Application of IoT in the Development of Intelligent Education System – A Thematic Literature Review

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ABSTRACT

Smart Education System makes efficient use of IT technology that takes advantage of IoT and cloud computing technologies to track and act on multiple educational system components. To maximize the battery life of IoT nodes, the systems need to provide access to nodes and gateways by that introduce an architecture that allows not only the latest wireless and wired technologies to provide a fair communication range but also reduced energy usage. Like other sectors integrating intelligent cultures, the education sector is no exception to this. The IoT confirms its important role in the field of Information and Communication Technology and social growth. More devices are linked in education; campus leaders will be able to derive even more value from the continuous stream of data and knowledge, helping them transition from a transactional relationship to an iterative process with students, teachers, administrators, and providers. A small, person-centered environment helps smart campuses to complement and fit with the overall smart environment strategy, allowing educational institutions to achieve full productivity, promote sustainability, and enhance their constituents' everyday conditions. This analysis of the literature is generated using the secondary data obtained by reviewing a good number of papers published in journals and online sources. The study aims to explain IoT's use in the growth of the Smart Education System. The limitation of the study is that it deals only with the subject matter's application components which leave physical components.

Keywords: Intelligent Education, IoT, Smart Education, Cloud Computing, Smart Campus, Senor, Actuator, teaching-learning.

1. INTRODUCTION :

IoT has the potential to add tremendous value to institutions of higher learning. Educational Institutions have great opportunities to benefit from IoT systems. Students may be given smart cards with IOTs. Students can obtain access to the grounds, laboratories, classrooms, libraries, etc. by using these smart cards. When a student enters the campus, he will receive reminders about the availability of reserved books in the library, his/her daytime schedules, etc. Students can get the custom schedule and venue of his classroom in a choice-based program as soon as he enters the campus (Mrabet&Moussa2017) [1]. A student can have great freedom to pick up his or her subjects or documents. This could be used by a biometric attendance program to track student attendance. It could later be linked to scholarships, mobile phones for parents, etc. Student wellbeing and hostel inmates may be tracked via the adoption of fitness apps. Automatic monitoring of temperatures may be done in laboratories and laboratory equipment. You could do interactive projectors, touch screens, automatic reading capture (Satu *et al.* 2019) [2]. You can attach touch boards to the internet, where you can download the stuff you need directly to the board. It allows staff and students to connect themselves with worldwide educational tools resulting in robust & hybrid learning environments. The database of the

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research submitted by the student could be preserved and evaluated to give students personalized advice (Pervez *et al.* 2018) [3]. If the conduct of the students after review shows that they are failing academically or socially, custom warnings can be provided so that administrators can respond quickly to fix issues. Profiles of students may be built up throughout their association with campus to assist them with work activities. Smart apps will alert workers and suppliers when to service equipment before it even presents itself with a problem. Smart doors, locks, and cameras can be used in different facilities to track and regulate movement. Customized learning could easily be done at one's speed and intellectual capacity (Mahmood *et al.* 2019) [4]. Prepaid canteen services may be offered with the help of smart cards. The IoT also lets administrators link all on campus, via a single stable, centralized network anywhere to control campus lighting, parking, and cameras, and provide useful data and analytics for resource optimization (Huda & Arwa 2018) [5]. The system is not free from challenges. A notable a few are: Big data development may be a bigger threat, because more computers, vehicles, homes, and other objects would be connected to the internet in the future. Many networking standards for both wired and wireless devices have yet to be developed to allow communication between different devices. Information protection and privacy could pose a greater danger because all data is stored in databases and access to sensitive and essential data can be easily accessed. High speed wideband shall be made available everywhere. Energy is also important, as many IoT systems take years to operate (Kavitha & Lakshmi 2016) [6]. This analysis of the literature is generated using the secondary data obtained by reviewing a good number of papers published in journals and online sources. The paper throws light on (i) IoT based Smart Environment, (ii) IoT Applications in the Education Industry, (iii) IoT in Education, (iv) How education industry is using IoT to its benefit, (v) Advantages of IoT Solutions for the Education Domain, (vi) Support directives for an Intelligent Environment, (vii) Important aspects for effective implementation of IoT in education, (viii) Summary of Literature Review, (ix) Future of the IoT in Education,(x) Research Gap, (xi) Research Agenda, and (xii) Conclusion.

2. BACKGROUND AND MOTIVATION :

Work is essential to the future gain and the effect of the IoT evolution principle is same in both learning environments - physical &virtual. It is important to examine the use of the IoT in the later and e-learning programs within an intelligent campus. Besides, the usage of the smart city model is evident where improved accessibility and interoperability improves the services offered to residents. Increased connectivity and device smartness will improve the value-added and smartness of the educational system to provide services to the learner. New applications are emerging day after day in the light of recent research in this field. The targeting of users interested in using the technology for education is common to the applications, as these users are by definition digital natives. But it is for educational purposes to explore and build upon the latest paradigm. Regardless of the paradigm's features, the user should be able to access just-in-time information on a network of devices capable of holding machine-to-machine (M2M) communications with each other and other consumer devices (such as smartwatch or smartphone). This research tries to discover details of these interactions in scenarios that relate to the smart physical campus. The use of IoT to improve the educational experience for students, faculty members, and other team members provide possible new learning opportunities and scenarios. The limitation of the study is that it deals only with the subject matter's application components which leave physical components (Elsaadany & Soliman 2017) [7].

3. RESEARCH AIM AND METHOD :

This qualitative analysis, based on the business model of education. The main aim of this work is to gain an understanding of the situations that require the introduction of IoT in education, the benefits of this integration, and the difficulties in such an environment. Furthermore, this study is intended to provide a context for promoting new research activities on this subject. To fulfill its aim, this research formulated the following

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questions:
- RQ1: How has IoT Applications influenced Smart and Intelligent Education System development?
- RQ2: What are the technological and architectural criteria for the Smart and Intelligent Education System?

Five sub-research questions arose to encourage the answer to the first question with the limit of scenarios discussed:
- RQ1.1. What level(s) of education is presented?
- RQ1.2. What subject(s) of education is discussed?
- RQ1.3. What perspective(s) was presented, for example, by the teacher, student, and staff?
- RQ1.4. What learning concepts are addressed?
- RQ1.5. What educational environments are dealt with?

