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TOPICAL REVIEW

Exploring the Connectivity Between Education 4.0 and Classroom 4.0: Technologies, Student Perspectives, and Engagement in the Digital Era

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ABSTRACT The democratic welfare government is equally committed to quality-driven, impartial, and egalitarian education. The major contribution of this study is to examine the problems and opportunities posed by the incorporation of digital technology in the classroom via the lens of Classroom 4.0 (CLSR4) and education 4.0. The commitment of the democratic welfare government to equitable and quality education is investigated, in line with the Global Agenda SDG 4 goal of ensuring comprehensive and lifelong education for everyone. The modern classroom is witnessing a clash between traditional teaching methods and the digital competency of today's tech-savvy generation. The goal of this study is to examine the connections between education 4.0 and classroom 4.0 by looking at developments in classroom architecture and the use of digital platforms. The biggest issue found is instructors' inability to adjust to changing conditions. In terms of methodology, confirmatory factor analysis is used in this work to investigate the dynamics of correlations in the context of Classroom 4.0. This method offers insights into the variables influenced by metaverse technology, resulting in a thorough comprehension of the evolving educational scene. This study's findings shed insight into how students see the changing classroom and the role that various platforms play in engaging them. The study underscores the need for educators to effectively integrate these tools and address this digital transformation to improve teaching and learning experiences. However, there are study constraints, most notably the limited contextual scope, which is exclusively focused on the Indian educational setting. Further research in other worldwide contexts is required to generalize the findings. In the future, it is critical to investigate and build creative instructional practices that effectively synergize with Classroom 4.0. Furthermore, further research should be conducted to determine how governments and educational institutions might adapt to this paradigm shift, ensuring a smooth and effective transition into the digital era of education.

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INDEX TERMS Classroom 4.0 (CLSR4), digital classroom, teaching learning, metaverse technology, sustainable development goal (SDG-4).

I. INTRODUCTION

The 4th Industrial Revolution is a topic that almost everyone is discussing (4IR). Because the 4IR wave is so strong, change is unavoidable, particularly in the educational setting. If we focus on sustainable development, then SDG-4 has a key role to play in upgrading the quality of education [1]. The landscape of educational innovation has transformed as a result of the Fourth Industrial Revolution (IR 4.0). Artificial intelligence (AI) and digital physical frameworks that enable a more general human-machine interface are in charge of IR 4.0. So here, the famous buzzword among educationists today is education 4.0. The Education 4.0 framework aims to encourage the development of soft skills like teamwork and lifelong learning in addition to the digital technologies [2] that are needed for Industry 4.0. The shift from Education 3.0 to Education 4.0, however, is not without its difficulties for the educational system.

In today's era, learning zones promote various learning methods and aspects of the creative process. In both the classroom and the school as a whole, clusters of kids are active in zones of collaboration, independence, play, and presentation. Everybody is involved in the learning phase and motivated to learn the latest technologies. Higher education is a major concern, as is adapting the latest technologies to upgrade you. Without entering the classroom, it is not possible to grab a lot of general knowledge as well as connect through social ethics. Here, the classroom is the actual medium to adapt the subject knowledge as well as the interactive media. In between, multiple technologies are performed on multiple scales. So every interactive medium makes a classroom with the replacement of smart classrooms [3]. A seamless and scalable reconfiguration of the sensor devices and virtual learning scale environments within the classroom would be necessary in a real-world [4], futuristic scenario with smart classrooms where consecutive lessons take place (with 15–30 minute breaks) in order to both deliver the lesson and take advantage of vastly different MMLA (Multi Modal Learning Analysis) solutions. In between, the motivational factor of this study is to identify the classroom architecture and the level of motivational reinforcement and aid that instructional designers should provide learners to help them advance intellectually. At the initial stage, these two terms, education 4.0, or it may be classroom 4.0, have major concern for the upcoming growth of higher education. For further study, we have now focused on the basic classification of education 4.0. As of now, we only describe the basic illustration of the education system, so a general illustration of education is mentioned in Figure 1.

With SDG-4, Classroom is such a place where student's entity comes alive. Students are able to think critically, solve issues, and collaborate in this environment. Classrooms in the 21st-century must adapt such that all students have equitable access to learning through active participation [5]. Classrooms should move from a memorization-based reading-writing-arithmetic method (drill and kill) to a more collaborative active approach, according to design and experience. Here we precede the revolution of classroom from 1980 to 2030 in Figure 2.

FIGURE 1. Classification of classroom 4.0 in multiple directions.

There is a small gap, as given in Figure 2. Where COVID-19 has come and suddenly the classroom concept has been converted into an online pattern. And we can say that some time ago, along with study in COVID-19, the

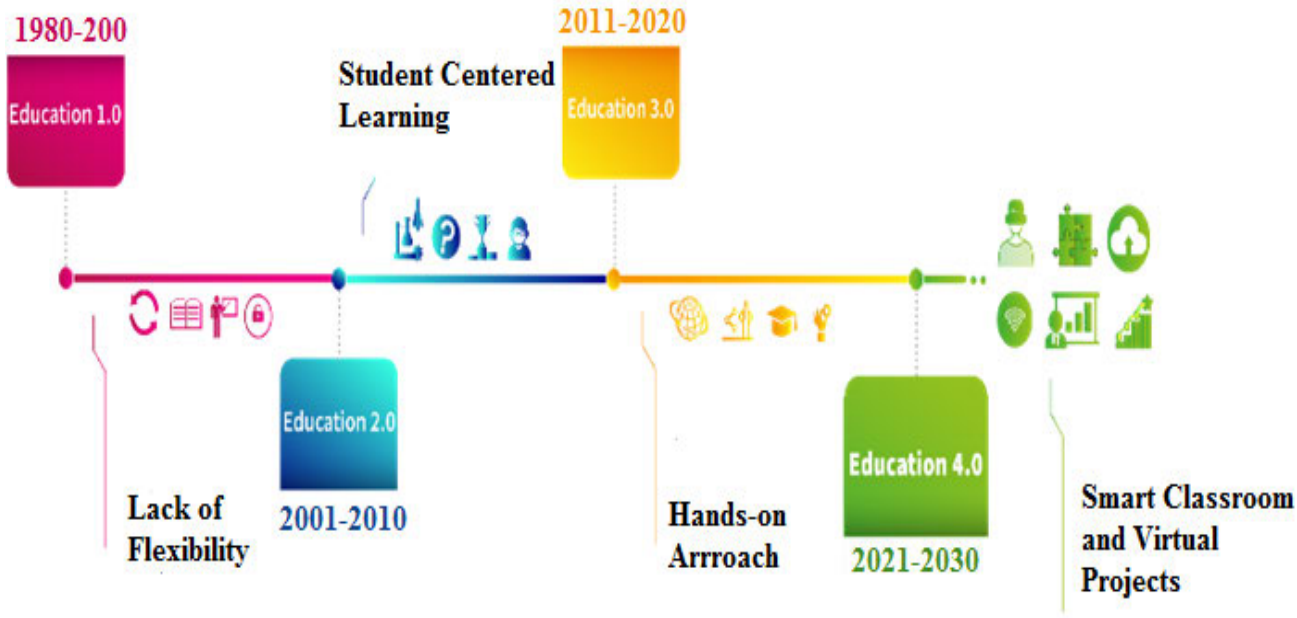

FIGURE 2. Classroom revolution with different years.

classroom pattern also changed a lot. When the study pattern came online, people adapted the online system and used new technologies. The past tense of conventional education has emerged. Education has seen significant changes as a result of the combination of technology and the classroom [6]. The scope of this study is to explore the usage of technology in classroom architecture year by year, and the student learning strategies have been totally changed so they may perform their task from anywhere without any dependence on teacher physical assistance in 2030. The aforementioned factors provide the complete inspiration for this work, which analyzes the emerging technologies used in classrooms and how they may present a roadmap toward classroom 4.0.

The paper explores some research questions as follows:

- What are the challenges faced by educators in adapting to the digital transformation of the classroom under the frameworks of Classroom 4.0 and Education 4.0?
- How can educators efficiently integrate digital tools and platforms to improve the teaching and learning experiences in the modern classroom?
- How do students identify and be involved with the changing classroom, especially in light of the usage of technology and digital platforms?
- What is the impact of the new technologies, such as metaverse, on several variables in Classroom 4.0, and how does it affect the educational landscape?

The objective of this paper is to study the challenges and opportunities linked with the integration of digital technology into the modern classroom, mainly through the framework of Classroom 4.0 and Education 4.0. It explores the commitment of democratic welfare governments to provide equitable and high-quality education, ensuring comprehensive and lifelong education. The study uses confirmatory factor analysis to analyze correlations in Classroom 4.0, examining metaverse technology's influence on variables and students' perspectives on digital platforms' engagement.

The contribution of this paper is to examine the classroom architecture from the initial pattern to the advanced pattern as follows:

- The fundamental approach and importance of education in the industry revolution are covered.
- The technological implementation in the classroom and how it is growing rapidly in multiple aspects (reading, assessment, etc.), the role of technologies in classroom architecture is examined, including machine learning, artificial intelligence, the Internet of Things, cloud computing, edge computing/fog computing, robotics, drones/anti-Drone, augmented reality/virtual reality, digital twins, deep learning, block chain, big data, explainable artificial intelligence (XAI), and the metaverse.
- A recommendation is made for future research after reviewing past studies that are directly connected to Industry 4.0.
- Additionally, multimodal learning analysis has been discussed with different patterns of classroom as well as classroom atmosphere and covered maximum parameters during this study.
- We also proposed a model based on metaverse technology for the upcoming education generation, based on higher learner engagement, adaptive learning, increased collaboration, and security aspects.

This paper evaluates the impact of Education 4.0 and Classroom 4.0 on classroom architecture and digital platform

usage, highlighting challenges faced by educators. It advocates for effective digital integration and creative instructional practices but acknowledges its limited scope and calls for further research.

The remaining sections of this paper are presented as follows: Section II completes the review study and literature background. The use of numerous technologies in the classroom and the role of technology in the contemporary educational age in terms of providing high-quality education that addresses the SDG-4 are all covered in Section III. The review work's findings are proposed in Section IV. The discussion and recommendations for the education sector are located in part 5, and the study's conclusion is provided in the last part. The overall goal of this study is to concentrate on SDG Goal No. 4, which is centred on high-quality education and delivering cutting-edge technology

II. BACKGROUND

Information technology (IT) was used to automate processes during the third industrial revolution, or Industry 3.0, whereas Industry 4.0 focuses on improving connectivity with cyber-physical systems and automation using big data. Industry 4.0 [7], with its new technology enablers including the Internet of Things (IoT), big data analytics, cyber security, additive manufacturing, augmented reality, cloud data management, and computing, is anticipated to result in substantial changes for all industries, including the sector of education [8].

In between, Schools and universities must prepare students for professions that will not yet exist, technology that will not yet exist, and issues that we do not yet know will exist because of the rapid economic and social development. The higher education system is under pressure to meet the demands of online communities.In recent years, education system is facing a lot of issue due to the scope other activities of related subjects so here some subject's areas are covered and mentioned in the following Figure 3.Education experts explore the various ways that education's content - at all levels - and learning processes will need to alter in the years to come. After discussing the level of learning, our main approach is to focus the actual involvement of recent technologies and their complete usage during the study or it may be used in classroom-based environment [9]. The background study justifies the complete usage of classroom structure and almost every IT based technology. Here we reviewed some classr parameters [10] and usage of technology year wise and finally justified some outcomes as per recent publication. Literature work has been performed in Table 1 and for research analysis for students, confirmatory factor analysis is performed in figure 3.

