Review Article

Emerging Technologies to Smart Education

K. Palanivel

Computer Centre, Pondicherry University

Abstract - *Digital transformation is all set to change the face of education towards the coming decade. Along with technology, the transformation is bound to be a parallel shift across learning. Today, technology like the Internet of Things, augmented reality, artificial intelligence, Blockchain, cloud technology, mobile Internet, machine learning, deep learning, etc., have the potential to add significant business value. These technologies play a major role in shifting from traditional education to smart education. Smart education is one of the main segments with the biggest impact in the smart environment. The objective of this research is to study the emerging technologies that are used to design smart education systems. With these emerging technologies, education is becoming intelligent, institutive and ubiquitous. The emerging technologies increase the effectiveness and enhance the efficiency of smart education.*

Keywords - *Smart education, smart learning, smart teaching, smart classroom, smart learning environment, smart pedagogy.*

I. INTRODUCTION

The education industry has embraced recent technological advancements and developments. These developments have made the learning process more comprehensive and simplified for students. Nowadays, the focus of Information Technology (IT) is on remaking colleges and universities through some primary themes such as adaptiveness, decision-making, student outcomes [36]. In ICT or modern education, the technologies allow personalization and customization according to students' needs.

Higher education institutions (HEI) have started to use modern technologies to improve efficiency, transformation, completeness, and social experience. Todays, HEI face challenges in advancing digital equity [18] and adapting traditional organizational models to advance the future of the workplace. In addition, HEI faces funding, demographics, quality and competition. Their success requires a change in the form of new teaching and learning that will prepare students for success. HEI continues to be slow to adopt technologies that are more advanced. Improving digital fluency and advancing digital equity is among the most significant challenges of slowing the adoption in higher education. It needs to find ways to adapt technology in order to attract students and teachers, operations and cut costs.

A. Technological Trends

The use of technologies is among the most important changes in higher education. Today, technology plays an important role in the availability and accessibility of learning content, including for disabled students.

Learning technologies can enhance affordability, accessibility and ultimately student retention. By leveraging technology-enhanced education (TEL), HEI has better met the needs of students and increased equity of education. In addition, the use of open source technology and educational resources provides cost savings to students. In addition, learning analytics is gaining importance to measure and boost student learning and success [16]. According to the Educause horizon report [31], an analysis and technological developments are likely to affect HEI in future.

B. Challenges in Higher Education

Some of the challenges of HEI are question paper leaking, creating a different learning experience, the introduction of smart learning systems, etc. The question paper leaking can affect the quality of education compromised and erosion of ethical standards. Smart learning systems can create great value for society. This creates a different learning experience for students from traditional teaching. There are some new systematic challenges related to the technologies [27]. They are informal learning, effective formative assessments, personalized learning, Massive open online courses (MOOC) model, professional development, resistance to change, etc. HEI needs to cope with the methodology and adopt a *new approach* to education.

HEI focuses on competencies, credentials and certifications [14]. HEI needs to refine how they certify what graduates know and can do. HEI is sufficiently focused on the skills and competencies that are transferable to fields. Without a rapid change in higher education, large-scale solutions in the market may circumvent traditional approaches. HEI need to prepare technological solutions that are flexible and modified quickly according to the students and teachers**.**

C. Solutions to the Challenges

To overcome the above challenges, HEI can use *modern or* the *latest technologies* in education. Some of the latest technologies are augmented reality (AR), virtual reality (VR), mixed reality (MR), robotics, machine learning (ML), deep learning (DL), and artificial intelligence (AI), which are changing education. These technologies find their place in higher education and contribute to better prepare for future education. For example, today, *chatbots* are responding to questions about registration, course availability, and homework assignments. In addition, changes brought by AI and robots are taking place in the professions faster than they are in HEI.

The above technologies are gaining increasing popularity in the education industry, changing both education models and ICT development. HEI may integrate these technologies with teaching, learning, research, management, and public services. They offer a new approach to universal, high quality, and life-long personalized learning, conserving resources and reducing cost.

ICT in education may enhance the efficiency of the lessons [37]. ICT enabled learning may arouse students' interest to a bigger extent, independent learning and made even more efficient by applying cooperative learning methods. The ICT dimension is a set of ICT tools that are being used for providing different aspects of smart education. Smart education provides a huge intellectual volume of data processing and automatizes the management of the education process. Smart education redefines the impact of new technologies, communications, infrastructures development, educational platforms, personalized experiences, learning analytics and case studies.

This paper studies the emerging technologies that are used to design smart education solutions to HEI, their features and their potential uses. The goal is to reveal the important difficulties in traditional education and modern technologies available to overcome the difficulties. The objective of this paper is to survey the emerging technologies that are used in designing a smart education system for HEI. These emerging technologies are changing the traditional education system to a smart education system. The objective also includes finding and exploring the advantages of such intelligent paradigms and the challenges faced by the developers and knowledge engineers in developing and deploying smart education systems.

II. BACKGROUND TECHNOLOGY

Recently, a number of developments have taken place in education. Technologies are helping students to acquire education with ease and comfort [40]. In this modern era, educational apps have helped students to connect with teachers online. With technologies, teachers are able to read their smart lesson plans easily and with more accuracy. In addition, they make use of tablets, smartphones and laptops to generate lessons for smartboard. Both teachers and students can benefit from these techno-driven inventions. Hence, electronic learning (or e-Learning) has become of essential importance in today's world.