The emphasis of this paper is above research questions, and we also pose several research gaps concerns that we address in Section 4.9 based on the discussion.

4. LITERATURE REVIEW :

Educational institutions have continually adopted technology as this may be one of the most important factors for improving learning outcomes. More than just hiring a teacher, submitting a library, or studying in the field, IoT has also found that consumers are interested in education, such as flipped classrooms, Virtual Reality and Augmented Reality enabled smart boards or accessing safe learning spaces (Abbasy & Quesada 2017) [8]. In terms of education, IoT is dignified to play the role of a big game-changer as this technology is now utilized by many educational institutions. Along with that, connected smart devices are used by many institutions for supporting the even now available e-learning and smartboard infrastructure. Some reasons are mentioned below:

- As cloud service is easily available and also affordable, it plays a key role to increase the popularity of IoT-enabled devices.

- Unlimited storage with pay as the user makes it easier or cheaper to store, analyze, and access the data.
- A highly customized application has been created to meet the needs of the educational institution.
- IoT technology has the power of making life easier for each stakeholder, including students, educators, management, and parents (Zhamanov *et al.* 2018) [9].

Applications of IoT are designed for the almost all facets of the field of the education, such as

- A solution for educators that facilitates stakeholder interaction
- Application management solution for feasibility and cost optimization
- Classroom management solutions for improving education

4.1 IoT BASED SMART ENVIRONMENT

Mark Weiser's theory of smart environments tells us that there should be smart tools and smart environments everywhere ready for us to perform daily tasks. Smart environments may include smart houses, smart workplaces, smart classrooms, and other intelligent areas. The primary aim of smart environments based on IoT is to offer ease in the daily routine tasks. Through using sensors, actuators, and smart devices, all this information can only be accessed from one's voice.
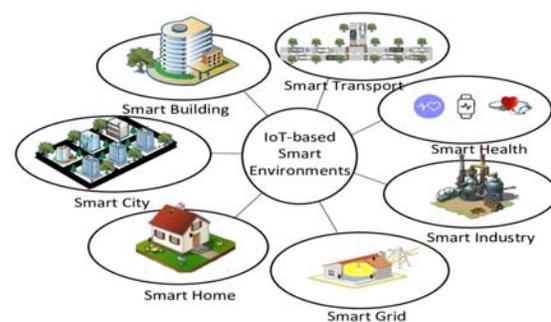

Fig. 1: IoT based smart environment (Ahmed *et. al* 2016) [10].

In the Smart world, three primary goals are understanding, reasoning, and prediction. In other words, creative environments need to know and appreciate how the world functions and thinks, and they need to be able to respond to the action or circumstance. An intelligent environment can

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be described "as one that can acquire and apply information about the world and its inhabitants to enhance their experience in this area" (Gul *et al.* 2017) [11].

4.2 IoT APPLICATIONS IN THE EDUCATION INDUSTRY :

IoT may help to make education more geographically available, capabilities, and status. The opportunities to integrate IoT-enabled solutions to the school environment are endless. These serve as the strong base on which to make a wide understanding of its the application in education. Further, technology can improve teaching rather than hiring new staff. Some teachers and students need technical support to showcase their teaching talent. IoT Solutions for Education understands this and provides solutions that improve the quality of education worldwide. The opportunities once enjoyed by healthy students were now evenly distributed among students with disabilities. Simplified expressions of complex formulas, ideas, and theories are now a clear possibility (Basset *et al.* 2019) [12]. Learning in the classroom has become fun, interesting, and interactive. Indeed, IoT devices have been able to balance a significant amount of modern education to fully promote global society. It has never been accessible and interactive in education. IoT in education is essentially the future of scholars. With IoT, instructors have easy access to powerful teaching tools. Teachers can use IoT to provide student-specific one-on-one instruction to each student with a specific educational design. For example, it uses data to determine the most effective supplement for each student and automatically generates content from the student's on-demand lesson content (Xue *et al.* 2011) [13]. Application of technology in the education spectrum improves the professional development of scholars because they understand that they truly work and learn to create better strategies, as well as repeating old or invalid practices. IoT also enhances the knowledge base used to implement standards and practices in education. Educational research is suffering from accuracy problems and a general lack of data. IoT is a massive, high-quality, real-world dataset

focused on teaching design (Zhong *et al.* 2017) [14]. It is derived from the unique ability of IoT to collect a large amount of strange information everywhere. Also, IoT helps each student learn adaptation by giving them access to their needs. Every student can monitor his or her experience and participate in the design of instructions. Many are done passively. Students simply use the system, and the performance data essentially shapes the design. This offers highly effective education, thus reducing the costs of planning and adapting education (Ahlmeyer & Chircu 2016) [15].

Smart Classroom

Classrooms fitted with IoT tools can be used to track and evaluate the students' performance and effectiveness. IoT devices will monitor students' attendance automatically. Teachers and educators are now required to remotely administer tests and assignments. The students' safety can also be monitored using IoT wrist bands. For any potential learning space inside the classroom, ventilation, air quality, temperature, and humidity can also be managed and optimized. This will ensure that the facilities are run smoothly and will encourage a personalized active learning (Bijju *et al.* 2011) [16].

Smartboards

Now that time has changed, students enjoy smarter boards than blackboards. A smartboard is an interactive whiteboard that projects an image of the subject. Allow teachers and students to interact with it. Simply enter or rotate in class. At this point, it seems to be more fun and exciting. It is common to consider whether a smartboard can replace a blackboard by any means. The answer is yes. Blackboard and textbook words and images are too short to communicate the concept of the text within minutes. Perception conflicts become commonplace and the classes are pools of confusion. Here, the application of IoT in education has made learning and information exchange easy, interesting, and interactive. With a smartboard, teachers can take a deep breath. Infographics, tutorial videos, and complex formulas can be solved quickly, especially in math (Aldowah *et al.* 2017) [17].

