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Research paper

Opportunities and Challenges of Using IoT (Internet of Things) in Education for Creating Sustainable Learning Environment among School Students

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Abstract

The use of IoT in educational settings has made room for novel concepts that will enhance the overall quality of the educational experience for both students and teachers. The Internet of Things (IoT) is the subject of research that is being done right now, and it is being used to build smart classrooms, laboratories, and even whole campuses. Research has been conducted on the effectiveness of IoT-based intelligent learning systems, and there is still a significant amount of information that has to be uncovered on the Internet of Things (IoT) in the classroom. Despite the many potential benefits that may be gained by using IoT in the classroom, there could be a cost to pay in terms of the loss of confidentiality and safety. Unique answers to each of these issues may become available soon. The Internet of Things, which will be constructed on a foundation that is unique to digital technology, has the potential to have a tremendous influence on how we will learn in the years to come. Students may simplify classroom duties such as taking notes, checking schedules, and doing research by using portable Internet of Things devices.

The most significant benefits for educational institutions would be a decrease in overall operating expenses and an increase in energy efficiency. The Internet of Things (IoT) is a network that is constantly growing to accommodate more "connected things" than ever before. The use of Internet of Things technology in academic institutions is analogous to entering a new, transformative phase. This new phase offers unique options for upgrading educational facilities as well as the teaching and learning process. This study investigates the Internet of Things (IoT) and the many applications that it may have in the educational setting. In addition to this, it intends to explore the present state of research, the challenges that have been experienced, as well as the possible future implications of the Internet of Things on educational institutions.

Keywords: *Internet of Things (IoT); Education; Chi-Square Analysis.*

1. Introduction

The idea that different devices and things may be connected has made it feasible to use "Smart" technology in any setting. When several devices are connected through a network, such devices may share information and collaborate to make more informed decisions. The concept is referred to as the "Internet of Things," which is a term that describes the concept. Mark Weiser believes that the most successful ideas are the ones that are ultimately forgotten about. They become unrecognisable from everyday life because of their seamless integration into everyday activities. Kevin Ashton was the one who first introduced the phrase "Internet of Things" in 1999. He was also the one who came up with the term. Since its inception, academics have been attempting to define what the Internet of Things, or IoT for short, is all about by labelling it everything from the Internet of Anything to the Internet of People to the Internet of Signs to the Internet of Services to the Internet of Data to the Internet of Processes. According to the findings of some researchers, the Internet of Things (IoT) might be "anything at all, depending on requirements." When Cisco talks about the "Internet of Things," what they mean specifically is "connected devices." Cisco treats both physical and digital objects with the same degree of importance when defining the Internet of Everything. According to Cisco, "the Internet of Everything (IoE) brings together people, processes, data, and things to make networked connections more relevant and valuable than ever before, transforming information into actions that generate new capabilities, richer experiences, and unprecedented economic opportunities for businesses, individuals, and nations." (Internet of Everything (IoE) brings together people, processes, data, and things).

Many different types of devices may be connected over the IoT network, including laptops, tablets, smartphones, personal digital assistants (PDAs), and other embedded portable devices. Other examples include wearable biochips for farm animals or pets, robots, autonomous automobiles, domestic appliances, and devices that detect heart rate and blood pressure. These are only some of the possibilities. These devices make use of a wide variety of sensors and other information-gathering technologies to collect meaningful information, which is then sent to central computers for analysis and decision-making.

Internet of Things-enabled "Smart Classrooms" Students' ability to interact and learn from one another has been significantly boosted by the introduction of technology into the classroom. There has been a significant amount of change brought about by the Internet of Things in schools. The Internet of Things has not only changed the method that lessons are delivered but also the way that schools are organised physically. Because the phrase "Internet of Things in Education" may refer to both a technical tool that is used to enhance educational infrastructure and a topic and course that is used to teach fundamental ideas in computer science, it is sometimes regarded as having two distinct meanings. The phrase "Internet of Things in Education" refers to both a subject or course that is used to teach fundamental concepts in computer science.

