IoT Based Virtual E-Learning System for Sustainable Development of Smart Cities

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IoT Based Virtual E-Learning System for Sustainable Development of Smart Cities

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Abstract Globally, cities are emerging into Smart Cities (SC) as a result of sustainable cities and the adaption of recent Internet of Things (IoT) technology. It is becoming essential to involve students in sustainability as engineering and technology are crucial elements in fixing the past adverse effects on our globe. Engineering e-learners are being educated on the sustainable development of SC in many Smart e-learning Tools (SeT) and infrastructure faculties around the world, especially in developing Asian countries such as India. This research paper presents an advanced solution for interactive Smart Learning Environment (SLE) systems based on new IoT technologies in the Virtual Reality (VR) and Augmented Reality (AR) found in Smart Learning Environments (SLE) for SC people. The proposed IoT-Ve-LS system provides an optimized solution for online classes to attend classes using VR/AR glasses to feel the interactions between Smart Digital Devices (SDD) as practically as in practice. The new Virtual e-Learning System (Ve-LS) is experimental, allows automatic Information and Communications Technology (ICT) development, and offers an extraordinary SLE for increased global recognition. This paper focuses on IoT-Ve-LS, a tool for SLE. The IoT-Ve-LS domain has been fast-growing through the

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emerging technological trends of the IoT. The IoT-Ve-LS method used in the design and implementation allows flexible usage and integration of the online courses by SLE. The impacts of empirical E-learning evaluation on implementing IoT techniques in online tutoring have been analysed to find out its research hypothesis. Our IoT-sensor-based Reservoir Computing allows the classification of short-term learning language sentences relatively quickly, highlighting the minimal training time and optimized solution of real-time cases for controlling temporal and sequential signals at the cloud computing level. The triangulation analysis in information gathering endorses the theoretical models that use computable and personalized approaches.

Keywords Sustainability · Internet of things · Reservoir computing · Smart e-learning environment · Virtual e-learning-IoT tool · Smart city mobility · Urban development · Smart city governance

1 Introduction

During the span of the modern generation, there has been increasing technological growth in the SC population, besides the migration of rural people to SC. In 2021, the ratio of pepole dwelling in smart cities was predicted to increase by up to 65%. By the year 2050, 75% of the world population will be living in SC because of the persistent and fast migration of people from rural to SC. [1]

Inventiveness can be advanced, and SC stakeholders promote the modern tools for offering Modern Education Development to immigrants. The initiatives focus on immigrants' career development, filling the gap between formal education and access to the labour market, and creating awareness among employers and civil society organizations while working with immigrants. Suitable investments are made to construct smart infrastructure, including smart industrial parks and centres, smart cultural, smart healthcare and academic institutions, etc. SC should use specific actions to avoid seclusion in educational institutions, leading to community clusters. Moreover, the problems of commencing a business and offering the entrepreneurs training and mentoring support involved in administration and regulation should be eased by SC since enhancing the entrepreneurship of immigrants can assist the local economy [2].

The two forms of learning are online and classroom-based education. However, each has its own teaching and learning methodology, learning networks, and guidelines. For student groups, online learning provided a wide range of devices, such as live chat, blog posts, video calls, and shared documents, that decided to make courses dynamic and easy to follow. This asynchronous system allows students to attend classes, work, start communicating, do online assessments, and access content from any location. Students' self-determination and learning interests, group learning activities, logical analysis, and self-directed acquisition of knowledge are all enhanced by virtual classrooms. This system also continues to expand the types of knowledge. Students in the classroom-based teaching process go to a classroom setting where they do most of their teaching methods. With this method, the students perform a more passive role and apply it to the teacher's rhythm and testing phase. The primary source of information is the tutor.

Generally, ICT is extensively used in SC to aid cities in making the best use of the resources in various urban areas. The technological development and inventiveness integrated into the conventional city infrastructure are termed "SC", but it also involves the involvement of consumers. The societal development in terms of economy is supported well by the architectural design of a SC and further provides the citizens with a better scope with a greater level of endurance and mobility–enforcing Machine Learning (ML), Artificial Intelligence (AI), automation plans and robotics [3].

There has been incredible development of Smart Digital Devices (SDD) like smart appliances, actuators, smartphones, and sensors that take to broad commercial goals of the Internet of Things (IoT).

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The fusion of these SDD was not possible in the past. There is a feasibility of interconnecting all e-devices and interacting via the Internet. Similarly, there is a need to collect this information for the *day-to-day* management of activities and sustained development planning in the SC [4].

An increase in the power of data computing, processing, and analytics has been highly demanded by society to find solutions to the existing issues. Reducing the emphasis on overpopulation and overcrowding in cities is one of the existing issues. A study stated that "more than half of the global population lives in SCs now. The IoT can provide innovative solutions to these growing population trends. IoT is "the integration of physical objects into the information networks in an unobstructed manner and their active participation in business processing." The capacity of society can be improved by interconnecting IoT technology while constructing SC [5]. The aspect in which IoT has much influence is the field of a SLE that converts the educational form into a unique scheme in the near future development. The smart objects deployed in the future of the SLE.

The blooming of the Internet stretches its horizons towards inventing SDD. The physical and virtual connections between everthing can be provided by IoT. Communicating with each other and sharing data with an incorporated device would opt for some choices. Hence, some benefits are inherent in a learning environment. A leading model is used physically in the luminous or well-known space. The SLE is a prominent example of this idea. Mark Weiser quoted, *"The crucial developments have become invalid"*. Its integrated e-learners are into the standards of daily affairs till they are vague. Earlier, Kevin Ashton used the term IoT in [6]. From the beginning of IoT, analysts tried their hands to describe IoT in many ways, like Services, Digital Signs, People Connect, Anything, Everything, Data and Processing.

A set of back-to-back services in which external providers have an agreement with businesses for constructing, designing, and operating IoT solutions and installing them are offered in addition to advisory consulting for IoT planning.

How IoT-Digital Signs modify the organizations associated with consumers through advertising. For delivering highly focused ad campaigns and powerful marketing based on real-time geographic data, permission is granted by innovative signage solutions to industries.

IoT-People Connect IoT devices use the Internet to connect SDD by allowing them to sense, analyse, and send data, whereas social media networks use the Internet to connect people. Organizations, for example, can communicate with other devices at their workplaces and other locations.

IoT describes the network of real-time objects embedded with software, sensors, and other technologies so that the devices and systems stay connected and exchange data.

The computing, mechanical and digital devices, animals, people or objects furnished with Unique Identifiers (UIDs) are interconnected in the IoT–Everything system. In the absence of *human-to-human* (or) *human-to-computer* interaction, it also possesses the skill of transferring data on a network.

The network of devices and physical objects linked to the Internet is called IoT–Data and Processing. Either collect data and pass it via the Internet, imbibe information from the Internet, or perform both the things meant to be connected with the Internet.

IoT converses with 'everything with an unbound imagination based on essentials.' Cisco exemplifies the incorporated material things of the IoT. The word "Internet of Everything" is utilized by Cisco for Virtual and real things. The application of IoT in various environments is described in Fig. 1.

This research article attempts to answer questions such as the impact of the IoT's creation and execution in the SLE. The application of IoT rids away from traditional classroom teaching methodology and is oriented into real-time models with exposure to new teaching strategies like e-learning activities. The research necessitates discovering how IoT-based SDDs modify daily activities and enhance unique use case circumstances.

The importance of assessing IoT at distinguished heights and the need to find out the flexibility of IoT in executing e-learning activities and accessibility to the learning resources decide the prominence of IoT at the outset of education. The effect of IoT-Ve-LS's invention on training is assessed by understanding learners' awareness of such a vision and their perception of its future educational scope. Grounded on that, we investigate the learner's involvement in this SLE

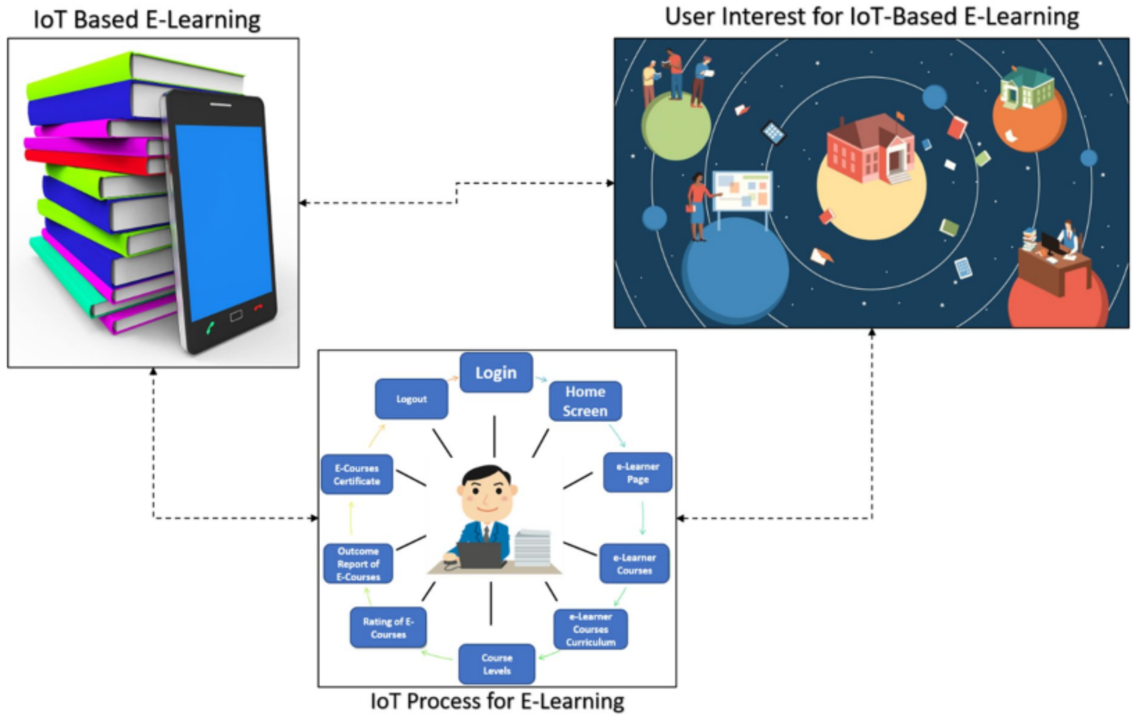

Fig. 1 An overview of IoT based SLE

model and its applications in multi-disciplines and SC lifestyle outcomes, including assembling, transportation, and public protection [7].

There is an inducement for a personalized and customized course using the latest devices to be compatible with learners' needs. The customized e-learning module perfectly conveys systems, communication, integrated endeavour, etc.

Consistent developments need the present E-learning framework and the learner's preferences, admiration, potential, etc. The IoT enhances the learning experience by providing sensors, actuators, and SDDs for SLE and attention-grabbing classrooms. Web-based resources are widespread in software industries, informatics, education, etc. The web-only brings in a critical thinking model for combining several people as member.

1.1 Problem Statement of Ve-LS

A disaster is a natural phenomenon generating information about the concerned framework. To encounter a lot of 21st centuries natural and societal disasters, higher courses integrated with SDD proved to be trustworthy in response to such a disaster as a tremor in New Zealand, windy waves in Sri Lanka and Japan, torrents in Australia, and tropical hurricanes and shooting in the US changed the nitty-gritty of its systems and fast pace of Education with digitalization [8]. Later, there may be notable changes for a certain period. These contingencies may lead the organizations to create fluidity and have similarly accelerated the co-development of futuristic educational development.

The IoT-Ve-LS serves the SLE system. Hi-tech educational institutions must be aware of contingencies, which are subject to closing down the organization for a while and thus intruding on the academic year's routine activities. Willingness to adopt online skills is a crucial factor that authorizes individuals to adapt and fit into real-time situations. Ve-LS enables *state-of-the-art* educational methodologies to overcome contingencies imposed by SLE constraints. ICTs are mainly used for handling contingency conditions and supporting research work. This study attempted to gain knowledge in Ve-LS, which has long-term development and adequate support in enchantment and its impact in every establishment.

1.2 Research Objective of Ve-LS

The purpose of conducting the assessment is to Ve-LS's progress in investigating the development of profound discovery. It proposed to intentionally strengthen the basics of the higher education system and considerable Ve-LS outcomes to facilitate a degree of advanced learning. Provided, the overall growth of transformative measures followed by emergencies has offered an opportunity to understand these protocols. This paper provides information about how a team of instructors, backing by Online Tutors (OT) and e-learners reacted to the digital transformation of Ve-LS, succeeded by the internet-based contingencies.

1.3 Aim of Proposed Ve-LS Method

Many governments implement e-Learning to resolve learners' *day-to-day* problems, especially unusual ones. As Ve-LS is Internet and WWW assisted, the e-learning setups increase bewilderment. E-Learner's major accomplishment with innovation-based Ve-LS is determines if they often use the framework. Training undergone in person is an alternative but contrary to Ve-LS.