At the end of table, some parameters are compared and discussed the utilization of technology so now we just look in to the more discussion about classroom strategic and its architecture. In between we have to understand the background related activities where these activities are relevant to the existing technologies like as machine learning, artificial intelligence, Internet of Things and many more. The development of technology has caused many ways to determine the classroom architecture. By this way parameters and technologies are usually compared in the following Table 2.Revolution of learning has been changed completely technology involvement has been increased day by day. So here we move to next section which is based on smart classroom with recent trends in education sector

III. SMART CLASSROOMS: RECENT TREND IN EDUCATION SECTOR

In complete discussion of education 4.0 here we have to clear all the points those are related to smart classroom and smart classroom must be developed through these technologies are discussed.A learning management system offers an online learning environment where students can study whenever and wherever they want without being constrained by time or location. Now we discussed the complete strategic approach using e-learning tradition into the classification of last couple of years in Table 3.

Total duration started as traditional era of teaching adopted with minor technologies from 1980 and placed with new generation. Among the e-learning concepts, components and e-learning usage has been discussed.

A. MACHINE LEARNING

Teaching, learning, and research are all being radically altered by machine learning (ML), which is revolutionizing education. Machine learning (ML), which is revolutionizing education, is drastically altering teaching, learning, and research. Teachers are using ML to identify problematic students earlier and take appropriate action to boost success and retention. Researchers are accelerating their research with ML to make new discoveries and gain new insights. Localization, transcription, text-to-speech, and personalization are increasing the impact and reach of online learning content. Last but not least, AWS is collaborating with public sector leaders to adjust to the new ML reality and better provide students with the knowledge and abilities they need to thrive. The major benefits are covered through machine learning:

- Improve Student Outcomes
- Increase Online Learning Reach
- Accelerate Research and Discovery
- Improve Operations

In classroom environment, smart education system has become more strategic and essential in terms of multiple devices. So here, this study has been reviewed with the objective of the study and relevancy from the limitation in machine learning through the Table 4.

B. ARTIFICIAL INTELLIGENCE

Artificial Intelligence may be considered as remote learning access for further stage. Now the new generation came with the online interaction with instructor or multiple teachers at the same time. AI may assist with answering student queries in an online classroom, frequently even quicker than the

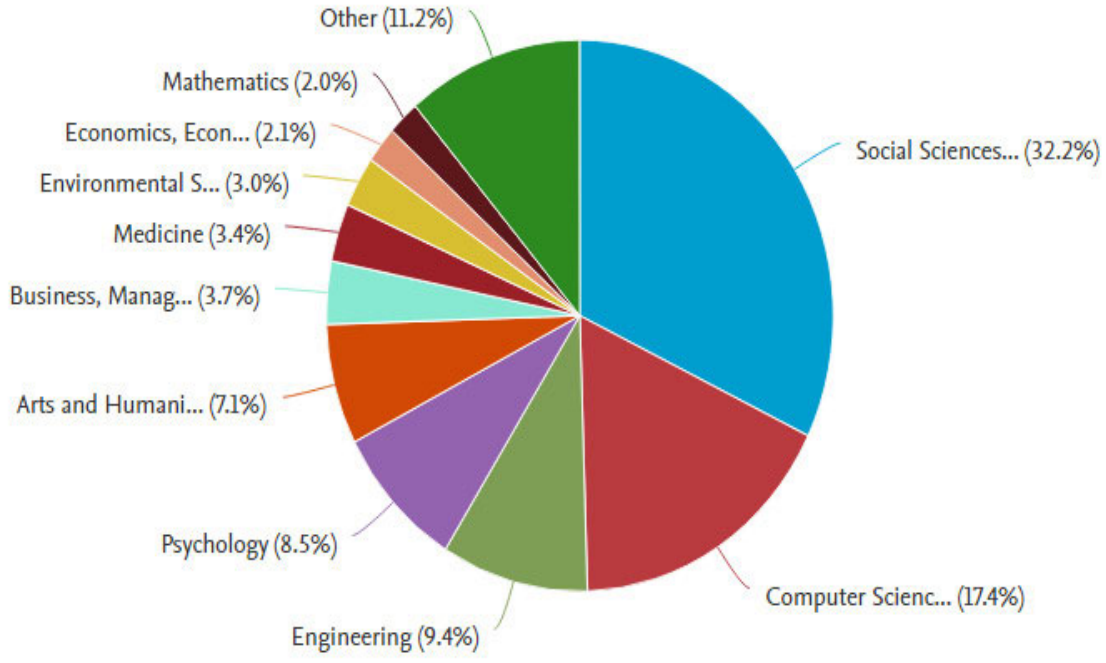

FIGURE 3. Year of production with subject areas of literature as confirmatory factor analysis (CFA).

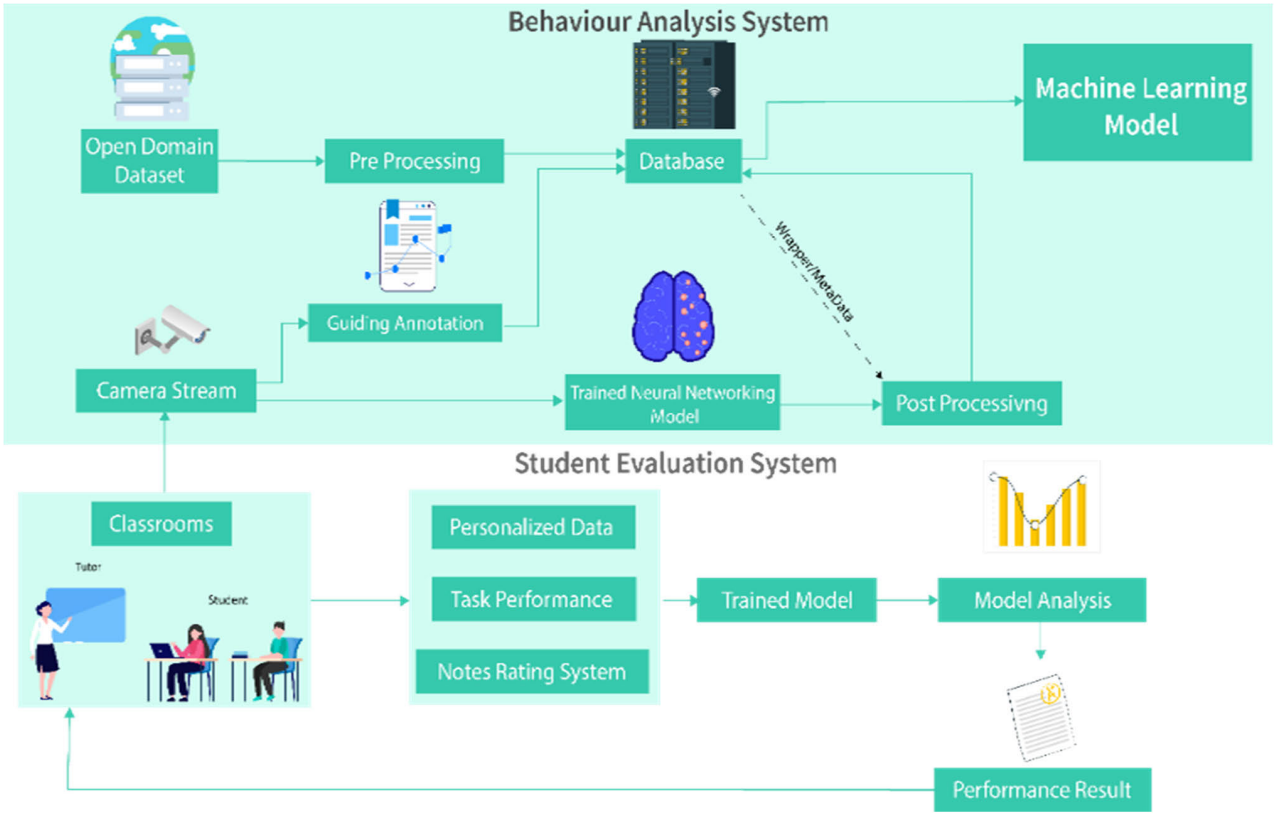

FIGURE 4. The pattern of machine learning in classroom.

teacher. This gives the teacher more time to give the kind of individualized feedback that pupils really need, which is frequently challenging to find time for.

With this study, education system needs to train the student at the assessment level so AI literacy is cognitive challenge now. Here this study covers the objective as well as limitation

TABLE 1. BACKG3ROUND study with various technologies.

Reference	Technologies / Parameters	Machine Learning		
[19]	Rigorous and meaningfulldisciplinary challenges	Higher level thinking approaches.	Problem solving for complex tasks.	Strategic development and thinking for planning.
	Culture and context support for learning	Knowledge tapped.	More information included as chapter.	Making home and school community.
	Language, communication and collaboration	Large scale opportunity for verbal language expression.	Interaction with teachers in peer to peer.	Teacher assistance with questioning and listening.
[20][21]	**Parameters**	**Artificial Intelligence**		
	Administration	It performs administrative tasks such as grading system in exams and feedback system.	Identification of learning style and learning plan.	Data Driven Work with updated instruction by assistant.
	Instruction	Analyze the syallbus structure and customized content.	Supporting collaboration for higher level education.	Create lecture plan for each and every student.
	Learning	Prediction of career path for each student.	Apply new intelligent adaptive intervention to students.	Customization of university updated course and uncover learning of shortcomings.
[22]	**Parameters**	**Internet of Things (IoT)**		
	Physical Conditions	Air Quality	Acoistic, Noise	Experimental
		Measurement	Automation Control	--
	Smart Classroom Incubator	Air Quality	Acoistic, Noise	Experimental
		Measurement	Automation Control	Energy-saving
		Thermal	Lighting	Financial sustainability
[23]	**Parameters**	**Cloud Computing**		
	Institution	Monitoring unit deals with the course schedule.	Communication Unit with answering students' questions.	Technical unit explores digitizing course materials and supporting teachers in recording their video lectures.
	Presidency	Monitoring explains the daily exchanges with the ministry.	Communication unit maintaining press release and coordinating the entire operation.	Technical unit creates the academic address and monitoring the quality of the network.
	Others	Posting Assignments	Posting Lecture Notes	Posting Assessment Marks and discussions with students
	Parameters	**Edge /Fog Computing**		
	Wide Area Connection	5G	Fiber Optic	-
	Communication Resources	Dedicated Network	-	-
	Access Technologies	5G	Wifi	-

TABLE 1. *(Continued.)* **BACKG3ROUND study with various technologies.**

[24][25]	Computation Resources	eMEC	-	-
	Educational Application	Virtual Simulation Test	VR for Education at 30 Mbps	-
	Hardware Layer	Wireless Communication Model	Video Terminal Hardware	-
	Software Layer	Embedded Operating System	Preprocessing and Target detection coordinate transformation	-
[26][27][28][29][30]	**Parameters**	**Robotics**		
	Robot Snake Acativities	Wriggle	Slip	Move Separately its tail
		Detect and wriggle around an object	Make movements from left to right	Make waving movements from left to right
	Robot Snake with program Activities	Movements of head from left to right when button is pressed	Make its eyes blink while raising its head	Flash its eyes and open its mouth
[31][32]	**Parameters**	**Drone/Anti Drone**		
	Classroom Network Accessibility	Wireless Connectivity using 4G and 5G	-	-
	Monitoring	Geography	Geology	Drone Training
	Application	Wide Range	-	-
[33][34][35]	**Parameters**	**Virtual Reality/Augmented Reality**		
	Management /Lab/Library	Procedural Practical Knowledge	Declarative Knowledge	Analytical and Problem Solving
	Academic	Communication	Collaboration	Soft Skills
	Report Analysis	Qualitative	Bibliometric	Meta
[36][37]	**Parameters**	**Digital Twin**		
	Presentation Layer	Provide face to face interface or experience when simultaneously teaching online and offline students	Supports various user types	Video Wall Interface
	Data Layer	Generate the student's digital twin	Produce enriched on-demand content	Design learning recommender system
	Infrastructure Layer	Monitor student using university spaces	Make teachers comfortable during teaching mode	Sensor based learning
[38][39][40]	**Parameters**	**Deep Learning**		
	Academic Activity	Identification of Student behavior	Improvement of Feedback system	Identification of e-resources
	Admistrative Activity	Student Facial detection for Examination fee clearance	Scalability Testing	-
	Classroom Activity	Student Teacher Interaction with different angle	Daily Attendance monitoring	Assignment Progression on date
[41][42]	**Parameters**	**Blockchain**		
	Blockcerts	Teacher hash certificates in a transaction	Verification Service for Consumers	-
	Blockchain University	Teachers gives assessment contracts for their courses	Students Adds submission for an assessment	Assessment Smart Contracts (Smart Auto Making)
	Client Applications	Learner based Applications	Teachers based Applications	Reader based verification Applications