There is no question that the Internet of Things is advantageous to education on all levels, from primary school all the way up to graduate school. Students, instructors, individual classes, and even whole campuses might all stand to profit from the use of this technology. One such method for gaining insight into the impact that the Internet of Things has had on the educational system is to make use of sensors. The Twine7 product offered by Super Mechanical is a little box that has been marketed as "the simplest way to connect stuff to the Internet." This box gives consumers the ability to connect almost any physical device to a local area network. Installation can be made much simpler using Twine since it connects sensors to a web-based platform. When you connect Twine to your home's WiFi network, the Twine web app will automatically discover the sensors and display the values they provide in real time after it has done so.

Anyone with even a little amount of skill in programming should be able to use it since it sends out updates by text message and email on the detected things and surroundings. The Internet of Things is used as a research and teaching tool in the academic world. Academics contend that the Internet of objects (IoT) may increase communication between humans (students and teachers) and non-humans (physical and digital objects) if it were included in educational settings as a new actor. There are several potential pedagogical options available, one of which is to introduce students to fundamental concepts in computer science by leveraging the Internet of Things. The Open University in the United Kingdom established a new course for undergraduate computer science students called My Digital Life that is focused on concepts related to the Internet of Things (IoT) after realising that IoT is a subject that is now being actively researched. Students can use the Internet of Things as a tool to learn about and evaluate their immediate surroundings, as well as their location within those settings, with the assistance of My Digital Life, which interactively trains students in the English language via the use of the Internet of Things. This technology, which uses voice and visual sensors to help learners of English improve their pronunciation and oral structure, may be beneficial to students of the English language. Students are also introduced to programming languages based on the Internet of Things. Annotated objects and a learning management system (also known as an LMS) may be used to assist in the process of data gathering and analysis of the various learning strategies used by students.

The following are some of the current initiatives that are making use of the Internet of Things to make schools and the lives of educators better. A determined effort was made by the University of Padova to embrace and implement Internet of Things technologies. The primary objectives of their research were to first create a structure for a Web Service Model for Wireless Sensor Networks and then use a case study to determine whether this model was viable. The Department of Information Engineering at the University of Padova was the one that ultimately put these services into operation. The study investigates the ways in which cloud computing and the Internet of Things may be used to manage course materials and provides a framework for doing so. Another piece of study investigates how modern e-learning is impacted by technological developments such as the Internet of Things, Cloud Computing, Data Mining, and Triple-Play. The research differentiates between smart campuses and digital campuses by defining smart campuses as those that use IoT and cloud computing and describing the distinctions between the two types of campuses. Now available to educational institutions is a single architectural paradigm for the development of Internet of Things solutions.

2. Review of literature

Mark Weiser forecasts that in the not-too-distant future, everyone will be able to do their day-to-day responsibilities with ease. This will be made possible by technological advancements such as enhanced controls and technology that is simple to use. A smart environment may include intelligent structures such as places of employment, private residences, and public institutions. The goal of creating smart environments based on the Internet of Things is to make routine tasks easier to do. For example, if we are driving somewhere, we could want to change the station on the car radio or check up on the latest traffic reports so that we can choose the most direct route. The use of one's voice is all that is required to get access to this data, thanks to the existence of sensors, actuators, and other forms of intelligent technology. A few examples of the various concrete features that may be found on any given campus are windows, doors, projectors, printers, classrooms, laboratories, parking lots, buildings, and more. These common items may be transformed into "Smart objects" by incorporating Internet of Things technology, which may include RFID, NFC, QR tags, and other similar components.

A school that equips its classrooms with technological resources that are up to date is referred to as having "smart classrooms," and the phrase "smart classroom" is used to characterise such an institution. These "smart" devices may include built-in cameras, microphones, and other sensors that may be used to gather data on a range of aspects linked to the learning settings of students. The useful item makes the administration of the course much simpler and more expedient. There is a possibility that the Internet of Things (IoT) might make both the teaching and learning processes in the classroom much more effective.