Attention to Attendance

The rules are separated by the educational

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institution. Some feel that a certain percentage of students need to take the exam. With IoT, managers can find accurate information about attendance. There is no human error in the data. The hostel's students' real-time location can determine safety and quality of life (Wan & Zeng 2015) [18]. For management, attendance is frustrating to count. The IoT-based attendance system makes it easy for students to calculate attendance and regularity, punctuality, and personality reports. Time savings can have a big effect on lab employee satisfaction. Also, IoT has identified the need to digitally register attendance to make students more regular in the classroom. If a student goes missing from an educational institution for any reason, a simple electronic message will be sent to the parents. This is a very good measure of security (Ali *et al.* 2017) [19].

Significant Safety

Whatever the fun form of security for emergency indicators, audio enhancements, Wi-Fi watches, and deaf notifications, the lab has a short circuit, and the IoT sensor detects it instantly and sends an instant alert to reverse the situation. If someone gets stuck in the elevator, an "auto" real-time alert will also be sent. In our note of serving, the significant impact of globalization can be seen in various forms of the world. The probability of an earthquake is suddenly changing with severe weather and becoming commonplace. This is because schools and other educational institutions invest in IoT sensors and meters when concerns about natural disasters occur (Uskov *et al.* 2016) [20].

Adjusting Disability

A few years ago, it was very difficult for children with disabilities to learn and reflect on new things. The modern technical design allows them to learn and perform new things just like any other skilled student. Some segments of the population are challenged with hearing loss. With an integrated glove and tablet system, conversations can be translated into sign language. The incentive to convert words into written words is noteworthy. The world of children with disabilities is bright because IoT

devices lead to providing educational support to children with disabilities in a constructive way. It guides their intelligence and passion for trivial success (Alnahdi & Liu 2017) [21].

Mobile Apps and Tablets

Millennial students need to restrict the use of gadgets. Unfortunately, however, the lives of these modern students seem to revolve around smartphones, tablets, and other screen-based electronics. IoT specialists have shifted this particular focus to educational themes in gaming and social networking gadgets. It is now easier to engage people around the world with the same goals and interests (Tianbo 2012) [22]. The Internet of Things of Education sensor collects data and automatically suggests academic topics of interest to students sitting on the other side of the screen. The use of smartphones and tablets is helpful for students' grades almost overnight.

4.3 THE ROLES OF IoT IN EDUCATION :

A very smart component of today's universities and classrooms is that IoT improves schools and improves fees for physical services and systems. An elusive university has the advantage that it can easily provide a better level of knowledge at the individual level. Smart gadgets are used throughout campus to employ the Wi-Fi community to transmit information and receive orders (Sklavos *et al.* 2017) [23]. Further, the computational IoT gadgets for facility and learning facilities help to create smarter lesson plans, maintain coordination with key resources, and improve admission records, design secure campuses, and so on. The Internet of Things will integrate into more education systems shortly. Many schools use this to train their students for greater understanding and other schools may use it to save data and save resources and other similar needs (Assante *et al.* 2018) [24]. IoT needs to change the understanding of education to integrate into education. The educational institutions that make practical and reasonable products the educators, students, and administrators
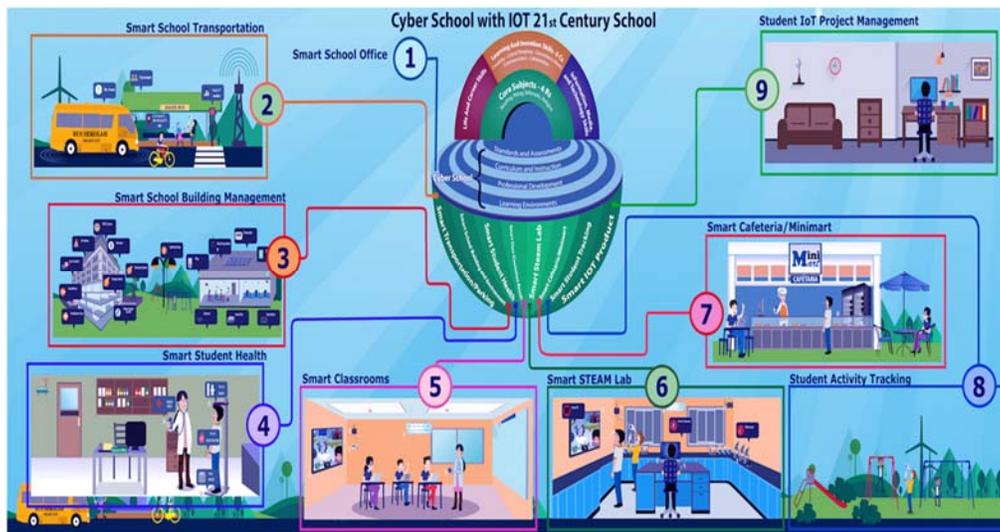
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Fig.2: IoT's Application in Education
Source: https://data-flair.training/blogs/iot-in-education/

Interactive Learning

Today, learning is more than just a combination of images and text. Many textbooks have been added to web-based sites, with additional videos, materials, animations, ratings and other content to assist in the learning process. It provides a broader perspective for students to gain knowledge about new subjects, including better understandings and communication with teachers and friends. The actual professional problems are discussed by the education professionals in the classroom and the students produce answers to these issues (Bagheri & Movahed 2017) [25].

Security

It is not an easy task to track each student's location and activities, because many student organizations attend classes. Also, institutional students are at greater risk than other workplace populations and their need for intelligent protection can add a lot of value to the security of IoT schools, universities, and other learning centers. Strategies such as 3D positioning allow students to be tracked 24/7 at any time and report their presence. These technologies can also provide a sad button option for triggering alarms where needed. Recently, significant improvements have been made to computer vision technology, which allows the speed monitoring of signatures. This activity allows you to automatically prevent unexpected events from occurring (Saravanan *et al*. 2019) [26].

Educational application

The educational applications of the benefits of IoT are seen as a powerful creative tool and teaching and learning methods are changing. Teachers and students can create and take notes in 3D graphic textbooks using video. This app can be considered a game-changer because of the large number of educational games available. These games offer a lot of features that offer interesting teaching and learning possibilities. It has made education more attractive than ever (Banica *et al*. 2017) [27].