A. Learning in the Digital Era

Today, imagination, innovation, inspiration, interaction, interconnection and improvement are new paradigms pushing from the pillars of education. Some of the new ways of learning the digital era [26] are social, customized, blended, interactive, immerse, adaptive, continuous, etc.

- *Adaptive Learning*. Adaptive learning, in its basic form, is learning that adapts to the learner. It gives the digital ecosystem the task of creating training programmes and presenting them at the right time to the right person. It enables customized lessons to be offered to each learner. It is based on several principles of the collection of data in real-time, the analysis of the learner's behaviour, the analysis of results and the adjustment, if necessary, of the difficulty of their training sequences.

- *Blended Learning*. The concept of blended learning meets the requirement in terms of user experience. It has the advantage of mobilizing different approaches and types of material.

- *Continuous Learning*. Technologies are capable of monitoring the activities in digital learning. They are constantly able to propose appropriate training and the acquisition of new skills. This seems obvious, and relatively few people aspire to continue training throughout their lives.

- *Customized Learning*. In this learning, digital technologies enable profiling, delivering content on a personalized and localized basis. Customized learning gains in efficiency seem immediate.

- *Immerse Learning*. With digital innovations, the learner in a real-life situation and allows them to train in a particular skill or technique to perform it in multiple environments. This immersion is naturally more engaging for the learner.

- *Interactive Learning*. Interaction is at the heart of a more engaging form of teaching and learning. This implies more flexibility and responsiveness, more adaptation to the real-time situation on the part of the teacher. In the digital age, the teacher and their digital aids are agile.

- *Social Learning*. Social learning allows the learners to create fun learning games and quizzes to help revision. The learners are grouped around a shared screen, and they can participate simultaneously.

In addition, Peer-to-peer learning (P2P) computing enables everyone to pass on his or her knowledge and to request help in return. The quality of the teaching thus comes with P2P learning.

B. Technology Enhanced Learning

Traditional education systems are facing many challenges, which jeopardizes the quality of education. Therefore, it is high time to think about a more secure and flexible system that can prevent issues in the future education system [3].

Technology-enhanced learning (TEL) can be implemented and utilized in helping teaching and learning. Technologies can be as media or tools for accessing learning content, inquiry, communication and collaboration, construction, expression, and evaluation in TEL [39]. TEL is used to provide flexibility in the mode of learning. Intelligent technologies, such as cloud computing, learning analytics, Big Data, IoT, wearable technology etc., promote the emergence of smart education.

- Cloud computing, learning analytics and big data focus on how learning data can be captured, analyzed and directed towards improving learning and teaching. They support the development of personalized and adaptive learning.

- IoT and wearable technology support the development of contextual and seamless learning. The IoT can connect people, objects and devices. Students carrying smart devices can benefit from various related information that is pushed to them from their surroundings. Wearable technology can integrate location information, exercise log, social media interaction and visual reality tools into learning.

- Blockchain technology enables a way of creating and storing transactions, contracts or anything that requires protection against tampering, accessing etc. This provides a solution for the question paper leaking problem

As a new educational paradigm, smart education bases its foundations on smart devices and intelligent technologies.

C. Smart Education

Smart education has become an essential need for everyone with its conveniences and adaptability. It has gathered the attention of people by interlinking various fields and disciplines of knowledge by means of communication for educational purposes. Smart Education scope covers the learning modes, activities of educational institutions, academic projects, research, anywhere access and related skill development.

The smart classroom is the high-end form of a digital classroom. It is a typical ecosystem for smart learning. *Smart Education* is a set of technology-based solutions that leverage the Internet and other smart technologies combined with engineering excellence to enhance learning, affordable education and reachable to the target audience [41]. The availability of high-speed cellular technologies, wireless technologies and smartphones make the communication and learning system easier. These sophisticated technologies can bring immense advantages to the methods of delivering and acquiring knowledge.

The *smart education system* uses a variety of digital tools. It actually encompasses the new technologies to impart education. The components of a smart education include smart classrooms, smart teaching, smart learning, smart learning environments and smart campus. These components are discussed below.

a) Smart Classroom. Smart classrooms allow students to see a real purpose for using technology to learn. A smart classroom aims to enhance teaching and learning. It is generally equipped with a number of multimedia components. A smart classroom can be defined as "an advanced implementation of technology for educational institutes by providing tools and content for learning". It is considered the concepts of smart classrooms in terms of pedagogical setting and arrangement during the design. Smart classrooms allow teachers and students to see how they actually want to teach and learn. The advantages of smart classrooms [33] are pedagogy, flexibility, imparting knowledge, improved thoughtful skills, interaction, sharing educational content, etc.

b) Smart Campus. A smart campus is a term used to describe educational institutions that use emerging technologies woven seamlessly within a well-architected infrastructure. This enables a digitally connected educational institution. It can enhance the campus experience operational efficiency and provide accessibility. A smart campus is more than a collection of applications, platforms, or infrastructures leveraged in a siloed manner around campuses.