This investigation identifies fundamental factors that disturb e-learner's fulfilment and employability. It is noticed from the ongoing related research study that many e-learning methods of research have been directed, which is beneficial for e-learners. However, the factors that motivate the students in the age group of 25 years to adopt E-learning for seeking better career prospects cannot be discovered by any research development activities. Understanding the stance of the e-learners on E-learning and the factors that cause a change in their user behaviour is very significant for the OT, which can thus aid the businesses in running their learning programmes in a globally economical and fruitful manner. Hence, exploring various e-learning factors related to employability skills and seeking e-learning factors that develop specific job skills are the main objectives of this study.

The investigation of the research study's essential variables influencing the usage of IoT-Ve-LS furnishes a complete analysis of its impact on the associates, viz., e-learners, OT, and businesses [9]. This paper aims to describe and analyze the characteristics of a typical SLE in SC and the correlations between these typical SLEs.

- To discover various segments of IoT-Ve-LS on e-learners and OTs.
- To assess the identification and mindset of progressive e-learners regarding IoT-Ve-LS.
- To understand the real-time challenges confronted by e-learners in IoT-Ve-LS.
- To learn about the effects of online learning and optimism on the IoT-Ve-LS e-learning task.

Our IoT-sensor-based RC computing allows the classification of short-term learning language sentences relatively quickly, highlighting the minimal training time and optimized solution of real-time cases for controlling temporal and sequential signals at the cloud computing level. An RC structure capable of a high-performance computing model enabled by in-memristor computing and the usual process of optical inputs without added sensors or processors with a standard device system is still a challenging task. The low cost of training and real-time computation of spatial-temporal signals for optoelectrical stimuli pave the way for cloud-based ML that is effective [10].

1.4 Reservoir Computing Adaptation on an IoT-based E-Learning System

Modern AI technologies that are trained on sensor signals lose the computational resources required for in-situ training and flexible inference to obtain real-time information. Due to the IoT's demands for privacy, network capacity, and task communication overhead, it is not always possible to leverage backhaul resources. Reservoir Computing (RC) [11], our new AI model that supports general retrainable and Machine Learning (ML) ideas on portable smart devices (such as mobile phones), is used to implement a solution. Using a bio-inspired approach, RC is particularly well-suited to time-dependent processing of information in an efficient manner. A more efficient method to train an ML algorithm is to use RC in ML solutions to separate the input features into binary classification classes. As a result, RC has a significant advantage over other AI in terms of fast learning and low training costs.

- Furthermore, the reservoir without adaptive updating can be implemented using a wide range of physical systems, substrates, and devices, making it more flexible than with adaptive updating. A growing number of researchers are turning their attention to physical RC. To handle real-world problems efficiently and quickly, this proposed ring network uses ML to design its RC model [12].

1.5 The Effects of Smart Classrooms

- Online Resource Utilization: In smart classroom learning, the OT can use digital resources to support e-learners' acknowledgement. When it comes to e-learning, the Internet has revolutionized the way. The internet is a powerful resource for those who want to learn more than the coverage of a textbook. Like even the textbook syllabus, the internet's resources are hugely advantageous.
- Use an e-Device to Take Notes: OT uses presentation software presentations, text documents of lecture notes, lecture images, video lecture content, and OT audio recordings instead of writing on the board. The e-learners receive these resources on compact discs, memory cards, or email messages. This eliminates the need for e-learners to write notes. They are provided notes so they can concentrate solely on the online lecture.
- Win-Win situation for Absentees: The online lectures are recorded in a smart classroom. If an e-learner is unable to attend lectures, they can listen to the video recorded lecture at any time. The lecture notes are also in digital format so that the e-learner can access them. A login ID and password are required to access the recorded lectures.
- Accuracy in Interpretation: E-learners in smart tutoring systems can teach any particular topic through many platforms, including multimedia. Instead of listening, e-learners gain knowledge more from what they see. As a result, in smart classroom teaching, e-learners understand all of the complex subjects rapidly and effectively.
- Augments the Learning Skill: Smart classroom innovation is interesting and enjoyable. For the e-learners, the class becomes more interesting and fun. There isn't a single student who is drowsy. Even e-learners who don't genuinely enjoy attending classes discover that the classroom environment has always been something they look forward to.
- Hypothetical Presentation is Improved: The use of new e-devices in the smart classroom improves e-learners' knowledge. The subject's basis becomes more excellent and more powerful as the subject matter becomes clear. Exams are much easier to take and are based on a better understanding of the subject matter and a strong understanding.
- Technology-based Communication: Video lecture calls in the smart classroom are entirely feasible with the modern technology used in smart classroom tutoring. This gives OTs new knowledge about their subject domains that is not covered in their textbook syllabuses. E-learners learn about specific problems in their subject domains. They learn about new modern innovations and subject concepts that are being developed. In the near future trend, this will be very valuable to e-learners.
- Health-conscious: There are no or very few markers/chalks in an intelligent classroom teaching methodology. Digital/e-resources are used to help e-learning. As a result, there are no risk factors for allergies.

1.6 Smart Classroom Drawbacks

- Expensive In Education: Smart classroom methodology is the most expensive. The majority of parents are unable to provide such an expensive academic performance for their children. The smart classrooms are not available to e-learners.
- Demand in Trained Faculty: A smart classroom cannot be used until there are appropriately prepared OTs. If teachers don't get professional training, new technology can cause trouble instead of making things better.

- Maintaining e-Devices: The gadgets used in modern technology in e-learning, like all digital devices, need to be regularly maintained. Furthermore, because these e-learning devices transmit a lot of heat, the rooms should be maintained as air-conditioned facilities. For the maintenance of e-gadgets, technical faculty must be hired. This adds to the expense. The devices must also be updated regularly, which takes time.
- Technical Issues: All electronic devices are susceptible to failure. They require some time for orientation operations. When a device fails, the entire day is assumed to be a failure.

The first part of this research article is an introduction about sustainable development toward modern e-learning systems for SC people. The second part is a collection of new and old works related to virtual IoT and VR/AR in education and administration, as well as cloud computing methods for data storage for the digital lifecycle. Section 3 consists of the proposed model IoT-Ve-LS for SLE with various practises in different platforms/environments, and Section 4 consists of Empirical Evaluation: Measuring Knowledge and Skill Levels with varying sets of data for e-learners from traditional to recent technologies. Section 5 shows various data analyses of the IoT-Ve-LS proposed model with performance evaluation. The final point is the conclusion in Section 6, which includes the outcome of the proposed methodology and provides the final development of e-learning in different domains.

2 Related Works

Training and learning advancement have played a pivotal role in integrating and educating e-learners. IoT has brought significant changes in educational institutions. IoT has changed the stereotypes, practices, and setup of educational institutions. IoT in education is a term that has dual views; one as a mechanical device to support the pedagogical structure and the other as a course for expressing computer engineering content. Holistic training at every place, including schools, universities, etc., assumes job availability in an IoT innovation. This technology benefited many things, from the learner to the tutor and from the classroom to the campus [13].

Sensor-based IoT in education is one of the approaches. An example is Super Mechanical's Twine7 item—a little box described as "a simple methodology for incorporating the object with the internet"—thus helping customers associate any real object with the Local Area Network (LAN). A cloud-based [14] administration synchronises embedded sensors by twine, using a simple arrangement. In reality, even individuals who do not know how to code can get information from whatever objects or conditions the case perceives.

IoT, an extremely dynamic platform, grabs e-learners' attention to express their software engineering ideas. The standard practise of teaching and carrying out research effectively makes use of the IoT. As stated, "integrating IoT in education motivates the involvement of OT/e-learners and (real/virtual) complaints found in the educational sector". In India, most colleges have introduced an add-on course called "My Digital Life [9]" for imparting the

Table 1 Purpose of real-time IoT for new trends

Field of Services	Assessment Rating*							
Descriptions	Primary Economic Development	Inventories	Commodities Services	Marketing	Healthcare	Financial Services	Education Development	Government Sectors
Retailers	2	3	1	3	2	1	1	2
Tread Market	3	2	4	1	4	4	3	4
Good Delivery	3	3	2	1	1	4	2	3
Management: Society	4	3	4	1	4	2	1	4
Engineering	4	1	1	4	2	3	1	1
Luxuries Products	1	1	1	2	4	2	3	3

*Rating of Services 1-Good, 2, Better, 3-Best, 4-Excellent [Survey conducted by 2000 e-learners]

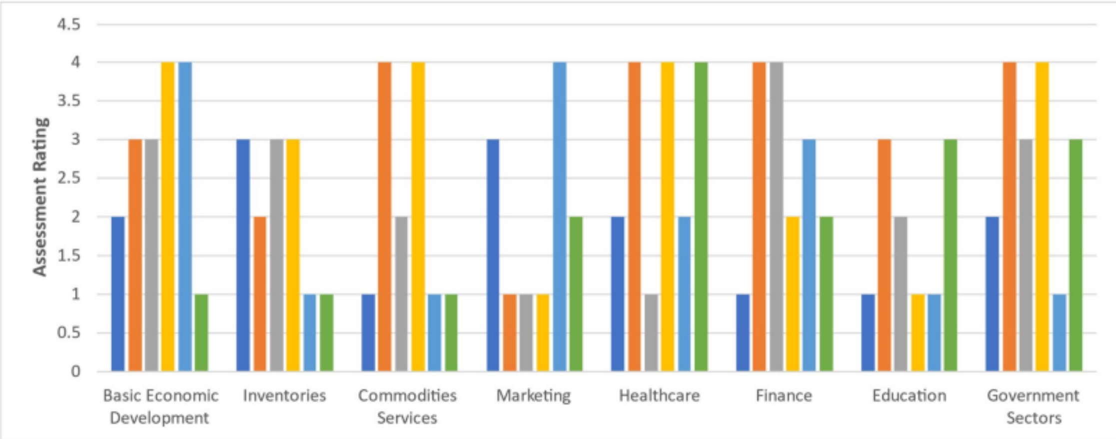

Fig. 2 Assessment of IoT applications

concepts of information practises to software engineering students. "My Digital Life" helped e-learners use IoT to understand and study their learning environment and their responsibility to adopt IoT.

An IoT-based model has been created for English-language purposes. This model uses voice and visual sensors to identify the e-learners' agents and address pronunciation-related matters. Besides, IoT is used to express the fundamental ideas of programming language to e-learners. The other model utilizes labelled objects and Ve-LS to collect information and investigate e-learners' learning strategies using the Ve-LS for SLE. The following Table 1 describes the investigation of IoT applications [15].

Mark Weiser's opinion about the SLE is that SD and SLE [14] have access to the physical world, mainly when everyone does routine work. Smart Workplaces, Dwellings, Classrooms, etc., are some of the essential components of SLE. The main intention of the IoT is to do the regular work to be done quickly.

Fig. 3 Setup of SLE functions

While driving the vehicle, we think about the street conditions, the best roads, traffic jams, tuning the radio, etc. These multi-tasks can be done by hearing the user's voice, using sensors, actuators, and smart devices. The primary objectives of SLE are learning, thinking, and predicting. Like before, innovation means perceiving the smart environmental functions and reacting to the activities. SLE can be defined as "one used to study the world and its inhabitants and make them adapt to such situations".

It is expected that all modern educational institutions will be connected to the Internet. There are different things on smart e-learning campuses like ventilators, entrances, projectors, printers, laboratories, parking, etc. These things can be converted into smart things using RFID, NFC, QR labels, and sensors [16]. A SLE is defined as the integration of the following smart things into a single framework:

- IoT-e-learning SeT in education.
- IoT-Enable Classroom.
- IoT-Smart Laboratory for Practice.
- IoT sensors enable the sharing of e-learning materials.
- Compact SDD with IoT-Embedded Sensors.
- Campus IoT-Wi-Fi.

Using the RFID system, a sound modern digital e-campus may have various other amenities like smart parking lighting using the RFID system [17]. Figure 2 shows the educational institutes, which have smart classrooms, smart corridors with information sheets, and data centres to store a wide range of information and keep it in an organised way.

An effort has been made to create a smart organisation using web-based tools and various techniques. The purpose of this study is to collect information from e-learners. Advanced e-learning educates us with emerging trends, utilising the idea of a smart classroom. To make the classes interesting for the e-learners, some smart objects such as cameras, microphones, and various other sensors can be provided [18]. These SDDs can give accessibility to different intricate concepts and keep them comfortable in a classroom setting, thus transforming it into an elegant IoT campus (Fig. 3).

Using advanced technologies, an assessment is conducted to monitor and test the e-learner's performance in response to the Online Tutor's (OT) input. The quality of the OT depends on the student's concern. E-learner feedback is constructive and helps improve the OT's quality. IoT smart classrooms equip OT in a few dimensions, gradually improving their quality [19].

