed study with related reviews and surveys to demonstrate the supremacy of this study.

To the best of our knowledge, this is the first unique study, reviewing the existing work and proposing the structure of smart education. The rest of the article is structured as follows: Section 2 explains the concept and terminologies used in this study. Section 3 presents the IoT, its applications, and explores the IoT platform which includes the IoT hardware, connectivity, and software. It further covers the human resources involved in smart education; Section 4 covers the research methodology used in this paper to collect the related literature; Section 5 classifies the related studies; Section 6 investigates the use of smart devices in educational institutions; Section 8 explores the possible use of smart devices and IoT in educational institutions; Section 9 discuss the possible challenges and resistance to smart educational institutions; Section 10 compare this study with related surveys and reviews to confirm the supremacy of this work; and finally, Section 11 concludes the study along with future directions.

2 CONCEPTS AND TERMINOLOGIES

This is a multidisciplinary study covering education and ICT. Therefore, to make it easy for both disciplines, this section is divided into two subsections; (i) Educational terminology and (ii) Smart system terminology. These sections cover the basic concepts and terminologies used throughout this article. Furthermore, Table 2 shows the important abbreviations and notations used in this paper.

2.1 Educational terminologies

This subsection covers the important terminologies used in the education sector.

2.1.1 *Pedagogy.* Pedagogy deals with teaching methodology skills. The term pedagogy is broad and includes not only basic

Abbreviations	Description	Abbreviations	Description
ICT	Information and Communication Technol- ogy	LMS	Learning management System
CC	Cloud Computing	MOOC	Massive Online Open Courses
5G	5th Generation Technology (wireless)	MCU	Micro Controller Unit
AI	Artificial Intelligence	GSM	Global System for Mobile
VR	Virtual Reality	SIM	Single Identity Module
AR	Augmented Reality	NB-IoT	NarrowBand-Internet of Things
IOT	Internet of Things	WAN	Wide Area Network
RFID	Radio Frequency Identification	PDAs	Personal Digital Assistance
GPS	Global Positioning System	SOPs	Standard Operating Procedures
IoE	Internet of Every things	SSF	Smart Security Framework
IoLT	Internet of Living Things	BYOD	Bring Your Own Device
IoET	Internet of Educational Things	HDV	High Definition Video

Table 2. List of Abbreviations and Notations

terms related to classrooms (e.g, teaching, learning, and assessment skills), but also includes observational skills, feedback, psychology, etc [162].

2.1.2 Lesson plan. Before the start of the class, a written plan is drawn up for a specific topic to use the lesson time effectively. This helps the teachers to manage the classroom effectively and productively. The lesson plan is a blueprint that guides the teacher to lead the class [162].

2.1.3 Assessment. Assessment is the method used to evaluate students learning during or after the class or term. Assessment results are used to take final decisions related to the individual student, teacher, and long-term decisions relating to the institution [77].

2.1.4 Portfolio. A portfolio is a collection of students' and teachers' project records, results, and other activities. A portfolio helps in future decisions and can be used to train the AI algorithm [191].

2.1.5 *Engagement.* In educational institutions, the word engagement means the productive involvement of the learner in the classroom. Productive involvement means that students learn in the classroom instead of wasting time on other activities [77].

2.1.6 *Flipped classroom.* The flipped classroom is the reverse of the traditional classroom, in which learners watch recorded videos at home and do related activities at school under teacher supervision [95].

2.1.7 *Personalized learning*. Personalized learning gives learners the choice of what they want to learn. This positively motivates them to learn and improves their involvement in productive learning [75, 82].

2.1.8 Activities. Activities involve learners productively in learning. This involves them cognitively and physically in a task for the productive use of time. Research shows the major positive effects of activity-based learning [107]. 2.1.9 Question bank. Teachers prepare new questions every time when they take the exam. To manage it smartly, all questions of the topics are stored in a database and retrieved for question making. In a smart assessment, the application automatically populates the questions for assessment [55].

2.2 Smart system terminologies

This section covers the important terminologies used in the ICT sector.

2.2.1 Smart. The word smart means to intelligently handle some situations using smart technologies. The word "smart education" refers to handling educational institutions using the IoT, AI, and other related smart technologies [42].

2.2.2 Internet of Educational Things (IoET). IoET refers to all those devices used in smart education that is connected to the Internet. These devices include sensors, cameras, RFID tags, and other connected devices that can be used to collect data, monitor student activity, and provide feedback to teachers and administrators. [12].

2.2.3 Internet of Things. IoT is the web of connected devices using the wireless network and internet connections. It uses embedded technology and code to collect data or take automatic decisions [55]. As the name suggests, IoT is a large cloud of smart things. These devices and sensors are connected to each other for communication. Now, these devices are integrated with AI to make smart decisions [136].

2.2.4 MOOC. Massive Online Open Courses (MOOC) (e.g, Coursera [165] and edX [166]) provide online courses facility. Now, with advanced technologies, universities offer MOOC courses and students receive certificates at home. This is the future trend of teaching, learning, and certification [191].

2.2.5 Learning Management System (LMS). LMS is an online application used to interact with educational institutions for classes, assignments, quizzes, assessments, etc [191].

2.2.6 Virtual classroom. In virtual classrooms, learners remotely attend online classes on the Internet. With the emergence of 5G (having very minimum delay), virtual classrooms are becoming very popular [191].

2.2.7 *Collaboration.* 5G has made remote collaboration very easy and smart. Like virtual classrooms, they can use various applications (Zoom [173], Google meet [168], Skype [170] etc) to collaborate remotely on their subjects [109].

2.2.8 Artificial Intelligence. The AI enables smart machines to sense the environment and take decisions as per input [39]. AI is being utilized to comprehend and uncover the best methods of teaching using various forms of data, such as portfolios, classroom or tool-based recorded lectures, and so on [44, 175].

2.2.9 Virtual Reality (VR). VR provides a three-dimensional view and can be applied in entertainment and education. VR is now widely used for virtual meetings, training, collaboration, and lectures [59]. VR is making learning easier, faster, and more engaging.

2.2.10 Augmented Reality (AR). AR can be defined as a system that fulfils three basic functionalities: a combination of real and virtual worlds, real-time interaction, and accurate 3D capture of virtual and real objects [59]. AR may be utilized to enhance the learning process in both online and offline teaching techniques by allowing the linking of imagination with the real world through virtual means.

2.2.11 *Fifth generation (5G).* The fifth generation of communication technology provides high-speed network connectivity, which enables real-time communication. Real-time communication is essential for the adoption of AR and VR technologies in interactive learning and training sessions.

2.2.12 MCU. MCU stands for micro-controller unit which works as a hub for smart sensors. The sensors are connected with the MCU, and it further communicates this data with fog and cloud computing [139].

2.2.13 Fog computing. Instead of processing data on the cloud to overload the network and cloud computing, the data is processed on edge server. Processing or storing data on edge devices is called fog computing [123].

2.2.14 *Cloud computing.* Cloud computing provides desktop computer resources online on the network. These services are categorized as Infrastructure as a Service (IaaS), Software as a Service (SaaS), and Platform as a Service (PaaS) [188, 193].

3 BACKGROUND

The web of IoT is getting wider day by day. With the increase in internet speed and coverage, the growth of smart devices is also increasing. Giant tech companies and governments are working together to enhance internet coverage in remote areas using various technologies. Google is working to provide the Internet to far-flung areas using *balloon stations* [58], CISCO has a big share in communication devices. Furthermore, SpaceX is launching satellites to directly provide the Internet to remote areas from lower orbit

satellites. The difference between Starlink (SpaceX) and other geostationary satellites is that these satellites are located 35,000 km from Earth, which has a higher delay, however, the Starlink satellites orbit is about 550 km and provide a fast Internet connection. Although this technology is still in its infancy, however, marketing internet connections has already started [171]. With this speedy growth, it is expected that more than 75 billion devices will be connected to the internet by 2025 [81]. This figure is about nine times greater than the world population. This section covers the discussion on various smart education-enabling technologies.

3.1 Internet of Things (IoT)

The IoT allows us to create smart systems by connecting smart gadgets. Normally, any institution or building is smartly managed by hundreds of devices. Every electric appliance in a smart home, such as a refrigerator, lamp, fan, security camera, kitchen appliance, and other equipment, has its own sensors [192].

IoT improves device connectivity and fosters communication, teamwork, and experience sharing. To enable these devices to comprehend their surroundings and make critical judgements, artificial intelligence and AIOT are being combined [57].

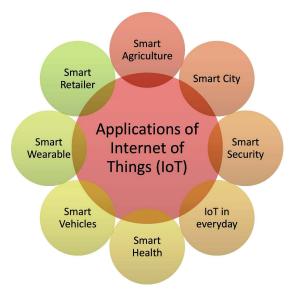


Fig. 2. Applications of IoT in different fields

3.2 Applications of IoT

IoT is used in every field of life, as shown in Figure 2. This new wave of smart technology goes beyond smartphones, tablets, or sensors. Today, AI is integrated into tiny devices, which empowers them to make automated decisions. This massive flood of smart devices around the world is opening several new doors and introducing new paradigms [85].

One of the powerful applications of IoT devices in *everyday life* is to read the surrounding environment and respond according to the sensed data. For example, handling *agriculture* traditionally is a waste of time and money. IoT manages these issues with smart

systems. The smart watering system saves water, and if water is needed for any field or crop, the pump automatically starts watering it. There is no human interference, and this is done automatically. In the greenhouse, the sensors read the environment, and it is automatically controlled [122].