The technological infrastructures and platforms siloed by strategy can seamlessly communicate to the smart campus. It looks decidedly different from the HEI of the past and the present [42]. Using technologies, the smart campus enables frictionless, touchless, and intuitive experiences have driven. The smart campus seizes true transformation to provide the level of service of their digitally native student and faculty. The smart campus allows global scalability and leverage technologies to provide seamless data-driven experiences. Using smart campuses, educational institutions can help ensure they stay sustainable and relevant, enhancing the experience for students, faculty, administrators, and researchers, as well as for the surrounding community in which they coexist.

c) Smart Learning. Smart learning aims to provide holistic learning to students using modern technology. Smart learning is an intelligent, tailored instruction-learning supporting system with changes in the overall smart education system such as pedagogy, curriculum, assessment, and teacher. It is a combination of human-centred social learning and adaptive learning in the smart communication environment. Smart learning is focused on learners and content more than on devices [10]. Smart learning combines the advantages of social learning, ubiquitous learning, learner-centric and service-oriented educational paradigm. Smart learning increase student independence in more open, connected and augmented ways by personally richer contexts.

d) Smart Learning Environment. The traditional learning environment has failed to meet the needs of today's society [43]. With the new technologies and pedagogies, the smart learning environment (SLE) facilitates and engages learners in a universal phenomenon. SLE supports many technologies and interacts with the learning systems anywhere and at any time. It provides the necessary learning guidance, learning suggestions in the right place, at the right time, and in the right form [44]. The goal is to provide a rich, personalized and seamless learning experience for learners. To realize a personalized learning experience, SLE can provide accurate and rich learning services by using learning analytics.

e) Smart Pedagogies. Smart education refers to making pedagogy education, which is merely a conventional theoretical concept into contemporary methods using ICT. With the rapid development of technologies, efficient learning methods for students are developed. In the learning process, the learner is an active recipient of the information who works to construct a meaningful understanding of information found in the environment [45]. This generative learning can enable learners to apply intelligence [48] to various relevant future situations. In generative learning, the instructional strategies include class-based, group-based, individual-based and mass-based. All these strategies encompass formal and informal learning in both the real and the digital world.

Smart Learning Analytics. Smart learning describes technological and social developments that enable effective, efficient, engaging and personalized learning. Therefore, learning analytics can clearly provide valuable information in designing and developing smart learning. It supports learners making progress and enables rich and personalized learning. Learning analytics is monitoring the learning process and then using it to predict the future performance of students. The teachers can offer informative feedback to learners through learning dashboards via learning analytics. This provides a general view of the learners' activities. They are related to their peers through visualizations for learners and teachers.

D. Emerging Technologies

HEI believe that the digital capabilities severely lag behind the private sector, and the educational administrators are in a position to take steps towards much-needed change [22]. It needs to understand how educational institutions can benefit from innovative technologies. Some of the innovative technologies are AR, VR, big data, IoT, personalization, security and SLE.

- AR and VR may sound prohibitively expensive for regular classroom use. They keep students engaged and excited about their studies, motivating them to learn, i.e., Google Expeditions.

- *Big Data technology* may offer greater insights into the skills and abilities of individual students compared to any standardized test.

- IoT can track whether homework/assignment was done and how much time was taken to complete them. This data can help teachers better understand students and which tasks they struggle with the most.

- *Personalization* increases the efficiency of smart education and information retention. The lack of personalization can make it nearly impossible to teach some students.

- SLE creates a better, more efficient, and smoother learning process. They allow students to absorb information from their environment and create opportunities for seamless transitions between the learning approaches.

- With the use of digital technology in education, students gaining access to more digital tools will increase the issues of cybersecurity. ML and AI technology aim to make digital security easier and stronger.

From the above technologies, it is hard to predict the direction of the digital transformation of education.

E. Educational Technology Platforms

Educational Technology (or EdTech) has the potential to increase the level of productivity of both teachers as well as students. Some educational technology platforms [4] emerging are Next Education, Udacity, Topper, Edx, Imarticus, etc. The above educational technology platforms changed what is possible in learning, from new sources of data to the potential for a global audience.

F. Smart Computing

To improve the standard of the HEI, there is an immense need to introduce innovative techniques so that the quality of higher education will improve. Smart computing is the latest cycle of technological innovation [39] and important technology in SLE. These technologies can effectively support learning to happen in different situations. They lead smart computing to a new dimension and improve the ways of learning. Smart computing allows computing technologies to be smarter. The key functions of smart computing are awareness, analysis, alternatives, actions and audibility. They support every stage of intelligent activities in smart computing.

Smart computing is a new generation of hardware, software, and networks that connects physical infrastructure with analytic computing systems. It is more complex than traditional computing techniques. The architecture of smart computing includes cloud, fog and swarm computing components.

- *Cloud Computing* is the innermost layer, which provides Software-as-a-Service (SaaS). It allows centralized data storage and online access to computer services and resources.

- *Fog computing* is the middle layer, which is exclusively located at the edge of the network. Through Fog computing, SLE can realize real-time interaction, location-awareness, large-scale sensor networks, support for mobility and so on.

- *Swarm computing* (or environment-aware computing) is the outermost layer, which can execute on swarms of smart devices and the networks of sensors. These sensors' data will transfer to modern data management systems for analysis.

Cloud computing and Fog computing may help control and manage the resources of swarm computing. Learning contents can move and be analysed across this smart computing.