TABLE 1. *(Continued.)* **BACKG3ROUND study with various technologies.**

	Blockchain/ Ledger	Smart Contracts with hyperledger	Composer Layer	Fabric Layer
	Client Service	Simple Testing Service	Assessment Service	Automated making Service
[43][44][45]	**Parameters**	**Big Data**		
	Instrumentation Data	RFID	Barcode	Video Feeds
	Unstructured Data	Notes	Consultation Recording	Diaries
	Diagnostic Data	Images	Vital Sign Monitors	Outcomes / Results
	Structured Data	ERP	Transactional Data	Payment Records
[46][47][48]	**Parameters**	**Explainable AI**		
	Method of Explainability	Learning Approach	Explanators	--
	Field of Approach	Underlying problems to solve	Domain knowledge	Quality/Type of data
	Purpose of explanations	Audit of Certification	Knowledge Discovery	Model's Functionality/ Development
	Type of Users	Domain Experts	Decision Makers	Researcher/Student
[49][50]	**Parameters**	**Exascale Computing**		
	Fast Computing	Data Processing with Audio and Video pattern	Quick response among student/teacher/researcher	-
	Reading Accessibility	National Digital Library	-	-
	Multiple Resource Availability	Student Assessment Submission on date	Online Classes Attendance in digital form	Utilization of devices on time

TABLE 2. **Classroom parameters discussed year wise.**

References/Year	Publication	Classroom Parameters	Technology Used	Outcome
[11] [12] 2020		Human Resource	IoT	Digital Education
	Scopus/SCI	LMS	Multimodal Learning Analytics (MMLA)	Policymaker
		MOOC	Edge Computing	Independent way
[13][14] 2021	SCI	Learning Map	Artificial Intellegence	Focused in AI Learning
		Classroom Environment	Physical Activity	Ideas on AI facts
[15][16] 2022		Node MCU Model	IoT	Camera Based System
	Scopus	Intelligent tutors	AL/ML	Intelligence in Smart Tutors
		Performance Prediction	Deep Learning	Promotion areas
		Analysis Graph	Review Data	Digital education
[17][18] 2023	SCI	Classroom Environment	Big data	New Classroom Design
		Management in classroom	Content Analysis	Classroom stages

in Table 5. The major aim is to focus the scale of intelligence level in education sector.

C. INTERNET OF THINGS (IOT)

The major concern about internet of things for smart classrooms are to identify the actual parameters during the ambient conditions. Numerous studies have been conducted in various aspects on the measurement and control the physical architecture of classroom. This is the real challenge in terms of hardware and software both. Thus, some of the most important factors influencing the learning environment include sound intensity and distribution, temperature, relative humidity rate, light intensity, air quality, and ambient pollution. Education must keep up with the more technologically advanced emerging generations. Smart boards and applications for school security that are IoT-enabled are enabling the education industry to change for the better. Cost and security are the two challenges, though.

Maximum equipment's or devices are available for fetching data among the multiple areas so here classroom is one

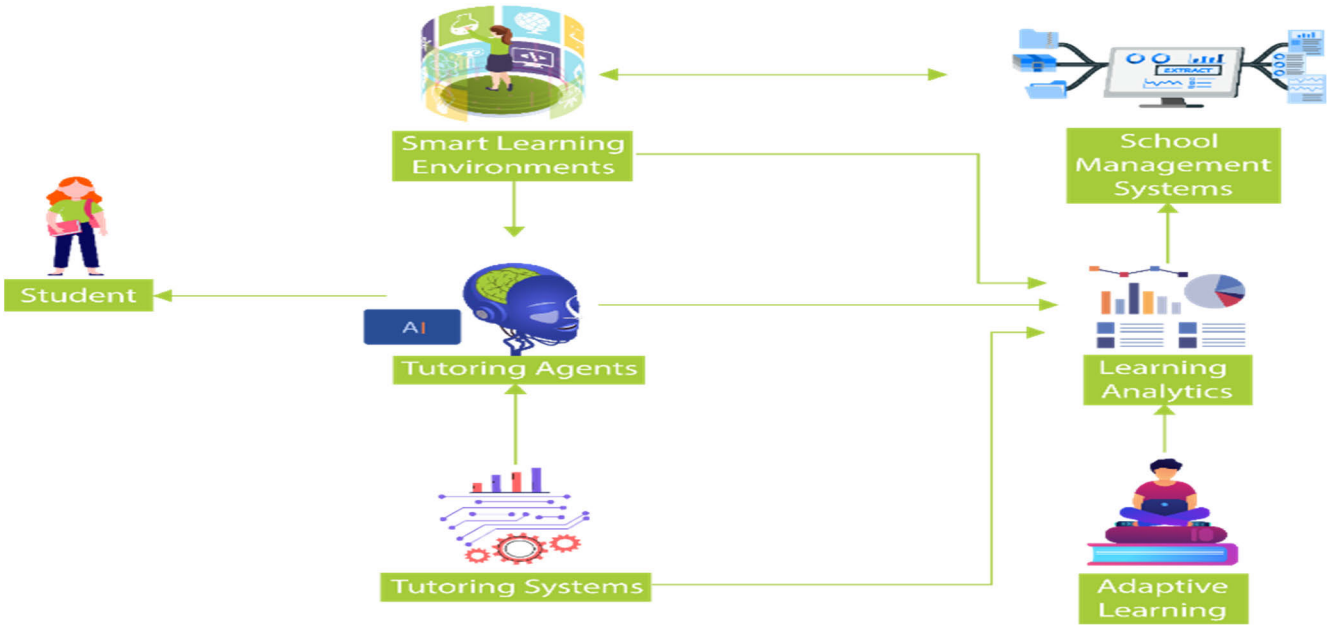

FIGURE 5. Artificial intelligence in classroom.

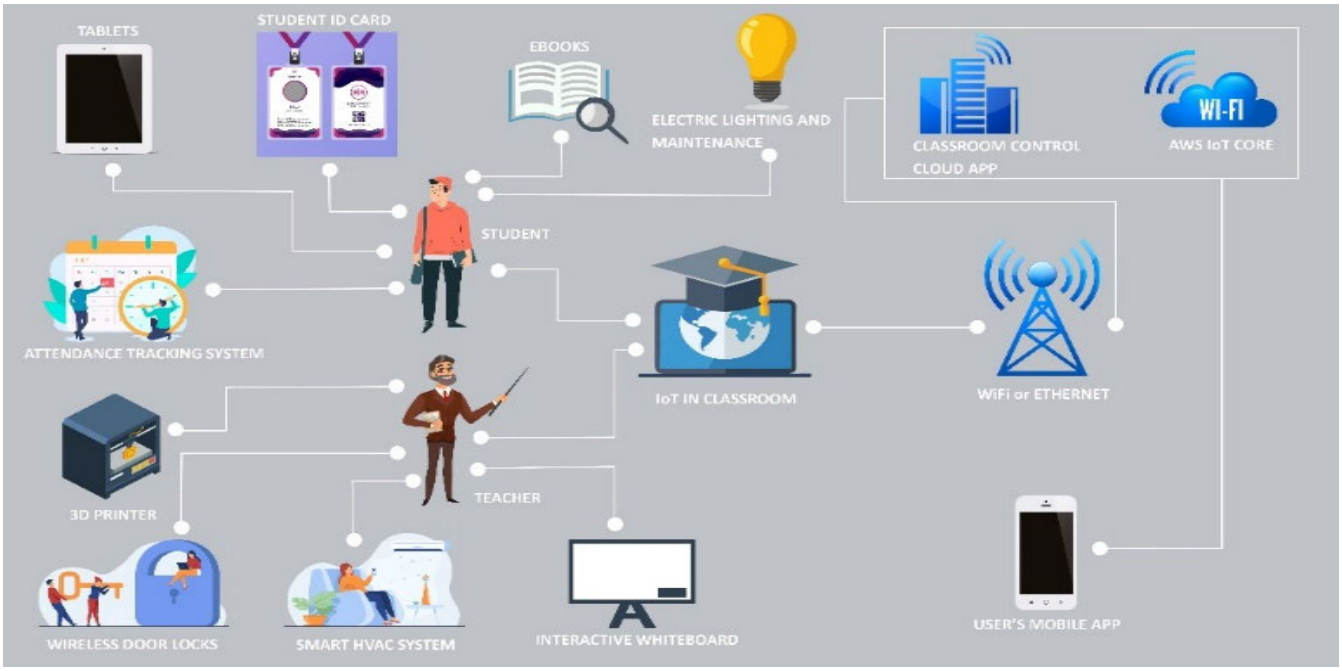

FIGURE 6. Internet of things in classroom.

the major area where IoT devices has major role to increase the quality of education. Through the Table 6, background study is reviewed with different segments to known the usage of internet and their connected devices

D. CLOUD COMPUTING

Many school districts employ cloud computing technologies in order to find more cost-effective methods to integrate technology in the classroom. Cloud computing, in addition to being less expensive, enables for more inventive teaching approaches and student engagement. Here cloud computing offers the new strategy, effective and cost effective way to adopt latest technology expand the cloud based technology for their computing needs. Modern classroom has made cloud technology to focus on professional development courses. As a result, students who are completely at ease with technology and have grown up with it are critical to the success of cloud computing technologies in the classroom. They quickly

TABLE 3. Strategic classroom method with e-learning concepts.

Year wise Classroom	Components Used	E-Learning Usage
1980-1990	Takhti, Dawaat and Kalam	Low
1991-2000	Chowk,Salet,Duster, black board	Low
2001-2010	Wi-fi, Projector, White board, Marker	Medium
2011-2020	Smart Board, Projector, Online access	High
2021-2030	Online access, Edge Device, Metaverse	Very High

TABLE 4. Literature study on machine learning.

Reference	Objective of the Study	Limitation
[51]	Classroom layouts are discussed with Structural Similarity Method (SSIM).	Potential Improvement Required.
[52]	Designed and implemented a gamified framework on 120 students for higher education.	Huge Amount for gamified framework.
[53]	Integration of machine learning into the broader K–12 computing curricula.	Need to be implementation of machine learning model in K-12 Classroom.
[54]	This paper is focused on stress management and rebuilds the policies to avoid unnecessary stress in education system.	Lack of strategies on policy makers and must be extended to financial or healthcare sector.
[55]	Systematic reviewed to find gap between students and online study materials.	It will increase the accuracy and the efficiency of education for future.

TABLE 5. Literature study on artificial intelligence.

