IEEE Access
Multidisciplinary ⋮ Rapid Review ⋮ Open Access Journal

Received 28 October 2023, accepted 27 November 2023, date of publication 4 December 2023,
date of current version 18 January 2024.

Digital Object Identifier 10.1109/ACCESS.2023.3339250

SURVEY

E-Learning-Based Cloud Computing Environment: A Systematic Review, Challenges, and Opportunities

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This work was funded by the Deanship of Scientific Research at King Khalid University through a large group Research Project under grant number (RGP.2/175/44).

ABSTRACT New technologies drive educational shifts, transforming offline to online learning. This study investigates e-learning and cloud computing integration to understand synergies and their potential impact. The study addresses two primary research questions: the influence of e-learning on factors like architecture, software, performance, security, hardware, network, and virtual aspects, and the examination of cloud computing services and models such as SaaS, PaaS, IaaS, and S.O.A. The research aims to provide insights into how e-learning is incorporated in a cloud computing environment. The motivation behind this study is to investigate the intricate relationship between e-learning and cloud computing. By analyzing 154 scientific papers, the study delves into the specifics of this integration, highlighting trends and areas that have received more attention. The study examines e-learning in a cloud computing environment, focusing on architecture (27%), general topics (21%), software (19%), and performance (18%). Virtual environments have fewer security issues, while storage and network focus are more prevalent. Cloud computing services are mainly all services, with software as a service (18%), infrastructure as a service (17%), and platforms as a service (10%). Most studies are based on public clouds (74%), all other models (11%), and hybrid clouds (3%). The study examines e-learning integration in cloud computing, highlighting limitations in hybrid and private clouds, specialized infrastructure, and a gap in platforms and infrastructure offerings.

INDEX TERMS Cloud computing, e-learning, environment, educational, e-learning based cloud computing, systematic.

I. INTRODUCTION

COVID-19 made us realize the importance of e-learning in filling the gap in the education process during lockdown. This resulted in the introduction of numerous e-learning

The associate editor coordinating the review of this manuscript and approving it for publication was Rebecca Strachan.

platforms that assist students and institutions in accessing and managing educational resources and real-time virtual classrooms. Simultaneously, the cloud computing environment has improved and is the standard for such applications. Cloud computing has changed the traditional web-based e-learning environment by providing internal or external programs that organize academic performance in a cloud-based environment and providing full software support and substantial computing resources implemented anywhere and anytime as the educational institution desires. Cloud computing improves e-learning performance. It is for higher institutions such as institutes and universities, and it is called Cloud Campus, as it reduces the infrastructure and is more flexible in technology [1].

In recent years, e-learning and cloud computing have become increasingly prevalent in educational environments, offering new opportunities for online learning and collaboration [2], [3]. E-learning, which refers to the use of electronic technologies to deliver educational content, has been shown to offer flexibility and accessibility to learners. In contrast, cloud computing, which involves using remote servers to store, manage, and process data, can provide scalability and cost-effectiveness for educational institutions [4]. However, there is still much to be understood about the interaction of these technologies and the potential benefits and limitations they offer in educational settings.

To address this knowledge gap, this study analyzed the impact of e-learning in a cloud computing environment by reviewing 154 related scientific papers. The study focused on research questions about the effects of e-learning and cloud computing services and models, including architecture, software, performance, security, hardware, network, and virtualization. By examining existing research in this area, this study provides insights into the current state of e-learning in a cloud computing environment. It highlights potential areas for future research and development.

Therefore, it focuses on detecting the dimension of the empirical use of cloud computing environments to build E-learning platforms. This systematic study method was used to answer the research questions. The results show that most selected studies focus on architecture, followed by general topics such as software, performance, security, storage, network, hardware, control, management, and virtualization. The objectives of this study are as follows:

- To present a comprehensive and systematic review of e-learning based on cloud computing simultaneously with their advantages and challenges.
- To review most methods in e-learning cloud-based and associated characteristics and drawbacks.
- To specify the supplementary services and models cloud computing can provide to e-learning.
- To discuss the challenges of integrating e-learning into cloud technologies.

A. AREAS OF INTEREST OF THE STUDIES

The web-based e-learning environment has become inappropriate to the requirements of society, as there are many problems, such as cost, maintenance, management, and others in e-learning systems, which have prompted educational institutions to search for practical solutions. The rapid growth of cloud computing and the provision of appropriate services such as word processing programs, presentations, and databases force educational institutions to turn to cloud computing companies for the right solutions in terms of Hardware, software, and cost so that applications, programs, and services can be run online with the option of expanding on demand [2].