III. EMERGING TECHNOLOGIES

A literature study has been done on various emerging technologies such as AI, AR, VR, big data, Blockchain, cloud computing, data science, machine learning, deep learning, service-oriented, STEM, IoT, learning analytics, etc. These emerging technologies have been discussed in the next section. From the literature, it is known that these techniques and tools enable rapidity, flexibility, and accessibility. These technologies have to be embraced by Higher Education to achieve concurrency and digital transformation efforts in education.

Smart education is a new paradigm in global education. The objective is to improve learners' quality of education and lifelong learning. It focuses on contextual, personalized and seamless learning to promote learners' intelligence emerging. It facilitates problem-solving ability in smart environments. Smart education confronts many challenges, such as pedagogical, educational technology, teachers' learning, educational structures and educational ideology.

A. Goals of Smart Education

Smart education understands the context of the HEI and the importance of technologies in education. It should be familiar with the context and the problems involved in the smart classroom, smart learning, smart teaching, smart library, smart assessment and evaluation, etc.

The goal of smart education is to provide fair, innovative, individualized and competence-oriented education. Emerging technologies play an important role in the design of SLE. SLE encompasses various learning styles. It aims to realize the continuity of the learning

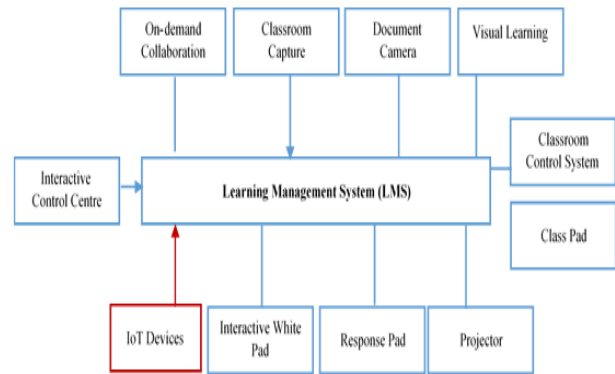experience for the learner. Smart education refers to intelligence, personalized and adaptive, as shown in Fig 1.

Fig.1 Smart Classroom

In addition to the above, the SLE provides a rich, personalized and seamless learning experience for learners. To provide a seamless learning experience, smart environments can encompass formal and informal learning. To realize a personalized learning experience, SLE can provide accurate and rich learning services by using learning analytics.

B. Key Features

The features of SLE are location-aware, context-aware, socially aware, interoperability, seamless connection, adaptability, ubiquitous, etc. Moreover, the key features of smart computing are adaptive practice, personalization, reports and analytics.

- *Adaptive*. Each learning activity can be carried out on a number of adaptive levels.
- *Personalization*. It facilitates personal learning definitions.
- *Reports.* A variety of detailed reports provides the teacher with a reliable, real-time picture of the class and students' progress.
- *Analytics*. It can monitor the geographic distribution of users, the number of downloads/uses, the average level of performance, the program, and much more.

C. Design Factors

The design factors of smart education transform learning spaces in modern smart classrooms. The basic design factors are adaptability or flexibility, comfort, connectivity with IoT, multiplicity, openness, personalization and safety/security.

D. Emerging Technologies

These emerging technologies are discussed in the below section.

a) AI Technology

AI introduced new personalized and rich educational methods that will dramatically transform students' learning experience [28]. AI technology can scale easily quickly and facilitate a one-on-one interface with a learner. AI helps in filling the needs gaps in learning and teaching. AI can drive efficient personalization and streamline

administrative tasks. AI tools can help make global classrooms available to all, including those who speak different languages which might have visual and hearing impairments. There are many more AI applications for education, including AI mentors for learners, the development of smart content and a new method of personal development through virtual global conferences. In smart education, AI provides individualized feedback to students. It provides examples of ways in which AI is being pioneered and applied in smart education [12].

b) AR, VR and MR.

These technologies can place students in any real-world or virtual situation with an active role in proceedings through various tasks they will need to complete. In smart education ecosystems, students can learn by doing, practising, experimenting and training until they reach their objective. The smarter education labs highlight the exciting ways that HEI and families are using technology to meet their needs.

AR is the integration of digital information with the user's environment in real-time [32]. This new technology blurs the line between what is real and what is computer-generated by enhancing what we see, hear, feel and smell. Teachers have now a powerful tool in AR. AR can motivate and engage students making the STEM and coding learning process faster, more fun, and better than ever before. VR is becoming more of a possibility in the classroom through mobile handsets. The use of virtual reality in the classroom is in its infancy. It also allows students to construct their own exciting learning worlds.

c) Blockchain Technology

Existing education systems are facing threat security, which jeopardizes the quality of education. Therefore, it is high time to think about a more secure and flexible technology that can ensure security and quality issues in the smart education system. Blockchain enables a way of creating and storing transactions, contracts or anything that requires protection against tampering, accessing etc., in the smart education system [4]. The Blockchain is often described as a digital ledger. It is defined as " is a distributed database that provides an unalterable, private or public record of digital transactions". This technology can give more secure and quality education,

There are only a very few HEI currently utilizing the Blockchain for educational purposes. Using Blockchain technology [5], the ledger account tracks everything it has ever learned in units called blocks. These blocks that have ever been earned is a permanent part of the growing public record of our collective learning and working. Researchers, educators, and developers have envisioned various roles for blockchains in education and training [13]. The possibilities for Blockchain are intriguing, but by far, their most popular use in education today is in providing authentic records of student credentials and competencies.

d) Big Data Technology

Big Data technology is now an important factor in education. It has transformed the field of education from the traditional way to the smart way. The goals of HEI are the ability to access, analyze, and manage vast volumes of educational content [29]. The big data application focuses on the challenges of the modern education system in a smart way. In addition, big data analytics can be applied to all of the areas of student enrollment, student management, and reporting with advanced research.