The method that a teacher takes towards the arrangement and administration of a classroom is often referred to as the "classroom management" approach. When students seem disengaged or preoccupied, instructors might use smart devices to give themselves the option of speaking out to the class. Because they provide a novel approach to both teaching and the administration of classrooms, educational institutions located all over the world are progressively embracing the use of Internet of Things (IoT) devices in the classroom. These objects are currently participating in an active. It is a time-consuming process to take attendance during a presentation or a lecture. Utilising the Internet of Things may help users save both time and energy. A smart classroom registration caller system (SCRCS) that is built on the architecture of the Internet of Things has been proposed to efficiently and accurately record student attendance at the end of each session. RFID chips are included in the student ID cards that are being issued. Every classroom is allowed to have access to the SCRCS, which has the capability of reading the entire student ID cards at once. At the beginning of each session, the total number of students and a display of their identity cards are shown on an LED board simultaneously in each of the SCRCS sites. The academic office not only records but also keeps track of each student's attendance. A further piece of research proposed installing NFC technology on mobile devices that run Android to power a web-based attendance system. The attendance of a student may be promptly recorded on the server by using an NFC-enabled Android smartphone to connect the student's matriculation card to the phone. Checking attendance using a mobile device is a possibility for both students and instructors.

According to a well-known proverb, "the college building (or campus) is the lab." This kind of thinking is often linked to the Living Labs movement, which may trace its roots all the way back to the European Union. Recent research has brought together a wide range of topics, including but not limited to: Pervasive Interactive Programming (PiP), the Internet of Things (IoT), the i-campus, living labs, and smart device design. The primary objective of the study was to develop an approach to instructing novice programmers in the foundations of programming by using a combination of IoT and PiP. The PiP assessment was completed by a total of eighteen individuals, including both teaching staff and students. According to the results of the evaluation, PiP assisted participants of diverse ages and educational backgrounds in better comprehending and applying the fundamentals of programming.

Researchers conducted a study in which they offered a lab development kit for wireless communication in the laboratory. This kit included Zigbee-enabled sensors as well as Raspberry Pi and Arduino boards. The module design methodology was used in the creation of the educational modules as well as the associated study aids. An investigation into the efficiency of the Raspberry Pi-based laboratory gear was carried out in the form of a survey. The findings demonstrated that the students provided insightful commentary. According to the authors of the study, the use of online virtual laboratories may provide schools with an advantage over their rivals in terms of both the quality of their education and their students' access to it. In this example, they read and displayed data from a temperature sensor by integrating the Internet of Things (IoT) and the Arduino Platform with the Xively web service.

Since data is stored on a network of Internet-connected devices in an IoT-based environment, the students' personal information and right to privacy may be put in jeopardy. If there is a breach in security, personally identifiable information about students, such as their medical history or their current financial situation, may be made public. If the firm utilises a wide range of devices and software that are not compatible with one another, it may be challenging for the organisation to set up an Internet of Things configuration that is dependable and user-friendly. Prerequisites for effective Internet of Things application in the classroom include an institution's existing IT infrastructure as well as teaching practices that can support students' use of IoT devices. Exploring and experimenting with Internet of Things solutions may be beneficial to educational institutions, despite the risks and challenges that are associated with the introduction of any new technology.

Although early insights of Mark Weiser and Cisco help offer insights on what IoT means, its implications on education still must be further explored. In the field of education, Weiser's views of ubiquitous computing focus on a seamless integration, but in the case of education, issues of hidden infrastructures that can exert an influence on the teacher's autonomy have to be considered. Cisco Internet of Everything builds upon IoT to a networked construct of individuals, procedures, and information, which implies that there is a higher potential for collaborative learning. But these frameworks also suggest gaps: there are not many studies that query the consequences of definition choice on pedagogies or accessibility. The critical synthesis reveals that although IoT has the promise of efficiency, it will contribute to the strengthening of systemic disparities if the implementation does not consider the context-specific needs of education.