Reference	Objective of the Study	Limitation
[56]	This article identified the scenarios that occupy the field of AIED.	Improvement of multiple tasks at the tutor end.
[57]	This study provides teaching generation and promoting the development of artificial intelligence.	It is necessary to prove the relationship between the variables by means of statistics or control group.
[58]	To achieve the goals of the article, the Ex-post factor approach and Derrida's critical method of analysis were both used.	Before proper appropriation can be made about AI's benefits in education and on human development, it is proposed that contemporary AI scientists and education technologists conduct extensive research.
[59]	Role of AI in remote sensing and Geoscience area.	Clearly mentioned such an infrastructure would be better for NASA's future Decadal Survey missions.
[60]	The purpose of the study is to raise student performance and interest in learning, as well as efficiency and quality of instruction.	Online and offline system are tracked but need to be more discussion.

TABLE 6. Literature study on internet of things (IoT).

Reference	Objective of the Study	Limitation
[61]	Overall study is about to control the electrical appliances to reduce energy consumption, and analyze the environment and utilization of the classroom.	Find better indoor IoT solutions to further reduce system energy consumption and to optimize the storage structure and reduce system overhead.
[62]	This work explains some benefit for school staff showcased in the recent literature. The paper also sheds light on security, privacy, scalability, reliability, and dehumanization in IoT applications.	Usage of Internet of Things in STEM (science, technology, engineering, and mathematics).
[63]	IoT system has been designed to decision support system.	The proposed study is planned to be tested and later for adopting the deep learning based predictive models exploiting the IoT-based data.
[64]	Improved the inter-cluster data aggregation of IoT based smart classroom.	More parameters are required for better optimization.
[65]	To design a flexible IoT architecture tor smart education as "IoTASE".	Maximum activities are redundant and need more flexibility as infrastructure.

adapt to its use in the classroom since they are continuously exposed to cloud-based technology in their personal lives. Cloud based computing in the smart classroom include the major terms like as virtual classroom, secure data, collaboration, automation and speed of innovation etc. Additionally, cloud computing provides software solutions to manage a number of the typical chores completed by instructors and school management, freeing up time for more imaginative activities. Multiple ways to utilize cloud computing in classroom include.

- When not all students can be in the classroom at once, live lectures can be given.
- Students can listen to and take notes on lectures that have been recorded at their convenience.
- Uploaded files and links to student resources.
- Electronic books.
- Releasing grades.
- Virtual excursions to far-off locations
- Making online tests.
- Students can communicate and work together in chat rooms and discussion forums (such as Google Hangouts).
- Building dashboards to monitor student development.
- portfolio offerings and Conduct conferences/meeting with the parents

Now e-classroom is the future of learning in term of education 4.0. Apart from this, architecture of cloud computing is a couple of group of Service Oriented Architecture (SOA) and Event Driven Architecture (EDA). To know the betterment of cloud technology, Table 7 is detailed about the scope of cloud computing in implementation and restriction in classroom architecture.ted by instructors and school management

E. EDGE/FOG COMPUTING

The main goal of edge computing is to locally process data in order to improve visuals, response times, and confidence. For time-sensitive applications, the edge offers high-performance processing capability directly to the centre of the activity. Edge computing has the potential to have significant effects in classrooms from kindergarten through high school as the education sector learns to harness the power of classroom devices. In virtual classrooms, edge computing enables speedy and seamless communication between students and teachers. Learning can be hampered by choppy virtual reality communications. Edge computing enhances learning outcomes and virtual experiences. Edge can help reduce expenditures over the long term.

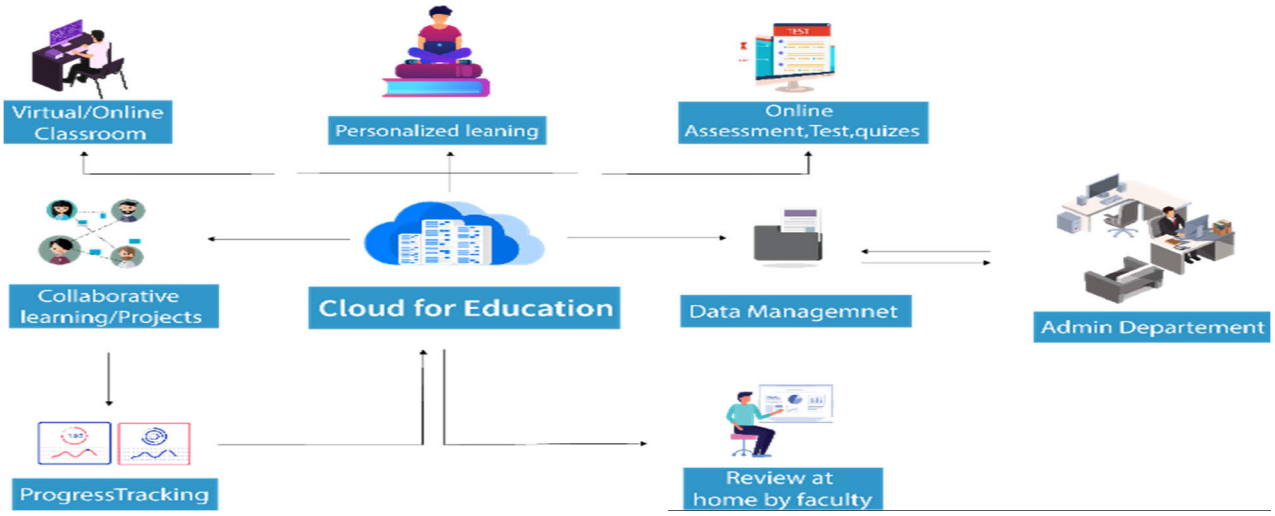

FIGURE 7. Cloud computing in classroom.

TABLE 7. Literature study on cloud computing.

Reference	Objective of the Study	Limitation
[66]	This article identifies the slow rate of adoption of cloud computing including strategic guidelines.	Solution must be increased at university level.
[67]	This paper focused on the IoT paradigm in the teaching process with the integration of Cloud for complete education system.	Adjusting the time for teaching segments not for managing in other task and workflow.
[68]	The real-time picture acquisition application in English classroom instruction is covered in this article. It is based on a cloud computing database and remote system.	Implementation at large scale to use the resources of classroom.
[69]	Resources are analyzed at cloud computing architecture.	Restriction of rapid fusion.
[70]	It developed and validated an instrument to investigate the determinants of cloud computing services (CCSs).	This instrument can be used by CCSs to look at the cognitive factors that contribute to CCSs.

Here, three professionals in education and technology discuss how edge computing might improve student learning in the classroom.

1) Augmented and Virtual Reality: Virtual and augmented reality, which are becoming more and more common in schools, is made possible by Edge.

2) Internet of Things: School districts without the bandwidth to send sensor data to the cloud benefit from processing data locally with edge computing. This will enable teachers to fully utilize IoT devices.

3) Student Outcomes: Edge computing's real-time feedback capabilities could power performance-improving learning systems.

A Massive amount of data is generated globally. In between data source and data response will matter during the execution. Edge/fog computing acts as intermediate among the devices. A complete description and objective of the study of cloud data center, Fog nodes and Edge devices are described in Table 8.

F. ROBOTICS

Robotics in education is a growing field in which machines train pupils while interacting with them using technology that recognizes their emotions and has human-like facial features. To mention a few, robots can serve as teaching assistants, private tutors, small group facilitators, and peer learners. In between ICT has major concern to play the role of latest technology in education sector.

We must respond to the following inquiries as ICT usage in education increases: How can technology are used to increase the effectiveness of learning? How can technology enhance differentiation and inclusive education while being customized to individual needs? Robotics and digital technologies have the ability to fundamentally alter how we plan and build structures. Although these technologies are widely utilized in manufacturing, their usage in the built environment has been limited thus far because of the intricacy of construction and the challenges associated with operating such sophisticated gear.

Major benefits of robots in education arena:

1) Stronger Social Skills: Education robots have eyes, mouths, and other facial features that people use to read emotions in order to appeal to humans' social nature.

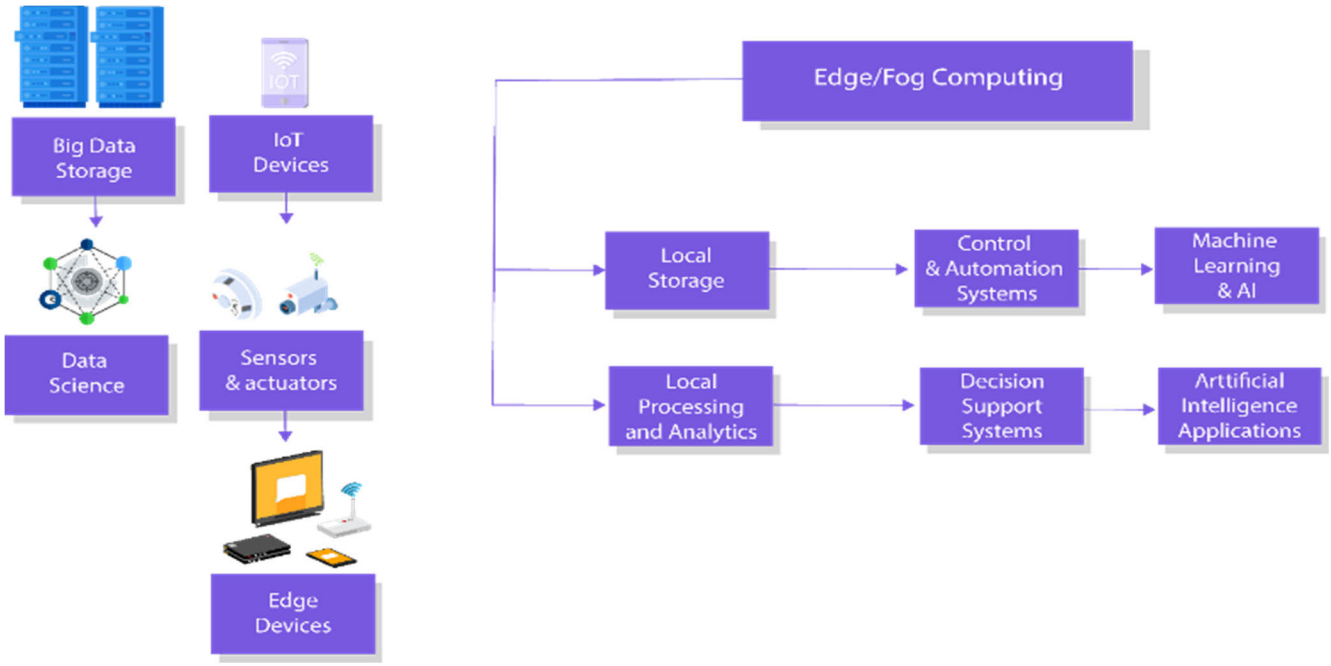

FIGURE 8. Edge/fog computing in classroom.

TABLE 8. Literature study on edge/fog computing.

Reference	Objective of the Study	Limitation
[71]	This article is to solve or investigate the network problem in online teaching and increase the student's interest in English learning.	System is developed in practical application mode but more consideration requires maintaining discipline during classroom.
[72]	Making as model of data mining to identify the three level of learning.	Refining the learning environment and reformation of smart classroom.
[73]	Case study in Student Response Systems (SRSs) using learning analytics.	Promotion factor is required with the usage of SRS border range.
[74]	To improve the demand of resources and business, collaborative architecture is constructed.	Factors on resources reduction and saturation.
[75]	In order to enhance the hybrid teaching (Online/Offline), mobile edge computing is proposed.	Simulation results show low rate on teaching efficiency.

2) Personalized Learning Options: Robots now possess sufficient autonomy to engage in one-on-one interactions with children.

TABLE 9. Literature study on robotics.