Big data platforms can offer both data archival and advanced analytics to the business challenges in HEI [29]. In smart education, educational data is acquired, organized and then analyzed to make meaningful business decisions. The big data help the HEI administrators to analyze the student performance, assessment, learning style and their success in finding a job. This future will help students in choosing the right program and course. Big data improves student performance, customizes programs, prevents dropouts and learns from the results. The advantages of using Big Data in education are reliability, flexibility and efficiency.

e) Cloud Computing Technology

Cloud computing provides a solution in a smart way to the problems in the traditional education system. It offers significant importance to adapt the ICT in smart education solutions [9]. The role of cloud computing is (i) creating a flexible, unified and open platform for education information, (ii) sharing of educational resources among developers, teachers and students and (iii) alleviating the information gap between different areas of today's education. Many HEI has started to invest in mobile cloud computing (MCC) technology [45], which focuses on the positive effect in education. Cloud computing uses using intrusion detection systems (IDS) to overcome security challenges in smart education solutions.

The cloud education system makes the teachers identify various problem areas in which students tend to make mistakes in the present education. It allows teachers to improve teaching contents, styles and methods. The users of the education cloud include students, faculty and administrator [7]. Cloud computing systems reduces the utilization of resources, reduce the cost of operation and increase the accessibility of learning materials with other HEI. The advantages will be reduced cost, wide access to educational content, enhanced teaching and learning, openness to new technologies, offline usage, etc.

f) Data Science Technology

Data science technology is becoming more important in the modern educational context. Nowadays, data science methods are changing the learning methods [23] by applying hypotheses. The data science model understands the problem domain and the data, preparation of the data, mining of the data and evaluation of the discovered knowledge. For analysis, it gives rise to new important methodological developments in smart education. The

development requires experts from educational science and data science.

g) Machine Learning Technology

Machine Learning (ML) technology is a subset of AI. ML transforms education into a more customized learning experience, predicting career paths, less bias in grading and setting up appointments [19]. ML applications are designed to benefit the education community, such as learning analytics, content analytics, scheduling algorithms, grading systems, cognitive psychology active learning and experimental design. ML has the potential to improve student engagement, create clearer communication channels between teachers and students, and develop less biased grading systems. Robotic process automation (RPA) is an essential part of ML. RPA can amass large chunks of data pertaining to students and offer them an experience that fits their needs.

ML algorithms are classified as supervised and unsupervised learning. These learning algorithms help to find similar groups of students and to use different interventions with each other groups. ML methods can be used to predict a student's future performance, ability, learning styles, interaction, etc. In addition, ML techniques, especially in music education, enhance students learning and provide students with a richer, more personalized experience in the education context. Parents have continually interacted with their children and the educational institution's administrators via ML-based educational environments.

h) Deep Learning Technology

Deep Learning is a subset of ML technology. Deep learning techniques can be used to create content analytics in deeper that dynamically restructure and optimizes the learning content as per the need of the students. Nowadays, the students are accustomed to acquiring knowledge by doing, touching, practising and experiencing. Therefore, HEI should enhance this type of learning by providing an adequate environment in the present education. They should get ready by creating programs that require deep learning in their learning environment. This approach enhances thinking capabilities, cognitive ability and retention in academics. In addition, it reveals intricate formats among the educational data and provides novel insights to suggest improvements.

i) Learning Analytics Technology

Analytics technology plays a critical role in smart education. Learning analytics is the collection of data, learning patterns, retention capabilities and attainment. This technology improves and optimizes learning capabilities. Educational data generated through smart education solutions can be classified into institutional data and instructional data. Institutional data includes admissions statistics, instructional records and accessed support services. Instructional data consists of information related to grading, LMS and engagement. The student-generated data can be processed via learning analytics. Learning analytics mainly focuses on participating

students and their behaviours. Learning analytics support learning goals by targeting instructional, curricular, and support resources. In general, learning analytics is defined as the use of educational data and educational models to predict the progress and performance of students and the ability to take action on that information.