2.1. Literature synthesis

Author/Year	Focus Area	Key Insights	Relevance to This Study
Weiser (1991) [1]	Foundational concept of ubiquitous computing	Introduced the vision of pervasive computing	Basis for IoT-driven educational environments
Oriwoh & Conrad (2015) [3]	Defining IoT	Clarified boundaries of “things” in IoT	Frames educational devices in IoT ecosystems
Al-Fuqaha et al. (2015) [7]	Survey on IoT technologies	Reviewed enabling protocols and applications	Provides technical foundations for IoT in schools
Stankovic (2014) [8]	IoT research directions	Identified security, scalability, and data management	Informs the challenges section of educational IoT
Chen et al. (2014) [9]	IoT in China	Explored applications, opportunities, and risks	Shows the global context of adoption challenges
Mohanapriya (2016) [12]	IoT-enabled smart campus	Proposed i-Campus for e-learning	Example of campus-level sustainable education
Marquez et al. (2016) [14]	IoT in academic communities	Integration of IoT into virtual classrooms	Evidence of collaborative learning benefits
Chin & Callaghan (2013) [15]	Educational living labs	IoT-based labs for experimentation	Demonstrates active learning innovation
Cheng & Liao (2012) [17]	Lifelong learning via IoT	Linked IoT to analytics for continuous education	Expands impact beyond formal classrooms
Nie (2013) [20]	Smart campus via cloud + IoT	Combined platforms for management	Practical model for smart school systems
Barakat (2016) [4]	IoE in education	Discussed connected processes and data	Reinforces holistic educational ecosystem
Zeeshan et al. (2022, 2023) [24,33]	Sustainable smart education	IoT enables equity, accessibility, and sustainability	Directly supports the sustainability framework
Al-Taai et al. (2023) [25]	The importance of IoT in education importance	Identified IoT as a critical modern pedagogy tool	Empirical validation of IoT necessity
Badshah et al. (2023) [27]	IoT for smart education	Surveyed opportunities and risks	Synthesizes key challenges for adoption
Rakić (2023) [32]	IoT opportunities and challenges	Balanced analysis for teaching institutions	Aligns with challenge-focused objective
Kamruzzaman et al. (2023) [35]	IoT & AI for pandemic education	Supported resilient, sustainable education	Connects IoT to crisis-driven adaptation
Sultana & Tamanna (2022) [31]	IoT in pandemic (Bangladesh)	Benefits and barriers during COVID-19	Shows developing nation challenges
Khan (2021) [36]	IoT in healthcare	Addressed security and application issues	Parallels in privacy concerns for schools

Abiodun et al. (2021) [29]	IoT security challenges	Reviewed vulnerabilities and solutions	Supports privacy/security limitation analysis
Mishra & Pandya (2021) [30]	IoT intrusion detection	Summarized security threats	Extends data protection discussion for schools
Sadeeq et al. (2021) [34]	IoT & Cloud computing	Reviewed integration challenges	Adds perspective on interoperability
Wang et al. (2021) [28]	IoT adoption in China	Barriers: infrastructure, regulation	Mirrors the school system adoption issues
Hanaysha & Alzoubi (2022) [37]	IoT in supply chains	Benefits vs. adoption barriers	Parallel framework for organizational readiness
Shoomal et al. (2024) [26]	IoT in supply chain resilience	Identified efficiency and risks	Comparable insights for education scalability
Musa et al. (2023) [38]	IoT in smart traffic	Challenges in sustainability	Extends interdisciplinary link to urban systems
Adekanbi (2021) [39]	IoT in energy	Digitization of wind farms	Parallel energy efficiency in smart schools
Kumar et al. (2023) [40]	Healthcare IoT	Trends and challenges in H-IoT	Similarities in privacy and scalability issues

2.2. Challenges

In addition to the privacy and security threats, technical and organizational obstacles exist to the adoption of IoT in schools. The ability to grow is also a limiting factor when networks are expanding; bandwidth restrictions may upset real-time feedback systems. Even their compatibility with each other across devices and platforms necessitates upgrades that are expensive and become a burden to institutions. One more factor is teacher readiness; unless structured training is provided, teachers are likely to underutilize IoT tools, which decreases their effectiveness. The multi-tiered nature of these challenges depicts that IoT implementation is beyond a purely technical problem, and only systematic investments in infrastructure, professional growth, and long-haul maintenance plans will succeed. These dimensions can be addressed to avoid an imbalance of adoption among institutions.