B. MOVING TO CLOUD BASE E-LEARNING

Cloud computing is a standard that provides easy-to-request network contact for shared networking resources and is a type of service—platform as a Service (PaaS) and Software as a Service (SaaS). In addition to the N.I.S.T. definition, four types of clouds can access all services, including Hardware as a Service (HaaS), Database as a Service (DaaS), and Business Process as a Service (BPaas) [3]. Data as a Service (DaaS) container for several services for learning organizations within the use of cloud computing for it drives far away additional services supplied via the cloud, approaches a wide range of external data sources, and is capable of transporting positive impacts for organizations, particularly for developing countries that suffer from a variety of problems getting information and assistance among organizations for similar or related data and information—software as a Service (SaaS) on-demand prepared software according to their needs. Learning software could be involved as well. Customers are provided additional free or paid software delivered via the cloud that is not installed on the device. The PaaS (Platform as a Service) stores the data for testing, establishing, developing, hosting, and maintenance. On request, the software industry engineers in PHP or Java can use the software environment, such as the integrated development environment (IDE), or application software development stage, such as the software development kit (SDK). IaaS (Infrastructure as a Service) refers to infrastructure managed and delivered to users on demand, such as storage, memory, and networking. It must be allowed to manage the infrastructure through different types of consumer communication with the cloud domain [4].

C. MOTIVATION OF THE STUDY

The motivation behind this study arises from the transformative influence of emerging technologies on the educational landscape, particularly the shift from traditional offline learning to online platforms. This transition has been driven by the rapid advancements in new technologies, which have created innovative learning environments. As e-learning gains prominence, a natural curiosity arises about the potential synergies that could be harnessed by integrating it with another

groundbreaking technology: cloud computing. The impetus is to understand how the union of these two fields, e-learning and cloud computing, could result in a mutually beneficial relationship, potentially enhancing the quality, accessibility, and efficiency of educational experiences.

D. CONTRIBUTIONS AND DIFFERENCES FROM PREVIOUS STUDIES

Even though many previous studies have introduced e-learning in cloud computing, there are areas for improvement in explaining the interaction between cloud services and cloud development models and the affected areas in e-learning. Table 1 summarizes the related studies reviewed and surveyed in cloud-based education and compares this study to previous studies. The contributions of this study are summarized as the following points:

- Provide Analysis of the previous studies from 2010 to the present, which include e-learning-based cloud computing, answering questions, and presenting them in the form of diagrams.
- An in-depth analysis of the e-learning-based cloud computing environment from 2010 to date, along with their existing solutions and respective limitations.
- Analyze the performance of SaaS, IaaS, and PaaS on e-learning.
- Provide opportunities, open issues, challenges, and limitations of e-learning based on cloud computing.
- Analyze and compare the relevant studies in the same area, considering different factors, as shown in Table 1.

Through this study, we explain the interaction between e-learning and cloud computing by defining the type of service, type of development model, and the solution provided in education, whether it is software, performance, storage, or a virtual environment, for previous studies in the period from 2010 to 2022, to clarify the interaction in the e-learning environment based on cloud computing and its limitations, as well as trends and future work.

II. RELATED WORK

There are logical reasons to move to cloud computing, such as lower cost per usage, improved performance, availability of software packages and higher processing capabilities in Hardware, automatic software upgrades, saving login times to the cloud, and increased data reliability. All data is complete in the cloud. No one can an unauthorized individual have access to data, which improves security [5]. Cloud computing technologies are commonly used to improve educational institutions' effectiveness, cost-effectiveness, and acceptability [6].

A. STRUCTURAL DESIGN OF E-LEARNING SYSTEMS

The structural design of e-learning systems refers to the organization, architecture, and framework that underlie the development and functioning of digital learning environments. It encompasses various elements and components designed to facilitate effective online education.

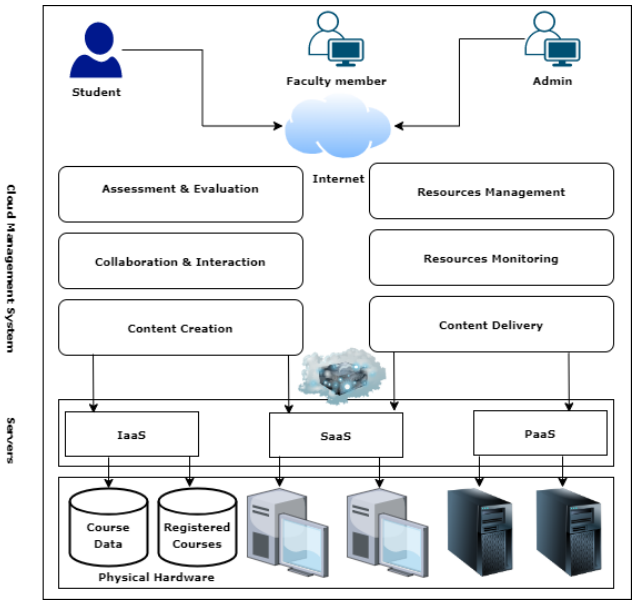

FIGURE 1. Communal structural design of e-learning systems in cloud computing [7].