Reference	Objective of the Study	Limitation
[76]	It aims to promote robotics learning in classroom environment.	Challenging task for smart assistance in classroom task.
[77]	The investigation of anthropomorphic robots (as human activity) with active role in classroom.	Delivery of learning materials as well as delivery of feedback.
[78]	Social robot is identified in classroom setting and autonomous interaction between robots and children.	Social robot is not effective than human teachers for safety point of view.
[79]	The prerecorded and synthesized human voices are suitable for many teaching tasks.	Limitations occurred on robot play, participants, degree and skills.
[80]	This study provides an overview of the numerous technologies, application domains, and problems related to mobile robotic telepresence in the literature.	The development and analysis of mobile robotic telepresence systems.

3) Affordable Teaching Alternatives: The urge to teach more pupils has increased due to teacher shortages, but robots are reducing some of the burden.

Robotics has been become more essential for classroom architecture. It performs as classroom assistant to deliver the artificial task. With the help of Table 9, Major parameters have been covered in terms of limitations and scope of it.

G. DRONE/ANTI-DRONE

The education sector has been quick to recognize that drones are altering the landscape of several businesses and that their

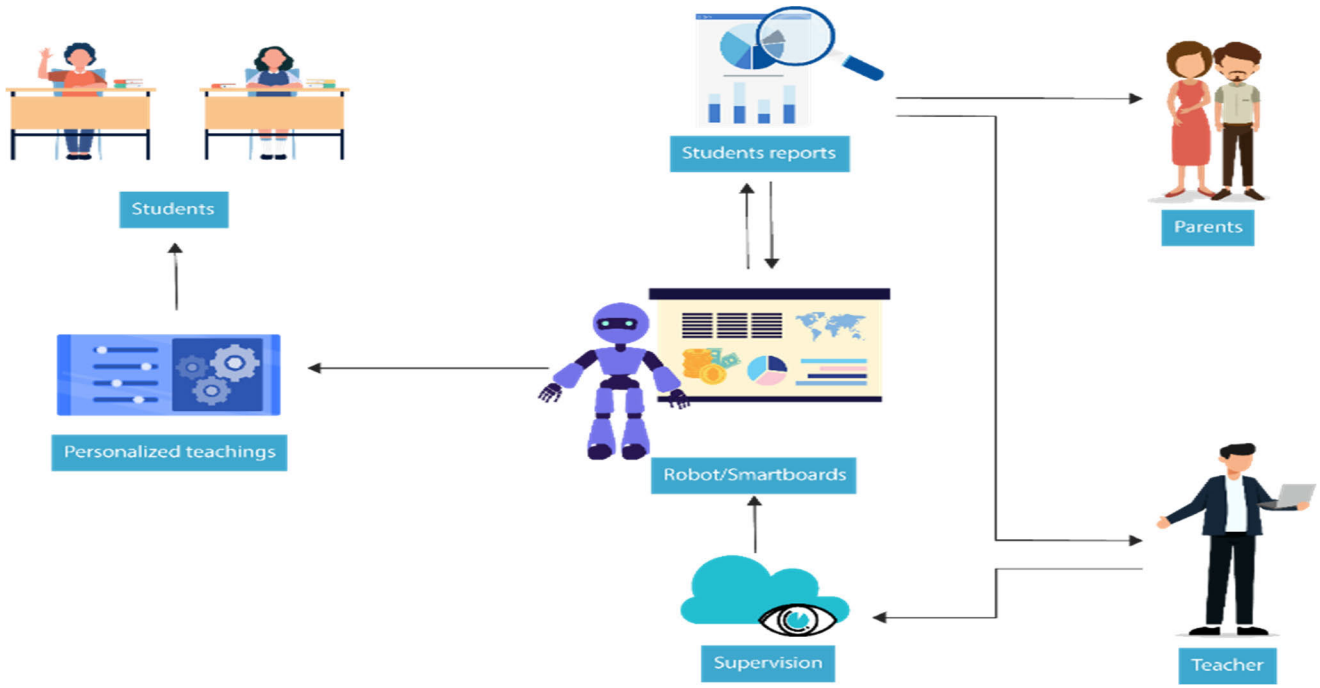

FIGURE 9. Robotics in classroom.

students must comprehend and become familiar with the future if they want to succeed after graduation. Middle school drone education initiatives encourage kids to pursue their curiosities and ask key questions as they learn about STEM ideas. If a drone does not take off, its creators can consider why and perhaps start to comprehend the factors that cause their craft to hover.On the other side, anti drone has vital role where unwanted drones and unmanned aerial vehicles are detected and/or intercepted by anti-drone systems (UAVs) [20]. They are used to guard locations like airports, vital infrastructure, sizable gathering places like stadiums, and military sites and battlegrounds.There are some four major aspects which are covered using drone technology in education sector.

- To teach mathematics.
- To spread knowledge of geography.
- To teach environmental science.
- School trips are also marked.

Basically, architects use drones for gathering architectural information [124] in the form of images and other segments. This approach will focus on the section of classroom architecture where it helps the particular angles of classroom. This literature will help to know the difference among previous literatures in Table 10.

TABLE 10. Literature study on drone.

Reference	Objective of the Study	Limitation
[81]	This self-goal study's is to determine how social studies teacher educators (SSTEs) can examine their emotions in a critical manner.	Critical emotional reflexivity in teaching and learning social studies content.
[82]	The work focused on drone improvisation and circle stringing and it may be easily integration into the orchestra curriculum.	Traditional ensemble-based classroom experiences.
[83]	The work examined whether drone-based virtual field trips can maintain or update the benefits of Virtual field trips (VFT) as real field trips.	Drone-base VFT does not provide adequate details.
[84]	Depth analysis of the interactive flipped classroom model for a digital micro-video.	Maintaining task at high level for reading, learning and other interactive task.
[85]	Developed a framework for autonomous robotics framework and course designed for robotics academy.	Future improvements to Robotics Academy will focus on adding more activities and expanding the current full course.

H. AUGMENTED REALITY/VIRTUAL REALITY

India's higher education system is about to experience an intriguing inflection point. Digital technology is already increasingly being used in educational settings. Higher education is currently being pushed into the experiential sphere by the forces of augmented reality (AR) and virtual reality (VR).

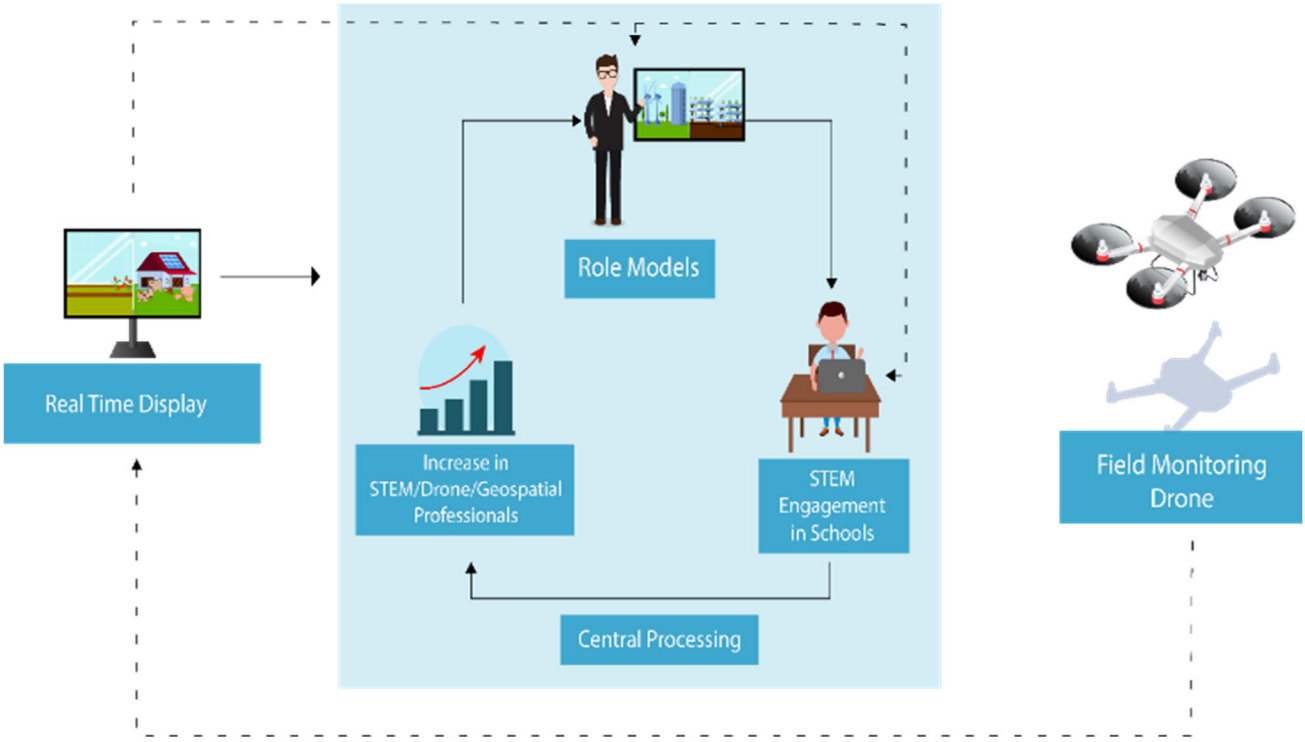

FIGURE 10. Drone technology in classroom.

AR/VR in higher education has the potential to change learning possibilities in the classroom and boost student results while also engaging students creatively and preparing them for new opportunities. In between, major discussion is to establish the importance of AR/VR in classroom environmental pattern. The following Benefits of VR and AR in Higher Education is student learning outcomes.

- Learning becomes immersive and experiential using AR/VR.
- Students' memory retention is improved as a result.
- It is very helpful to students who have learning challenges.
- For easier understanding, it breaks down and clarifies difficult subjects and ideas.
- It encourages pupils to learn for themselves and be independent.
- It is an excellent training tool that gives students confidence. It makes distance learning fascinating and engaging.

The traditional learning process could soon be affected by augmented reality (AR), which might give students access to additional digital knowledge on any subject and simplify difficult information. In this fast-paced environment, using AR animated content in lessons could hold students' interest.AR inspires kids to learn. Students would have an extra deeper knowledge of subjects if additional information, Like as brief biographies of individuals, trivia, historical information about locations or events and graphic based 3D models, were added. General study is covered in Table 11.

TABLE 11. Literature study on augmented & virtual reality.

Reference	Objective of the Study	Limitation
[91]	This study proposed framework will monitor the quality of online class and remote access based institution.	Incorporate all the features for multi-linguistic content monitoring and matching support for smart boards.
[92]	It proposed architecture for Spiral of Creative and to create a first prototype with promising results.	Additional spiral rounds are required to incorporate end users and a variety of applications.
[93]	This study summarized a theoretical approach on digital twin as well as the application of digital twin in aviation, vehicles, education and ships etc. utilization of HTC Vive, a teaching, and research device as a digital twin component.	Implementation to manage whole life cycle with physical component and equipment.
[94]	A brief report on physical robot along with classroom infrastructure.	Future development on robotic tools.
[95]	Main description with community on aspects of learning factor.	It will be considered as cyber physical tools and product.