Smart industries are the major part of IoT application. Instead of creating a product manually, robotic hands commercially produce the product automatically. This drastically increases the speed, accuracy, and reliability of production. IoT optimizes the time and cost; increases the quality and production of products [97, 146].

IoT helps in medical examination and analysis of the results and empowers the *health care* system to improve medical reports. This reduces the time and cost invested in the health sector. Smart devices are attached to critical patients. If the patients' condition goes down, the sensors generate a notification which is communicated to the physician and relatives [28, 114, 168].

IoT applications are used to control city traffic, parking, waste management, security, and safety systems, and many more. The environment is read with IoT sensors to give a good environment to the citizens [144].

IoT provides a good solution for *security*. Sensors and security cameras detect the insecure situation and alert concerned officials.

3.3 IoT platform

IoT platform is categorized into three different layers. These are IoT hardware, IoT connectivity, and IoT software. IoT hardware, connectivity and software create a fleet of IoT devices (IoT Cloud).

3.3.1 Physical layer. IoT hardware consists of smart boards, sensors, actuators, and other smart devices. The core component of IoT is Micro Controller Unit (MCU), which gathers data from other associated devices and interprets it to make various logical decisions. The sensors may be installed in the MCU or they work separately. Some health care and security-related gadgets are also worn [52, 167]. There are various companies that manufacture and do research on IoT hardware. Table 3 shows the detailed comparative analysis of smart system circuit boards.

Arduino is a single-chip open sources project. Its hardware and software are free to be used or modified for different projects. Arduino has various circuit boards with different capabilities, for example, it comes with onboard Wi-Fi, Ethernet, and USB connections. It uses Linux as the operating system. Arduino's simple programming functions are used to program it for different tasks [16].

Raspberry Pi is a single-board computer chip. It is an open-source project and can be freely modified for any project. Raspberry Pi provides a range of single-board computers which are used according to the requirements. Raspberry PI 4 provides a choice for RAM up to 4 GB; a powerful microprocessor is installed. Apart from that, it provides a USB port, Wi-Fi port, and other micro HDMI ports [132].

Cloudbit-little bit uses the littleBits circuit, such as the button placed on the door to be opened. When the littleBits button is pressed, it generates a message which is sent to the required destination. In this, small other modules work, which can be connected according to the need. All these modules are magnetically attached to each other. This facility makes it more attractive [45].

Particle works on all three main pillars of the IoT. They work on devices that have hardware, software, and interconnections. They provide cellular and Wi-Fi connections in their particle boards. This is the main benefit of the particle, which other companies do not provide. They also handle security, scalability, and reliability [129].

UDOO was developed in 2013. This is the next step to develop a power full IoT connectivity. This provides different types of boards such as DUAL/QUAD, NEO, X86, and BLU. UDOO is well in a webbased platform for monitoring and organizing [182].

Sensors and actuators are smart devices that read the physical changes in the environment. These readings are sent to the MCU. IoT has a variety of sensors such as motion sensors, temperature sensors, frequency identification, sound detectors, water detectors, smoke detectors, and many more [30, 85].

3.3.2 Communication layer. Connectivity is the foundation of IoT. It is a key decision to select appropriate devices for connectivity. This may increase the cost or reduce the performance in case of a wrong selection. Connectivity device selection is made on behalf of range, data throughput, energy efficiency, and device cost. Table 4 shows the detailed comparative analysis of connectivity technologies (wireless).

MCU uses *GSM* circuits and cellular phone SIMS to connect the object to the internet, which provides long-distance control to the objects. *Wi-Fi* (802.11), is a wireless protocol for short-range connections having a range of about 100 m and performs well in short ranges. *Ethernet* connects the devices with a physical wire, usually used to directly connect the device. Unique IPs may be used if required. *Bluetooth* is a short-range connectivity technology, now rarely used after the emergence of Wi-Fi. *ZigBee* is a low-power WAN, used for smart system communication. The use of ZigBee has several advantages over other networks because it is simpler and cheaper. The transfer distance of ZigBee is more than 100 m. *Narrowband IoT (NB-IoT)* is a pioneering technology in IoT communication. It covers more distance and consumes less power compared to Wi-Fi.

3.3.3 Software layer. A range of languages are used to develop IoT applications. For circuit board programming, mostly Java and Python are used. They have built-in functions, which are employed with these languages. Linux or Windows 10 is used as an operating system in MCU. Apart from these, other OSs may also be used in different MCUs.

3.4 Human resources

This section discusses the stockholders involved in the teachinglearning process.

Learners are the core entity for which all this is being done. Today children are the next leaders. They prepare the next society. If we train them as good humans today, surely, they will form a sound human society of tomorrow.

Board	Summary	Processors	Processor Speed	Size (mm)	USB Port	Memory	Price
Arduino Uno [15]	Current "official" Arduino USB board, driverless USB-to-serial, auto power switching	ATmega328	16 MHz	73 x 53	USB 2.0	1 GB	\$ 29.99
Raspberry Pi [133]	Single board Linux computer with video processing and GPIO ports	ARM 1176JZF-S	700 MHz	85x 56	USB 2.0	64 MB	\$ 39.99
CloudBit [46]	Customized Arch Linux ARM, No video processing	MX233	454 MHz	55 x 19	No	64 MB	\$ 59.95
UDOO [183]	UDOObuntu, Android, XMBC, Yocto, Arch Linux, OMV	ATmega 256RFR2	1 GHz	110 x 85	USB OTG USB 2.0	1 GB	\$135

Table 3. Comparative analysis of Micro Control Units (MCUs) used in market

Any country's education system is as important as its *teachers*. Teachers are the core of the learning process. Empowering teachers with smart technologies can improve the education system manyfold. By integrating smart technologies into the education system, teachers can adopt smart technology to innovate their teaching methods and make their classes more interesting, engaging, and effective [20].

Administrators take decisions on behalf of the data and reports received by IoT layer. Their role is important because they make decisions for the progress of institutions or the whole education system. To assist decision-making, top administrators can utilize smart technologies to generate more precise and accurate data.

Children are the most important assets for *parents*. Unfortunately, in developing countries, parents are not involved in the educational process. Because of their financial problems, they are also not keen in supporting their children. It is crucial to properly involve them in the teaching and learning process. Due to their passive participation, children are not properly focused in the learning process. The fog layer automatically keeps them up to date when certain conditions are met.

4 RESEARCH METHODOLOGY

The recent development in smart systems and a massive increase in smart devices encourage us to review the integration of smart systems and education. As per the importance of education, it is not yet integrated into smart systems (e.g, smart cities and smart health, etc). Exploring the literature shows that only limited research articles are available on smart education. Because of these limitations, we have analyzed the literature in depth for issues in traditional education, possible smart solutions, and the challenges in smart solution implementation.

The emergence of the IoT and smart systems is not so earlier, however, education has been since the start of human beings. To get a broader vision of pure education, we have looked at earlier research papers, however, for the smart education implementation, we have only included the document from 2015 to 2020. We further included projects carried out to make any component of education smart (e.g. learner attendance and security systems etc). We used Google Scholar, Scopus, IEEE Xplore, and Science Direct for searching the target papers. Google Scholar gives access to every paper published in any journal and the research libraries give access to limited highquality papers published in attached journals and publishers.

To search the digital world, the searching string is needed and the quality of searching depends on this searching string. The search string is the keywords covering the population, methodology and outcomes. This research paper methodology is divided into three phases (i) The planning phase, (ii) Conducting phase, and (iii) Reporting phase. The remaining part of this section explores these phases.

4.1 Planning the Review

In the first phase, we planned the study protocol, searching related journals and papers, inclusion and exclusion criteria, and reporting. The planning phase covers two important aims; (i) the importance and need of the study which distinguish this study from other related studies; and (ii) developing the protocol to search the studies and inclusion and exclusion criteria.

Recent technologies are revolutionizing the way of living and thinking. Every aspect of life is getting smarter, such as smart cities, smart health, smart agriculture, smart power plant, etc. Education is the most important domain; which includes every human being. However, the research was not done based on its importance. The assumption of 75 billion devices means 10 devices per head. Most of the time, these devices are used for entertainment, not for learning. Smart education can radically change education by using these devices to make every aspect smart.

Developing the review protocol is crucial and critical. The appropriate protocol leads us to a good review; however, the invalid protocol may lead the authors in other directions, leaving the main focus point. Therefore, emerging research questions, search strategies, and selection criteria are discussed and identified at this stage.

Table 4. Comparative analysis of IoT devices connectivity

Board	Network	Bandwidth	Date Rate	Range	Standardization
Bluetooth [7]	PAN	1 MHz	1-3 Mbit/s	100m	IEEE 802.15.1
Wi-Fi [8]	PAN	20 or 40 MHz	10 mbps	100m	IEEE 802.11
ZigBee [9]	WAN	2 MHz	250 kbps	Less than 1 km	ZigBee alliance
NB-IoT [174]	WAN	200 KHz	200 kbps	More than 1 KM	3GPP

Table 5. Research string used to search the related literature

Area	Keywords	Synonyms in literature
Population	Education	Education OR Campus OR University OR Class
Methodology	Smart Devices	Internet of Things OR IoT
Outcomes	Smart Education	Smart Education OR Smart Campus OR University

4.2 Conducting the Review

In this phase, the research is conducted as per the protocol designed in phase 1.

The most pivotal is the research identification and for this purpose, every research is analyzed for three important checks.

- (1) The first one is the *population* of the research. For example, this research covers education and the IoT, therefore, the population of this article is *educational* and emerging *technologies*.
- (2) The second check is the *methodology* or *technique* which is used to get the desired outcome. In this article, smart technologies are techniques to get the desired results.
- (3) The third one is the *outcome* achieved at the end of the research. In this case, the outcome is smart education.