Labs are presumed to be a significant part of the development of e-learning. Other areas exposed to research studies are I-Campus, living lab, smart box plan, and Pervasive-intuitive Programming (PiP). E-learners' critical programming skills rest in integrating IoT and PiP to take the examination. All the

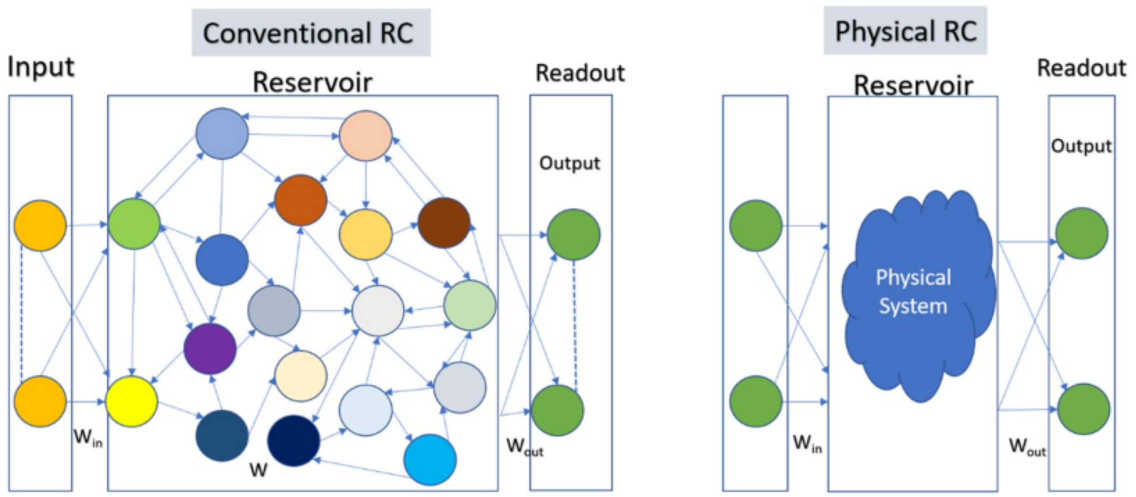

Fig. 4 RC Models (**a**) Conventional (**b**) Physical

100 participants, including OT and E-learners, are interested in PiP-based assessment. The study results showed that PiP helped various age groups to understand and practise the programming and development skills they needed [20].

According to the course module, the lab courses were planned. An investigation was recommended to examine the Raspberry Pi-based Lab unit. The e-learner's optimistic input was mentioned in the investigation reports. Researchers' opinion is that online enhanced research activities can give similar personalized training plans for their study. IoT and Arduino platforms and Xively [21] web administration examine temperature sensor information collection using the related research.

2.1 Backgrounds of Reservoir Computing to Support E-Learners

An ML-based framework, RC, is ideal for processing time-based data [22]. A reservoir-based ML transforms input data into spatial and temporal patterns in a high-dimensional space in RC. As depicted in Fig. 4, pattern analysis is then performed on the spatiotemporal patterns in the digital display. Recurrent convolution uses a simple learning algorithm like linear regression to train the readout weights (W_{out}), but not the input weights (W_{in}) or recurrent connections (W) within the reservoir. The most significant advantage of RC is that its simple and rapid training process drastically minimizes the computational cost of learning compared to conventional AIs. For example, [23] successfully implemented RC models for temporal pattern classification, prediction, and generation.

2.2 Recent Trends of Reservoir Computing

An approach to ML known as RC is based on the idea that complex dynamical systems have their own computational resources. Transformation and extraction of data from a specified time-frame-dependent data stream is a typical problem. Direct computation on a computer may not be feasible in most cases because the target transformation may be unknown or computationally expensive [24]. Consequently, supervised ML is implemented. Typical learning processes are: (a) the training phase optimizes the reservoir virtual machine's malleable parameters, and (b) the testing phase assesses the learned behaviour. The RC uses a dynamical model with a 'reservoir.' Networks of neural models were first proposed for these systems in the initial cycle. With multiple parameters, such as the laser's neuronal voltage, or an input light pulse into an optical network, the information is fed into the system. When data is input into the dynamical network model, it accesses some path in its phase space. This procedure is called "expansion in feature space" because the outcome can be much more challenging than the raw data. Reconstructing the desired output is then achieved by examining the dynamical reservoir's high-dimensional reply. For RC, the 'reservoir' is assumed to be fixed, whereas ML schemes place heavy emphasis on the training of the network's internal degrees. Training only impacts the linear weighting of the output, which is found using linear regression.

Training procedures can be simplified by requiring only a linear combination of reservoir degrees of freedom to achieve the desired transformation. However, this reduction in training time comes with an increase in system size. There are many degrees of freedom needed in order for the system to be

Table 2 Conceptualizations for RC applications [27–30]

Class	Case description's
Bioscience	Heart rates, metabolic disorders, Mass index, eye tracking, mammogram, lung images, MRI, Electrocardiogram, Electromyography
Graphics	Images and video content
Decoder	Monologue, music, and bird calls
Engineering	Fuel cells, gas supply, diesel fuel, mines, heavy hydraulic equipment, steam turbines, roller machines, pedestrian bridges, and air conditioning systems
Communication	Electromagnetic waves, voice calls, and Data traffic
Social	Language, grammatical structures, sentence construction, and smartphones

Table 3 Capture to RC applications and performance metrics [32–35]

Applications	Benchmark tasks
Classification of a Pattern	Waveform classification, human action recognition, and handwritten digit image processing
Forecasting of Time Series	Time-series data prediction, disorderly time-series data prediction
Designing Patterns	Limit cycle generation, Sine-wave generation
Adaptive Filtration and Regulation	Signal amplification of the channels
Comparative System Modeling	Temporal XOR and Temporal Equalisation
Temporal Memory	Storage capacity

sufficiently computation time powerful. Instead of being "condensed" to contain only the most beneficial information of an AI [25], RC [26] can still have high computation costs, even when highly trained. Since reservoir computers are always higher than fully trained computers, they can always be predicted to be more prominent as well. A time-discrete RC is also termed an 'echo state network'. Natural systems that change over time can act as fixed reservoirs. With the RC platform, it is possible to use the natural computing power of physical phenomena (Table 2).

Over the last few years, research on RC has grown exponentially. Real-world applications of RC have already demonstrated its effectiveness in many cases. For one thing, researchers outside the field of AI have realized the benefits of RC. Non-expert developers are attracted to the easiness of the RC training model [31]. Table 1 summarizes case studies of RC-addressed subjects. Pattern classification, time-series weather prediction, pattern generation, and adaptive filtering are among the most common ML applications in these research findings. Real-time processing and low training costs can be met by RC in these cases. Table 3 lists benchmark tasks associated with these applications.

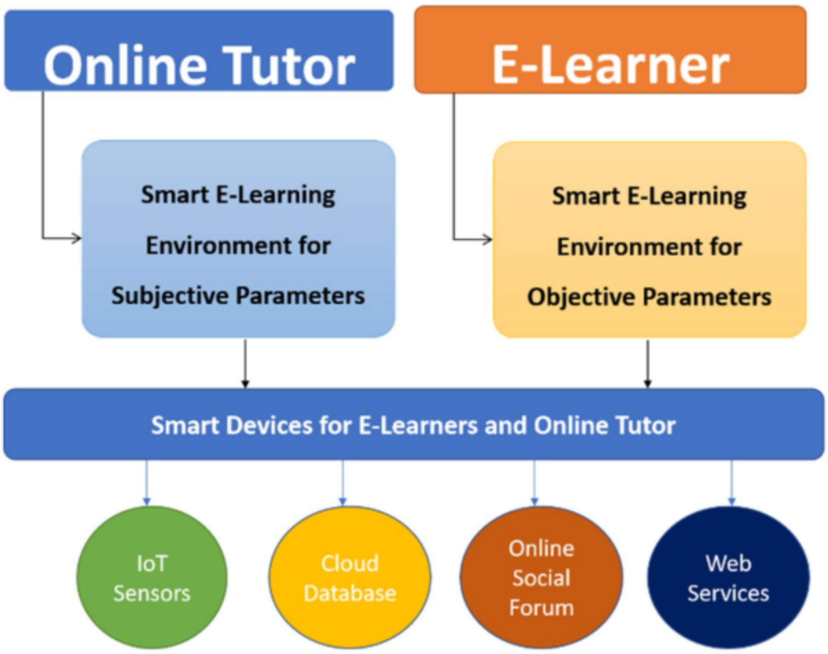

Fig. 5 Proposed IoT-Ve-LS model for SLE

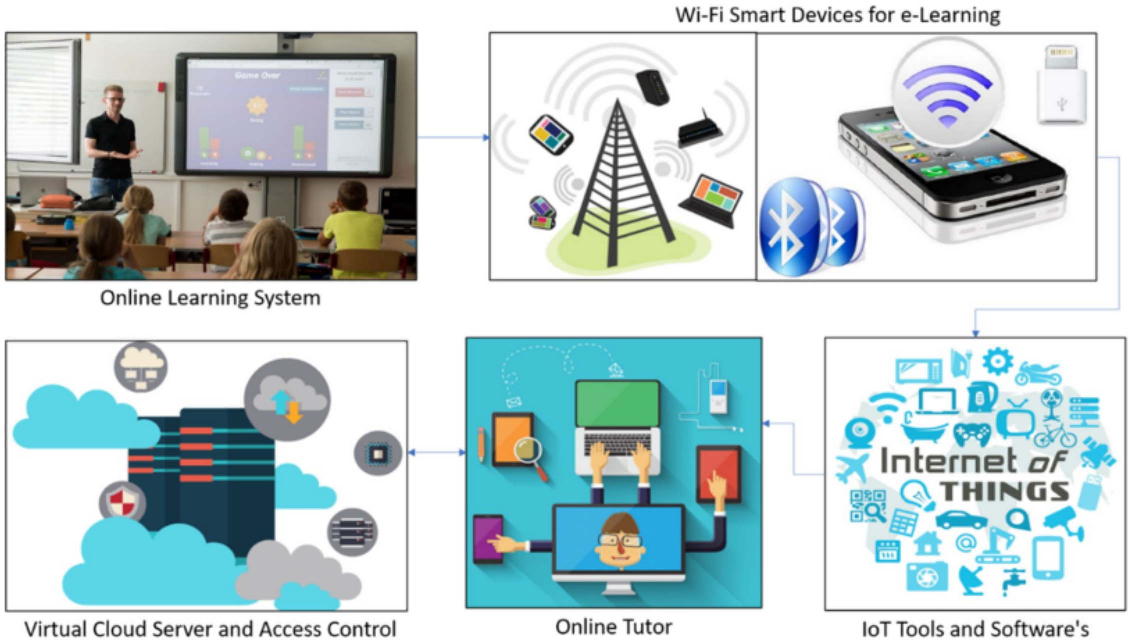

Fig. 6 Teaching and learning methodology for SLE

3 Proposed IoT-Ve-LS Model for SLE

Some restrictions regarding e-learners' requirements, potentials, and desires are collected to enhance meaningful learning and training practices. The conceptual parameter were collected when e-learners communicated their views about the different portions of instruction forms. For example, temperature, volume, voltage, and many other things are put together with the help of different sensors by target parameters, which are physical sizes [36].

The Institutional SLE model is represented in Fig. 5. The essential element of this SLE model is the e-learner's requirements for enhancing the SLE. A standard SLE contains some distinct features. The basic unit of intensive SLE is undoubtedly smart classrooms that address SLE. Figure 6 represents the strategies followed in two smart classrooms, out of which e-learner's abstract parameters are used in one classroom, and objective parameters are used in the second classroom [37].

Learners review the present classroom lecture, which uses a personalized approach. Every e-learner assesses the classes' eminence, attractiveness, and content. At all costs, they can suggest ways to improve the courses in event of dissatisfaction with study aspects. Learners' suggestions can be rated using IoT-Ve-LS.

An SLE integrates IoT-Ve-LS into the pedagogical process, but even the learners use it to prepare e-learning materials. For instance, humidity, heartbeat, and photo sensors. The heartbeat sensors can be utilised to calculate the learner's curiosity level; if the student is curious, the pulse records more than a hundred beats. When most of the e-learner's temperature goes to 32°, the coolness/warmth rises to reach that value. E-learners connect their SDDs to data sheets using an advanced remote system. For instance, Bluetooth obtains essential data about classes and tests [38].

Finally, all the collected information in the data center and some separate servers collect and process information from the data center's sensors. Similarly, data centers contain learning board frameworks that enable client and database servers. The collected data is analysed, and its outcomes are made publicly accessible.