Increase efficiency

Most schools invest several times on events that do not respect their existence's main purpose. For example, students need to be present several times a day. This information must also be forwarded to the central office aimed at specific purposes. IoT can eliminate this inefficient system. This data so collected sent to a central data server with IoT end devices, which automatically eliminates the need for data interference. This revolutionary change in IoT can reduce the tedious work of teachers and students. Students will focus more on teaching-learning as it the heart of the education system (Roy *et al.* 2016) [28].

These are some significant territories where the IoT can be applied

A. Poster-boards into IoT-enabled boards

This is certainly very problematic tolerate the presentation board of older age with the multimedia poster board of these days. Era

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presentation boards with present-day multimedia poster boards. It is to be sure hard to contrast the established time introduction loads up and present-day sight and sound notice load up. Web-equipment like Glogster has improved this simplicity and allows the people for creating digital posters without any issue merging with video, photos, text, hyperlinks, and audio. Such interactive boards could then be distributed via e-mail to cohorts and educators (Bhatt & Bhatt 2017) [29].

B. Interactive gaining of knowledge
Becoming familiar with the modern era isn't controlled to the blend of pictures and texts yet something more than that. It gives the students a more comprehensive viewpoint to breakdown things with clear[i]understanding and interaction with their educators and their companions. Besides, the instructional experts are bringing genuine world difficulties in the exam room and allow the students to locate their answers (Chatterjee *et al.* 2018) [30].

C. Learning at any-time and any-where

IoT plays a significant role to develop a system using extraordinary web-based frameworks. Cutting edge creativity gives the scholastic the power to demonstrate the researchers' advancement. Edmodo is a tremendous form of verbal communication between teachers and students. Edmodo brings newcomers the potential to benefit data from any area whenever they are. IoT permits students and educators to impart using remarkable strategy, reading messages, and forthcoming occasions simultaneously when away from the study hall or in any event, answering to posts. It likewise permits a client to spare their particular notions and class undertaking without stressing and guarantee them their full privacy (Riggins & Wamba 2015) [31].

D. Higher safety features
This application is critical because it could be useful to incorporate the superior innovation responses inside the school rooms and to prepare territory. This provides crisis markers, sound enhancement, Wi-Fi tickers, and hearing impeded alerts that give a sense of security to researchers and a variety of staff (Xia *et al.* 2012) [32]. The IoT empowered interchanges

framework likewise be used for diverse cases, e.g. exceptional crisis tones, live announcements, and pre-recorded instructional messages to coordinate the gathering of laborers and students at some pointy of crisis (Bogdanovic *et al.* 2014) [33]. A student GPS tracker is a small tracking device that can be placed in the pocket, knapsack, or coat of the student. A student's location can be identified using satellite dependent positioning. A GPS tracker can also be placed imperceptibly in spots such as a stroller, allowing a student to be tracked via a GPS tracker (Mathew & Gondkar 2017) [34].

4.4 HOW EDUCATION INDUSTRY IS USING IoT TO ITS BENEFIT :
The most critical activity for any developing society is imparting education. So, it becomes obvious to utilize the advanced technology of modern days to make learning more effective, vivid, and fun for the students.

i. Smart automated student tracking
With the help of the system of smart automated student tracking, it probably won't be vital for the students to be present at a given time in a given place to be marked present. Moreover, students are allowed by it to seek after their benefits as long as they are signed into the system of automating tracking (Plauska & Damasevi 2014) [35].

ii. Personalized learning
As all students bare not the same, particular ways to deal with learning can draw out the best of their capacities. The efficiency of education along with the maintenance of data can be increased by personalization and absence of personalization it becomes difficult for some students to draw out the best of their capacities (Bautista *et al.* 2019) [36]. For instance, students with dyslexia are generally intellectually equivalent or higher than the greater part of their companions, yet typical learning techniques aren't appropriate for them. It cannot be possible to teach them with the help of textbooks. Then again, instruments like speech-to-content programming permit them to utilize their voices to finish composed assignments so their outcomes aren't reliant on their capacity to peruse and compose (Chin & Callaghan 2013) [37].

Gathering information about the performance of

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the students during the test just as lessons empowers the teachers to customize further learning according to their enthusiasm just as their abilities. This turns out to be much progressively urgent for higher investigations where students have better possibilities at finishing their examinations if the way is customized for them. Disinterest and distraction of students can be detected immediately by the connected systems (Zhu *et al.* 2016) [38].

iii. IoT empowered smart boards and the new generation textbooks

Envisage a circumstance where the history educator can reproduce the battle of Normandy on the smartboard at the time of teaching World War I. Then again, virtual animals can be dissected by the students at the time of studying science. Then again, a live experience of the eruption of a volcano can be experienced by the class, at the time of studying geography (Wang 2010) [39]. The act of learning will become more immersive using the IoT empowered smartboards and students will be motivated by this to take part in learning. Alongside that, physical course books are costly as well as become obsolete in only several years. Learning content gave on IoT gadgets are consistently forward-thinking and can be redone according to the necessity of the students (Comel 2015) [40].

iv. AI-powered research

Effective specialists have consistently teamed up to accelerate development by learning from one another. ML along with AI can be utilized for connecting databases, analyzing research data as well as gaining insight into those data for future purposes. As the majority of the examination part is taken over by these interconnected frameworks, researchers can concentrate on the exploration part better (Page 2017) [41].

v. Supporting special-need students

IoT can be a beneficial aspect for those students who need special care. Voice can be converted by a hearing-impaired student to the text, whereas VR headsets can be used by a visually-impaired student for viewing the smartboard. Along with that, the requirement for building the educational facilities and separate curriculum might be diminished by IoT (Dlodlo & Kalezhi 2015) [42].

vi. Improved security of learning spaces

It is not that only in terms of the core education Internet of things can assist. Likewise, to improve the security of the learning procedure, IoT plays an important role. a secure and safe environment to impart education is also created by IoT. CCTV cameras are utilized for checking school and college spaces and certifying the safety of the students. Immediate action can be taken if there is an emergency, only when all the CCTVs are connected and constant checking is done by the school authority. It has been watched and demonstrated over and over that a safe educational condition improves participation, focus, commitment, and learning in the students (Ning & Hu 2012) [43].