3. Methodology

The primary objective of this study is to examine the benefits and drawbacks of using IoT in educational settings to provide a learning environment for students that is more sustainable over time. Now that teachers have access to increasingly interactive digital technology like smart whiteboards, augmented reality, and virtual reality, they can provide their students with richer and more engaging learning environments in the classroom. These technologies make it possible to gather and analyse data flexibly, both within and outside of the classroom. They might improve both their own teaching and the outcomes of the learning of their pupils by analysing a range of data to determine the areas in which they are lacking. They might also use this information to tailor the lectures to the specific requirements of each learner. Students who use digital notebooks, on the other hand, have quick access to a library of knowledge that is continually updated to satisfy any new requirements that may come up throughout the course of their studies. This solution might potentially be beneficial to both families economically as well as environmentally.

The current study is based on a convenience sample that includes 138 teachers, which marks a starting point on the topic but fails to allow generalization. External validity using a more representative design would be enhanced by a more representative design, e.g., stratified sampling by rural, urban, and semi-urban schools. In addition, there are no specifications on the design of questionnaires. Question-wording and scale design, and reliability coefficients like Cronbach's alpha, should be reported in future versions to determine the internal consistency. Increased transparency in reporting the instrument would enhance reproducibility as well as enable the readers to make critical judgments on the validity of the results.

A structured questionnaire comprised of closed-ended and Likert scale questions was used as an instrument because it supported the research objectives. They organized into four dimensions, namely, classroom delivery, real-time feedback, management support, and investment to guarantee content validity. Likert scales were used, whereby disagreement was rated on a scale of strongly to strongly agree (1-5), so that perceptions could be measured regularly. Inasmuch as convenience sampling was employed in seeking the perception of 138 teachers, this limits the possibility of generalizability. Future studies should consider stratified random sampling of rural and urban acr-urban-semi-urban schools so that external validity can be enhanced and more representative ideas about the opportunities and challenges of IoT in education can be obtained.

4. Research Objectives

The main aim of the study is to explore the opportunities and challenges of using IoT in education for creating a sustainable learning environment among school students

5. Research Hypothesis

- There is no significant difference between better classroom delivery and creating a sustainable learning environment among school students
- There is no significant difference between real-time feedback to students and creating a sustainable learning environment among school students
- There is no significant difference between the support of the management and the creation of a sustainable learning environment among school students
- There is no significant difference between the investment required and creating a sustainable learning environment among school students

6. Data Analysis

This section is mainly involved in performing detailed analysis through percentage analysis, correlation analysis, and the Chi-square test

6.1. Frequency analysis

Table 1: Frequency Analysis

Gender composition	Frequency	Percent
Male	83	60.1
Female	55	39.9
Age composition	Frequency	Percent
Less than 30 years	37	26.8
31 - 40 years	52	37.7
41 - 50 years	18	13
Above 50 years	31	22.5
City	Frequency	Percent
Living in Metro City	90	65.2
Living in a Metro City	48	34.8
Designation	Frequency	Percent
Trained Graduate Teacher	59	42.8
Post Graduate Teacher	70	50.7
Head Master / Mistress	9	6.5
Experience	Frequency	Percent
Less than 5 years of experience	35	25.4
5 - 10 years	36	26.1
10 - 15 years	26	18.8
15 - 20 years	9	6.5
Above 20 years	32	23.2
Total	138	100

From the analysis, it is noted that 60.1% of the respondents are male, 37.7% are in the age group between 31 - 40 years, 65.2% live in Metro City, 50.7% are Post Graduate Teachers, 26.1% have experience between 5 - 10 years

6.2. Correlation analysis

The analysis further focuses on understanding the nature of the relationship between independent variables: Better classroom delivery, Real feedback, Support of management, and High investment, and dependent variable: Sustainable learning environment.

Table 2: Correlation Analysis

Karl Pearson's Correlation	Better classroom delivery	Real-time feedback	Support of management	High investment	Sustainable learning environment
Better classroom delivery	1	.899**	.848**	.871**	.839**
Real-time feedback	.899**	1	.857**	.871**	.850**
Support of management	.848**	.857**	1	.850**	.770**
High investment	.871**	.871**	.850**	1	.811**
Sustainable learning environment	.839**	.850**	.770**	.811**	1

Based on correlation analysis, it is noted that the correlation coefficient between better classroom delivery and sustainable learning environment is +0.839, also the correlation between Real time feedback and Sustainable learning environment is +0.850, furthermore, Support of management and Sustainable learning environment possess a correlation of +0.770, and lastly, the coefficient of correlation is at +0.811 between High investment and Sustainable learning environment.