I. DIGITAL TWIN

Learning science research throughout the years has shown a variety of characteristics of effective teacher-student

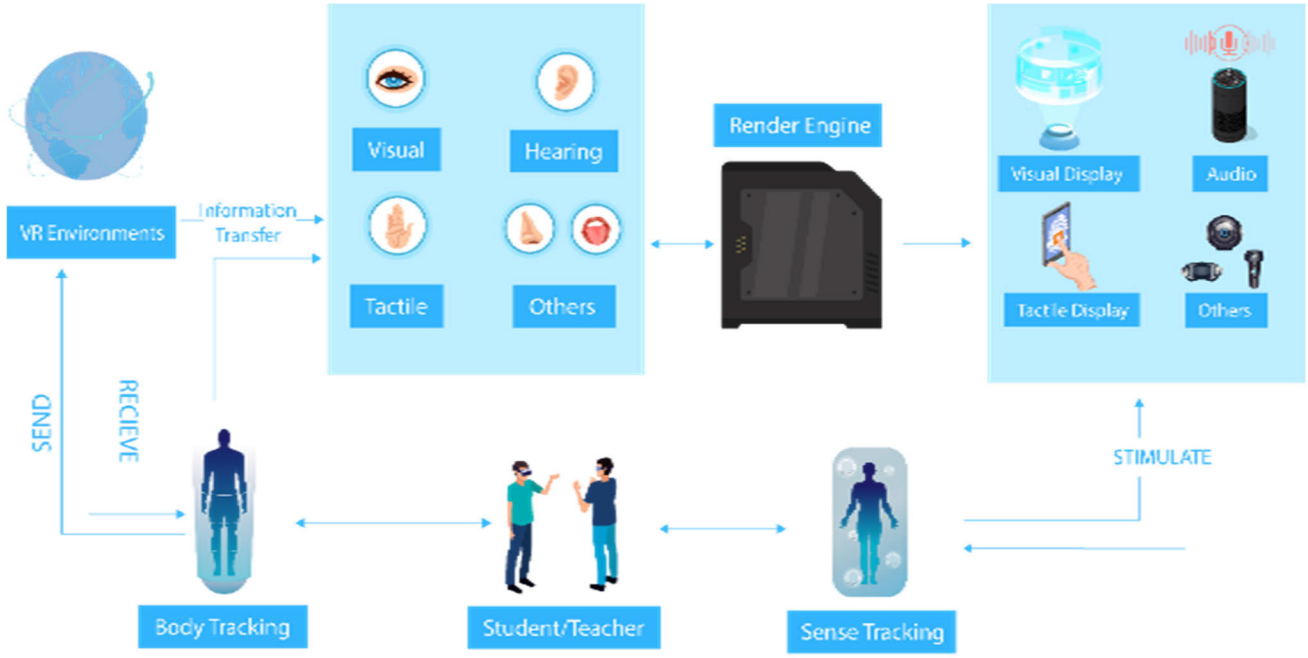

FIGURE 11. Augmented reality & virtual reality in classroom.

interactions that result in positive results for students like enhanced learning, higher self-efficacy, and more student voice in the classroom.A digital twin is a virtual representation of an object or system that spans its lifecycle and is updated from real-time data that is created through simulation, machine learning, and reasoning.A significant and growing field of study that has enormous potential to enhance training is classroom sensing. Automated pedagogical professional development systems can attend every class and record minute information of every student, complementing professional observers the current best practice.

Digital twin is dynamic representation of physical system of classroom so literature is done on various aspects of virtual representation as described in Table 12 where accessibility of the devices and creativity may be increased through this study.

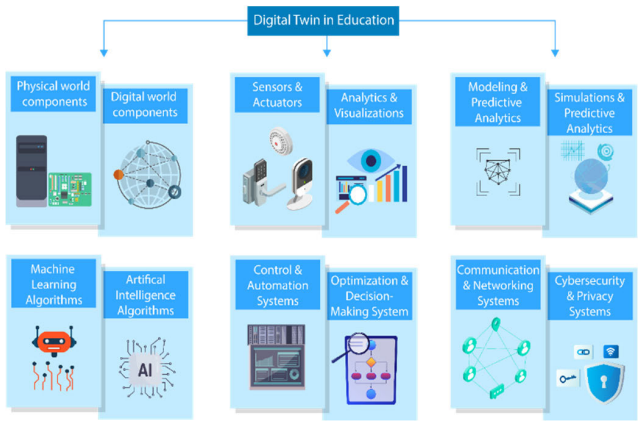

FIGURE 12. Digital twin in classroom.

J. DEEP LEARNING

On the other side, deep learning is encouraged by teachers as points mentioned here:

- Demonstrating a keen concern for the subject.
- Highlighting the subject's structure.
- Focusing on and providing enough time for important ideas.
- Addressing the misconceptions of the kids. Encouraging active learning among students.
- Utilizing evaluations necessitates thought and the integration of ideas.
- Connecting fresh content to knowledge and understanding of the pupils.
- Allowing errors to be made without repercussions and praising effort.
- Assessing announced target learning outcomes with fairness and consistency, building trust

Deep learning provides students with the advanced learning skills to deal with a real world and to encourage for valuable knowledge in education sector that really make sense. Some studies have been captured in Table 13.

K. BLOCKCHAIN

The term ''blockchain'' wasn't very common a few years ago.

These days, the financial industry uses it a lot. The phrases blockchain and cryptocurrency have occasionally been used synonymously.Blockchainis also utilized in education industry as decentralized ledger. The use of blockchain in education has two advantages: data security and data protection even in the event of a compromised node. During

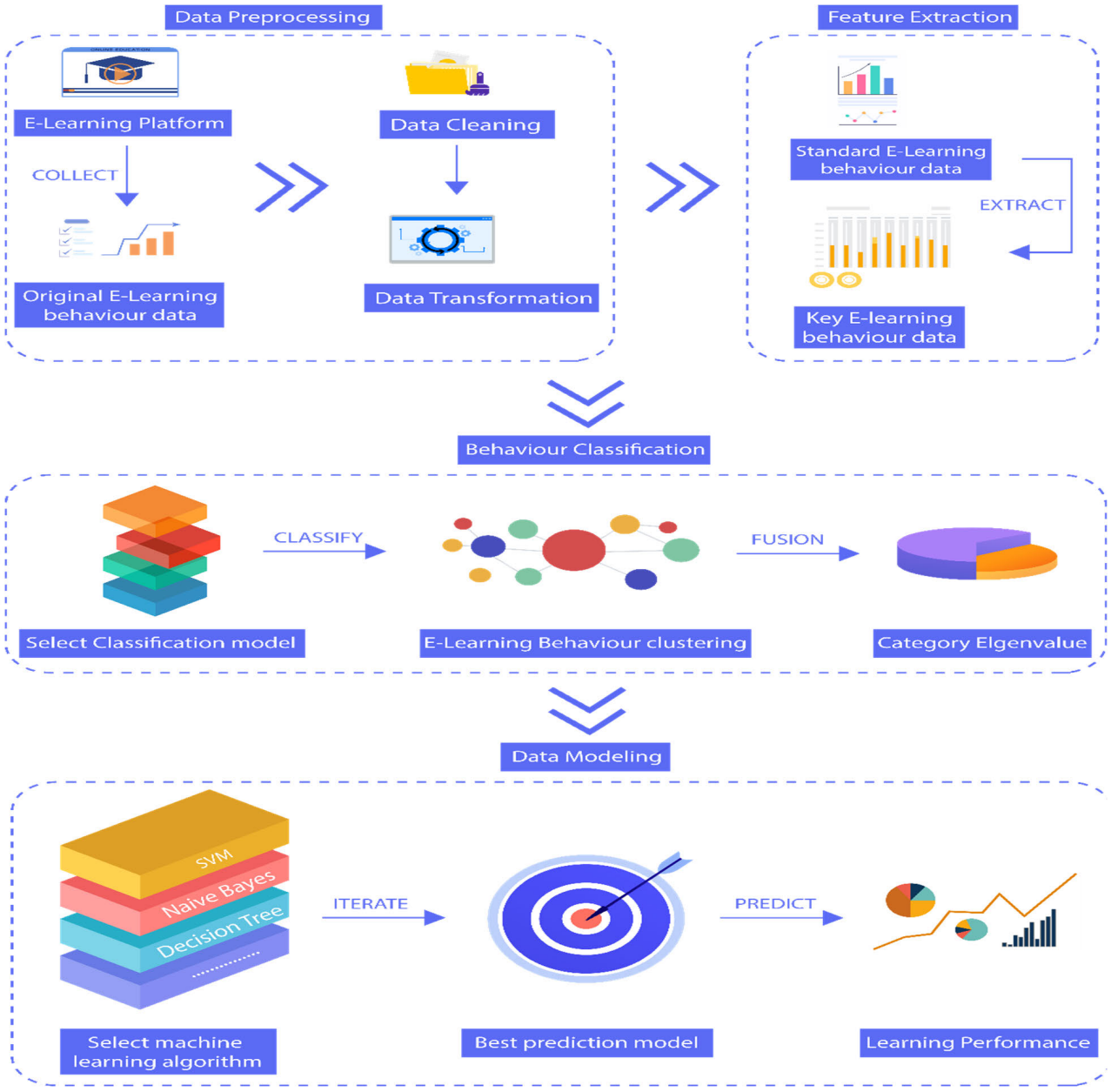

FIGURE 13. Deep learning approach in classroom.

the outbreak, the education industry reacted fast to digitization. Blockchain technology has the potential to completely alter this business [20], [121], [122], [123], [124]0. First and foremost, blockchain has the potential to significantly alter student-teacher collaboration and academic record management. The distributed ledger technology of blockchain has the potential to have a significant positive impact on the transparency and accountability of the education sector.Various methods of blockchainisaffecting the Education Sector so here these are as mentioned:

- Smart Contracts for Courses and Assignments
- Degrees, Report Cards, and Paperwork
- Incentivization of Education
- Streamlining Fee Payments
- Universal Access and Lower Cost

Blockchain has the capability to transform how academic information is managed, and how teachers and students both may interact. Apart from this, blockchain's distributed ledger technology has major potential to have a good impact on the transparency as well as accountability of the education sector. These issues are covered in Table 14.

L. BIG DATA

Big data is a catalyst for the informationization of education, and wisdom education built on a big data environment will be a weapon in the classroom [125], [126].The intelligent

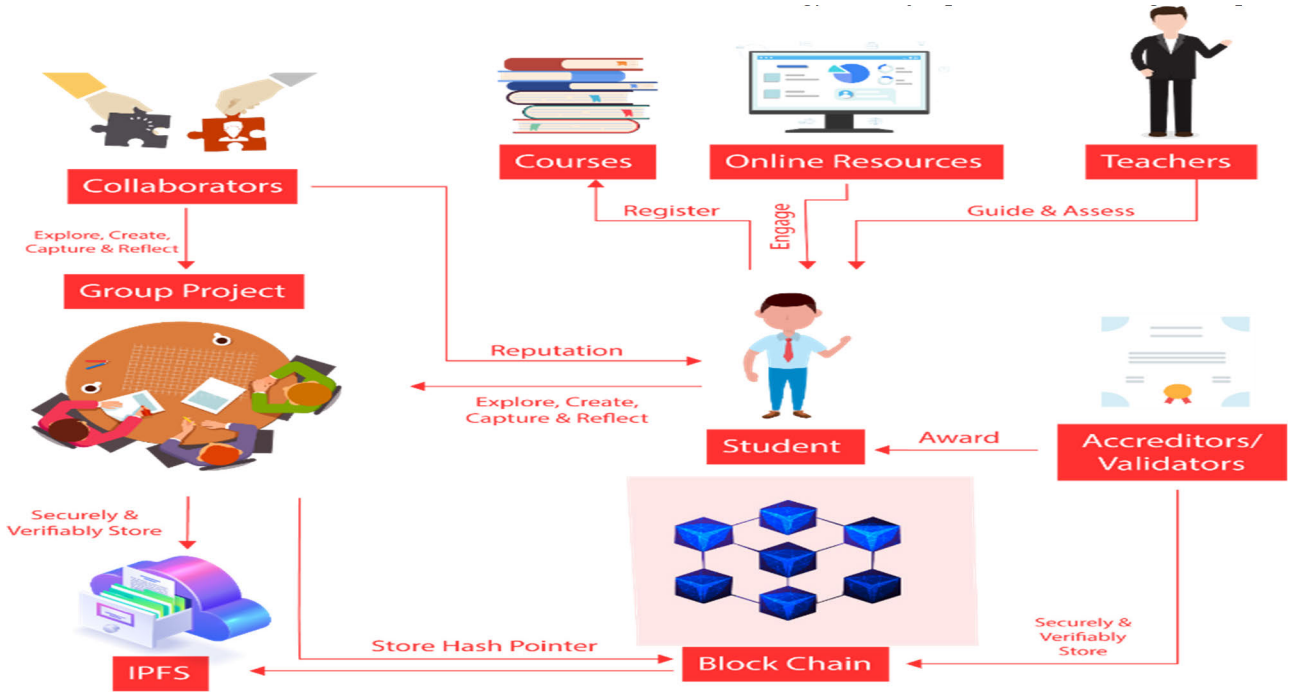

FIGURE 14. Blockchain technology in classroom.