Pursuing these checks, the next most important phase is to design research questions. In this context, the research questions are;

- (1) How many research papers are published discussing the integration of education and smart systems?
- (2) What are the main issues in the traditional education system?
- (3) What are the possible uses of smart devices and techniques in smart education?
- (4) What are the possible smart solutions to the issues in the traditional education system?
- (5) What are the main computational and social challenges in implementing the smart education system?

RQ1 deals with the population, RQ2 deals with methodology, and RQ3 and RQ4 deal with the outcome.

For complete strings, we combine them with "AND", for example;

Population AND Methodology AND Outcomes.

Now putting the related literature synonyms using OR logical operator.

> (Education OR Campus OR University OR Class) AND (Internet of Things OR IoT) AND (Smart Education OR Smart Campus OR University)

Table 5 shows the creation of the research string.

4.3 Quality Assessment

The quality assessment of this study depends on the number of parameters. To cover this study, we have taken the following parameters to ensure the quality of the papers.

Inclusion criteria:

- Papers covering the smart technologies (IoT, AI, 5G, Augmented Reality (AR), and Virtual Reality (VR) etc) integration in education in terms of smart pedagogy, smart classrooms, smart assessment and smart administration etc.
- (2) A detailed description of the data in terms of devices and technology used for smart education.
- (3) The presentation of the methodology and results in a proper way
- (4) Smart education received very limited attraction, therefore, we have included all those papers, which got one citation last year.
- (5) Research articles published since 2015.

Exclusion criteria:

- The research papers discuss education or technology (single disciplinary) but do not integrate technology with education for smart education.
- (2) Research papers not properly presenting the results and methodology used for desired outcomes.
- (3) Research papers failed to get a single citation last year.

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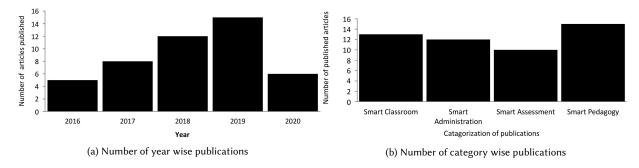


Fig. 3. Number of publications

(4) Research articles not published between 2014 and 2020.

4.4 Reporting the review

In the last stage, meaningful papers covering the keywords and research questions were extracted and presented in this study. The success of the review totally depends on the way how the final review is presented in the paper. Table 6 and Fig. 3a show the year wise and Table 11 and Fig. 3b show the category-wise publications since 2015.

5 LITERATURE CLASSIFICATION

IoT, AI, and 5G are changing the world and way of living. It has its share in all fields of life. Educational institutions are part of everyone's life and as per their importance, it has not been investigated to make them smart. IoT in education requires further research. This section has reviewed and classified (as shown in Fig 4) the related investigations and summarized the findings in Tables 7, 9, 8, and 10.

5.1 Smart classroom

With the development of technology, teaching procedures changed. Now technology is used to engage the learners and make the classroom productive. Smart classroom uses smart technology to enhance the learning environment. Table 7 shows a detailed review of the related studies in the smart classroom.

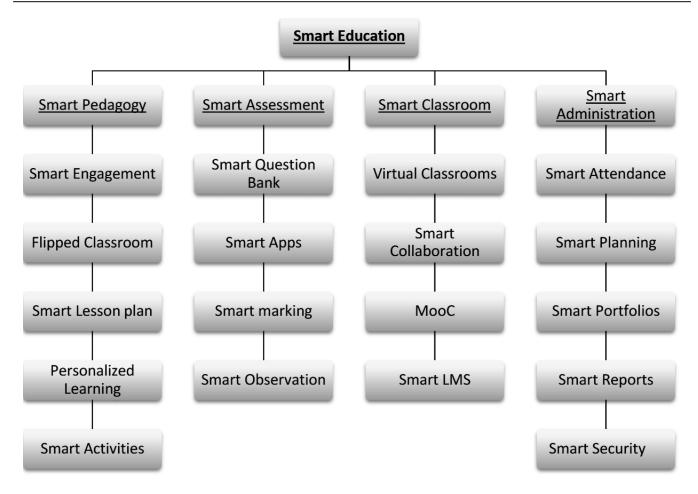
In most regions, cultures, and religions; co-education is not liked (male and female learners are not liked to sit in one classroom). In this social context, Mariam et al. [102] investigated this issue and proposed a framework where male teachers teach male and female learners virtually attend lectures on a laptop, tablet, or mobile. Riccardo [140] further explored the virtual learning environment and the role of IoT in it. They used the fog and cloud computing layers to process large amounts of data produced by different devices in virtual learning. Authors in [196] proposed a two-way digital teaching method. The learner computers and tablets show the learner agents, similarly, the teacher's tablet shows the teacher agent. The main challenges with virtual classrooms are that teachers are not able to effectively monitor the learners. Furthermore, students learn with different teaching methodologies, however, the virtual classroom does not support allowing different methodologies [36]. Classroom and seating management is also a challenge in educational institutions. Authors in [115] proposed a framework to schedule the classroom for students. This study was further pursued by Wang et al. [187] and proposed a smart framework for educational institutions to smartly manage the attendance and seating layout. Learning increases with flexible classrooms and decreases if the classroom environment is not appropriate, especially in temperature. Aaron et al. [1], investigated this further by proposing a flexible classroom. In this classroom, learners can easily change their location and directions for better interaction. The instructor taught Introduction to Electronics Circuits (IEC) as a traditional class for one year and then a flexible classroom for the next year. They found that the flexible classroom results were better than the traditional classroom. Pursuing the same concept, Thanchanok et al. [178] focused on the underutilized classrooms on a university campus due to the gap between enrollment and attendance. They used IoT sensors to efficiently use classrooms in real-time. With AI (to predict the presence and optimum performance assignment of classrooms), they minimized the waste of space. AI faces different challenges in practical life. In the above case, it needs a powerful algorithm to detect the seating space in the room. Furthermore, there are also chances to make mistakes in reading and allotment [103].

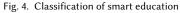
In learning-centred classrooms, learners are engaged in creative thinking and learning. Piotr [134] discussed the effectiveness of a learner-centred teaching approach. He explored the barriers towards learner-centred such as learners' significance of e-learning materials, the extra time required for e-learning material, learners' resistance to taking an active role, and teacher resistance towards learner-centred approaches. Xiangyangm et al. [191], further explored the use of smartphones to increase learner engagement. Similarly, authors in Martinez-Maldonado et al. [104] developed a real-time feedback system named as MTFeedback. This automatically monitors the collaboration of smart groups and notifies the teacher in real-time.

Open education is seen as an evolving teaching method. MOOC is the new trend in open education and the world-famous universities offer MOOC courses. The integration of AR and VR with MOOC is also interesting, attracting the masses there. The authors of Ip et al. [75] evaluate how MOOC lessons work. The result shows that it

Table 6. Detail summary of year wise publications since	2015
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Category	Subcategory	2015	2016	2017	2018	2019	2020	Total
Smart Classroom	Virtual Classroom, MOOC, Smart LMS, Smart Collaboration	1	1	2	3	4	2	13
Smart Administration	Smart Attendance, Smart Planning, Smart Portfo- lios, Smart Reports, Smart Security	2	1	3	2	3	1	12
Smart Assessment	Smart Question Bank, Smart Marking, Smart Ob- servation, Smart Applications	0	2	2	2	3	1	10
Smart Pedagogy	Smart Engagement, Flipped Classroom, Smart Ac- tivities, Personalized Learning, Smart Lesson Plan	1	1	1	5	5	2	15
Total		4	5	8	12	15	6	50





not only improves students' knowledge but also makes lessons easy and enjoyable.

One of the dominant concerns with large classes is that students become shy and they cannot dare to ask questions or take part in the classroom's communication. It is a universally accepted truth that such students pay a high price for shyness in future. To overcome this issue and increase the collaboration among students, the authors in [65] developed a framework where learners collaborate with each other to complete and discuss a task. This increases collaboration among students.

5.2 Smart assessment

Assessment is a crucial part of teaching and learning; used to assess learners, teachers, and syllabus performance. The smart assessment uses ICT technology to automate and transparent this process. Table 8 shows a detailed review of the related studies on smart assessment.

For transparent reports, Salsabeel et al. [147] investigated the mobilebased assessment. They developed an application having a teacher and learner interface. Teachers develop tests for learners and learners solve these tests on mobile or tablets. The papers are automatically marked, saving time and cost. Zhou et al. [200] developed an application which facilitates teachers to create assessment activities for students to create high-order thinking activities. Similarly, Benotti et al. [24] developed a chatbot programming application for learners' assessment. This application aimed to increase students' engagement and task completion. The case study results show that Chatbot users were more engaged than the other learners. In another study, Roldán-Álvarez et al. [142] proposed an application where teachers create different types of activities for learners and learners solve these activities on their mobile phones and tablets. The application automatically calculates the status of the learner in any subject.

In another case study, Llamas-Nistal et al. [95] combined the flapped classroom and continues assessment. The results show a great inclination. The dropout rate was reduced and the learners passed both the practical and theoretical portions. The most important of this model is that the learner accepts this combination for learning and assessing. Tejedor-García et al. [176] developed an application which helps learners to improve their pronunciation and assess their learning at the end of the class.

5.3 Smart administration

Smart administration is the use of a sensor-enabled environment, where it reads the physical changes and automatic decisions are made. Smart administration has been under discussion since 2010. Table 9 shows a detailed review of the related studies on smart administration.