With the help of deep learning, learning analytics improve the accuracy of the results by tuning the insights of educational data, learning content and behavioural patterns. In addition, sentiment analysis, natural language processing (NLP), computational linguistics and text analysis techniques are used to seed, extract and analyze subjective information. This analytics technology can be used to find the educational sentiments of students and what subjects they should learn to reach their desired level of competence. It tries to find the actual educational requirement of a student [32].

j) Service-Oriented Technology

HEI has many unique challenges associated with connected education, integrating business, academic processes and technologies. Smart education needs a concept of adaptability with the demands of system administrators and the changing conditions of the execution environment. The adoption of service-oriented technology [2] in higher education help to solve the problems of adaptability, integration, reusability, interoperability and agility of learning system. The emergence of service-oriented technology enables the adoption of complex IT systems in smart education.

k) STEM

STEM stands for Science, Technology, Engineering, and Mathematics. STEM is important because it pervades every part of our lives [15]. STEM has paved the way for students to learn these subjects with ease. It provides platforms for educational institutions, innovation and digital learning into the curriculum. STEM provides an environment to students where they can learn by experimenting, discovering, thinking and collaborating. STEM ensures higher retention levels by using experiential learning simulations, vivid imagery and glossaries.

l) IoT Technology

IoT is an ecosystem of connected things coupled with sensors that capture information in their environment, store, process and analyze either at the device itself or in the cloud or remotely to create value. IoT provides an engaging medium for educating students and improving efficiency by automating certain administrative tasks. With this approach, educational institutions can make learning more agile and improve the quality of education. Smart campus, smart classroom, digital content, smart examination, remote learning, campus safety etc., are the results of IoT.

For example, educational institutions can install IoT-powered appliances such as smart light bulbs and smart thermostats. Smart lighting can detect vacant rooms and turn them off automatically. Smart heating systems can

automatically control cooling systems to ensure the temperature in a room. Smart Education with IoT enhance learning, add efficiency, enable remote monitoring of activities, make the environment more secured, track attendance and monitor in real-time, etc. The IoT gives rise to multiple applications that can enhance student safety, offer communication channels, and assist disabled students. The advantages of IoT in education are better learning experience, improved operational efficiency, and reduced cost, reliability, and safety considerations. However, IoT technology is facing security risks. The existing security protocols are not adequate to provide security because of the decentralized structure of IoT. Blockchain can mitigate this issue with its security infrastructure.

m) 5G Technology

5G is the fifth-generation network that can expand the scope of connected devices and technology within the classroom. 5G Technology enable quick downloads and increased efficiency. There is better engagement with seamless connectivity, thus closing the gaps in learning for international students.

n) LMS & App

LMS (Learning Management System) & App contains information about users, various courses and their content. The teachers can upload the educational content, and the students can view the uploaded materials by logging onto LMS. LMS provides an educational platform to learn and teach at any time and anywhere. Therefore, LMS has changed the way of teaching and learning with the help of modern technologies. LMS combines education and technology for effective learning.

E. Advantages of Technologies

Integrating technologies enhance the learning experience in modern education. Both teachers and learners must adapt the technology to eliminate entry barriers. Technologies define clear learning objectives and get feedback every time from the learners. They create interaction and group activities with students. They help the HEI administrator to define key performance indicators and evaluate the results. Table-I shows a comparison of the advantages of modern technologies applied in smart education.

Table 1. Comparison of modern technologies

Technology/ Features & Challenges	Agility	Adaptability	Integration	Interoperability	Reuse	Reliability	Quality	Learning Exp.	Cost	Safety	Proof of Work	Op. Efficiency
Traditional Education	C	C	C	C	C	C	C	C	C	C	C	C
AI	I	M	I	M	M	M	I	I	R	-	N	R
AR and VR	I	M	I	M	M	M	I	I	R	-	-	-
Big Data	-	I	I	I	I	I	I	I	R	R	-	-
Blockchain	I	I	I	I	I	I	I	I	R	I	B	B
Cloud Computing	-	I	I	-	I	I	I	I	R	I	'	I
Data Science	-	-	I	-	-	M	I	I	R	-	-	M
IoT	-	I	I	C	R	I	I	B	R	R	-	S
ML and DL	-	I	-	-	I	-	I	I	R	I	-	-
5G	B	B	B	-	-	B	-	-	R	-	-	-
LMS &App.	B	B	B	B	B	B	I	I	R	-	B	I
STEM	Experiment, Discover, Thinking, Collaboration, etc.											
C-Complexity, I-Increased, R-Reduced, B–Better, M-Moderate, S-Support												

F. Smart Education Model

Smart education solution is designed based on the technologies available to meet the requirements of teachers, students, parents, staff, etc. It is also designed to scale learning data capacity (e-content) and business or educational function. Smart education solution has an education cloud platform that includes smart campus, e-resources, smart devices, social communications and system integration services [47]. The smart education cloud platform provides teaching, learning, intelligent resources, data analysis and other services. It can assist teachers in teaching research and making personalized learning plans for students. It can also help to communication between home and HEI and efficient management. A smart education model is shown [46] is

shown in figure 2. A typical smart education institution has many components. A smart classroom is one of the components that represent the learning and teaching cores of institutions. Different sensors, such as temperature

sensors, humidity sensors, heartbeat sensors, photosensors, can be used in a smart classroom.
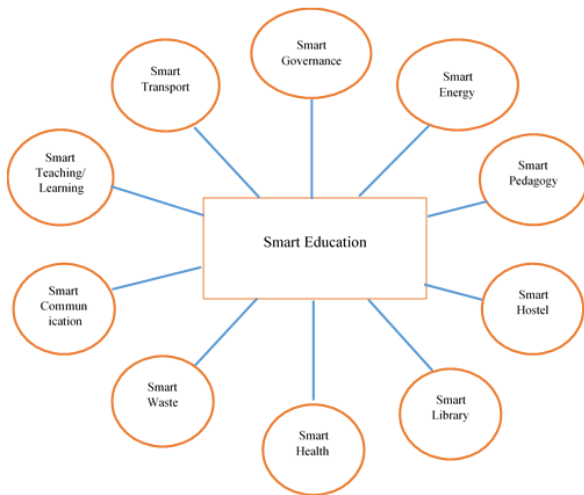
Fig. 2 Smart Education Model

The proposed equipped with smart information & interactive boards, learning environment, smart devices, LMS, apps, data centres, dashboards, communication & collaboration, etc.