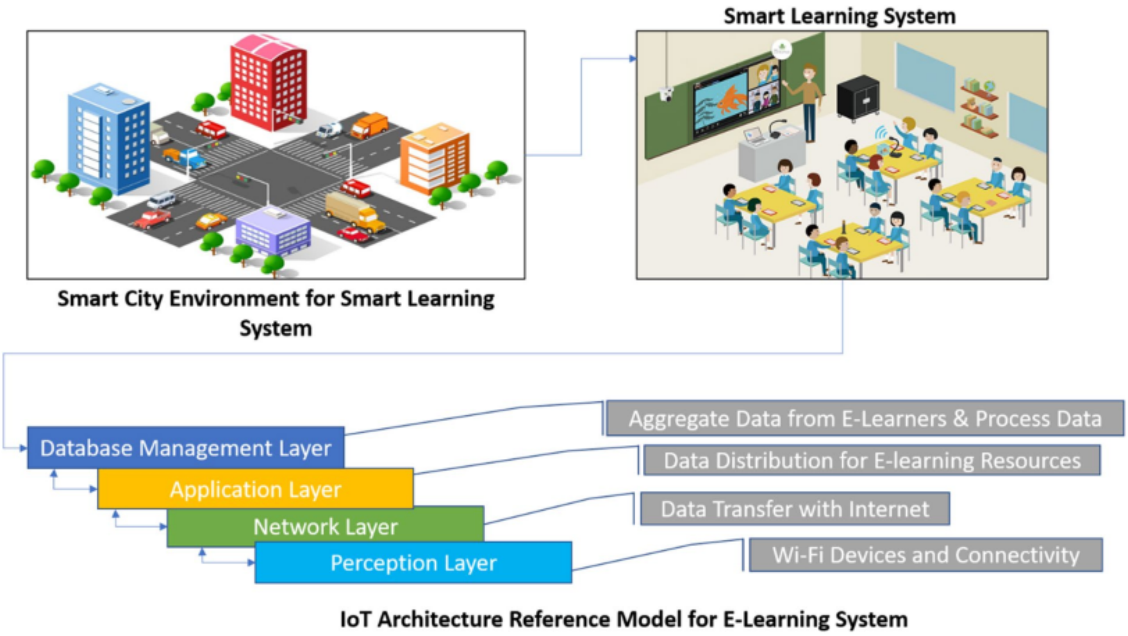

Fig. 7 An adaptive IoT-Ve-LS architecture for SLE

3.1 SLE of IoT-Ve-LS Architecture for Smart City

The SLE has a significant influence on ICT [39]. Such integrations have grown in popularity among the general public and have provided options in e-Learning systems. There are some demerits in SLEs due to the absence of status, which agree with managing misrepresentation, for example, the use of advanced SDD inside the premises. The methodology of IoT results in thinking about the possible production and adopts the capable systems correspondingly when analyzing its attractive features from various perceptions. On the one hand, those perceptions incorporate the learner's interest in recent innovations and increase learning possibilities. Launching an IoT SC campus entails identifying alternative perceptions in requirements, planning, and communicating risks. Figure 7 describes the proposed IoT-Ve-LS for the SLE.

A technological stack with three layers is known as an IoT architecture, and they are IoT devices, gateway, and platform layers. While rendering IoT services, each layer plays a crucial role. Before entering the cloud, where the IoT platform layer exists, data is generated in the device layer and goes via the gateway layer.

3.1.1 IoT Device Layer

All the SDs linked to the systems are comprised of the IoT device layer. SDs are products or assets capable of sending data over the Internet and are embedded in actuators, sensors, and processors. From SLE, they can gather data and circulate it among SDDs, users, operators, and applications associated with the system. For collecting data from SLE, SDs can utilise various kinds of sensors. Soil moisture sensors, which assess the water content in the soil; temperature sensors, which set the atmosphere's temperature; and humidity sensors, which assess the moisture content in the air, may be included in an IoT device specifically for agriculture. Collecting data from just one device, viz., a home surveillance camera, is one of the most accessible IoT implementations. Hundreds or even thousands of devices may be integrated by other implementations that need massive back-end infrastructure for the purpose of handling voluminous data and operations.

3.1.2 IoT Gateway Layer

In between the IoT device and the platform layer, the IoT gateway layer is placed. A real-time device/software program, which gathers data from SDDs and passes it to the cloud, is contained in this layer. Two benefits are offered to the IoT architecture by the gateway layer: management of load through data preprocessing and security. There are sensors in some SDD's that can actually create up to a ten-thousand-thousand data frames per second. Let a set of 12 networked high-definition security cameras be considered, with surveillance footage in 4 K recorded by each one. The network transmission costs, time taken to respond, and bandwidth do not face any problems, and everything might be expensive if all the data were uploaded directly to the cloud [40]. Before transmitting the dedicated software programme to the cloud, it can be contained in the gateway layer, which does data preprocessing. The data transmission from SDDs is protected using gateway devices. In order to prevent horrific attacks against IoT devices and protect data transmitted to the cloud, attributes like hardware random number generators, encryption, and tamper detection can be implemented.

3.1.3 IoT Platform Layer

The tools and applications in the IoT platform layer process the data from the IoT once it is uploaded to the cloud. In management, archiving, and data analytics, the platform layer that contains Edge IT and cloud-based/physical data centers plays a significant role. The IoT platform layer consists of applications that perform analytics, monitoring, data transformation, and other functions and services. The tools that monitor the processed sensor data on user-facing SDDs are also incorporated into the IoT platform layer.

3.2 Perspective of E-Learners on IoT-Ve-LS

The learner is the principal consideration to focus on training. In the e-learning process, learners' interests, comfort, and motivation are the most critical factors. Since their invention, the younger generations have been driven by new technologies and are skilful in using them. The proper implementation of IoT is a threshold for entering into higher academic prospects and improving the academic results from a learner's viewpoint. E-Learners with extreme skill, E-learners would perceive the environment as controlled by computers whose course objectives could be accomplished with gratification [41].

3.3 The OT View of IoT-Ve-LS

When e-learners can benefit from the knowledge acquired from the SLE, the mentor's significance is a big question. OTs are happy about e-Learner's dedication and learning from the tool they rely on. The hallmarks of a SLE strengthen the OTs. The computerised models are attractive and convey the completeness of the E-learning activities.

3.4 SLE Test Case for IoT-Ve-LS

The e-learners may be affected by eye problems when studying the OT material on mobile phones. Sometimes his SDD might have technical issues during their study time. Concerning the social proposal, co-workers recommend some e-learning programmes and encourage them to accomplish it. IoT devices feature accessibility features, and they demand more brightness.

The programme organiser warns about such problems (the possibility of distraction, technological issues, and unorganised trainees), so the materials were tailored to the student's needs. The printer provides extended learning materials.

- Chances of Distraction. The trainee is very convenient in online tutoring; however, there are also many distractions—the trainee is deprived of the opportunity to embrace the advantages of online tutoring if he gets distracted. Unlike the real-time presence of an OT, the trainer can not detect this issue in this case. The trainer may be unable to help at a time of frustration.
- Issues Related to Technology. Everyone cannot access a consistent and quick Internet connection, which is an obstruction for both parties. When video conferencing or watching the "video lectures", fast and consistent Internet access is mandatory for a trainee to imbibe the benefits of online tutoring.
- Disorganized Trainees. The learning ability of the trainee, which is not under the trainer's control,

may sometimes be affected due to the absence of motivation and determination. This type of communication will probably not give any input to people who are least bothered about learning.

IoT's new requisition for acquiring information boards and mining of information includes [42]:

a. SDD identification and contemplation as mandatory factors.
b. Guaranteed Privacy during the execution of IoT-Ve-LS.
c. Establishment of IoT with the help of Online Database Management.
d. Multidimensional analysis aided the online data distribution center.
e. Semantic transparency and interoperability for pursuing diverse information for the IoT.

3.5 Data Aggregation and Distribution

The collected information for IoT is stored and sent to the database using heterogeneous sensors. A new technique is mandatory to collect the pertinent information and the timestamp. Moreover, it needs strength to face the embedded sensors' non-critical failure that monitors and distributes the system structure's positive features. For example, acceptance of information gathering decreases the quantity of information broadcast [43].

3.5.1 Accompanying Features of the Information

1) In general, SDD's online data possesses demonstrable semantics.
2) SD's online data has the possibility of being inaccurate and not very much in place/time.
3) SDD sensors are an instance in the IoT-based e-learning atmosphere for SDD sensors.

3.6 Cloud Integration of IoT-Ve-LS

The fundamentals of e-learning need analysis and insight to understand the hidden knowledge that prompted enhanced approaches and plans for better arrangement, observation, assessment, and cost-effectiveness to improve e-learners' standards. The representation instruments with the necessary leadership enhanced support and data sharing [44].

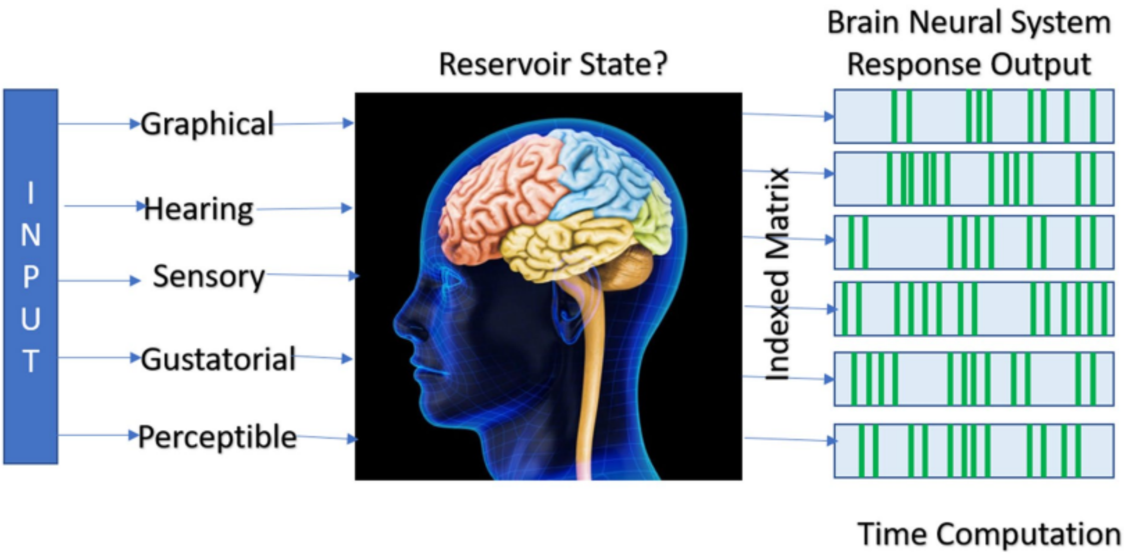

Fig. 8 Working process of human brain system with reservoirs

3.7 Biological Reservoirs Computing for E-Learners

One of neuroscience's unsolved mysteries is the mechanism underlying the brain's computing ability. Many users have attempted to describe the brain's computing functions using an analogy to computer modelling in ML [45]. To better understand how the brain functions with temporal information, researchers have proposed which regions of the brain can be considered reservoirs or sensor data and how sub-neuro systems of the brain function within RC. Numerous neurocognitive research findings on cortico-striatal systems for context-dependent sequential data processing demonstrate the RC theories and models with clarity. It was driven by the real-time computation of time-frame data by cortical microelectronic devices; since then, researchers have openly discussed whether RC is implemented in the brain and which regions of the brain can use this ML conceptual model (Fig. 8). For state-dependent data processing in brain networks, RC is one of the common frameworks that emerge from the interface between sensory input and internal dynamics in ML.

4 Empirical Evaluation: Assessing Knowledge and Skill Levels

The e-Learning process doesn't make an exception from the general principles of the assessment process. The basic steps of the evaluation process in an SLE can be summed up as follows:

- To measure the performance achieved by e-learners;
- To determine if a student is prepared or not to proceed to the next level of SLE;
- To provide feedback to both e-learners and OTs to identify the areas creating learning difficulties and establish the necessary solutions. Also, the OTs can use the input to determine at which size the OT process is not practical.

4.1 Experiment study

The set of Research Hypothesis Questions (RHQ) from the research questionnaire has been conducted by 2000 e-Learners. Based on that, the assessment rating is described in Table 2 and the migration of SLE for the smart city people.

4.2 Research Aims (RA)

- RA1: Theoretical evaluation.
- RA2: IoT-Ve-LS's evaluation for determining e-learner.
- RA3: e-learner's tactic acquired with the help of IoT in the SLE.
- RA4: IoT's drawbacks analyzed by the e-learners.

UG and PG e-learners from the Computer Science Engineering department of Anna University Affiliated Institutions showed interest in the experiment. It should be noted that not many other courses have held IoT-Ve-LS hypotheses and claims in our specialised area recently. RHQ is displayed in Table 4. Liker scale questions are assessed where 1 is "Strongly Accept,“ 2 is "Accept,“ and 3 is "Not Accept.“ In

Table 4 IoT-Ve-LS' RHQ

RA	e-Learning Features
1.	New technology enhances the use of AI-based IoT-Ve-LS
2.	Recommended campus for IoT-Ve-LS enrolment
3.	The motivation to read helps to improve IoT integration
4.	IoT-Ve-LS frameworks would be more effective
5.	IoT-Ve-LS should not be used due to security concerns
6.	E-Learners suggest SDD is connected to the new smart campus SeT
7.	Automation processes are chosen for e-lecture attendance
8.	IoT-Ve-LS supports additional innovations
9.	IoT-Ve-LS can improve e-learners and their classmates' e-learning opportunity
10.	E-Learners are currently not equipped to use IoT-Ve-LS

Table 5 Evaluation of RHQ and response from the study

RSO	μ	σ	Mo	Rating of E-Learners		
				Strongly Accept	Accept	Not Accept
1.	1.43	0.92	1	19	6	0
2.	1.78	1.22	1	16	4	3
3.	1.73	0.89	1	15	7	1
4.	1.69	0.75	2	14	3	3
5.	1.65	0.51	1	16	4	0
6.	1.84	0.87	2	11	3	1
7.	1.98	0.76	1	13	8	0
8.	2.13	0.79	2	19	2	0
9.	1.56	0.81	1	16	3	0
10.	1.34	0.82	1	19	8	2

the same way, if the number is the least, then it is to secure knowledge.