vii. Smart learning environments

Many digital components are there in terms of Smart learning environments with the help of which more effective, smoother, and better procedures of learning will be created. Preferably, an exact interaction between the digital and physical realities is created by the Smart learning environments, through which students are permitted to retain data from their environment as well as it also makes the prospects for consistent changes among several learning methods: informal and formal setting, group and individual learning, learning through digital or simple formats, etc. Moreover, how much time is needed by the students for completing the assignment can also be reviewed by the IoT devices (Duan *et al.* 2017) [44]. This approach can be beneficial for the teachers as they come to know whether the method is working properly or not, in which students require extra help to complete their tasks and what kind of tasks are become difficult or the students.
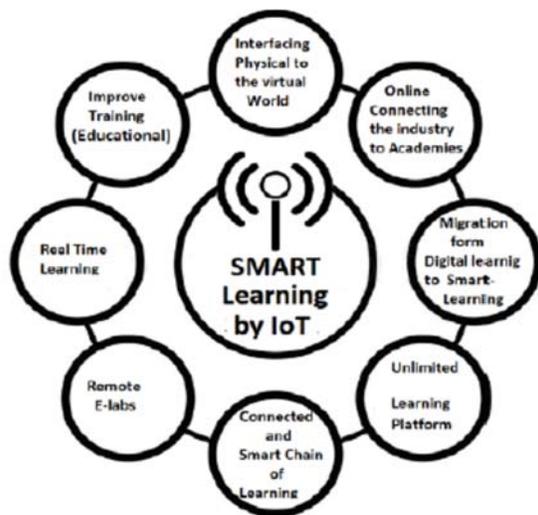
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Fig. 3: Smart Learning Dimensions by IoT (Abbasy *et al.* 2019) [45]

A savvy study hall has AR-empowered smartboards that show advanced and engaging videos on topics being talked about. VR headsets are used by the students to gain immersive knowledge. The instructor can consequently stack assignments and tasks to be done on their devices of the students as the progression of the teaching, now and then just by expressing the project or word assignment, or homework (Moreira *et al.* 2018) [46].

viii. Task-based learning

Through the flipped classroom, before coming to the class, students gain the basic knowledge of the topic which will be covered in the class. To certify the full perception of the topic, the acts of learning in the classroom become more task-based. Those devices which are linked with the IoT network certify that students work together and share their knowledge for completing the assigned task in a better way. As well it ensured by the IoT devices students can be able to take the help of their teachers wherever and whenever needed (Mohapatra *et al.* 2018) [47].

ix. Augmented and virtual reality

Even though AR and VR may sound excessively costly for use in the classroom daily, it becomes more affordable and available with the help of products like Google Expeditions. A vast range of virtual possibilities is opened by this tool, such as students can be able to visit many geographical locations that are not possible to reach physically (like Mount Everest), besides, they can be able to

be "available" at significant events of history. The act of learning comes to be highly visual and hands-on by the usage of this technology as well as students become more excited and motivated to pursue their study (Elsaadany & Soliman 2017) [48].

4.5 ADVANTAGES OF IoT SOLUTIONS FOR THE EDUCATION DOMAIN :

1. Enhance Efficiency

It is important to improve the skills of young people to prepare for the upcoming periods. Capacities like proficiency of learning, self-direction along basic reasoning can be improved enormously utilizing the IoT. The investigation of Houghton Mifflin Harcourt Team uncovered that those students who use tablets to learn Math can enhance their score by 20%. Through giving interactive experiments at the individual level, the modified IoT application can significantly upgrade the efficiency of the students. The IoT innovation additionally infiltrates alongside wearables in the. Even, by using IoT in the smart classroom, the process of learning can become more interesting. The productivity of the students and the teachers can be increased by IoT technology (Mehmood *et al.* 2017) [49].

2. Student-Focused Approach

The act of education requires the interest of the student and also their attention. Education organization is enabled by the IoT innovation to receive the student-centered approach. It is conceivable to get data about the diverted contemplations of students on account of wearables and IoT blend. Teachers are assisted by this to keep up students' core interests. Vital parameters of the students are measured by all the sensor-empowered gadgets, and on that premise, day schools can structure and improve their sustenance programs (Gao & Bai 2014) [50].

As well the institution can work to reduce the stress as well as to build a student-oriented approach that can devote to their all-round improvement.

3. Improved Security

Nowadays, many institutions have remained worried about their security issue. Just employing a security watch isn't sufficient. A critical role is played by the visitor management to ensure the security of the school as well as the security of

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educational institutes. Advancement of the technology can be promptly incorporated into the linked gadgets to improve visitor management. Visitor management will enhance students' protection by implementing a biometric system; identification software along with other redid IoT-based applications (Mavroudi *et al.* 2018) [51].

4. Strong Networking

Global networking is facilitated by IoT among the mentors, students, teachers, and guardians through linked devices. As blurb sheets convert into 'canny' IoT-empowered sheets, and advanced highlighters have emerged, students can be able to interact with their tutors and peers easily, while sitting in the solace of their home or study hall. It is additionally conceivable to improve the learning procedure utilizing the virtual posters as well as the interactive boards by which users will be enabled to share, receive, and recognize the data easily. Another advantage of IoT innovation is that it can give a more extensive standpoint to any idea while encouraging students to dissect and think of their inventive arrangements (Gomez

et al. 2013) [52].

5.Efficient Management

It is a monotonous task to manage the day to day work at colleges and schools. The Internet of Things arrangements can streamline everyday activities and mechanize assignments. Along with that, not only a lot of time is saved by this but also the efforts of the teachers and the management will be saved by it (Marquez *et al.* 2016) [53]. Subsequently, instructors can concentrate more on educating, and the supervisory crew can focus on other beneficial errands. For instance, RFID innovation is utilized to follow assets like equipment of lab, projectors, and so on. It spares time and empowers the administration to dispose of recruiting individuals to deal with assets. Likewise, the educational institution can get help from an IoT application advancement organization to diminish vitality costs.