- The Students can connect to the LMS portal through their smart devices – smartphones, tablet, and desktop computers using Wireless technology, Mobile Internet technology, near field communication (NFC), Bluetooth.

- The students can get the latest information about their studies, classes, contents, assignment and examinations.

- All collected data in SLE are processed to Datacenters equipped with different servers, including portal, LMS, storage, analytical, Blockchain, gateway servers, etc.

- All collected data can be processed, and results can be informed to the students through e-mail, SMS, social networks, etc.

- The Educational Administrates can view these details through the facility of the dashboard.

The smart education model allows collaboration among students, teachers, parents, administrators and staff in a smart way. This model allows innovative approaches, methods, strategies, etc., that are used to improve educational processes, which is useful for smart learning systems. Overall, this model improves the environment and customize the students' needs.

G. Smart Education Architecture

Smart education architecture covers multiple aspects such as smart classroom, smart education analysis, and smart management. Fig.2 shows the smart education architecture using smart computing architecture. This architecture has a smart learning application layer, smart computing layer and smart campus layer.

a) Smart Learning Application Layer

The smart learning application layer consists of a smart classroom, smart analysis, smart management, smart monitoring & tracking, smart analytics and users like domain experts and end-users.

- A smart classroom component can use AR, VR (or both) and hologram technologies to provide interactive classroom, individual and immersive teaching experience. The smart classroom provides an interactive teaching environment that enables interaction between teachers and students. Hologram technologies provide intuitive, 3D, and immense experience. It supports real-time and multipoint interaction in a smart education solution.

- Smart analysis component analysis the behaviour of both teachers and students in the classrooms. The data are collected and then analyzed. It uses AI and ML technologies to analyze student behaviours and emotions based on the behaviour model. From the analysis, the teachers can optimize the teaching design and guide students to improve learning skills. In addition, the behaviour of the teacher is analyzed to evaluate the quality of teaching in the classroom. The analysis includes classroom, homework, examination and doing exercise. Collecting statistics on student attendance can identify abnormal behaviours. This also enables immediate diagnosis and treatment of mental and physical issues.

- Smart Management provides effective use of educational resources, administration, spaces, and development archives for faculty, students and parents. Smart management supports the audit of students' internet usage and avoids over-usage.

- Smart monitoring & tracking integrates the student monitoring system with automation technology. It monitors students and their activities in more convenient, secure and cost-effective ways. The Radio Frequency Identification (RFID) technology can in integrated with a smart attendance system to produce an automatic system. This integration process gives better performance and efficiency to smart education systems compared to traditional methods. In smart monitoring & tracking, the RFID tags enable the HEI administrators to supervise and monitor the student movement in and out of the campus.

- The smart analytics component regressively analyzes the captured data to derive value out of it. Smart analytics may apply regression or ML on top of the collected data.

- The domain experts of the education industry add the required value by giving the insights and sharing the experience with the data scientist or analyst who can then build an education software model.