TABLE 12. Literature study on digital twin.

Reference	Objective of the Study	Limitation
[91]	This study proposed framework will monitor the quality of online class and remote access based institution.	Incorporate all the features for multi-linguistic content monitoring and matching support for smart boards.
[92]	It proposed architecture for Spiral of Creative and to create a first prototype with promising results.	Additional spiral rounds are required to incorporate end users and a variety of applications.
[93]	This study summarized a theoretical approach on digital twin as well as the application of digital twin in aviation, vehicles, education and ships etc. utilization of HTC Vive, a teaching, and research device as a digital twin component.	Implementation to manage whole life cycle with physical component and equipment.
[94]	A brief report on physical robot along with classroom infrastructure.	Future development on robotic tools.
[95]	Main description with community on aspects of learning factor.	It will be considered as cyber physical tools and product.

TABLE 13. Literature study on deep learning.

Reference	Objective of the Study	Limitation
[96]	Complete description of Auto Class-II for the vision of generating databases based on a Bayesian statistical technique.	Probabilistic descriptions are required for each object.
[97]	This research used mixed methods consisting of tracking data on quantitative and qualitative student feedback.	Approach on flipped classroom with latest technology.
[98]	The observations were discussed within the framework of the literature and research on how deeper learning is promoted.	The time allotted for each class is limited, and neither the goals of the teachers nor the experiences of the students were taken into consideration.
[99]	In order to encourage the reuse of educational resources, this study developed an automated method for creating multi-modal educational knowledge graphs that incorporate speech as a modal resource.	Overall Limitations on the development of large-scale, high-quality, multimodal education knowledge graphs that would benefit both teachers and students.
[100]	They designed a bimodal learning engagement recognition method based on CoAtNet and ResNet50.	Limitations are discussed on combining the video sequence and spatial features of student distribution using the deep learning technique.

interactive system gathers educational big data using data mining technology, examines the issues that students face while studying and their level of knowledge retention, and then gives them accurate learning results analysis data.Many systems and platforms currently gather a lot of information about the learning process from students in the background,

TABLE 14. Literature work on blockchain technology.

Reference	Objective of the Study	Limitation
[101]	This study proposed a framework on NOTA (Novel Online Teaching and Assessment) and it also motivates both learners and teachers to persist in their endeavours.	In further, add some functionalities to NOTA framework including distance supervision and tutoring, dissertations defense, and lab sessions etc.
[102]	This work gives the details on atmosphere of the Blockchain-for-higher-education narrative.	In this approach, blockchain entertains the educational technology will be transferred with block wise non-digital technological alternatives.
[103]	This study examines the importance of teachers' perspectives and experiences on blockchain in the course design at Chinese institutions, as well as the usage of blockchain in course design and evaluation.	The design of the reward system and how it influences instructors' motivation, initiative, and cooperation will also be the subject of future research.
[104]	In this research, a novel web-based approach with digital badge and micro credentials system for the learners to acquire the desired skills was proposed.	Future work will be based on the development of mobile version which is useful for the students of the usage of digital badges.
[105]	In this article, a large collection of major blockchain value propositions and have a conversation about how they might support the development of digital platforms and the collaborative economy through a methodical literature study.	Blockchain Technologies is most impactful innovations but despite the hype surrounding it, it is still in its infancy.

examine the consequences of applying specific examples in the classroom, and monitor the results of test-based instruction.

The physical platform for data storage and computation, the supporting platform for data gathering and sorting, and the management platform for data analysis and processing are all connected through big data applications. Data links every component of the smart education system.The main point with big data such as how to use big data in education so data existed before computers, but technology has undoubtedly accelerated the daily production of data. Complete literature produces at least 2.8 quintillion bytes of data every day thanks to mobile devices, the internet of things (IoT), social media, and other information sources!

This amount of data is obviously too complex for conventional methods to acquire, store, and handle. A data management programmer can help with that. The appropriate software will combine all of your required data sets and present them in an intuitive dashboard. It has some following advantages over education:

- It helps to find answer of hard question.
- It is very quick
- It is accessible
- Time saving methods

During pandemic, education faced real issues and challenges. At the end alternate solution was online classes and online study whereas large amount of data was produced through online course. Related work has been described in Table 15. To indentify the importance of big data in online classroom is explained in Table 15.

TABLE 15. Literature study on big data.

Reference	Objective of the Study	Limitation
[106]	Using real-time big data, this work sought to offer a unique process model for creating a scalable room-level energy benchmark.	Energy saving scale must be incorporated at given parameters.
[107]	General study on English classroom and calculate the accuracy up to 90%.	Evaluation indicators must be incorporated from the expert's side.
[108]	This synthetic review defines the affordances and applications of micro level, mesolevel, and macro level big data.	The core challenge is to utilize the scope of data science in educational graduate program.
[109]	The tested results provide a design of computer network and used for mathematics teaching resources.	The load balancing is the major factor affecting the performance of the algorithm.
[110]	The general personal situation of course learners, learning expectations, course participation, learning experience, and learning impacts are investigated using questionnaire surveys and interview surveys in this study.	For improvement purpose, two major suggestions has been proposed i.e. MOOC with flipped classroom and processing speed on large-scale data With SVM.

M. EXPLAINNABLE AI

Because of a combination of procedures and techniques known as explainable artificial intelligence generation and their output with consequences of machine learning algorithms may now be understood and accepted by human users. This complete procedure is known as explainable artificial intelligence (XAI). An AI model, its anticipated effects, and potential biases are all described in terms of explainable AI systems utilizing AI in education (AIED) may also employ a variety of sophisticated AI techniques to develop the crucial interface for the learning process. As we show in this figure as input considered (x) and at last method for explain ability.While larger uses of AI and the function and need for XAI in education have a lot in common (such as accountability for accuracy, fairness, and privacy management), XAI in education has specific needs, and the nature of its data presents specific obstacles. Especially learning and reasoning about such data is noisy on many different levels since data includes numerous sources of noise. Here few outlines are covered in Table 16.

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N. EXASCALE COMPUTING

Exascale computing is a new level of supercomputing that can serve the massive workloads of convergent modelling,

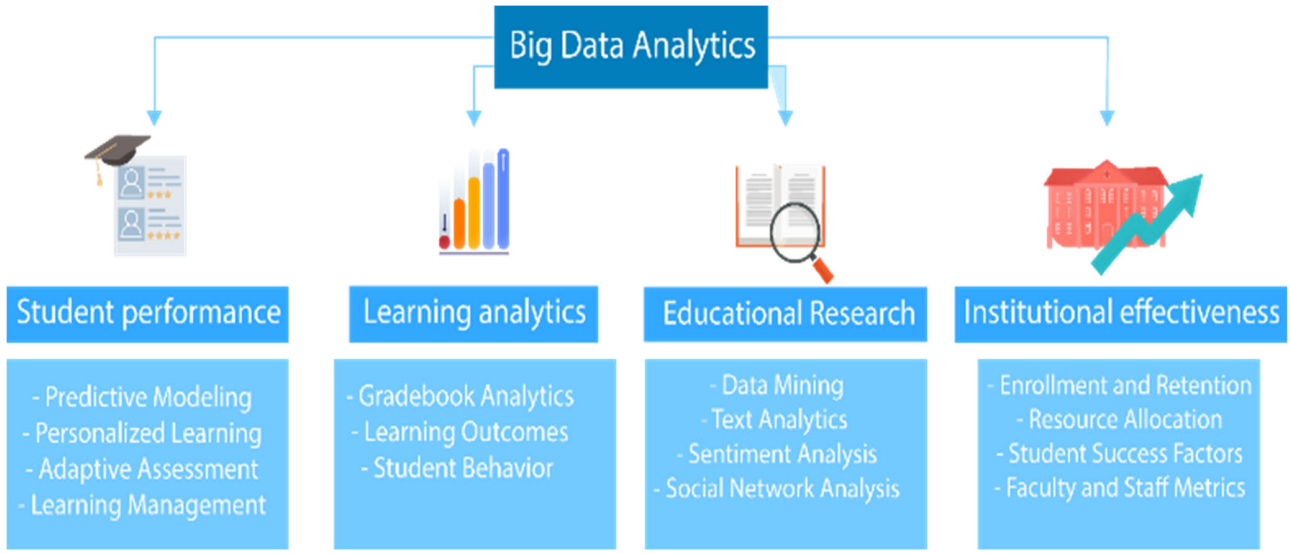

FIGURE 15. Big data technology in classroom.

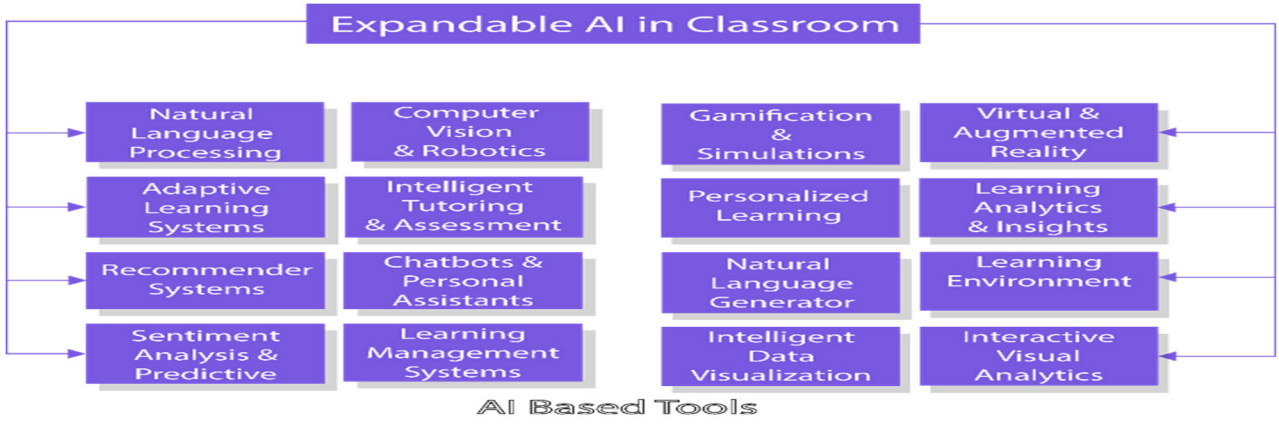

FIGURE 16. Explainable AI in Classroom.

simulation, AI, and analytics with at least one exaflop of floating-point computations per second. Here, exascale computing is the current challenge to define new education policy and certain guidelines.

Exascale computing allows improved major scientific applications and better prediction accuracy for future study so Table 17 elaborates the significance work in education field.