4.6 SUPPORT DIRECTIONS FOR AN INTELLIGENT EDUCATIONAL ENVIRONMENT :

Table-1: Supporting strategies for a smart learning environment (Stoica *et al*. 2018) [54]

No.	Support direction	Meaning
1	Conversation, dialog	The educational atmosphere needs to allow the student to engage in group discussions on specific topics.
2	Reflection thought	The educational environment must have student self-assessment instruments based on success and results, identifying practices and skills that can be improved for better educational performance.
3	Innovation, originality, creativity	To help instruction the educational environment has to rely on new and emerging technologies.
4	Self-organization, self-control	The educational system needs to include the ability to rearrange resources. I also comprise control mechanisms to enhance its efficiency over time, refine how it communicates with participants under different conditions

Given the functional elements, designing and implementing an intelligent educational system needs to understand the four directions. At first glance, the technical perspective seems accessible: rapid growth in recent years, materialized in multiple "technological revolutions" is an admissible assumption for the concept of adequate infrastructures. Such

technological innovations (mobile communications, smart devices, environmental intelligence, cloud computing, fog computing, etc.) along with the rapid digitization of individual everyday activities position him in an original world, commonly called the Internet of Things (IoT). Of course, we must find cloud computing and fog computing among the

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emerging technologies that can be invoked to create an intelligent learning system in the sense of IoT. In this sense, in the ecosystem identified by IoT, we must see the intelligent educational environment as a superior type of manifestation of the knowledge society. The intelligent world thus surpasses the open environment that in turn leads to a virtual educational environment (Stoica *et al*. 2018) [54].

4.7 IMPORTANT ASPECTS FOR EFFECTIVE IMPLEMENTATION OF IoT IN EDUCATION :

As talked about, IoT can affect the act of learning in a basic manner. The fruitful usage of IoT will rely on these six basic components.

1. Storage

The hybrid cloud is used by many organizations as their operating infrastructure for hosting IoT applications. The combination institutions' tech-savvy students and the proliferation of tablets and mobile devices have opened up new avenues of enhancing the efficacy of business infrastructure, digital technology, research, and learning eco-system. In ubiquitous computing where the cloud offers seamless access and services to the information infrastructure providers. Educational organizations are increasingly dependent on cloud infrastructures with private cloud computing services, while instructional applications are gradually migrating to public clouds. Enterprise infrastructure in these organizations needs to reduce latency due to the demand for data and material in instructional technology, the enormous increase in audio and video instruction, and the need for networks (Aldowah *et al.* 2017) [55].

2. Instructional Technologies

Learning Management Systems (LMS)such as Moodle and Blackboard are increasingly being used to produce structured/unstructured data in large volumes, such as audio/video content. There is, therefore, a growing need for school rooms equipped with advanced electronic tools such as lecture recording systems and video sharing enables students to access instructional material on demand at all times (Aldowah *et al.*

2017) [55].

3. Quality and Ethics

The standard of online and on-campus education and the increasing educational costs have been intensively discussed in recent years. IoT offers unique opportunities to deliver digital training courses. However, this often creates difficulties in maintaining the quality of teaching and evaluation of students' work. To improve academic quality and address ethical issues within the education system, IoT educational applications allow students, professors, and the researchers to have resources and technology (Aldowah *et al.* 2017) [55].

4. Security

With youngsters being included, protection of the partners and security of information gathered is critical. Educational institution and Guardians require not only to guarantee from the service provider but also successful execution of protection and safety efforts. Likewise, questions like responsibility for personal and collective information should be tended to before IoT can be actualized immensely in the instruction area (Gubbi *et al.* 2013) [56].

5. Integrity

It is likewise imperative to guarantee the respectability of the information being gathered. Right technologies should be used for this. A significant phase in this direction will be the usage of a public platform that can be utilized by all the parties engaged without making additional ventures (Maksimovic 2017) [57].

6. Education policies

IoT in training is a basic change in the manner in terms of which instruction is imparted and learning occurs. To any transformational change to be successful, strategy choices need to be taken and actualized by the skilled specialists. On account of actualizing IoT in educational institutions, training arrangements must support the utilization of innovation in study halls and other instructive environments.

4.8 SUMMARYOF LITERATURE REVIEW:

Table2: Summary of findings proposed by different authors between 2010 and 2020.

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SN	Author(s)	Year	Inventions/Findings/Results
1	Wang	2010	Developed IoT-based Interactive English Teaching Model.
2	Xue et al.	2011	The detailed technical architecture of the ubiquitous learning environment powered by IoT outlined across three main layers: a layer of perception, a layer of the network, a layer of an application.
3	Biju et al.	2011	Introduced IoT technology, its future use in the education sector, and addresses the advantages and challenges of IoT. It also addressed how IoT technology can encourage a smart education system or a smart learning environment.
4	Tianbo	2012	Carried out a study of the relationship between IoT and higher education.
5	Ning & Hu	2012	Presented reorganized U2IoT architecture for future IoT
6	Chin & Callaghan	2013	Proposed Educational Living Labs with emphasis on to use of Pervasive-interactive-Programming, along with the IoT, to teach programming.
7	Gomez et al.	2013	Proposed a system forcing students to communicate with physical objects around them that are digitally connected with a learning subject.
8	Gubbi et al.	2013	Presented the latest trends in applications-driven IoT research and the need for convergence across many interdisciplinary technologies.
9	Kortuem et al.	2013	Discussed the possibilities of integrating collaborative learning into university education on a wide scale.
10	Bogdanovic et al.	2014	Presented a web-service oriented cloud platform for conducting IoT classes.
11	Plauska & Damasevi	2014	Presented a principle of collective learning using educational robots (smart mobile components of IoT).
12	Gao & Bai	2014	Proposed an IoT Acceptance Model.
13	Wan & Zeng	2015	Identified key success factors with a grounded theory for innovation implementation of IoT
14	Cornel	2015	Demonstrated use of IoT by connecting the Arduino platform to the Xively web service for reading and displaying data from sensors.
15	Ahlmeyer & Chircu	2016	Proposed IoT security framework outlining key security criteria in five areas: "IoT security levels, IoT security activities, IoT security value chain, IoT security standards, and IoT security education".
16	Uskov et al.	2016	Described the ontology of IoT applications with special references to smartness levels, components, features, and functions in smart engineering education.
17	Zhu et al.	2016	Proposed a research framework on Smart Education with three essential elements: smart environments, smart pedagogy, and smart learner.
18	Marquez et al.	2016	Presented a model for incorporating objects accessible with the Virtual Academic Communities (VAC) in educational environments.
19	Haroon et al.	2016	Reviewed literature research relating to IoT-based Student