4.3 Experimental Analysis of RHQ

The research survey was carried out in SLEs, and a total of 2000 e-learners RHQ were collected. Table 5 illustrates segments of the result review, which expresses speculation and targets. Expression of information such as μ, σ, and M_o is appropriated to every Research Study Outcome (RSO).

4.4 Study Analysis

The associated speculations appear to have feasible affirmation using the testing analysis.

- RHQ1: Regarding IoT, e-learner possess logical thinking and a portion of their perception and function.
- RHQ2: From e-learners' perception, the IoT framework supplements e-learners' SLE awareness.
- RHQ3: E-learners have resulted from a growing SLE, and technological advancements motivate IoT applications in the real-time e-learning state.
- RHQ4: It is critical to have a well-defined use case situation to integrate IoT-Ve-LS and its consequent outcome.
- RHQ5: The characteristic feature of IoT-Ve-LS that protrudes with enhancement has a crucial impact on e-learners.
- RHQ6: The characteristic feature of IoT-Ve-LS protrudes the estimated e-learning scope, which has no drastic influence on the e-learner.

4.4.1 E-Learners' Practical Challenges About IoT-Ve-LS

The RHQ based IoT- Ve-LS applications' awareness is crucial to this approach. (From RSO:1 to RSQ:10). The complete information of interested Computer Science and Engineering e-learners shows the application direction's learning level associated with the comprehensive knowledge of IoT. Similarly, reviews contribute to assessment (RHQ:1-RHQ:6). Likewise, 67.892% either agree or those who are not willing to consider the idea's familiarity is 97.986%.

4.4.2 IoT-Ve-LS Understanding

This assessment includes (RSO:1-RSO:10) expressed inquiries. When everything is done, we get the results to assess this theory. 85% either fully (or) partially agree with this theory. The outcome additionally occurs with (RSO:1-RSO:10) results.

4.4.3 Use Case of IoT-Ve-LS

The vitality of this application and the e-learners is clear with the given RHQ1. RSO:1 to RSO:10 explain the significance of the situation, which is advantageous to the learners. These investigative assessment results (1.4568, 0.6565, 1.021) exhibit the zeal to be

Table 6 Survey on e-Learner RHQ

RHQ	Study of e-Learner RHQ	Disagree	Agree	Strongly agree
RHQ 1	How supportive is your OT?	12.3	45.19	78.19
RHQ 2	How often do you understand your OT's explanations?	10.29	41.39	81.39
RHQ 3	How often does your OT try a different strategy if you have trouble understanding the lesson?	8.29	51.10	79.39
RHQ 4	How often is the goal for each OT session clear to you?	17.28	63.19	89.39
RHQ 5	How often does your OT make you think critically?	20.30	49.29	91.32
RHQ 6	To what extent do you feel that your OT respects your background?	19.37	53.59	94.67
RHQ 7	How respectful is your OT towards you?	11.29	49.23	89.39

part of such a circumstance. Either 97.2365% agree, or strongly agree with the inquiry. Computer users' keenness also indicates they embrace innovations for automation, which is increasingly challenging for different age groups. The resulting review shows that the e-learners' information level is estimated to be 72.56%, which means everyone is not attentive to how the IoT-Ve-LS functions. The developments in the latest E-learning courses are acknowledged. In any circumstance, 90.134% of the e-learners strongly believe in the drastic upliftment IoT-Ve-LS can bring in user services, assembling, and transportation. Many E-Learners' (83.134%) acceptance of IoT-Ve-LS awareness helps them enhance the activity platform.

IoT-Ve-LS improves the E-learning knowledge and their friends' using the demonstrating number of E-learners (88.898) and helps them learn different innovations. Every E-Learner integrates the smart learning process to obtain every instructive administration using SDDs. They wish to get into an IoT-Ve-LS campus. They wanted to use IoT applications in everyday e-learning because they were computerised users (RHQ:1-RHQ:6).

Figure 6 represents the views of e-learners regarding the appropriateness of IoT-Ve-LS. 24.6754% of the e-learners are bothered about privacy protection and the advanced development of IoT-Ve-LS. Area-based applications cause inconveniences like E-learner's security, which is very important, and hence a perfect framework should be proposed to address these issues. Some learners believe that IoT has some demerits as it causes many disturbances in the e-learning protocol and wastes time using recently presented administrations. The e-learners' overall feedback shows that the IoT-Ve-LS framework would positively respond to the e-learners themselves. In this situation, it is very important that the learner wants to use the new trends for e-learning.

4.5 Investigational Model

The investigation was performed to check the validity of the inventions. It was accepted as an appropriate technique to glance at the proposed theory.

Table 7 Survey on OT-RHQ

RHQ	e-Learners Survey RHQ	Disagree	Agree	Strongly agree
RHQ 1	How often did sessions focus on the most critical skills your e-learner needed?	2.49	68.39	89.30
RHQ 2	To what extent has your child improved academically as a result of OT?	7.19	71.39	91.33
RHQ 3	How informed are you about e-learners' progress in the OT program?	10.39	67.39	93.12
RHQ 4	How effective were OTs in leveraging data to target e-Learner sessions?	15.29	72.93	94.29
RHQ 5	To what extent do you feel that OTs had strong content knowledge?	21.29	78.30	92.35
RHQ 6	To what extent do you feel that OTs have developed effective professional relationships with e-learners?	18.39	79.29	93.48

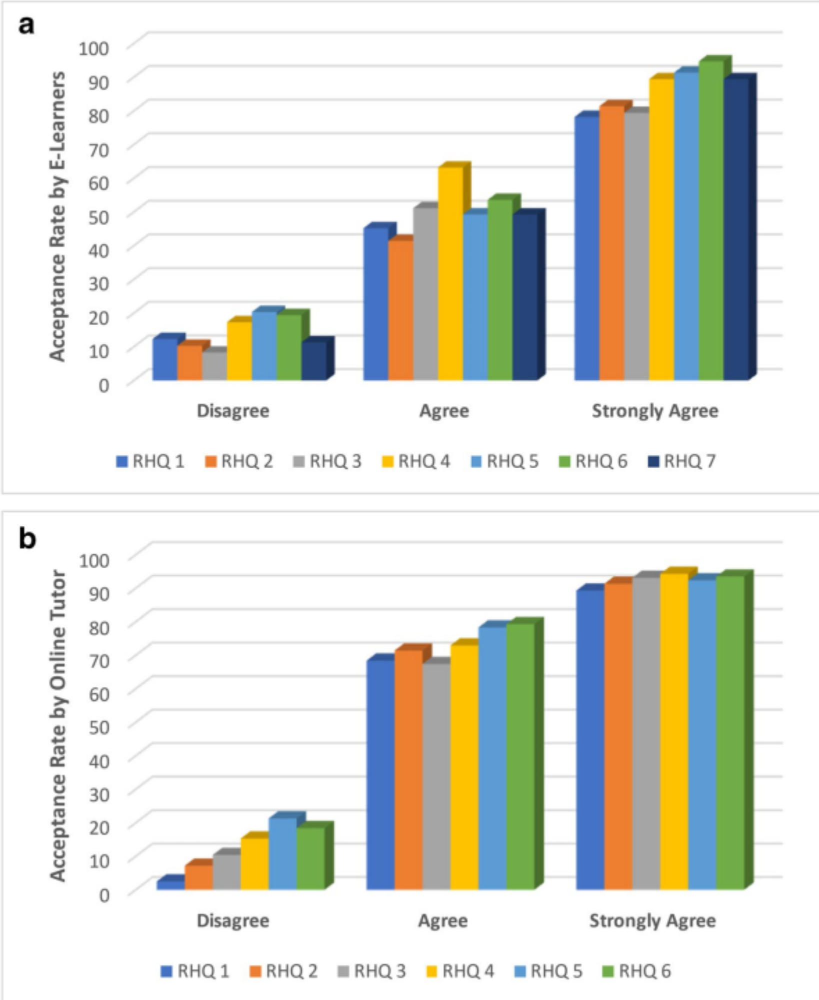

Fig. 9 RSO of IoT-Ve-LS (**a**) responsiveness by e-learner, (**b**) responsiveness by OT

4.5.1 Sampling of Review

The research survey information was collected from members to integrate e-learners and OTs. The blended technique approach brought an aggregate of 25 predefined elements into this feedback form. 2000 is the targeted standard population (Tables 6 and 7). An illustration is the pilot study's determination of estimation done using the Cochran equation [46, 47]. Hence, approximately 300 was the correct number. Figure 9(a) and (b) display the graphical summary of the OTs/E-learners-oriented research survey outcomes. The review-based information views both the varsity of e-learners and OTs.

4.5.2 Findings of RHQ

IoT-Ve-LS displays a vast quantity of hyper-associated objects associated with them, which exposes the count of OTs who gave their acceptance. The results showed that most of the OTs (95–99%) agree that the possibility of IoT-Ve-LS application in advanced smart education generally affects the personalised part of adaptation. For instance, consider e-learning proficiency and teamwork [48]. IoT's application in advanced SLE like e-schools and e-colleges opens doors for researchers just like e-learners.

Figure 10 foresees IoT-Ve-LS's possibly less effect on the Internet's flexibility in teaching. Figure 11

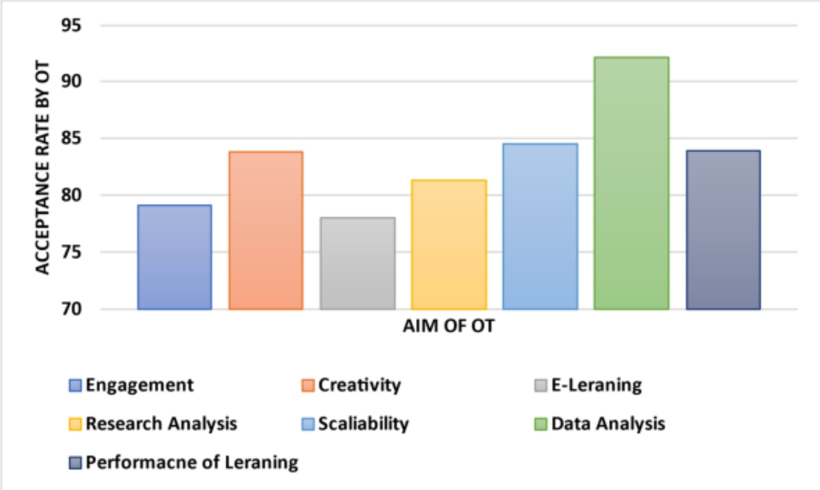

Fig. 10 Investigation of OT's objective

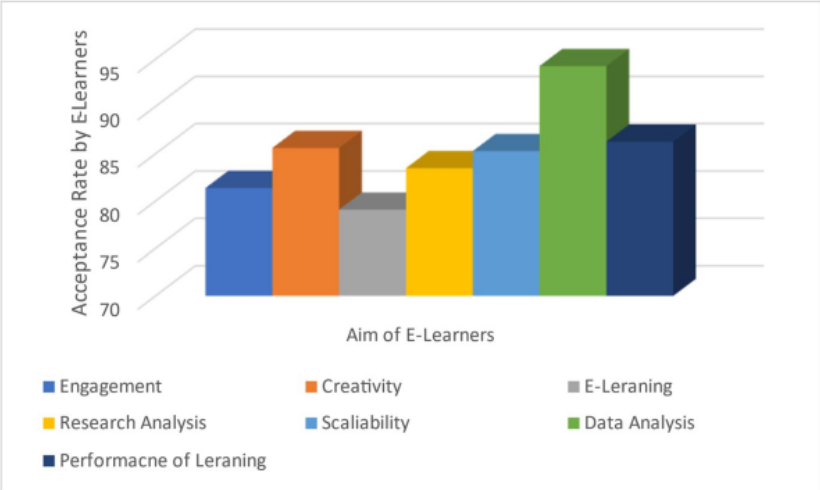

Fig. 11 Investigation of e-learners' objective

anticipates how IoT can produce insight and standards to overcome the previous prototypes, and such novel approaches are not superior and swing in the range of 60.19% and 80.88%. Figure 10 also describes the OT and student gap in the execution effect and different components. Similarly, the IoT is not empowering OTs and e-learners to participate in the e-learning process. Nearly 50.1% of the people who were interviewed think that IoT can't be a significant part of e-learning.

The e-learner's agreement with the result is represented in Fig. 10, and sometimes the forecasting of the e-learner is surprising and has certain similarities to the OT's statement. It outlines two forecast adaptations.

Figure 11 exhibits a graphical correlation outcome and both involve the intersection of three variables: e-learning, research opening, and hyper-network. Both the collections admit that IoT influences those elements in IoT-Ve-LS based avant-garde education. The significant difference is that if physical learning perspectives occur as the learners think, the primary factor affects market research. The self-learning factor, which satisfies the e-learner simultaneously, is not considered significant in the OT's view. The impact of IoT-Ve-LS on teaching and teamwork is another difference between the two views. Educators believe IoT-Ve-LS encourages collaboration and support, but e-learners do not give the same importance as OTs. Finally, e-learners discover how IoT-Ve-LS execution can improve creativity in advanced SLE (Fig. 12).