Attendance irregularities badly affect educational institutions' performance. However, now biometric, Radio Frequency Identification (RFID) and face detection technologies are used to automatically manage the attendance [11] . Mahesh et al. [98] used the RFID for learner attendance system. RFID was installed on Microcontroller. Each learner receives integrated cards with RFID technology. When learners enter the classroom, their attendance is automatically marked [27].

Paper	Year	Idea		Findings	Device / Technology Used	Limitations
Mariam et al. [102]	[2018]	Virtual room	class-	In some regions (social and religious context) boys and girls are not like to sit together. The au- thors proposed a framework where male teach- ers teach the male learners and female learners virtually attend lectures on laptop, tablet or mo- bile.	Fog computing, cloud computing, PDAs, and laptops	In virtual classes, the main issue is to engage and monitor the learners. The authors did not discuss, how the learn- ers are observed and engaged in virtual classrooms [36].
Thanchanok et al. [178]	[2019]	Smart room	class-	Authors used IoT sensors to efficiently use the classrooms in real-time. With AI (to predict the presence and optimum assignment of class-rooms), they minimize the waste of space.	Al, Fog computing, PDAs, and Laptop	This automatically shows the used and available spaces, however, the case of lack of building still exists. Furthermore, IOT may make mistakes in reading the space [103].
Riccardo [140]	[2018]	Virtual room	class-	Authors proposed a big data and fog-based e- learning environment, where learners virtually attend the classes. With virtual classrooms, a personalized learning environment was created for students.	Fog computing, cloud computing, PDAs, AI	In virtual classes, the main problem is to engage and monitor the learners. Stu- dents learn with different methodolo- gies. The major lacks in virtual classes are that this framework does not sup- port multi-teaching methodologies [36].
Gunn and Raven [68]	[2017]	Smart room	class-	This is a case study replacing the lecture method with the smart classroom. They proposed active learning classrooms to actively engage learners in classes. The results of this case study were promising.	Smartboards, PDAs	This research study is limited to engineering students studying in the Middle East
Ip et al. [75]	[2019]	Smart room	class-	This is a study case to evaluate the working and performance of MOOC classes.	Mobiles phones, laptop etc	Such like applications helps the adults. This study misses discussing the solu- tion to use it by kids.
Montori et al. [115]	[2018]	Smart room	class-	An algorithm was developed to sense the ca- pacity of the classroom and allow this to the students as per the morning attendance	Cameras, AI, Mobile phones etc	This uses the AI which is not so mature to correctly sense the classroom envi- ronment [103].
Wang et al. [187]	[2017]	Smart room	Class-	Authors proposed a smart framework for ed- ucational institutions to smartly manage the attendance and seating layout	Cameras, AI, Mobile phones etc	The major challenge with this frame- work is the use of AI to detect the seat- ing capacity [103].
Yu [196]	[2017]	Behaviour recognition	ur ion	Authors proposed a teaching method using the teacher and students agents. This technique is used to monitor the learner behaviour on teacher tablets	Cameras, AI, Mobile phones etc	This uses the AI for behavioural recog- nition, however, the AI is not so mature to perfectly sense the classroom envi- ronment [103].
Table 7: It ends from the previous page.	he previous page.					

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Paper	Year	Idea		Findings	Device / Technology Limitations Used	Limitations
Salsabeel et al. [2016] [147]	[2016]	Smart ment	Smart Assess- ment	Authors developed an application for mobile- based learners assessment. They utilized a NodeJS server that communicated with CouchDB, an MQTT broker, and an analytic engine to run this application.	PDAs, mobiles phones, database, cloud comput- ing	This study did not discuss the solution for kids appearing in the mobile-based assessment [186].
Roldán- Álvarez et al. [142]	[2018]	Smart ment	Smart Assess- ment	Proposed an application where teachers cre- ate different types of activities for learners and learners solve these activities on their mobile phones tablets	Social media, mobiles phones, laptops etc	Creating activities is time taking task. Furthermore, most of the teachers would not be able to create activities.
Tejedor-García [2020] et al. [176]	[2020]	Smart ment	Smart Assess- ment	Proposed an application for learner pronuncia- tion improvement and analysis	Mobiles phones, laptop etc	Such like applications helps the adults. This study misses discussing the solution to use it by kids.
Benotti et al. [2018] [24]	[2018]	Smart ment	Assess-	Proposed a Chatbot application. Student pro- gram it to learn the basic concept of computer programming. It provides a formative assess- ment to the students.	laptop, mobile phones	This application is missing such like application used in kids.
Llamas-Nistal et al. [95]	[2019]	Smart ment	Smart Assess- ment	They developed an online tool which supports teachers in paper-based exams. The tool's result shows transparency, quick response and error- free results.	laptop, mobile phones	Such applications help adults. This study misses discussing the solution to use it by kids.

Table 8. Detail summary of studies related to smart assessment

The smart-university concept was discussed by Cață [34]. They proposed an IoT setup to automatically manage the university, such as smart lighting, smart parking, smart tracking, smart inventory etc. Similarly, authors in [91], explored the potential benefits of IoT in education. This study covered cost reduction, performance improvement, new revenue generation, customer experience enhancement, differentiated service creation, and the power of IoT in the classroom.

The teaching process is progressing towards digitization. Patton [130] investigated digitization and discussed the key impacts and challenges in this process. It was expected that learners, teachers, curriculum, and institutions would possibly take benefit from this conversion. They further discussed the role of leadership, culture, technology, and the methodology used to do the conversion. Bibhya Nand et al. [26] further investigated the use of ICT in the education system. Zhu et al. [202] discussed smart education to solve traditional educational issues. They focused on personalized and seamless learning. Panjai et al. [128] worked on NEdNet (National Education Network) in Thailand. Their finding shows that ICT increased the quality of education.

Internet of Everything (IoE) extends the concept of IoT to machineto-machine communication. Michelle et al. [108] discussed the use of the Internet of Everything (IoE) in education. According to their statistics, about 50 billion devices will be connected to the internet by 2025. The authors discussed people, processes, data, and things as key pillars of IoE. Key factors to successfully implement the IoE in education are security, data integrity, and educational policies.

Security is a critical issue in institutions. Records show that hundreds of learners were killed in institutions due to the lack of security measures. Afzal et al. [4] proposed the Smart Security Framework (SSF) for educational institutions. This work was motivated by the recent attacks on the Pakistan and USA educational institutions. Smart devices are used to read the physical environment. The data is forwarded to fog computing. The fog layer generates a notification in case of any threat. Higher-level authorities are informed in case of serious threats.

AI is playing a big role in society. Po-Hsuan et al. [135] proposed an idea to teach medical students using AI. They further proposed to use AI devices to directly interact with patients. Mohamed et al. [113] proposed a framework for smart decisions in the school. They discussed the educational institutions' issues which can be handled through IoT as in other fields such as health, agriculture, etc. Benedict du [22] proposed an idea which uses AI techniques and cognitive science to try and understand the nature of learning, teaching, and creating systems to help teachers to apply new skills or understand new concepts.

5.4 Smart pedagogy

Pedagogy is the heart of the teaching process and smart pedagogy relates to the methodologies used in teaching and learning. As a science, it searches for new ways to enhance student learning. The most important development in pedagogy was seen in 1956 when the learning taxonomy was presented by Bloom Benjamin [23]. Table 10 shows a detailed review of the related studies on smart assessment.

The first detail work was carried out by Uskov et al. [184] developing a complete structure for smart learning and assessment. Shahriare et al. [149], explored the Intelligence of Learning Things (IoLT). The proposed framework is based on collaborative learning, middleware, and personalized learning. The available technologies were used to get cost-effective solutions for developing countries. The result analysis shows that the IoT has a big impact on cost, performance, and safety. Similarly, the authors in Atabekov et al. [18] proposed an indoor learning framework for deep learning through the working of the algorithm.

Smart glasses have key potential in the education system. Nallapaneni Manoj et al. [120] explored its potential use in teaching and learning. They found that smart glasses have the key potential for teleconferencing, telemetering, online evaluation of teachers and trainers, listener experience, real-time teaching, etc.

The use of mobile phones is rapidly increasing. This may be used in smart learning. Riyukta et al. [141] reported a research project in a university, where every employee voluntarily brings their own devices. They used this project to measure the quality enhancement of assessment using smart devices. They worked on Bring Your Own Device (BYOD) and six Cs (i.e, connect, communicate, collaborate, curate, create, and coordinate) to analyze the results. The results proposed that instead of the above BYOD and 6 Cs, there are a lot of other needs to convert the institutions to smart institutions. Similarly, Tejedor-García et al. [176] developed an application to enhance language pronunciation improvement and learner engagement.

Passive classes waste the learners' time. The flipped classroom is a new teaching methodology where learners watch videos at home and do activities at school under teacher supervision. Gunn and Raven [68] tried to replace the traditional passive classes with active learning. In the same way, Terry and Peter [177] further explored the flipped classroom to deliver classes online with smart devices and these lesson activities are carried out in class. Instead of faceto-face teaching, learners attend classes at home using Learning Management System (LMS). During the face-to-face session, related activities are carried out to keep them engaged in productive activities. Learners access all material at home. As a case study, Jose Manuel [80] used a flipped classroom for the subject of the web server for master classes and worked on the improvement of assessment. The results show that learners' response was optimum comparatively to previous years' results.