6.3. Test of hypothesis

The last part of the section involves verifying the hypothesis using chi-square analysis.
Null: There is no significant difference between better classroom delivery and creating a sustainable learning environment among school students.

Table 3: Chi-Square Analysis of Better Classroom Delivery

Better classroom delivery	Value	df	P Val
Pearson Chi-Square	210.263a	16	0.00
Likelihood Ratio	164.698	16	0.00
Linear-by-Linear Association	96.443	1	0.00

Based on the above table, it is noted that the p-value is 0.00, which is less than 0.05; therefore null hypothesis is rejected and alternate hypothesis is accepted. Therefore, there is a significant difference between better classroom delivery and creating a sustainable learning environment among school students.
Null: There is no significant difference between real-time feedback to students and creating a sustainable learning environment among school students.

Table 4: Chi-Square Analysis of Real-Time Feedback

Real-time feedback	Value	df	P Val
Pearson Chi-Square	216.879a	16	0.00
Likelihood Ratio	163.808	16	0.00
Linear-by-Linear Association	99.054	1	0.00

Based on the above table, it is noted that the p-value is 0.00, which is less than 0.05; therefore null hypothesis is rejected and alternate hypothesis is accepted. Therefore, there is a significant difference between better classroom delivery and creating a sustainable learning environment among school students.

Null: There is no significant difference between the support of the management and the creation of a sustainable learning environment among school students

Table 5: Chi-Square Analysis of Support of Management

Support of management	Value	df	P Val
Pearson Chi-Square	187.103a	16	0.00
Likelihood Ratio	147.039	16	0.00
Linear-by-Linear Association	81.282	1	0.00

Based on the above table, it is noted that the p-value is 0.00, which is less than 0.05; therefore null hypothesis is rejected and alternate hypothesis is accepted. Therefore, there is a significant difference between the support of the management and the creation of a sustainable learning environment among school students.

Null: There is no significant difference between the investment required for creating a sustainable learning environment among school students

Table 5: Chi-Square Analysis of High Investment

High Investment	Value	df	P Val
Pearson Chi-Square	206.674a	16	0.00
Likelihood Ratio	164.098	16	0.00
Linear-by-Linear Association	90.141	1	0.00

Based on the above table, it is noted that the p-value is 0.00, which is less than 0.05; therefore null hypothesis is rejected and alternate hypothesis is accepted. Therefore, there is a significant difference between the investment required and creating a sustainable learning environment among school students.

7. Discussion

IoT in education overlaps with even more interdisciplinary areas that must be studied more carefully. IoT and smart classrooms have the potential to optimize energy consumption by automating air conditioning and lighting in schools, hence school energy costs might be cut by 20 percent.

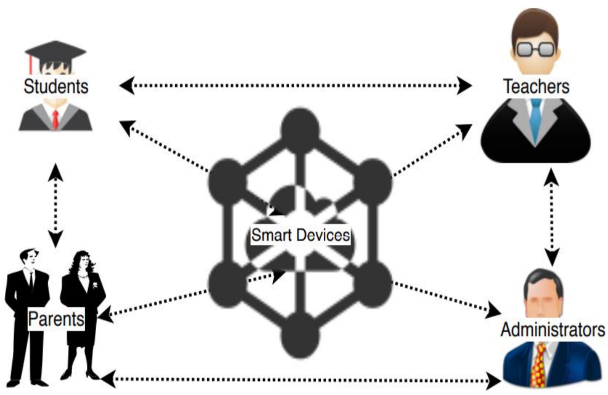

Fig. 1: IoT in Education System.

(Source: [41]).