Some sets of research surveys were done to collect information from e-Learners. Inquiries 1 to 4 and RHQs were bound to examine the statistical reports of the respondents. For breaking down business insights, inquiries 5, 6, 8, and 10 were proposed to facilitate the goal of distinguishing the employability factor. Researchers are enabled from inquiries 9, 11, 12, and 14 to get satisfactory answers to understand the difficulties ahead.

Similar inquiries bind e-learners. The socioeconomics is decided upon by inquiries one to four, and the learner's decision is determined by inquiries six to nine. Inquiries 5, 6, and 10–15 reveal E-Learner's inclination towards online training, prospectuses, and course materials. The inquiries 16 to 22 focus on the OT's vehicle, communication language, the institution's allotment of offices, and the accessibility using specific devices.

Table 8 Learning level of E-learners by the course

Online Program (OP)	% of Acceptance
Online Under Graduation OP	2.345
Online Post-Graduation OP	7.567
Online Doctoral OP	26.689
Online Values Added OP	88.678
Online Certification OP	98.831

Table 8 mentioned earlier makes the e-learning courses apparent and their desires amid specific examples used. It could affect e-learners who take up e-learning courses for professional qualification from the assessment.

Figures 13, 14, and 15 show that hybrid programmes are the most sought-after e-learning courses compared to traditional learning programs.

Table 9 shows that a local is preferred when a course is pursued through IoT-Ve-LS.

Table 10 shows how important it is for innovation to take a course when it is pursued through IoT-Ve-LS.

Above, Table 11 portrays the evaluation handed over to the accessibility of material when a course is chosen to be pursued through IoT-Ve-LS.

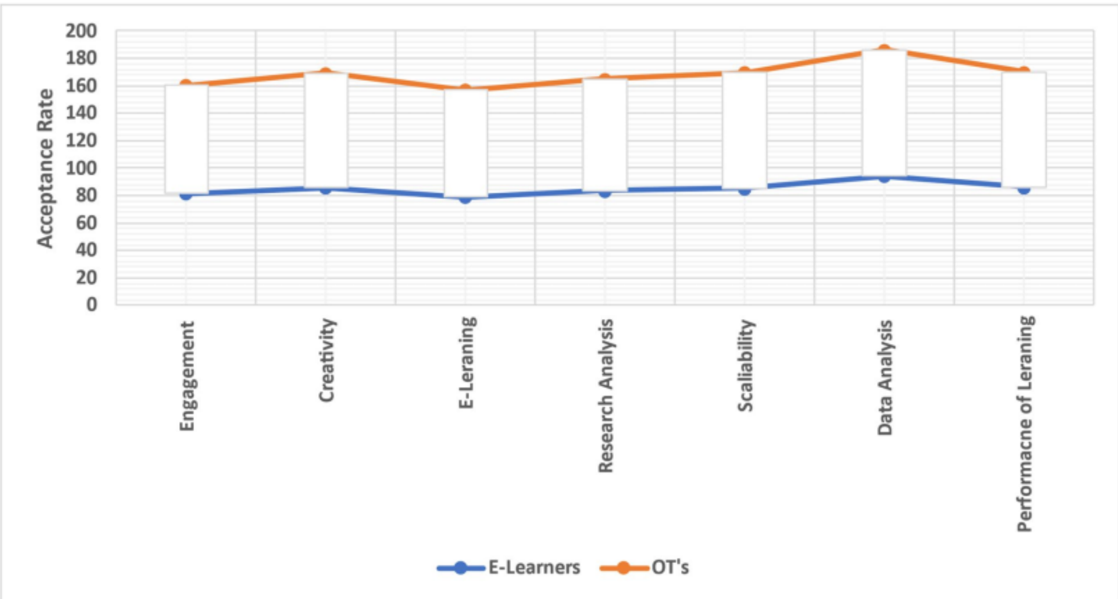

Fig. 12 Performance metrics of e-learners vs. OT

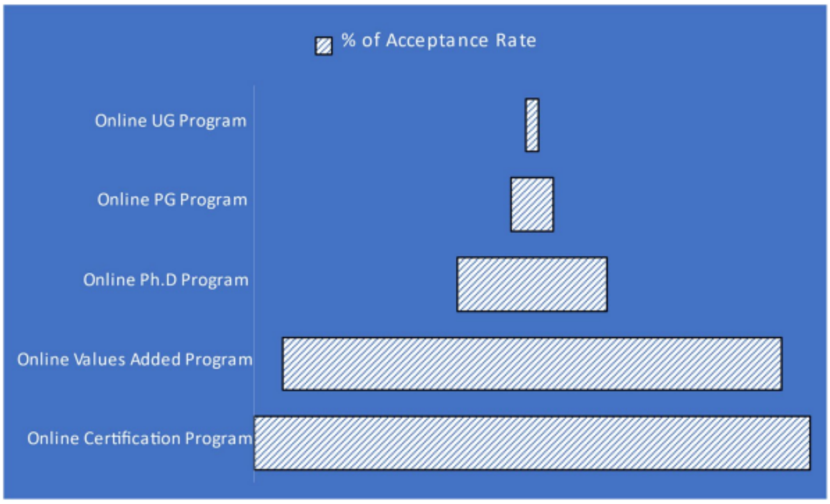

Fig. 13 e-Course wise user-friendliness for E-learners

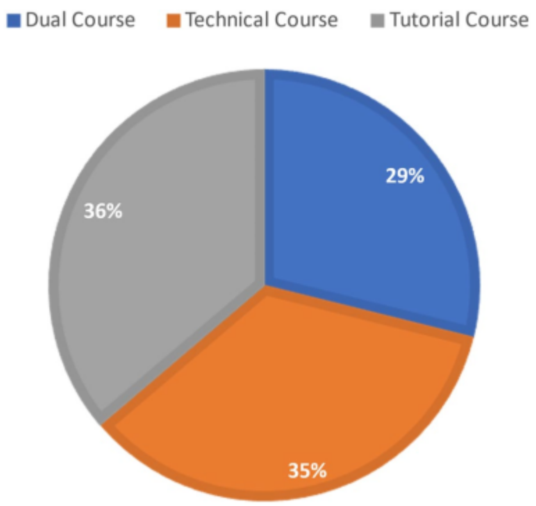

Fig. 14 Preference for e-Course wise Module by E-learners

The rating given to the institution offers the online course while pursuing an online course through IoT-Ve-LS that evaluates the dominant part as shown in Table 12. Table 13 represents the rating given to time convenience when an online course is chosen to be pursued through IoT-Ve-LS and provides an excellent rating for this parameter. Table 14 shows the allotted rating for the flexibility of time when a course is chosen to be pursued through IoT-Ve-LS and offers a top rating for this parameter.

The course OT holds multiple positions when a class is chosen, as shown in Table 15.

5 Data Analysis of IoT-Ve-LS

To restrict the individual responses, a configuration of closed inquiries has been embraced. For example, with the help of a 3-point Likert scale sprawling over 1 to 3, upholds 'Strongly Accept' to 'Not Accept' and also allows only 'Yes/No' answers (Tables 16, 17, 18 and 19). An investigation was conducted into each SLE. A total of 500 research studies were publicized, and 250 researcher investigations were completed, giving a reaction pace of 76.187%. By all means, three distinct classifications from each incorporation were attained. The SLE employs empirical ICT analysis [49–52].

5.1 Analysis of E-Learner Response

The data presented in this section is from a research survey conducted between December 2019 and September 2021. A total of 2000 surveys were shown, in which 1550 were obtained entirely, giving a feedback pace of 76.187%, sufficient in the field. The statistics of the respondents are represented in Fig. 16. In terms of gender, around 66% (72.187%) were male, and 33% (27.138%) were female. Considering the respondents' experience, most of them (94.126%) possess PC experience of more than two decades, whereas

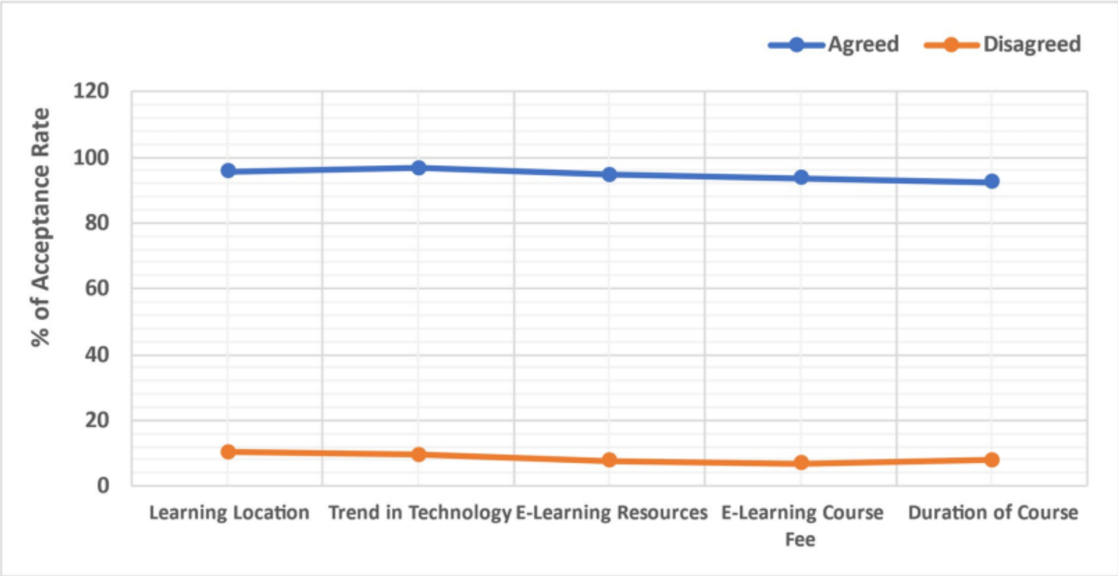

Fig. 15 Investigation features for IoT-Ve-LS

Table 9 Factors for pursuing an online course by e-learning [46]

Assessment of acceptance factors		
Minimum	Average	Maximum
Learn to Understand the Vision	Cost of SDD for SLE	Current IoT to follow the online courses
Course OT	e-Learning Time Consumption	Improve online resource accessibility

Table 10 Rating of learning place

OP Level	% of Acceptance
1.	73.87
2.	89.79
3.	82.82
4.	96.38
5.	99.48

Table 11 Rating of IoT

OP Level	% of User Acceptance
1.	54.15
2.	88.39
3.	64.45
4.	87.66
5.	47.75

Table 12 Rating of e-Learning resources

OP Level	% of Acceptance
1.	84.17
2.	78.19
3.	70.19
4.	77.19
5.	67.19

24.567% are somewhere in the series of 10–15 years, and around 5.281 have PC practice in the range of 1–9 years. People with less PC experience make up approximately 0.98% of the total respondents.

Table 13 Rating of online course fee

OP Level	% of Acceptance
1.	54.17
2.	88.19
3.	81.19
4.	77.19
5.	59.19

Table 14 Rating for e-Learning vs. OT

OP Level	% of Acceptance
1.	66.18
2.	78.18
3.	92.34
4.	67.18
5.	76.10

Table 15 Rating of e-Learner vs. OT

OP Level	% of Acceptance
1.	56.18
2.	18.19
3.	95.19
4.	67.19
5.	66.18

Concerning age, the outcomes show that most respondents (53.455%) were in the age group of 5–10 years, followed by the age group of more than 25 years with approximately 33.454%. The investigation followed the age grouping of 11 – 15 (25.454%) and subsequently 16–20 with 67.89% of the absolute defendants. Lastly, young scholastics and administrators younger than 25 years are 83.577% of the total respondents, and the outcome is explained in Figs. 17 and 18.

5.2 Future Impact of IoT-Ve-LS

In the future, the teaching and e-learning process will be upgraded by IoT-Ve-LS and will make online teaching and e-learning accessible for e-learners and OTs. It is anticipated that IoT-Ve-LS devices will engage and connect E-learners and OTs and gratify the various needs of many E-learners. Worldwide, learners spend 2000 h studying. More than 500 of the 2000 h are poorly paid with aggravations like the circulation of learning resource materials or time taken to start and end the class. This proves that IoT-Ve-LS benefits beginners who waste consistent intervals in the smart classroom and are deprived of amenities. OTs would be likely to invest less effort in direct methods and spend more time with E-learners to monitor their progress. They can likewise enable E-learners to handle issues in a limited capacity.