Paper	Year	Idea	Findings	Device / Technology Used	Limitations
Mahesh et al. [98]	[2016]	Smart atten- dance	Attendance irregularity is the main concern of educational institutions. In this article, a smart attendance and notification system was pro- posed for learners to efficiently manage atten- dance.	MCU, RFID, PDAs, Mo- bile phones	The main concern with smart atten- dance is that it does not work in a re- mote areas, where internet connection problems exist [114].
Afzal et al. [4]	[2019a]	Smart security	Authors proposed a smart security framework for educational institutions for learners' and teachers' safety. They used cloud computing, fog computing, IoT and various sensors. The results of this study were promising	MCU, cameras, sensors, fog and cloud comput- ing.	This project was simulated and not tested in a real physical environment. Therefore, it may not be trusted in real environments.
Mohamed et al. [113]	[2018]	Smart adminis- tration	Authors proposed a framework for smart deci- sions in educational institutions. They used the IoT and related technologies to efficiently make decisions for teaching and learning.	Cameras, mobile, tablets, fog and cloud	Smart administrations are usually re- sisted by employees. The authors did not discuss how to overcome these chal- lenges [21].
Benedict du [22]	[2016]	Smart learning	They developed a framework using AI and cog- nitive science to understand the nature of learn- ing and teaching and according to this analysis, teachers apply new skills for teaching.	Cameras, mobile, tablets, fog and cloud	The major challenge with this is the use of AI because the AI is not so mature to trust its results [103].
Govaerts et al. [65]	[2018]	Smart collabo- ration	Developed a framework where learners collab- orate with each other to complete and discuss a task. This increases collaboration among stu- dents.	Social media, mobiles phones, laptops etc	online collaboration have issues such as network failure etc [161].
Cață [34]	[2015]	Smart univer- sity	Authors proposed an IoT setup to automatically manage the university such as smart lighting, smart parking, smart tracking and smart inven- tory etc.	AI, sensors and cameras	The use of AI faces many challenges for correctly configuring the things [103].

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Paper	Year	Idea		Findings	Device / Technology Used	Limitations
Nallapaneni Manoj[2018] et al. [120]	j[2018]	Smart gogy	peda-	Authors investigated the use of smart glasses in the teaching and learning process. This case study shows that smart glasses, virtual and aug- mented reality have enough potential to en- hance the teaching and learning process	Smart glasses, Virtual Reality, Augmented Re- ality	Smart glasses help to improve learning by presenting the topics in 3D concepts, however, these are expensive and every department cannot support to buy and use [37].
Po-Hsuan et al. [2018] [135]	[2018]	Smart gogy	peda-	They proposed an idea to teach medical students using AI. They further proposed to use AI de- vices to directly interact with patients	Artificial Intelligence, cameras, mobile, tablets, fog, and cloud	The project is limited to medical stu- dents. Furthermore, the use of AI in education is complicated. The authors did not explore, how they employed the AI in teaching and learning [126].
Benedict du [22]	[2018]	Smart gogy	peda-	They proposed an idea which uses AI techniques and cognitive science to try and understand the nature of learning and teaching	AI, cameras, mobile, tablets, fog, and cloud	The use of AI in education is compli- cated. The authors did not explore, how they employed the AI in teaching and learning [103].
Jose Manuel [80]	[2019]	Flipped room	class-	Authors used flipped classroom (Learners watch recorded videos at home and perform activities at school under teacher supervision) for one of the master classes. The result shows that learn- ers' response was good compared to previous years' results.	Cameras, mobile, tablets, fog, and cloud	This system does not guarantee that learners watch the recorded video at home and come to school perfectly pre- pared for the activities [43].
Terry and Peter [2013] [177]	[2013]	Flipped room	class-	Flipped classrooms is the emerging teaching methodology. They used Classroom Response Systems (CRS) in which learners respond to the classroom's activities on mobiles or PDAs.	Mobiles phones, PDAs, cameras, cloud comput- ing	As discussed, the challenge with the flipped classroom is that usually stu- dents do not watch videos at home and come to school unprepared.
Yeon and Changsun [194]	[2018]	Flipped room	class-	Flipped classrooms is the emerging teaching methodology. The authors in this paper worked to combine the flipped classroom and traditional classrooms. The result of the study was promis- ing in terms of critical thinking and knowing.	Cameras, mobile phones, tablets, fog, and cloud	Flipped classrooms and traditional class- rooms are two different ways of teach- ing. This article lacks a suitable frame- work to combine the two in one class.

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Table 10. Detail summary of smart pedagogy

Yeon and Changsun [194] further explored the flipped classrooms for engineering learners which enhanced the creativity and engagement of the learners. Gregory et al. [66], carried out experimentation on electrical engineering classes by using the traditional class and flipped classrooms. Separated two classes of 20, 20 learners were created. In the flipped classroom, video lecture was the primary source of teaching. The comparative result shows that overall the flipped class learners' performance was better than the traditional one.

6 THE KEY ENABLING TECHNOLOGIES FOR SMART INSTITUTIONS

This section discusses the key enabling technologies for smart institutions.

6.1 Smart devices

Different types of smart devices and sensors are used to update data on servers working on the fog layer. These are devices installed in the institution, working automatically or palmtop operated by teachers, learners, administrators, or parents (e.g. sensors, cameras, smart board, tablet and laptop etc). Sensors read the physical or chemical changes in something.

RFID: It automatically identifies the objects by the frequency attached to them. In institutions, RFID technology is used in smart cards (learners and staff) to make their attendance in classes. RFID readers are installed at the entrance to the class. When a teacher or learner enters the class, attendance is automatically marked on the database with the entrance time. RFID saves time for the classes, which is usually wasted in taking roll calls. Furthermore, due to exact timing reporting, teachers and learners attend the class on their proper time which is usually not seen in under-developed countries [33].

Smartboard: Learners forget what they listen, they learn what they watch. The interactive smart board helps them in their learning. They watch the practical doings instead of only listening to theoretical lectures by teachers. Smartboard is the iconic hub of modern classes. This uses modern teaching methodology to keep learners engaged. Teachers may display their own models or search for any other one on the cloud or internet. Interactive boards are easy to use and anyone may use them. Game-based activities may easily be used to teach children to make their interest in learning [2, 60].

VR and AR: VR and AR are becoming a part of teaching and learning. This helps the teachers to teach the concept of a threedimensional environment just like real physical objects. This simulates the real environment for learners [35]. Studies show that it develops creativity, promotes visual learning, and increases students' attendance [73].

Smartphones: Research shows that in the coming years, massive smart devices will be connected to the internet. Now, even in developing countries, usually, every family has a smartphone. Flipped classrooms, which are becoming a popular teaching methodology depend on smartphones [96].

Sensors and actuators: Different types of smart sensors may be installed in the institutions. These sensors monitor and sense the intuition for different parameters in real time. Actuators are action devices, which are directed by a central control system for any action.

Cameras: Cameras are installed in the institutions and classrooms for the monitoring system; which sends their data in real-time towards the fog layer. Cameras increase the security and transparency of the school.

Sound frequency detector: Smart frequency sensors may be installed in the classrooms. This continuously monitors the voice level in the classrooms. When the voice level increases to a certain level, a notification is displayed at the head office.

Smart speaker: The smart speaker provides interactive actions. These act like smart devices and provide a facility of Wi-Fi and Bluetooth for connectivity. Smart speakers may be used to interact with learners and teachers. To give a special message to any class or to broadcast it towards all classes. Smart speakers may be connected to Alexa and programmed to the institution's timetable for automatic notification [33].

Voice and gesture activated Virtual assistants: Controlling the smart environment with the traditional way of device control limits the potential use of smart devices, and it can be more tiring for the user. The voice and gesture-activated smart environment along with AI enhance the potential use. For example, Alexa works with spoken instruction, developed by Amazon and uses speech recognition technology to communicate with smart applications and human users. With speech recognition technology, it can automatically help teachers and students. Alexa can be connected to local servers for detailed reports. If necessary, it can also announce the information in speech form [88].

Smart glasses: Among modern inventions, smart glass is one of the portable wearable devices which is capable of handling a wide range of smart activities. Smart glasses are widely considered a next-generation smartphone. Primarily, it is used for human-machine interactions [87, 119].

Fingerprint: A fingerprint is a mark left by the human finger. Attendance systems and crime investigations are important applications. Along with RFID and AI technology, this technology is popularly used for learners and staff attendance [138, 195].

Wearable technology: Wearable electronic devices, such as smartwatches, smart bands, smart glasses, and smart neckless are used for various purposes. These devices can play a vital role in the smart education system. In smart education, this may be used as a sensor, tracker or timetable notifier, etc. Smartwatches are probably the most widely available device of wearable technology. It offers almost all the facilities of smartphones. It has the installation of GPS, microphone, camera, and other sensors that can be used to track the child in need. The wearable technology market is expected to grow up to 1.1 billion by 2022 [83].