In health sciences, sensors can observe the well-being of students, e.g., with wearable IoT measurements that monitor stress levels or other posture-related health anxiety issues, which can guide prompt interventions. By combining these interdisciplinary views, IoT can be utilized as a method, beyond pedagogical utility, of providing sustainable infrastructure and whole-person student development. These associations open new horizons for the applicability of IoT studies, beyond the sphere of educational technology.

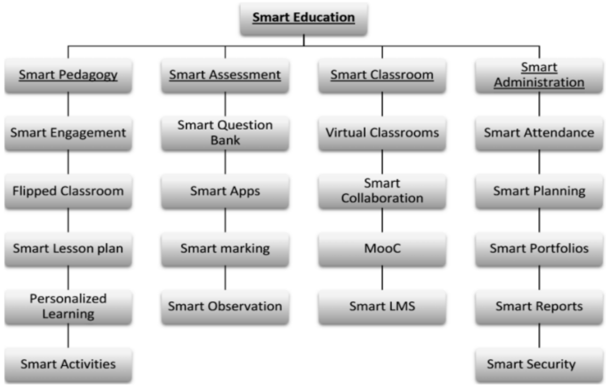

Fig. 2: Classification of IoT-Based Smart Education.

(Source: [41]).

As seen in terms of correlation results, real-time feedback has the most substantial relationship with the establishment of sustainable learning conditions, and it is one of the central solutions in promoting engagement among students and adaptive learning. This implies that fast, tech-aided interventions can enable teachers to close the learning gap within a matter of time, thus raising the level of academic achievement and efficiency in teaching. Similarly, robust associations were found between classroom delivery (+0.839) and investment (+0.811), underlining the overall significance of the quality of instruction and institutional support. These results are confirmed through the chi-square analysis, with significant differences identified regarding differential variables. These revelations validate that the application of IoT is effective in encouraging schools to be responsive to teaching, resource allocation, and sustainability in the long run.

7.1. Scientific insight and implications

The results that classroom delivery, real-time feedback, management support, and investment all predict sustainable learning environments effectively should be grounded as part of a larger framework of pedagogical theories. The IoT fits into the constructivist learning given that it facilitates interaction, student-centered learning, and differentiated instruction due to adaptive feedback procedures. On the sustainability front, smart systems powered by IoT can impact and support the United Nations Sustainable Development Goals through decreased energy usage in schools and equal chances of access to quality education. Relating such results to existing educational systems proves IoT not only as an additional technology component, but also as a facilitator of innovative instructional processes and long-term institutional viability.

8. Discussion and Future Directions

Future studies ought to go beyond pragmatic implications to explore more profound systemic effects. Longitudinal research can be used to determine the effects of long-term usage of IoT on the performance, retention rates, and learning equity in different settings. Particular attention must be paid to inclusive education, including IoT-based assistive technologies to provide access to students with disabilities. Closure to the likelihood of successful adoption may be offered to institutions by the cost-benefit analysis, whereas the comparative study of rural and urban schools may reveal the differences in the preparedness of infrastructure. To the extent that these focused questions will be posed, future studies will develop evidence-based initiatives that can take advantage of the potential of IoT in promoting educational excellence, as well as institutional resilience.

9. Conclusion

In the long run, the Internet of Things will make classroom education and student growth more effective. Both students and teachers will find the Internet of Things (IoT) to be a helpful tool in their daily lives. It will be simpler for teachers to carry out their duties, and students will pick up more information as a result. It is anticipated that the Internet of Things (IoT) would enhance education by facilitating the development of a system that is more visually appealing, versatile, interactive, and quantifiable, hence catering to the requirements of a larger number of students.

Though it could be said that teacher perceptions seem to lean to a positive side, the statements about the transformations carried out by IoT to make education universally more effective should be qualified. There is some evidence that it may be beneficial, but it is only effective in context: through institutional support, teacher training, and quality of infrastructure. Some examples of the case study include a decrease in administrative workload by 30 percent in some schools because of intelligent attendance systems, whereas in others, the intelligent attendance systems cause problems because of an unreliable connection. These examples draw attention to opportunities and constraints, which secures the fact that the impact of IoT is situational but not absolute. An empirical basis of results and case-based evidence should also be fixed to developments in the future.

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