Table 16 OT survey rating of OT on ICT teaching and learning skills

S.No.	RHQ	Strongly disagree	Disagree	Agree	Strongly agree
1	OT can install software on my own	5.9	29.10	51.18	21.29
2	OT search teaching aids from the Internet	1.9	2.18	68.19	31.08
3	OT can construct a E-learning website	4.1	55.18	45.19	2.8
4	OT always use the SDD in my classroom	4.5	45.12	50.19	10.29
5	OT teach my learner how to find information on the Internet	2.9	30.19	56.191	21.19

Table 17 Usage of OTs on SLE tools and things

S.No.	SLE tools and things	Frequently	Occasionally	Not ever
1	Multimedia SDD	25.18	55.28	16.81
2	Internet for SLE	29.12	67.38	31.57
3	Slide Projector	41.39	45.28	48.34
4	Light Pen	37.19	48.18	49.12
5	SDD–Projector System	41.93	61.39	29.17

Table 18 Survey score for learning place of OTs using ICT

S.No.	Learning place of OTs using ICT	%
1	Smart Class Room	55.67
2	SeT Laboratory	45.81
3	OT Room	78.19
4	OT Home	41.98
5	Other Places	21.19

Neuro sensors could be used to measure how smart E-learners are, and haptic vibrations could be sent to tell them to pay attention.

Still, some significant institutions have not upgraded to an IoT-Ve-LS, but it is not far. The number of related tools is growing tremendously, and several envisions have been made in this regard. As per Gartner's gauge, 30.45 new objects would be integrated with IoT-Ve-LS by the end of 2030. According to Machina's research, the development of IoT-Ve-LS is excellent: from 10 billion by 2020 to 30 billion by

Table 19 Survey rating of SLE supported for smart city people

S.No.	ICT integration statements for SeT	Strongly disagree	Disagree	Agree	Strongly agree
1	I utilize the computer as a SDD to demonstrate how it is working with the help of current presentations or something that others have made for me.	1.8	7.19	78.19	93.81
2	I use the SDD for all the novelties of the subject, i.e., directly deriving knowledge from the computer.	2.28	81.29	80.23	92.94
3	I motivate the class e-learners to seek pertinent information on the Internet.	2.91	12.36	76.28	97.17
4	The E-learning centre has explicitly articulated the vision and mission of integrating ICT.	10.29	31.58	76.29	98.19
5	My e-learners are taught to take into account the inferences and chances of using the SDD	2.19	31.18	76.92	89.29

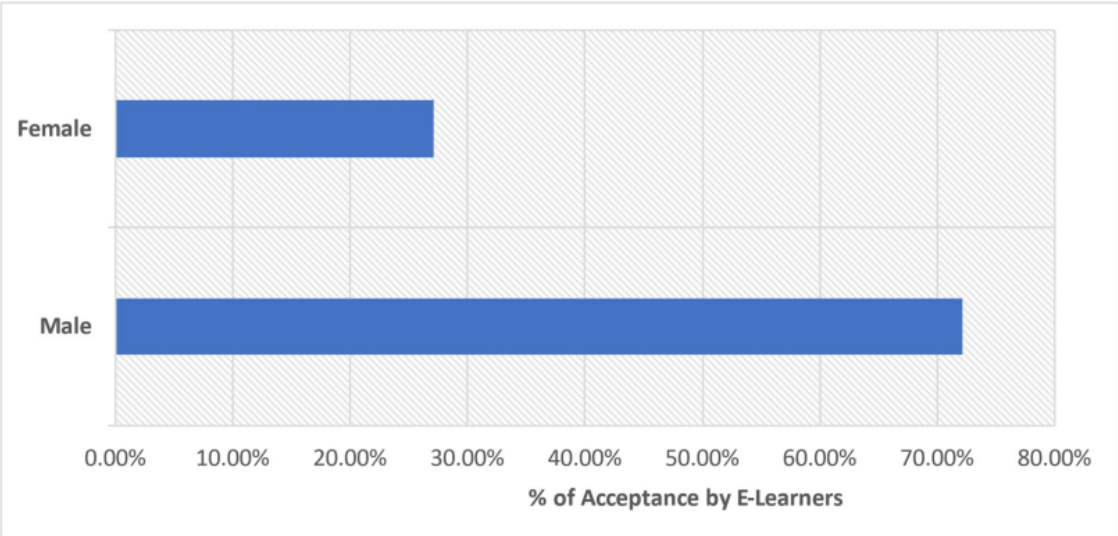

Fig. 16 Reviews of e-Learners

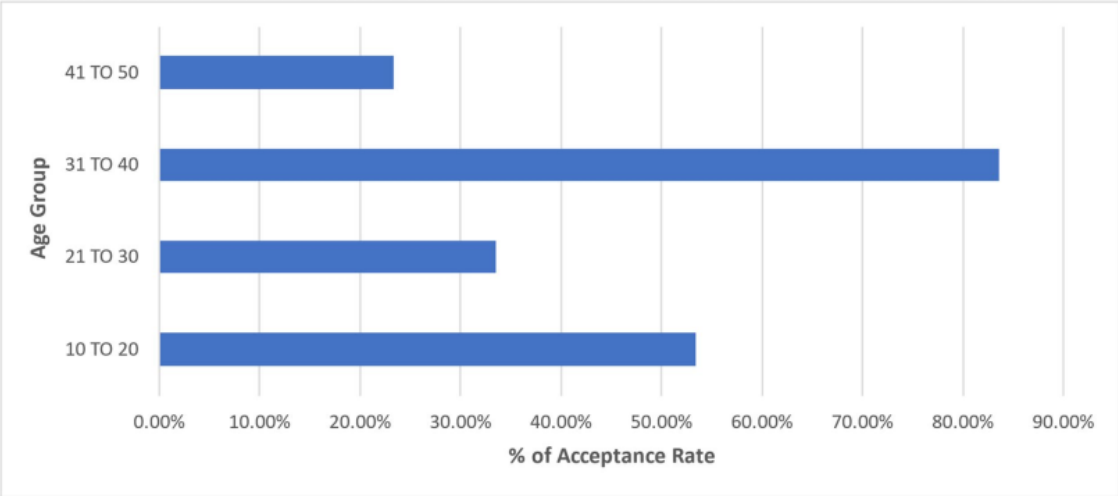

Fig. 17 SDD experience vs. age groups

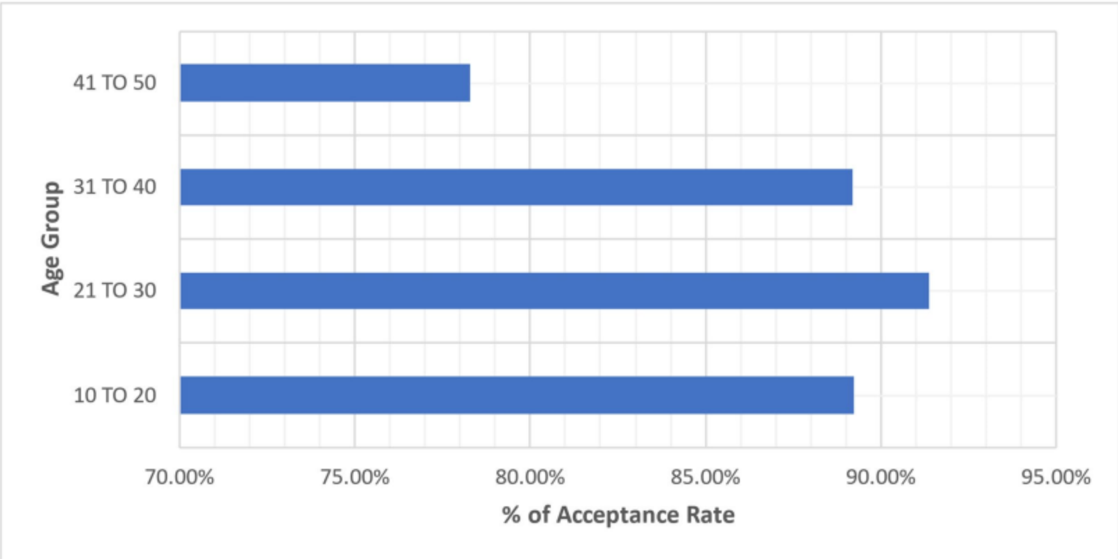

Fig. 18 Online user's responses vs. age groups

2030, as cited in Fig. 19. In 2030, IoT-Ve-LS's net worth would be 3 trillion dollars. Similarly, IoT-Ve-LS generates more than two yottabytes of information from the purchased SDD.

IoT-Ve-LS related frameworks are conveyed using remote development such as RFID and ZigBee. To a certain degree, IoT has some flaws, and some constructive IoT-Ve-LS applications depend on the potential needs of users (SC, Energy, Grid). IoT-Ve-LS's difficulties include security, accessibility, compactness, reliability, implementation, interoperability, flexibility, faith, and executives. This research

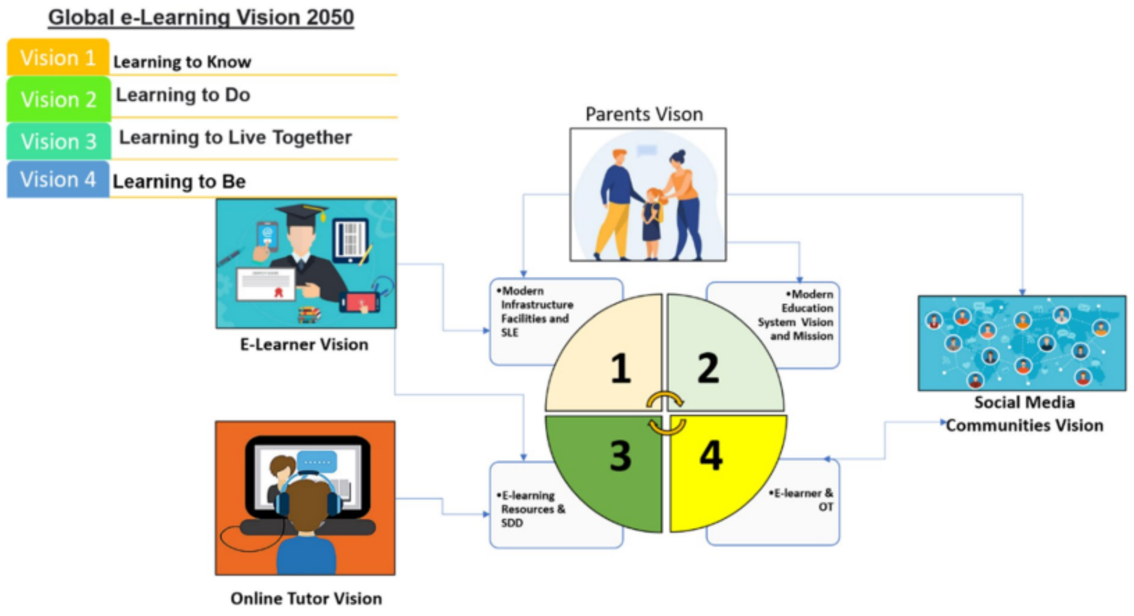

Fig. 19 e-Learning vision 2050: AI and SDD

article discusses the employability of IoT-Ve-LS in the spheres of SLE.

6 Conclusion and Future Work

This paper describes how SLEs are applied in smart city governance processes. The researchers suggested the IoT-Ve-LS model as a new SeT that tends to focus on synchronous e-learning to continue improving information depending on the requirements of e-learners. IoT-Ve-LS is comparatively an emerging technological trend, rarely used in the smart education system in SC. The utilisation of SDDs and IoT-Ve-LS enhances e-learning and OT domains. The proposed IoT-Ve-LS model is an extensive network, and it is essential for e-learners to access the OTs. IoT-Ve-LS aims to maintain a framework to embrace, store, and broadcast the information in a cloud database. The report split trains the organisation to improve the e-learner's deep-rooted e-learning nature. The hypothetical and brief local investigations exhibit the adequacy and impact of IoT in *state-of-the-art* SLE, and the e-learning process is predictable and shouldn't be ignored. The IoT-Ve-LS's real and favourable real-time situations are considered, creating a new evolution in teaching ecological systems for SC in the future, irrespective of the existing complications in educational development.

Due to this fact, our research focused on the IoT-Ve-LS applications in the new education sector. The nature of e-learning is exploratory, and the research was conducted by the e-learners of Anna University in the age group of 25 years with just 2000 valid respondents. Thus, a large population cannot be inferred from the findings. The competence and impact of the IoT-Ve-LS in higher education are shown in the theoretical and short-term regional statistical studies. The importance of preemptive e-learning should never be overlooked. IoT, AI, and VR technologies are joined together to make a much more reliable system that assists the OT in guiding e-learners during learning.

Furthermore, the reservoir without adaptive updating can be implemented using a wide range of physical systems, substrates, and devices, making it more flexible than with adaptive updating. A growing number of researchers are turning their attention to physical reservoir computing. To handle real-world problems efficiently and quickly, this proposed ring network uses ML to design its RC model.

Future extensions of our IoT-Ve-LS will primarily focus on more computer-assisted services based on embedded sensors that will assist the OT in detecting and responding to the behaviour of e-learners. The OTs can concentrate on the e-learners' better-learning outcomes with the help of IoT SDD. To explain it better, the classroom work of the educators will be enhanced by deploying new professional tools based on IoT and developing their rapport with e-learners.

Data Availability Not applicable.

Code Availability Not Applicable.

Declarations

Conflicts of Interest/Competing Interests Not applicable.