Table 11. Category wise publications since 2015

Category	Subcategories	Key studies
Smart classroom	Virtual Classroom, MOOC, Smart LMS, Smart Collaboration	Mariam et al. [102], Riccardo [140], Yu [196], Montori et al. [115], Wang et al. [187], Aaron et al. [1], Thanchanok et al. [178], Piotr [134], Xiangyangm et al. [191], Martinez-Maldonado et al. [104], Ip et al. [75], Govaerts et al. [65], Lu et al. [96],
Smart Administration	Smart Attendance, Smart Planning, Smart Portfolios, Smart Reports, Smart Security	Cață [34], Alotaibi [11], Mahesh et al. [98], labs [91], Patton [130], Bibhya Nand et al. [26], Zhu et al. [202], Panjai et al. [128], Michelle et al. [108], Afzal et al. [4], Po-Hsuan et al. [135], Mohamed et al. [113], Benedict du [22], Salsabeel et al. [147], Zhou et al. [200], Benotti et al. [24], Roldán-Álvarez et al. [142], Llamas-Nistal et al. [95],
Smart Assessment	Smart Question Bank, Smart Mark- ing, Smart Observation, Smart Ap- plications	Salsabeel et al. [147], Zhou et al. [200], Benotti et al. [24], Roldán- Álvarez et al. [142], Llamas-Nistal et al. [95]
Smart Pedagogy	Smart Engagement, Flipped Class- room, Smart Activities, Personalized Learning, Smart Lesson Plan	Uskov et al. [184], Atabekov et al. [18], Nallapaneni Manoj et al. [120], Riyukta et al. [141], Tejedor-García et al. [176], Gunn and Raven [68], Terry and Peter [177], Jose Manuel [80], Yeon and Changsun [194], Gregory et al. [66],

Table 12. Possible uses of smart devices in educational institutions (Part-I)

Smart Devices	Possible Use in Smart Education
MCU / Smart Circuit Board	MCU is a single board computer, working as a hub for IoT devices. This is used to connect all devices and make decisions as per the sensors' input. A number of MCU models are available, which are selected as per requirements. In educational institutions, this may be used to collect data from different sensors and smart devices
RFID	RFID chip is embedded in the card, which is identified through the radio frequency. This can help in the automatic attendance of learners and teachers. Instead of wasting time on manual attendance, RFID marks the attendance automatically. This will optimize the teachers' and learners' responses, performance, and behaviour
Smart & interactive boards	Learners forget what they listen, they learn what they watch. The interactive smart board helps them in their learning. They may watch the practical doings instead of only listening to theoretical lectures by the teachers. This may increase the interest and creative engagement of learners
Smartphones and PDAs	The use of smartphones are massively increasing and nearly every person has a mobile. Smartphones may easily be used for teaching and learning by teachers, learners, and parents. Flip classrooms, which are becoming popular teaching methodologies depend on smartphones.
Sensors & actuators	Sensors and actuators read the physical change in anything and actuators work and control according to the directions of the central system. These sensors may be used to monitor and sense the intuitions for different parameters in real-time, for example, the temperature, motion detection, security, etc.
Cameras & security cameras	Cameras are used for monitoring and security purpose. The camera's presence changes human behaviours. This may be used in face detection attendance. In the case of flipped classrooms, they may be used by teachers to record lectures for learners.

6.2 Fog computing

All data coming from IoT sensors and actuators are stored and processed on servers working on the fog layer. The reason behind using fog computing is to minimize the load on the network. A big stream of data is produced by smart devices which are used for smart reporting and decision [163]. Local servers are placed in the institution and all the IoT layer devices are attached to this. The local fog devices store the data, which creates a distributed cache network; the fog devices also process the incoming data and if needed, send it to the next cloud server [48][193]. Table 13. Possible use of smart devices in educational institutions (Part-II)

Smart Devices	Possible Uses
VR and AR	VR and AR is becoming a part of teaching and learning. This helps the teachers to teach the concept in a three-dimensional environment just like real physical objects. This simulates the real environment for learners.
Smart speakers & smart microphones	Smart speakers have different connectivity options. They may be connected by Wi-Fi, Bluetooth, or direct IP access. This may be used for announcement and timetable management. The smart microphone may be used in classes with VR capabilities to automatically update the home assignment [148].
Alexia	Alexia is a smart voice assistant. It uses AI and Voice Recognition (VR) to interpret voice commands. This put great effort into educational institution automation. Instead of using notification systems, Alexia may verbally explain the situation.
Smart glasses	Majorly, smart glasses are used in games and medical activities. This may be used in educational institutions to enhance the teaching and learning process. The smart glass has a good potential for telemetry and teleconferencing [119].
Biometrics & face de- tection	Manual attendance is an issue and time-consuming. It is also not secure. Biometric and face detection technologies may be used in the attendance system. This can help to keep the exact arrival and departure information.
Scan-marker	Scan marker is a device which scans the text and converts it into different languages. This may be used in reading other languages and converting text into audio. Scan marker is also called a digital highlighter
Global Positioning Sys- tem (GPS)	GPS generate the real location of the installed objects. GPS may be installed in school buses. This will automatically generate a message as the bus comes closer to the station. This will save time.

6.3 Cloud computing

This layer is the cloud of fog servers and other special servers connecting the education system. This connects the entire network to share the institutions' experiences, official records, videos, etc with each other [201]. The higher authority may also use the cloud layer to get detailed information from registered institutions. This layer uses smart algorithms to facilitate top authorities to actively monitor the institutions [5, 19].

7 STRUCTURE OF SMART EDUCATION

Smart education received very little attention, therefore, in the literature, there is no specific definition, structure, or environment. This section reviews the existing literature related to the concept of smart education.

7.1 Concept of smart learning

Smart education is a multidisciplinary domain, covering ICT and education. Smart education is an educational learning and management paradigm, in which smart technologies (e.g. IoT, AI, and 5G) are applied to make it more efficient and engaging. Smart education provides a digital environment to help students, parents, teachers, and administrators to improve learning engagement and motivation [84, 199].

Pedro and Ana Sofia [131] suggested a concept of intelligent learning as follows: first, it is more learner and content-oriented than device-oriented; second, it is efficient, intelligent, and personalized learning based on an advanced IT infrastructure. Additionally, Svetlana et al. [159] utilized cloud computing for smart learning. They believed that smart learning combines the benefits of social learning and learning everywhere, which is a learner-centred and serviceoriented educational paradigm, rather than a paradigm focused solely on the use of devices.

7.2 Smart learning environment

The smart learning concept provides a self-adaptive, personalized, and self-motivated environment for learners, teachers, parents, and administrators. Smart education is a digital environment enriched with smart devices to enhance learners' motivation and satisfaction. The Journal of Smart Learning Environment was launched in 2014 to facilitate the learners.

Svetlana et al. [158] clarified that possible criteria for an intelligent learning environment include context awareness, the ability to provide direct and adaptive support to learners, and the ability to adapt the learner's interface and content of the material. This environment facilitates administrators with learning and managing. Chen et al. [40] defined a learning environment as a physical environment which facilitates learners' learning. Furthermore, Gwo-Jen et al. [70] state that the smart learning environment offers the possibility to use the students' free time productively. It plays the role of a coach and guide to knowledge. It facilitates learners by offering selflearning, motivated and personalized services. Jonathan Michael [79] worked on effectiveness, efficiency, engagement, flexibility, and defectiveness in the smart learning environment.

The International Association of Smart Learning Environments is an association that works on smart learning environments to improve learning. They present the smart learning environment in 6 strategies, which follow; (a) infrastructure, (b) learning tools, (c) learning resources, (d) teaching and learning methods, (e) services

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for teachers and students, and (f) collaboration between government, businesses and schools [169].

7.3 Smart Learning Framework

In the literature, no specific framework for smart learning is defined, however, some of its subdomains are discussed. Zhanni et al. [198] proposed a framework (Flipped learning wheel (FLW)) for the flipped classroom. The FLW randomly groups the learner for a particular topic. Learners discuss these topics with each other after that expert groups are created for discussion and at the end, they are assessed. Authors in Svetlana et al. [158], presented a framework for the smart learning environment. Authors in Zhi-Ting et al. [199] presented a framework for smart learning. This framework has three components; smart environments, smart pedagogy, and smart learner.

8 POSSIBLE USES OF IOT IN EDUCATIONAL INSTITUTIONS

Smart devices improve educational institutions in a number of ways. This section explores in detail, how smart devices help to improve the learning and teaching process. Fig. 1 shows the structure of smart educational institutions and 5, 6 shows the smart solutions to the traditional education challenges. Tables 12 and 13 discuss the possible usage of smart devices in the education system.

8.1 Smart administration

Monitoring teachers' and learners' progress in institutions is critical. An important part of operating a school is keeping track of how well the teachers are doing and evaluating how effective are they in their work. With the proper evaluation of teachers and institutions, the performance can be improved to a significant extent as well. The smart system can transparently manage all these issues. Furthermore, administrative tasks have increased the burden on teachers. This burden may be minimized by smart systems, so teachers may concentrate on teaching only [55]. Fig. 1 shows the structure of smart administration.

Smart attendance: Manual or fingerprint attendance is time-consuming. It is also much more boring to mark attendance before every class. At the school level, it is even not possible where there are eight periods of 40 minutes. Where each class contains a minimum of 60 learners. *RFID smart cards* may be used to automate the attendance system of the school. This mark the learner and teacher's attendance as they enter the class. The smart system notifies the teacher and principal how many learners are present in the class. Smart cards also make sure of the teachers' presence and timing in the class. Technology is invisible and works silently. Smart attendance reports the parents on their arrival or departure from school, keeping them aware of their child. This also upgrades the learner log when he/she enters or leaves the library, cafe or labs, etc Ghani et al. [63], Wakchoure et al. [185].

Smart portfolio: learners' assessment, attendance, and character records are stored in the database. On new complaints, parents are notified through applications and messages. Teachers or parents may check throughout the summary of learners. This helps parents

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and teachers to diagnose the issues with any learner. The administrator of the institution monitors the institution in real-time. They can check any teachers' lesson plans, homework, courses covered and results, etc. The homework and lesson plan may also be directly viewed by parents to introduce the flipped classroom environment. Video as a sensor may be used for classroom close observation [72].

Smart reports: The administration takes decisions on the reports forwarded to their offices. With manual reports, there are major chances of report manipulation, which leads to wrong decisions and actions. The introduction of the smart system minimizes corruption and illegal report manipulation.