- In smart education, the end-users or the end consumer are the administrators of educational institutes / physical education bodies/ associations, the students, teachers, administrative staff, trainers, parents, academicians, coaches, etc.
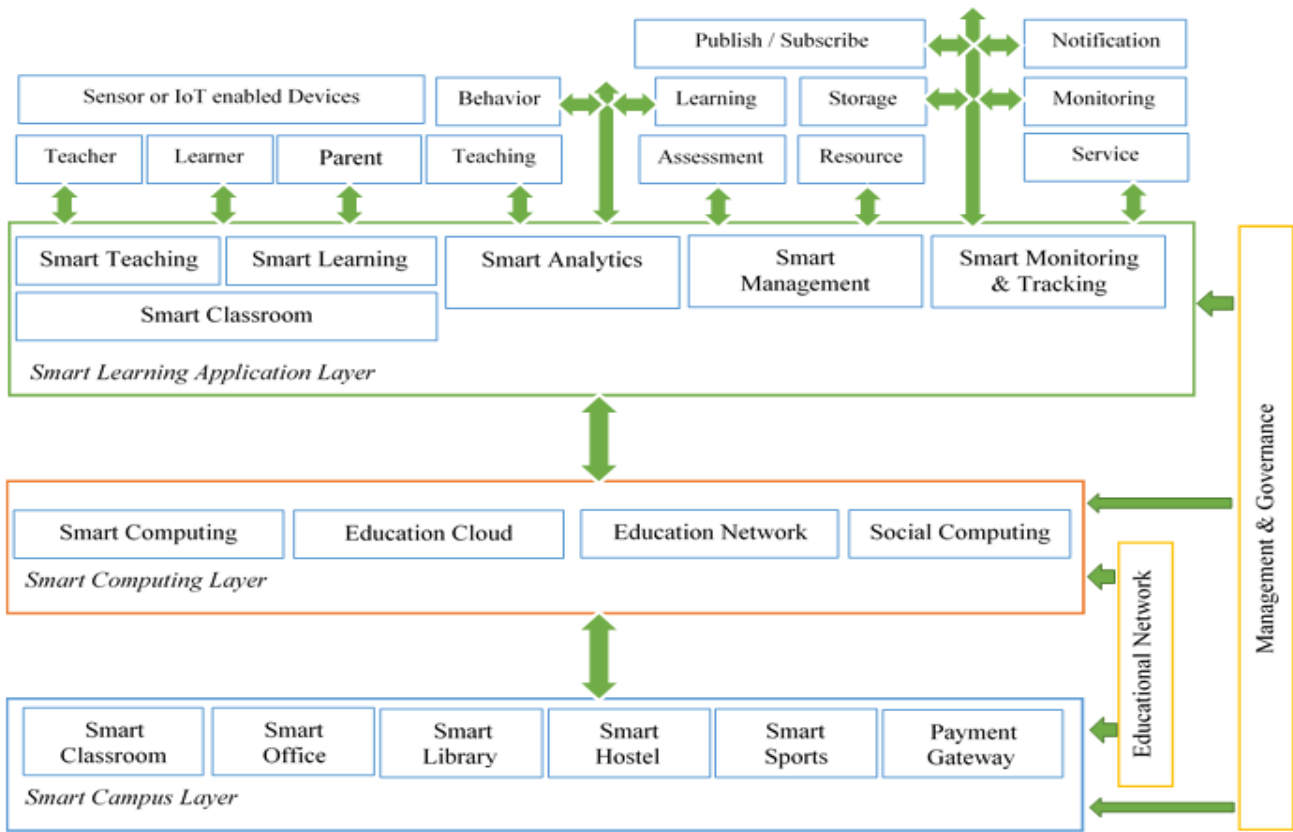
Fig. 3 Smart Education Architecture

b) Smart Computing Layer

The smart computing layer is a critical layer of smart education solutions. It includes smart computing, educational cloud, smart education network and social computing. The smart computing layer converts the data received from the smart learning layer and sent to the smart campus layer and vice versa. It supports distributed processing by utilizing cloud computing in ubiquitous computing to improve the performance of smart education.

c) Smart Campus Layer

The smart campus layer supports teaching and research, optimizes service quality and enables unified decision-making. Smart campus component is established with both wired and wireless networks. It provided integrated transmission of multiple devices using the Internet, Wireless, RFID and IoT technologies. Intelligent technologies ensure the safety of students, teachers and staff on campus. Intelligent technologies facilitate the management of assets, attendance of students, staff and teachers, transport or vehicle movement and their locations. A smart campus can also support mobile learning and mobile teaching.

Technology architecture, data architecture and application architecture are the main pillars of smart education. All services can be done in a centralized service

for easy access, monitoring and maintenance of smart education solutions.

IV. RESULT & DISCUSSIONS

The emerging techniques discussed in this article are well suited for getting a smart education ecosystem. With the help of modern technologies, smart education eases the task of teaching, learning, interaction and collaboration, instant alerts in more fruitful. Table II shows a feature-wise comparison of various technology-enabled learning approaches and conventional learning approaches. The comparison was made in terms of holistic progress, interaction & feedback, cognition, attentiveness, delivery methods, retention, understandability and attainment of the learners [25].

Table 2. Comparison of modern technologies (Feature-Wise)

S/N	Parameter(s)	Traditional Education	Smart Education
1	Academic Independence	Classroom only	Through technology.
2	Attainment Capabilities	Lower	Higher
2	Attention span	Very short	Fairly Large
4	Cognitive Ability	Limited	Enhanced
5	Evaluation	Prefixed	Continuous

6	Feedback	No provision	Evaluation with a feedback mechanism
7	Interaction	Limited	Enhanced
8	Learning Time	Fixed	Anytime & anywhere
9	Delivery	Teacher	Learner centric
10	Motivation	Teachers	self-motivated
11	Retention	Lower	Higher
12	Study type.	Not promote	Promote. Group/ Collaborative
13	Understanding the ability	Limited	Much better

Smart education enabled by emerging technologies improve the classroom, campus, management, decision-making, etc. The effective adoption of technology builds a scalable and cost-effective smart education solution to maximize the power and benefits. The educational administrators and end-users should understand the current use of emerging technologies in the educational environment and be familiar with examples of the use of these technologies in entrepreneurial solutions. All paragraphs must be indented. All paragraphs must be justified, i.e. both left-justified and right-justified.

V. CONCLUSION

Technologies are increasingly becoming commonplace in the recent educational sector. Modern technologies are leveraging today's education with enhanced teaching and learning with smart devices. This technology changes the educational platform to offer real-time, advanced search, sharing, collaboration, communication and to improve classroom experiences. The smart education solution includes smart teaching, smart learning, smart pedagogue, smart analytics, smart monitoring, smart reporting and a smart learning environment. They combine collaborative learning and teaching with entrepreneurial pedagogy.

The use of modern technologies in smart education solutions creates effective teaching and learning in smart education ecosystems. These emerging technologies are finding their footing in the learning industry. The application of emerging technology trends will lead to a transformation of educational models and architecture and completely reimagine the way students approach learning.

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