IV. FINDING

In new education classroom system, mostly students are facing problem during the class assessment, placement driven approach, self assessment pattern etc. Among all these things, classroom architecture and teaching skills must be considered. This study helps to create a big margin and gives better idea to know the education system with respect of architectural vision and find the gap between teacher and student. Here we enlist the some major finding in classroom are as mentioned:

- Technology intervention in multiple modes of classroom and skills upgraded to the new innovation of classroom 5.0.
- Maximum technologies discussions are made to identify the gap between education systems.
- Better understanding among student's entities and their coordinator.
- Classroom atmosphere and architecture revolution 2030.
- Considering few parameters like attendance &feedback system, evaluation process and strategically approach in new generation.
- Explainable Artificial Intelligence (AI) has emerging role in classroom area.
- Major discussion on various 15 technologies and considering the multiple aspects of classroom architecture.

V. DISCUSSION AND RECOMMENDATION

As The emphasis in constructing a modern 21st century classroom changes to developing an interactive and dynamic learning environment. Peer learning takes center stage, converting the instructor's traditional function into a facilitator of active interaction. Students are taught to study systems critically and implement real-world solutions rather than simply

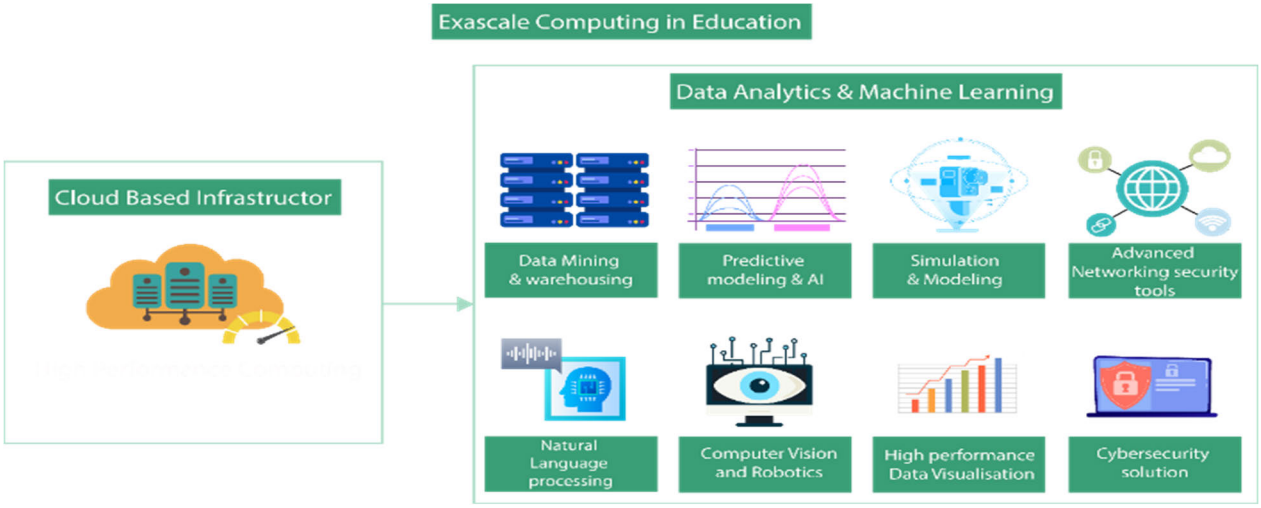

FIGURE 17. Exascale computing in classroom.

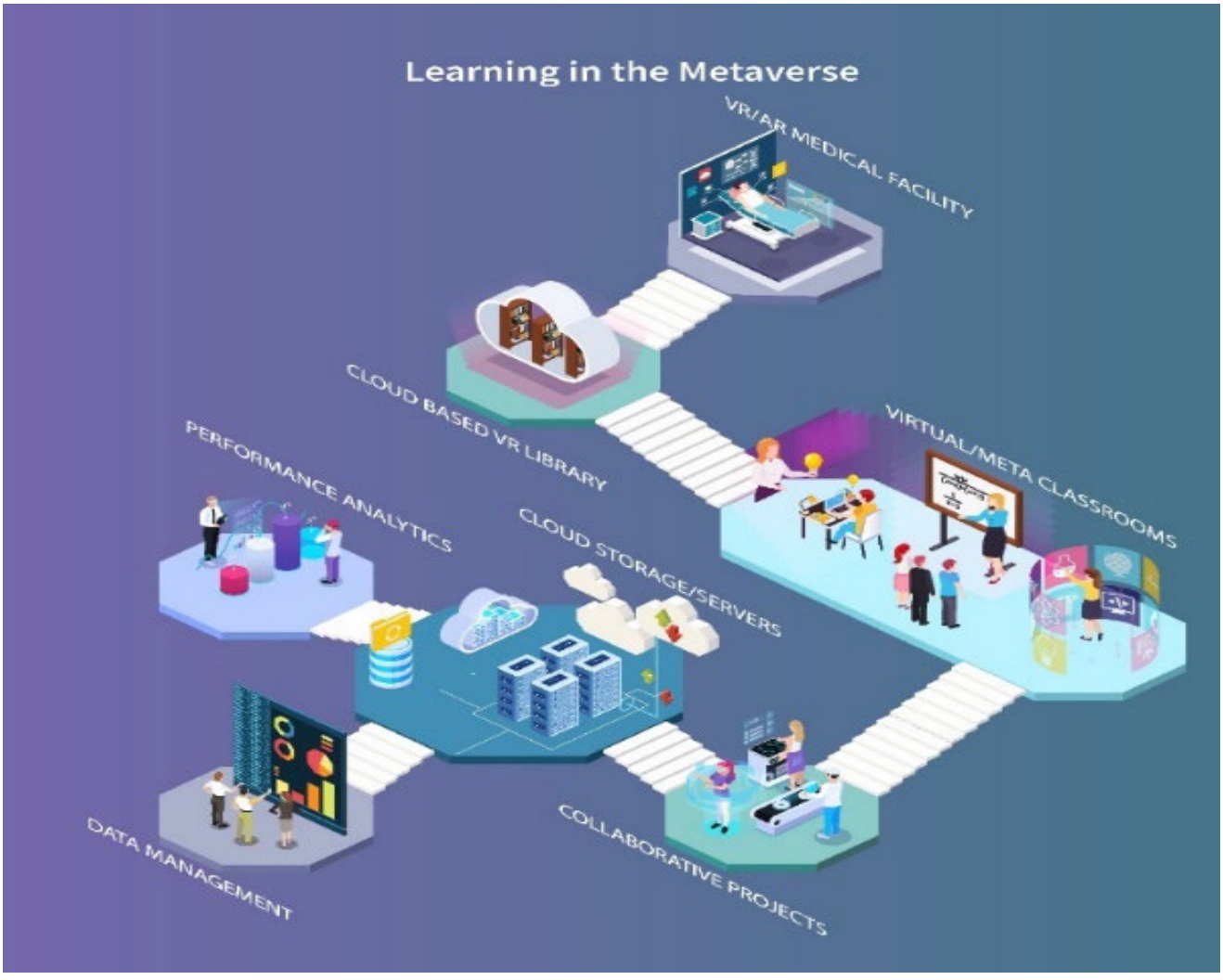

FIGURE 18. Metaverse technology in 2030 classroom.

taking notes. Figure 18 depicts a modern classroom design that allows for flexibility, allowing teachers to move freely and adjust to student needs. Key Elements of a Contemporary 21st Century Classroom Design are as follows:

TABLE 16. Literature study on explainable AI.

Reference	Objective of the Study	Limitation
[111]	This study proposed leukemia, especially Acute lymphocytic leukemia (ALL) and strategy recognized acute lymphoblastic leukemia as an automated procedure that is known as transferring the model.	Balancing and Improving the accuracy of deep learning (DL) system.
[112]	The proposed study is based on the interpretability of the prediction results using virtual learning environment (VLE) and Deep Explainable Artificial Intelligence (DXAI).	Further study is extended to the student's performance if the instructor intervention is imposed during teaching learning activities.
[113]	General review is done on capabilities of XAI tools and view point of researcher focused of AIED tool.	Try to formulate and upgrade of XAI tools in teaching or study materials.
[114]	Limitations, Applications, Opportunities are explained for Data Management Research.	Ordinary approaches may be converted into advanced XAI research tools.
[115]	eXplainable AI (XAI) is performed on practical examination data and taken multiple example.	Need to apply further tool during practical example technique.

TABLE 17. Literature study on exascale computing.

Reference	Objective of the Study	Limitation
[116]	In this research, a new model for process migration is presented by studying the reasons for dynamic and interactive requirements.	Limitation of migration technique in term of distributed exascale computing system.
[117]	It provided an overview of these activities as well as insight into key trends, advancements, and interesting research prospects in exascale computing.	Additional requirements are needed in research arena and these issues may be raised along with the applicability of exascale computing.
[118]	Through this study, software components may be broken up into pieces, known as "codelets" that can be dynamically scheduled in proposed system.	Not effective in high degree of parallelism.
[119]	They suggest a highly available distributed self-scheduler as a resource management system for the proposed middleware suite.	Distributed processing can be reduced, and the scheduler can be scalable in future work.
[120]	They proposed a hybrid NoC framework, combining buffered and bufferlessNoCs, to make the NoC framework aware of applications	No use of framework in existing classroom architecture.

- Encouraging peer learning among students to promote cooperation and active involvement.
- Transforming educators into engagement and learning facilitators
- Encouraging critical thinking while assisting pupils in analyzing and resolving issues in the actual world.
- Creating flexible, mobile learning environments that foster active involvement
- Using technology from the metaverse and virtual classrooms to improve learning experiences
- Utilizing cloud-based storage, collaborative projects, and libraries to create efficient tutorials and educational content

The findings basically elaborate on the learning outcomes and teaching satisfaction among the students, so these points are described:

- Learning Outcomes: Traditional Classroom: In traditional settings, factors like class size, teacher-student interaction, and the availability of resources all have an impact on learning outcomes. Standardized testing is a common assessment method.
- CLSR4 Classroom: CLSR4 environments often facilitate personalized learning experiences. The integration of AI, virtual labs, and adaptive learning platforms can cater to individual student needs, potentially leading to more customized and effective learning outcomes. Teacher Satisfaction: Traditional Classroom: Teachers in traditional classrooms may find satisfaction in the direct interaction with students but might face challenges in catering to diverse learning styles and adapting to technological advancements.CLSR4 Classroom: The introduction of advanced technology can enhance teaching methodologies, providing teachers with innovative tools and resources. However, there might be a learning curve and initial challenges in adapting to and managing these technologies.

VI. CONCLUSION

This study brings to light the transformative potential of merging Education 4.0 and Classroom 4.0 in our pursuit of reasonable, high-quality, and lifelong education, supporting the Global Agenda's Sustainable Development Goal 4. Digital technology is causing a dynamic shift in the modern classroom, and both the potential and the challenges are glaringly obvious. To find pertinent studies in this area, a thorough literature search using the keyword ''Education 4.0'' was conducted in this situation. The required filters were applied, and 41 articles were found and carefully examined. The next step is to do a complementary search using additional similar keywords in order to uncover research that did not explicitly include the ''Education 4.0'' term. The gaps in the literature are identified after the findings of these two searches have been analysed and interpreted. The investigation highlights the influence of various technologies on the current classroom framework. It presents its findings in two key aspects. Firstly, a comprehensive review of existing classroom practices uncovers their limitations. Secondly, it explores how emerging technologies like the metaverse can revolutionize smart education and online systems. This detailed analysis delves into crucial elements of classroom

architecture, encompassing the Internet of Things (IoT), machine learning, artificial intelligence, cloud computing, blockchain, digital twin, and exascale computing. Furthermore, it illustrates the practical implementation of these methodologies, offering viable solutions to issues related to student engagement and enthusiasm. This shift anticipates a future where contemporary classroom methods will be replaced by state-of-the-art, metaverse-driven educational institutions. The author's contribution is aligned with concepts such as education 4.0 and classroom 4.0, in addition to supporting sustainable development goal 4, which prioritizes ensuring quality education for future generations.

Conflicts of Interest: The authors declare no conflict of interest

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