Smart security: Thousands of students and staff study and work in educational institutions. With limited security equipment, they are easy targets for terrorists. The intelligent system plays a major role in security by installing cameras and other sensors. The rise of AI further improves the performance of this equipment [14, 67, 100].

8.2 Smart pedagogy

Pedagogy is a set of skills used for effective teaching in the classroom. It is not only limited to teaching but also covers the psychology skills to read and understand learners [47, 150]. Figure 5b shows the structure of smart pedagogy.

Smart engagement: Learners' motivation and engagement is the most appealing element in the teaching process. Learner engagement increases the critical thinking of the learners. In traditional classes, it is observed that minimum learners are engaged. To maximize the quality of education, learners' engagement must be enhanced. Authors and teachers have already been using IoT to keep the learners motivated and engaged in some particular subjects [17, 76].

Flipped classrooms: The fog layer helps in flipped classrooms. *Flipped classrooms* are a new emerging teaching methodology in which teachers record videos for learners. They watch these videos at home and do related activities in classrooms under the teacher's supervision. The fog server stores lecture videos and homework and also broadcast them to parents' smartphones. Flipped classrooms may be applied using Bring Your Own Device (BYOD) agenda [10, 137].

Personalized learning: One of the biggest issues with traditional education is that every learner has to cover the same course content. There is no age for slow learning. Information and Communication Technology (ICT) gives a facility of personalised courses for every learner. They can learn in their own space. This increases the interest and engagement of the learners.

Smart lesson planning: In public teachers, it is usually assumed that "you will force me to enter into the class, but you cannot force me to teach there", therefore, to overcome this issue and to have a look that the teacher is fulfilling lesson planning SOPs; the lesson plan should be created smartly. Principals, learners, and parents may review the lesson plan of every teacher and class. In case of low performance or violation of lesson planning, the system will automatically highlight the mishaps. Smart and transparent lesson planning is very important because it makes the teachers' work

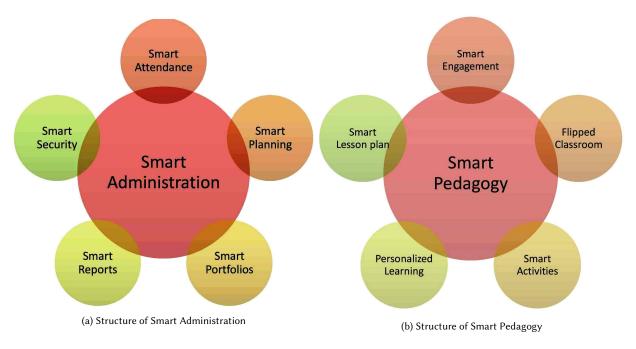


Fig. 5. Structure of Smart Administration and Smart Pedagogy

transparent to principals, parents, and learners. Previous lesson plans or borrowed lesson plans may be used which will save time.

Smart activities: Learning by doing increases the retention and understanding of the learners. Teaching other learners in activities increases retention by up to 90 percent. Smart activities (e.g., smart applications, games, and smart objects) keep the learners engaged with learning. China installed 400,000 3D printers across elementary schools to efficiently teach the concepts [160].

8.3 Smart assessment

Assessment transparency is important to evaluate teachers and learners. Smart testing services are used to take the examination of the learners and then to store these results on fog servers. These records help in transparent reporting and decision. Fig. 6a shows the structure of smart assessment.

Smart questions bank: A database is created for each topic for the smart assessment application. Teachers add questions to the database for each exam and automatically prepare the paper by choosing specific questions. The quality of these questions is monitored and improved over time. These smart question banks save teachers time in creating and marking tests.

Smart marking: During the creation of the smart question banks, their answers are also uploaded to the database. Therefore, during checking (this can be a code or an online exam), the application automatically checks the paper for correct answers. This saves time and effort. It also minimizes the exam cost.

Smart observations: Instead of taking a written or oral test, learners are passively observed for their behaviour and tendencies. Observation is an important part of the assessment and important decisions are made on its behalf. Psychological analysis is a crutial factor in teaching. Teachers are trained in their training to read their learners and to behave according to their mental state. The intelligent system and AI technologies can be used to read and engage learners. This will help teachers to deal with troublesome learners. It can also be used to group learners accordingly [164].

8.4 Smart classroom

Smart classrooms use smart technologies to help with teaching and learning. It provides interactive whiteboards for smart interaction, smart audio and video ads, uses smart and comfortable chairs, VR and AR to teach the 3d concepts etc. Rather than manual adjustment, it automatically adjusts the classroom lighting and temperature, and the smart systems automatically manage it. Smart cameras also assist in reading and behavioural assessment. Fig. 6b shows the structure of the smart classroom

Smart collaboration: Video conferencing is a need of today's educational institutions. This is used to connect different intuitions with each other. Learners and teachers interact with each other for idea sharing. IoT, AI, and VR may bring a dramatic improvement in collaboration. Smart glasses and VR may be used to evaluate the training sessions.

MOOC: MOOC courses are offered by a number of world top Universities and millions of learners are taking part in these courses. Smart devices (e.g., virtual reality sets, smart glasses and Alexia etc)

Table 14. Smart solution using IoT and smart system

Proposed Solution	Description	Devices / Technologies needed			
Smart attendance	RFID smart cards are used to automate the attendance system of the school. This mark the learner and teacher's attendance as they enter the class.	RFID, Cameras, Biometric, AI			
Smart portfolios	arners' assessments, attendance and character record are stored in Server, mobiles phones e database. Parents are notified through applications and messages. Cameras, Biometric, AI				
Smart pedagogy	Different smart methodologies and devices (e.g, flipped classrooms, video recording, AR, and VR) are used to creatively and actively engaged the students.	Cameras, AR, VR, IR, and smart boards etc			
Smart lesson planning	To overcome the class issue and to have a look that the teacher is fulfilling lesson planning SOPs; the lesson plan is updated online.	e lesson plan is updated online. Laptops			
Learner engagement	Engaging the learning by using IoT, AI, AR, VR and other smart systems.	Animation, AI, AR, VR and smart glasses			
Flipped classroom	In the flipped classrooms, students watch videos at home and do activities at school under teacher observation.	Cameras, AR, VR, Animation			
Massive Online Open Courses	In MOOC, online courses are provided by Universities and different institutions for students.	Cameras, Mobile phones, PDAs, Laptops			
Smart assessment	Smart testing services are used to take the examination of the learners and then store these results on fog servers.	Mobile phones, PDAs, laptops			
Smart collaboration	Video conferencing, AR, VR and AI is playing an excellent role to enhance remote smart collaboration among students.	Mobile phones, PDAs, laptops, AR, VR, AI			
Personalized learning	In personalized learning, courses and topics are assigned to the stu- dents as per their activities analysis.	Fog and cloud servers, AI, Data mining			
Smart administration	Smart devices and reports are used by the administrator to smartly manage the employees, students and other related activities.	Fog and cloud servers, AI, Data mining			
Learner Analysis	rner Analysis Learner analysis used the smart devices, their activities and learning reports to smartly analyse the learner and generate their report.				

Table 15. Criteria for studies assessment

Symbol	Criteria	Criteria Definition
C1	Review of related studies	This criteria checks whether the authors compare this study with the related studies and projects or not.
C2	Challenges in traditional educa- tion	Criteria two evaluates that the authors consider the challenges that exist in the traditional system.
C3	Proposed possible solutions	Checks that authors proposed possible solutions to the challenges that exist in the tradi- tional education system.
C4	Smart human resources	deals that how human resources (learners, parents, teachers and administrators) work with the smart system.
C5	Possible resistance	Every new invention has resistance in the community. What is the possible resistance to smart education is covered in criteria 5.

may be utilized to enhance this learning (in terms of smart teaching and smart assessment).

Virtual classrooms: Instead of attending classes physically, smart LMS is used to attend video lessons virtually from home. It is a technique that saves time and money. The rise of VR and AR reality

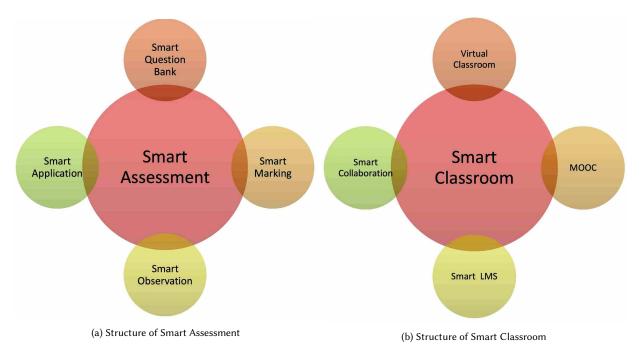


Fig. 6. Structure of Smart Assessment and Smart Classroom

improves the quality of virtual lessons by teaching 3D concepts [172].

Cyber-physical smart systems: Cyber Physical Systems (CPS) encompass a variety of technologies; including IoT, cloud computing, fog computing, and swarm intelligence [3, 49]. CPS is a robotic system that works automatically to perform any task. The merged reality or augmented reality can be used for conducting experiments and other practical work, where physical prance is required. With the use of augmented reality, students would be able to conduct experiments by controlling the robotic setup from home, similar to solutions already developed for performing surgery from distance. However, adopting such sophisticated solutions at different levels of education institutions will require a modified or customized setup [59].

Smart monitoring and tracking: Smart technology facilitates parents, teachers, and administrators to smartly track learners. The AI read the faces for expressions (e.g, sadness, happiness, surprise, fear, anger, and disgust) of the learners and describes their emotions. This will help the teachers to identify these students who feel boredom in the classroom. On the basis of this analysis, teachers may take decisions for warmer or energizer etc [74].