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			attendance systems.
20	Abbasy & Quesada	2017	Theoretically studied, along with statistical analysis, the predictable effect of IoT in higher education. Presented "Internet of education things model" and its components are outlined.
21	Zhong *et al.*	2017	Reviewed key technologies that encourage intelligent education.
22	Ali *et al.*	2017	Proposed "IoTFLiP- IoT-based Flipped Learning Platform"
23	Alnahdi & Liu	2017	Proposed a new IoT platform providing versatility concerning location changes.
24	Sklavos *et al.*	2017	Discussed IoT technologies regarding the security of trusted devices. Provided Trust Management infrastructure with a model for hardware system integration.
25	Bagheri & Movahed	2017	Categorized the implementation of IoT in education as i) energy management and real-time environment monitoring, ii) health care monitoring for students, iii) access control for classrooms, and iv) enhanced teaching and learning. IoT-impacted places in the business model of education.
26	Banica *et al.*	2017	Presented a new concept in IT&C, namely IoT. Also produced a model of IoT for Academia.
27	Bhatt & Bhatt	2017	Surveyed the different techniques used as part of the IoT-enabled e-learning program to provide better knowledge and immersive learning skills.
28	Mathew & Gondkar	2017	Worked out the various tools that can be used to capture data, track it on the cloud, and use analytics to improve the overall campus infrastructure. It also proposes an architecture to link these different technologies to the cloud.
29	Page	2017	The necessity to include the IoT hooked on the Industrial Design Curriculum was investigated.
30	Elsaadany & Soliman	2017	Experimental evaluation of aspects of the application of IoT in education is presented and explored with a view to testing hypothesis collection.
31	Mehmood *et al.*	2017	Proposed a customized Ubiquitous e-Teaching & E-Learning (UTiLearn) platform that leverages IoT, big data, deep learning, and supercomputing to facilitate intelligent learning in smart societies.
32	Aldowah *et al.*	2017	IoT's effect on higher education examined. An overview of Future IoT-based higher education has also been given.
33	Maksimovic	2017	Analyzes the possibility of Green initiatives being integrated into IoT and creating G-IoT with innovations such as green computing, green networking, and smart grid applications.
34	Gul *et al.*	2017	Presented Smart Campus ecosystem with smart elements such as smart e-learning, smart classroom, smart lab, smart notes, etc.
35	Kiryakova *et al.*	2017	Analyzed how the IoT could change educational practices and processes.
35	Leiton & Loaiza	2017	Based on work related to the e-learning opportunities of smart cities. The work presented a theoretical review.

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37	Zhamanov *et al.*	2018	Discussed IoT technology implementation with the flipped classroom as a component of IoT education. A comparative study of the data is made between a flipped classroom and traditional classroom.
38	Assante *et al.*	2018	Described the European project IoT4SME's early operation, focused on evaluating the labor market training needs related to IoT technologies.
38	Chatterjee *et al.*	2018	Empirical research aimed to recognize certain factors that influence the successful implementation of the IoT framework in conjunction with Artificial Intelligence in the education sector.
40	Moreira *et al.*	2018	Discussed the potential and evaluated key issues related to the use of IoT in education. Reviewed and identified applicable technologies and projects. It also discusses the incorporation of IoT technology in schoolbooks, including open data.
41	Mavroudi *et al.*	2018	Analyzed the design of IoT applications in lower secondary schools, using case studies in which students gathered in a laboratory and took on the challenging role of Internet of Things applications designers.
42	Stoica *et al.*	2018	Analyzed the field of education as an intelligent learning system in the context of fog and cloud computing.
43	Caviglione & Coccoli	2018	Proposed a reference architecture for future and big data-capable e-learning platforms to be built.
44	Van et al.	2018	Described the effect of IoT on higher education where new technology, smart devices, and technical advances are progressing every day. It also included a study of conventional education and online education.
45	Basset *et al.*	2019	Illustrated the role of the IoT in creating a smart educational process.
46	Bautista *et al.*	2019	Presented a conceptual framework for Smart University based on IoT infrastructure.
47	Abbasy *et al.*	2019	The work centered on the different benefits of smart e-learning within the Educational Learning System. In this review, a theoretical analysis is illustrated.
48	Kassab *et al.*	2019	Reviewed "Smart Learning" implementation along with principles that underpin successful learning.
49	Shaikh *et al.*	2019	Identified conceptual framework for the "Educational Things" (IoET) environment on the Internet to promote critical thinking between students. The paradigm uses the theoretical model of the Jigsaw Cooperative Learning Model and Interaction Theory, critical thought model of Mezirov, model of ADDIE and usability model.
50	Songsom *et al.*	2019	Presented a "Student Interaction Management System Architecture" using the IoT to capture the Digital Footprint of HEs.

5. FUTURE OF THE IoT IN EDUCATION :

The eventual fate of the IoT in instruction looks

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encouraging due to the huge potential it has. In any case, making IoT a piece of standard education will require some time. The most essential factor, in this case, is developing the fundamental technologies both open and simple to utilize. There should be an adjustment in the outlook of the instructors, guardians, and students, upheld by the change in the policies related to education.

IoT technology removes the constraint of physical presence and extends access to the redress of any education such as instructors, software, and wherever E-learning is effectively facilitated. IoT aims to have a huge effect on the higher education learning process by giving students and teachers access to international tools and opportunities. Hence one of the main impacts of the IoT-based learning environments is that the roles of traditional students and teachers can be dramatically modified. Students and teachers can practically maintain teaching material and/or laboratory at any time, from wherever they can interact. It is expected that the Internet of Things will facilitate the vast number of research opportunities for educators, students, and researchers around the world. Although it cannot contribute to the success of the great teacher & students, it can be encouraged by the student judge to include them in the learning process by connecting the real objects in their assignments, homework, and scientific study (Abbasy & Qusada 2017) [58].