References

1. Sethi, P., Sarangi, S.R.: Internet of Things: Architectures, protocols, and applications. J. Electr. Comput. Eng. **2017**, Article ID 9324035, 25 pages (2015)
2. Chen, Y., Yang, M.: Study and construct online self-learning evaluation system model based on AHP method, 2nd IEEE International Conference on Information and Financial Engineering: (ICIFE), IEEE, pp. 54–58 (2010)
3. Prasanna, S.: Expanding the learning environment by using Internet of Things for eLearning. International Conference on Intelligent Sustainable Systems (ICISS), pp. 361–364 (2017)
4. Ahmed, S., Ilyas, M., Raja, M.Y.A.: Smart living: ubiquitous services powered by Ambient Intelligence (AmI). IEEE 16th International Conference on Smart Cities: Improving Quality of Life Using ICT & IoT and AI (HONET-ICT), 2019, pp. 043–048 (2019)
5. Debabrata Bagchi, K., Kaushik, Kapoor, B.: Virtual labs for electronics engineering using cloud computing. In Interdisciplinary Engineering Design Education Conference (IEDEC), 3rd, IEEE, 39–40 (2013)
6. Munwar Iqbal, M., Farhan, M., Saleem, Y., Aslam, M.: Automated web-bot implementation using machine learning techniques in e-Learning paradigm. J. Appl. Environ. Biol. Sci. **4**, 9 (2014)
7. Ajaz Moharkan, Z., Choudhury, T., Gupta, S.C., Raj, G.: Internet of Things and its applications in E-learning. 3rd International Conference on Computational Intelligence & Communication Technology (CICT), pp. 1–5 (2017)
8. Xue, S., Churchill, D.: A review of empirical studies of affordances and development of a framework for educational adoption of mobile social media. Educ. Technol. Res. Dev. **67**, 1231–1257 (2019)
9. Sili, M., Sandner, E., Roedl, L.: Explicit and Implicit Human-Computer Interactions in Ambient Intelligence Environments. Ambient 2018, ISBN 978-1-61208-679-8 (2018)
10. Csáji, B.C., Campi, M.C., Weyer, E.: Sign-perturbed sums: a new system identification approach for constructing exact non-asymptotic confidence regions in linear regression models. IEEE Trans. Signal Process **63**(1), 169–181 (2015). https://doi.org/10.1109/TSP.2014.2369000
11. Galambos, P., Csapó, Á., Zentay, P., Fülöp, I.M., Haidegger, T., Baranyi, P., Rudas, I.J.: Design, programming and orchestration of heterogeneous manufacturing systems through VR-powered remote collaboration. Robot. Comput.-Integr. Manuf **33**, 68–77 (2015). https://doi.org/10.1016/j.rcim.2014.08.012
12. Kovács, J., Marosi, A.C., Visegrádi, Á., Farkas, Z., Kacsuk, P., Lovas, R.: Boosting gLite with cloud augmented volunteer computing. Future Gener. Comput. Syst. **43–44**, 12–23 (2015). https://doi.org/10.1016/j.future.2014.10.005
13. Sarwar, S., Qayyum, Z.U., García-Castro, R., Safyan, M., Munir, R.F.: Ontology-based E-learning framework: a personalized, adaptive and context-aware model. Multimed. Tools Appl. **78**(24), 34745–34771 (2019)
14. Ali, S., Uppal, M.A., Gulliver, S.R.: A conceptual framework highlighting e-learning implementation barriers. Inform. Technol. People. **31**(1), 156–180 (2018)
15. Charith, Perera, et al.: Sensing as a service model for smart cities supported by internet of things. Trans. Emerg. Telecommun. Technol. **25**(1), 81–93 (2014)
16. Kizilcec, R.F., Reich, J., Yeomans, M., Dann, C., Brunskill, E., Lopez, G., Turkay, S., Williams, J.J., Tingley, D.: Scaling up behavioral science interventions in online education. Proc. Natl. Acad. Sci. USA **117**, 14900–14905 (2020)
17. Ghazal, S., Samsudin, Z., Aldowah, H.: Students' perception of synchronous courses using skype-based video conferencing. Indian J. Sci. Technol. **8**(30), 1–9 (2015). https://doi.org/10.17485/ijst/2015/v8i30/84021
18. Guinard, D., Trifa, V., Pham, T., Liechti, O.: Towards physical mashups in the web of things. Proc. IEEE 6th International Conference on Networked Sensing Systems (INSS 09), Pittsburgh, PA, pp. 196–199 (2009)
19. Bao, W.: COVID-19 and online teaching in higher education: A case study of Peking University. Hum. Behav. Emerg. Technol. **2**, 113–115 (2020)
20. Joshi, G.P., Kim, S.W.: Survey, nomenclature and comparison of reader anti-collision protocols in RFID. IETE Tech. Rev. **25**(5), 234–243 (2008). https://doi.org/10.4103/0256-4602.44659
21. Phougat, K., Wakurdekar, S., Pruthi, S., Sinha, M.: An IoT approach for developing Smart Campus International. J. Innovative Res. Comput. Commun. Eng. **5**(4), 7405–7412 (2017)
22. Péter, G., Kis, T.: Approximability of scheduling problems with resource-consuming jobs. Ann. Oper. Res. **235**, 319–336 (2015). https://doi.org/10.1007/s10479-015-1993-3
23. Simon, J.E., Taylor, T., Kiss, A., Anagnostou, G., Terstyanszky, P., Kacsuk, J., Costes, N., Fantini: The CloudSME simulation platform and its applications: A generic multi-cloud platform for developing and executing commercial

cloud-based simulations. Future Gener. Comput. Syst. **88**, 524–539 (2018). https://doi.org/10.1016/j.future.2018.06.006
24. Gugnani, S., Blanco, J., Kiss, T., Terstyanszky, G.: Extending science gateway frameworks to support big data applications in the cloud. J. Grid Comput. **14**(4), 589–601 (2016). https://doi.org/10.1007/s10723-016-9369-8
25. Calyam, P., Wilkins-Diehr, N., Miller, M., Brookes, E.H., Arora, R., Chourasia, A., Jennewein, D.M., Nandigam, V., LaMar, M.D., Cleveland, S.B., Newman, G., Wang, S., Zaslavsky, I., Cianfrocco, M.A., Ellett, K., Tarboton, D., Jeffery, K.G., Zhao, Z., González-Aranda, J., Perri, M.J., Tucker, G., Candela, L., Kiss, T., Gesing, S.: Measuring success for a future vision: defining impact in science gateways/virtual research environments. Concurr. Comput.: Pract. Exp. **33**(19), e6099 (2021). https://doi.org/10.1002/cpe.6099
26. Romanchuk, V., Beshley, M., Panchenko, O., Arthur, P.; Design of software router with a modular structure and automatic deployment at virtual nodes. 2nd International Conference on Advanced Information and Communication Technologies (AICT), pp. 295–298 (2017). https://doi.org/10.1109/AIACT.2017.8020123
27. Tanaka, G., Yamane, T., Héroux, J.B., Nakane, R., Kanazawa, N., Takeda, S., Numata, H., Nakano, D., Hirose, A.: Recent advances in physical reservoir computing: A review. Neural Netw. **115**, 100–123 (2019). https://doi.org/10.1016/j.neunet.2019.03.005
28. Du, C., Cai, F., Zidan, M.A., Ma, W., Lee, S.H., Lu, W.D.: Nat. Commun. **8**, Article number 2204 (2017). https://doi.org/10.1038/s41467-017-02337-y
29. Moon, J., Ma, W., Shin, J.-H., Cai, F., Du, C., Wei, D., Lu: Temporal data classification and forecasting using a memristor-based reservoir computing system. Nat. Electron. **2**, 480–487 (2019). https://doi.org/10.1038/s41928-019-0313-3
30. Chembo, Y.K.: Machine learning based on reservoir computing with time-delayed optoelectronic and photonic systems. Chaos. **30**(1) (2020). https://doi.org/10.1063/1.5120788
31. Kiss, T., Kukla, T.: High-level user interface for accessing database resources on the grid. In: Kacsuk, P., Lovas, R., Németh, Z. (eds.) Distributed and Parallel Systems. Springer, Boston (2008). https://doi.org/10.1007/978-0-387-79448-8_14
32. Alomar, M.L., Canals, V., Martínez-Moll, V., Rosselló, J.L.: Low-cost hardware implementation of Reservoir Computers. 24th International Workshop on Power and Timing Modeling, Optimization and Simulation (PATMOS), pp. 1–5 (2014). https://doi.org/10.1109/PATMOS.2014.6951899
33. Costa, R., Brasileiro, F., Filho, L.: Using broadcast networks to create on-demand extremely large scale high-throughput computing infrastructures. J. Grid Comput. **10**, 419–445 (2012). https://doi.org/10.1007/s10723-012-9229-0
34. Kirthica, S., Saravanan, I., Sridhar, R.: Enhancing the Cloud Inter-operation Toolkit (*CIT*) to support multiple cloud service models. J. Grid Comput. **18**, 419–439 (2020). https://doi.org/10.1007/s10723-020-09516-0
35. Keengwe, J., Onchwari, G., Wachir, P.: Computer technology integration and student learning: Barriers and promise. J. Sci. Edu. Technol. **17**(6), 560–565 (2008)
36. Phougat, K., Wakurdekar, S., Pruthi, S., Sinha, M.: An IoT approach for developing Smart Campus. Int. J. Innov. Res. Comput. Commun. Eng. **5**(4), 7405–7412 (2017)
37. Mashal, O.A., Chung, T.Y.: Analysis of recommendation algorithms for Internet of Things. IEEE Wireless Communications and Networking Conference Workshops (WCNCW), pp. 181–186 (2016)
38. Islam, A., Anum, K., Dwidienawati, D., Wahab, S., Abdul, A.: 'Building a post-COVID-19 configuration between Internet of Things (IoT) and sustainable development goals (SDGs) for developing countries. J. Arts Soc. Sci. **4**(1), 45–58 (2020)
39. De Souza, L.M.S., Spiess, P., Guinard, D., Köhler, M., Karnouskos, S., Savio, D.: SOCRADES: A web service based shop floor integration infrastructure. In: Floerkemeier, C., Langheinrich, M., Fleisch, E., Mattern, F., Sarma, S.E. (eds.) The Internet of Things. Lecture Notes in Computer Science, vol 4952. Springer, Berlin, Heidelberg (2008). https://doi.org/10.1007/978-3-540-78731-0_4
40. Pal, A., Mukherjee, A., Dey, S.: Future of healthcare-sensor data-driven prognosis,. Springer Series in Wireless Technology, International Publishing Switzerland (2016)
41. UNESCO, Global Education Coalition.: Responding to COVID-19 and beyond, the global education coalition in action. Programme and Meeting Document, ED/GEC/2020/02, UNESCO, France, Paris (2020)
42. Aman, A.H.M., Hassan, W.H., Sameen, S., Attarbashi, Z.S., Alizadeh, M., Latiff, L.A.: IoMT amid COVID-19 pandemic: Application, architecture, technology, and security. J. Netw. Comput. Appl. **2020**, Art. No. 102886 (2021)
43. Gómez, J., et al.: Interaction system based on internet of things as support for education. Procedia Comput. Sci. **21**, 132–139 (2013)
44. Taylor, S.J.E., et al.: Enabling cloud-based computational fluid dynamics with a platform-as-a-service solution. IEEE Trans. Industr. Inf. **15**(1), 85–94 (2019). https://doi.org/10.1109/TII.2018.2849558
45. Vedavathi, N., Kumar, A.: An efficient e-learning recommendation system for user preferences using hybrid optimization algorithm. Soft Comput. **25**, 9377–9388 (2021)
46. Tan, C., Lin, J.: A new QoE-based prediction model for evaluating virtual education systems with COVID-19 side effects using data mining. Soft Comput. (2021). https://doi.org/10.1007/s00500-021-05932-w
47. Tarus, J.K., Niu, Z., Kalui, D.: A hybrid recommender system for e-learning based on context awareness and sequential pattern mining. Soft Comput. **22**, 2449–2461 (2018)
48. Chu, H.C., Tsai, W.W.J., Liao, M.J., et al.: Facial emotion recognition with transition detection for students with high-functioning autism in adaptive e-learning. Soft Comput. **22**, 2973–2999 (2018)

49. Afzal, N., Mitkov, R.: Automatic generation of multiple-choice questions using dependency-based semantic relations. Soft Comput. **18**, 1269–1281 (2014)
50. Ateeq, K., Mago, B., Pradhan, M.R.: A novel flexible data analytics model for leveraging the efficiency of smart education. Soft Comput. **25**, 12305–12318 (2021)
51. Singh, M., Kumar, R., Chana, I.: A forefront to machine translation technology: deployment on the cloud as a service to enhance QoS parameters. Soft Comput. **24**, 16057–16079 (2020)
52. Salomoni, D., Campos, I., Gaido, L., et al.: INDIGO-DataCloud: a Platform to Facilitate Seamless Access to E-Infrastructures. J. Grid Computing. **16**, 381–408 (2018). https://doi.org/10.1007/s10723-018-9453-3

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