Smart Video Splitting: Virtual classrooms, conferences, and MOOC courses have intensified the streaming use in teaching and learning. Leading platforms, e.g., Google Meet [168], and Zoom [173], etc are used to connect with teachers and learners. The classes or conferences continue long and the hours-long videos are recorded. In these long videos, it is hard to search for the required content nor these contents are easily conveyed. Various smart video techniques (e.g., video skimming [171], summarization [197], and condensation

[106]) are used to split the videos based on specific content. This ac ai based algorithms may be used to separately break the video as per the gestures or speech recognition and save it as a separate video. This will make it the learners and other users easy to search the required content easily [69].

9 CHALLENGES AND FUTURE DIRECTIONS

Rather than the tremendous benefits of a smart system, there are several challenges and resistance to its implementation. These challenges and resistances are classified into two categories; (i) computational challenges and (ii) social challenges and resistance.

9.1 Computational challenges

Computational challenges run parallel to the installation and integration of smart systems. The general challenges commonly encountered with smart devices are; network, battery, or communication failures. The next streong challenge is that the built-in functions stop working and these minor issues require experts. Then comes the code updating. If changes to the program need to be updated, the user cannot do this easily [86, 189]. Some specific challenges related to smart education are as follows:

Internet connectivity: Faraway areas are still deprived of internet connection. This system can not be introduced where there is no internet connectivity or slow internet access. Moreover, smart systems work with real-time input, therefore, in case of a slow internet connection, this may not be installed [41]. In case of slow internet, fog servers can help [118]. The data may be initially stored on fog computing and can be uploaded to the cloud at a slow speed, similarly, the downloads may be continued.

Paper	Year	C1	C2	C3	C4	C5
Winanti et al. [190]	2018	1	×	1	×	×
Dosheela and Binod [56]	2018	1	×	1	×	X
Dewar [54]	2019	1	×	1	1	1
Farhan et al. [61]	2019	1	×	1	×	X
Tiago and Paula [180]	2019	1	×	×	1	X
Shi et al. [153]	2019	1	×	×	×	X
Suwita et al. [156]	2019	1	×	1	×	X
Afzal et al	2020	1	1	1	1	1

Table 16. Comparative analysis of related studies

Privacy issues: User privacy is another important issue. It is a known fact that smart services require data to enhance personalized experiences. Personal data sharing with service providers and manufacturers can lead to a privacy breach. There are chances that the institutions' data and camera stream may be hacked by someone else. This data may be used for negative purposes [13]. Protecting the data from illegitimate access requires authenticated data access [32, 90]. Privacy has been widely researched and there are a number of solutions discussed in the literature which can be employed in smart education [29, 31, 154].

Compatibility and Interoperability: Devices compatibility and interoperability rise in every integration, especially at the school level to handle such technical issues. This is the third most powerful challenge, which resists the implementation of smart education [99]. The education sector is a big market. Everyone is connected (one way or other) to the education system. EduTech can be expedited to develop a smart education system commercially [71]. This will end the compatibility and intractability issues.

Data pollution: These massive devices produce massive data and most of the data is not in use. The learners detract from such large internet data. Particularly, the learners are addicted to social media and they spend hours consuming this data pollution [99]. Therefore, the challenge here is how to avoid learners from data pollution [124]. To overcome this challenge, a learners' monitoring module may be added to the smart education system to monitor the view history of the learners [125]. This history should be transparent to learners, parents, teachers, and administrators. With this log, learners will limit their activities to learning material only.

Artificial Intelligence: The major issue with AI is the lack of trust because it is not so mature to correctly read the environment or to hire high-level experts. Therefore, this may input the wrong data or anyone can give the wrong input. For example, students may give sad expressions to get warmer or break. Furthermore, the AI will increase the cost, which would not be paid from the budget [151]. Because of the challenges mentioned above, the use of AI should be limited based on budget and accuracy.

9.2 Social challenges

Despite the countless benefits, the smart system faces many challenges from the social side. The most general one is the use of modern technologies because the new person does not have enough information to use these systems [117]. The specific issues related to social challenges are as follows:

Employees resistance: Every new technology implementation has resistance from people, especially from employees. Monitoring is unfriendly for human beings and teachers do not like such a system where they are monitored on a real-time basis. Therefore, the major challenge towards smart institutions is the employees of educational institutions [21, 143]. Special incentives and motivation are needed to overcome the employees' resistance. One of the reasons for employee challenges is passive communication between employees and administrators. Therefore, the system may be further extended to include the proper correspondence system in the smart education system [202]. This will not only minimize the employees' resistance but also make them happy for handling their issues efficiently.

Use of smart systems: In most countries, teachers are not well aware of smart devices and smartphones. They are not able to use these devices for assessment and other tasks. They will create hurdles in successfully implementing this system. This challenge can be handled through training, however, disinterest may lead to issues. Therefore, a post-training assessment module can be added to the smart system to monitor the understanding of the employees. In case of a lower score, the training me to be rescheduled [128].

Lack of funds: In underdeveloped countries, lack of funds is the biggest problem. Institutions usually do not even have funds to build classrooms for learners or buy furniture. In such areas, where schools are allocated, a very low budget will face obstacles towards smart institutions [152]. Especially, the CPS system needs massive funds for installation and public institutions would not be able to support it. However, education is a big market and everyone is connected to it directly or indirectly. The system production on a large scale can reduce the cost [6].

Cultural issues: In some cultures, girls are not liked to capture photos or videos. In such like situations, people may resist installing cameras or sensors in educational institutions. Furthermore, some parents do not allow their children to use smart devices. Flipped classroom ideas may not work in such situations. However, the smart system also helps to overcome these issues by protecting the culture. For example, female students can attend the virtual classroom without facing male teachers [62, 102].

Technology addiction: The research article [186], concluding different studies shows that kids are heavily addicted to mobile phones. Therefore, one of the challenges with digitization is that students may addict to different applications, instead of giving time to learning. Overcoming and controlling technology addiction is a primary concern because this negatively affects the learners instead of facilitating their learning. The learner monitoring module can be embedded with the smart system to monitor the learners and check their watch history. This way, learners will try to control their watch history [38].

Digitizing books: All this will need to digitize the syllabus and make animation videos for AR and VR. This will need massive cost, time, and expertise [89]. Creating animated stuff is complicated, however, an intelligent system can be created for teachers (not experts in technology) to create animated videos for learners with very little effort [78]. This can be embedded with the teachers' application to manage the stuff along with their lesson plans, etc.

Training: Teachers will need to be trained in the smart system. This will also need massive cost and time. It is also possible that teachers may not get the required expertise after training and they may get failed to use the smart system [116]. For the easiness of the teachers and administrators, an automated module can be created and embedded with the smart education system to train the teachers [50]. The teachers can give time as per their schedule to complete the training and go through assessments to get the certificate.

10 COMPARATIVE ANALYSIS

This section compares this study to related studies. Unfortunately, very limited review papers are available on IoT in education. We used the criteria given in Table 15, to compare this study with related studies. C1 checks whether or not the studies and associated projects are covered; C2 discusses the challenges in the traditional educational system; C3 covers the possible solutions for challenges in traditional education systems, C4 addresses the working of human resources in the smart education, and finally, C5 evaluates the resistance in implementing the smart institution framework.

Winanti et al. [190] presented a systematic review of information system implementation in the higher education system. They reviewed the related studies and explored the challenges in existing information management systems. Dosheela and Binod [56] reviewed the role of IoT in the educational system. They further proposed some solutions to the existing challenges using of IoT. Dewar [54] reviewed the literature related to smart universities. They also presented the use of IoT in making campuses smart. Farhan et al. [61] explored the opportunities and challenges of using IoT in education systems. They explored the literature and presented some solutions towards smart education. Tiago and Paula [180] reviewed related studies and partially discussed the use of blockchain technologies in university campuses to ensure accountability, transparency, and cyber-security. Shi et al. [153] reviewed and discussed the main seven categories of IoT in education, including Intelligent Tutoring System (ITS), smart campus, Big Data in Education (BDE), knowledge graph, educational robots, virtual teachers, and personalized education. Suwita et al. [156] reviewed the literature about the use of IoT in MOOC and possible challenges towards integrating of IoT in MOOC.

Comparatively to these surveys and reviews, the proposed study is very wide and deep. This covers the literature including research studies and different projects; it explores the real issues faced by learners, teachers, and administrators in educational institutions. On the basis of these data and the specification of IoT and other smart technologies, solutions are proposed for the issues in traditional systems. It also explores the smart human resources model which explains how human resources will work with the smart educational framework. Every new technology faces resistance from the community and employees, therefore, this study explores the possible resistance to the implementation of smart education.

Keeping in view the above contributions and existing literature, it is crystal clear that this study is the first novel investigation which deeply investigates the integration of IoT, 5G, and AI in educational systems.

11 CONCLUSION

This article explored the IoT and smart devices integration in education and proposed a possible framework for smart education. This further explored the issues in educational institutions (running in the traditional way) and the possible solution to cover these challenges with smart devices. It has been observed (teacher training and mentoring session by the author) that students are not properly engaged, nor the standards are properly followed. Moreover, the teachers' time is wasted on administration tasks, which may be managed smartly. Smart devices convert the traditional activities of the institution to smart activities such as smart attendance, smart reporting, smart pedagogy, smart lesson planning, smart learner engagement, smart reporting, flipped classrooms, smart assessment, and smart security. This article concluded the related research articles and investigated the issues in the traditional education system and proposed the possible solutions using IoT and AI.

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