IoT is upsetting numerous territories of our day to day lives. From transportation to the management of the business, IoT's applications are gradually coming to be very common and important to keep up the first ace world of these days. Even though it might not appear to be an undeniable application, the education field has a lot to pick up from the IoT (Kortuem *et al.* 2013) [59].

IoT is an undeniably significant part of life, around the work environment, and analytics will just normally create and develop to deal with the huge amounts of information produced by the development of the IoT. For the individuals who don't know, the IoT is the idea of essentially associating any gadget by an on/off button to the Internet (as well as to one another). The advanced disruption has just brought about the usage of the web inside the American educational system, along with the procedure of e-learning coming to be very common (Gul *et al.* 2017) [60]. Another dimension is added by the IoT to this phenomenon, permitting for a more productive and vivid educational experience.

The IoT can be successfully used in secondary school and college settings, where students are as of now moving ceaselessly from paper course books to digital books on PCs and tablets. By utilizing cloud linked gadgets, teachers can track the progress of the students as well as they can monitor the students who require special attention. This flow in connected technology implies that the resource and time of the teacher can be utilized by the teacher on more initiated guidance, as the IoT would robotize forms that were recently directed manually (Kiryakova *et al.* 2017) [61].

For instance, the presence of the student within the classroom can be detected by sensors refuting the need to take the attendance manually, in this way saving the valuable time. Along with those benefits of IoT technology, it also helps those students who need special attention. They as well become benefitted by this technology. Such as students with impeded vision can be given exceptional cards that are identified naturally and connected devices will be informed to display the text at the larger font than usual. Through these progressions, the IoT can encourage equivalent access to education (Erasmus *et al.* 2019) [62].

As stated by Hariharasudan and Kot (2018) [63], "Technology allows teachers to design their lesson plans in a way that combines more than one teaching method. Incorporating a variety of technological enhancements enables a teacher to program each and then put learning into the hands of the students". This implies that every student can learn in their specific manner thinking about their own exceptional needs, boosting certainty, and making an elevating procedure of learning. Moreover, adapting the advance technology of IoT at the bigger scope inside the setting of higher education denotes that the possibility to associate with pioneers and experts, elevating an interdisciplinary way to deal with training which is becoming more applicable in these days' world.

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IoT technology has applications not only inside the classroom but also outside the classroom. Such as it helps to track equipment and resources for quick access to schedules, teachers and students can be able to save their precious time and money. Concerning this approach, IoT can be best used to expand vitality effectiveness and decrease working expenses. Another application is inside transport plans; students can be able to track the route of the bus so that they do not need to wait in an unsafe zone (Kelly *et al.* 2013) [64]. In any case, there are a few concerns with regards to the utilization of IoT. Invariantly, IoT will compel undesirable change upon a previously working educational system at a huge cost. Notwithstanding, Kassab *et al.* (2018) [65]points out that a large portion of students needs to utilize their cell phones more often within their classroom, along with that greater part of those students desire to use the technology for automating the tasks that are already done by them, like checking the schedule, conducting any research or taking the class note (Riju 2018) [66].

6. RESEARCH GAP :

There is a very insignificant amount of study on the application of IoT in the instruction industry. The focus has been given to knowledge management perspectives or initiatives broadly but knowledge sharing has received small attention. However, studies are focusing upon the education industry and they have been undertaken only the technological factors into consideration. This study is tried to fill the gap. Along with that, this research study is exclusive because, in a single study, the complete collection of the organizational variables, demographic variables, the opinion of teachers and students, the comparison of their descriptions and perceptions of the key factors of IoT in education has been taken into consideration.

This literature review revealed major work gaps concerning IoT education and its branches, such as physical systems (Kassab *et al.* 2019) [67]. These gaps are caused by a large number of ever-evolving technologies, highly diverse technology domains, various relevant standards, of IoT education's cross-disciplinary nature. Some of the research gap issues we found are:

Research Gap 1: Best tools for IoT pedagogy and the communication components.

Though IoT technology just emerging and is in its infant stage, a wide range of supporting devices such as sensors, actuators, processing elements, and storage based components are made available to the users and it would be difficult to represent specific components sets for any classroom or laboratory requirements. In this regard, there is a huge scope for research to understand and find out an effective and reliable subset of technologies contributing to the development of individual and autonomous components of the intelligent education system.

Research Gap 2: Teachers, staff, and students link and use IoT networks to teach and learn.

The primary prerequisite for an IoT focused education is the use of apt connecting technology. Stakeholders will have access to these developments inside and outside the campus. Which presents a range of financial, security, and privacy concerns? There is also a problem with low power consumption for IoT nodes backed by batteries, high-power requirements for physical devices, and, most notably, bandwidth utilization. Therefore, in resolving these issues there is research potential and seeking a solution for a secure and effective IoT infrastructure as regards its application to the education industry.

Research Gap 3: Education establishments mitigate software, hardware, communication, and storage complexities.

Resources required for the IoT solutions may its hardware, software, communication or storage are highly assorted and complex. There are several application standards for the use of IoT Systems and its resources. Therefore, there is a scope for IoT based Intelligent and Smart Education System must identify acceptable requirements, reconcile variations, and combine requirements.

7. RESEARCH AGENDA :

1] What conceptual model will make an educational institution smart and intelligent for the smart & intelligent teaching-learning process using adaptive IoT infrastructure?
2] What new technology platform can be proposed with the best use of IoT pedagogy

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and communication elements to incorporate an intelligent education delivery system?

3] What IoT Technology can be proposed for educational institutions that reduce the complexities of software, hardware, and connectivity and storage?

4] What IoT framework can be proposed to connect the key stakeholders in the education system under one smart campus solution?

5] What teaching-learning approaches have evolved concerning the IoT framework in educational institutions and will continue to improve?

6] What integrated IoT system can be proposed to incorporate the Smart Higher Education Program

8. CONCLUSION :

IoT has immense importance in the education field, as it makes the learning process smart and easier for the students. In addition, it can reshuffle a person's geographical position, as it provides further change in the field of education. In this way the learning experience will be improved by correctly applying the IoT technology and it will also have a healthy learning environment. The goal is to assess the potential benefits of IoT in education and how it leverages the industry while overcoming its challenges and reducing the associated risks. Our future work should concentrate on the implementation of IoT in Higher Education.

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