Many studies discuss the structure of e-learning in cloud computing. Study [6] provided a standard proposal or model of three layers. The first-layer Cloud Management System contains subsystems that enable content delivery, resource management, and content creation, as well as evaluation and monitoring, with which users interact via the Internet using user interface software. The second layer is a service provided via the cloud (software, platforms, and infrastructure). The third layer represents the hardware components of computers, networks, central processing units, and memory [7]. Fig.1 shows these layers in detail.

B. IMPLEMENTING E-LEARNING-BASED CLOUD COMPUTING CHALLENGES

Implementing e-learning-based cloud computing presents several challenges that organizations and educational institutions must address to transition to this technology-driven approach to education successfully.

Firstly, security issues are a concern in academic institutions, and secondly, the bandwidth could be improved if the internet bandwidth is available. We will not provide educational services. Acceptance is the difficulty of convincing officials to switch to another environment. Third, the rules of learning management. There are differences between traditional and cloud learning management, such as learning management, teaching, content, courses, exams, and learners [8]. Educational institutions, students, and teachers must be educated to transition to an e-learning-based cloud computing environment. In addition to choosing the transition

mechanism through paying for service or relying on resources within the institution, creating a cloud computing infrastructure, and adapting the e-learning structure based on the cloud [9]. The study [10] highlights the growing interest in leveraging technology, especially the Internet, for learning purposes. However, they show that e-learning systems often require significant hardware and software resources, which may require more work for some institutions to afford. Cloud computing is a potential solution for these institutions as it offers a cost-effective way to access necessary resources. The study emphasizes that cloud computing is the future platform for e-learning, and the paper focuses on the application of cloud computing in the e-learning environment. Another study [11] discusses the impact of COVID-19 on education and the need for educational institutions to become more efficient in the virtual delivery of quality teaching services. Cloud computing can be a valuable platform for educators to improve their teaching practices and productivity. The study explores the applicability of cloud computing in educational settings and describes various applications such as cloud rendering, gamification, and collaborative e-learning technologies. The study also highlights some challenges associated with using cloud computing in education. The study [12] aims to understand the significance of adopting cloud computing (CC) in higher education institutions (HEIs). The paper discusses the benefits of CC adoption in HEIs and analyzes the challenges that may arise due to its adoption. The study proposes early steps toward adopting CC while mitigating the associated risks. The study is based on a systematic review of various sources from different backgrounds and contexts. The study identifies several factors that impact CC adoption in HEIs, including administrative bodies and governments, internal stakeholders, cloud suppliers, firm attributes, socio-political changes, and IT infrastructure. The study suggests opportunities for future research and offers insights for cloud suppliers, advisors, governments, and academics to improve their services in HEIs. [13] Focuses on the usability and effectiveness of e-learning systems in education. The authors used a systematic review of 99 articles from 2010 to 2018. The results were analyzed using qualitative software, identifying four dominant themes: education systems, learning issues, student behaviors, and online learning tools. The study provides research propositions that can be used in a theoretical framework and proposes a new definition of e-learning. The findings suggest that e-learning has the potential to bring new opportunities for learning and teaching. Still, more research is needed to address interoperability issues and assess the usability of e-learning systems. [14] This study discusses using cloud computing tools for collaborative learning in a blended classroom. A review of 29 relevant studies categorized the tools into synchronized, LMS, and social networking tools and identified specific activities supported by each type of tool. The review also highlighted the opportunities and challenges of using these tools in a blended learning context. The findings suggest that cloud computing tools have the potential to enhance collaborative learning in education and offer insights for educators and researchers seeking to integrate technology into their teaching practices.

[15] Presents a systematic literature review and classification of research related to applying multi-criteria decision-making (MCDM) methods in evaluating the effectiveness of E-learning. The review includes 42 papers published between 2001 and 2015 in 33 academic journals and international conferences. The studies were classified according to the year of publication, MCDM techniques used, and the journals and conferences in which they appeared. The study identifies significant criteria for evaluating E-learning. It provides insights into the state-of-the-art MCDM application for E-learning evaluation, which could be helpful for researchers and practitioners in the field. The study [16] explores the adoption of cloud computing in e-learning within universities and institutes of higher education. Using a systematic literature review, the paper identifies critical success factors for implementing cloud-based e-learning, categorized into four dimensions: cloud service resilience, university technological maturity, university organizational readiness, and cloud-based e-learning imperatives. The findings aim to be helpful for policymakers and practitioners of e-learning in implementing cloud-based e-learning platforms. Study [17] evaluates the development of research on cloud computing for education (CCE) and analyzes the empirical validation of the literature. The study finds that the empirical investigations in CCE are weak. The necessary scientific development of CCE requires extending its scope of interest and involving scholars synergistically to create and maintain a ''common research agenda.'' The systematic mapping study review identifies research gaps. It suggests more effective research on the production and use of content in CCE to support better pedagogical developments and processes for better-quality studies. The study [18] conducts a systematic literature review to explore the current level of adoption of cloud computing in the education systems of universities and higher education institutions. The review identified seven empirical studies, which found that many universities are interested in using different cloud computing service models. However, there needs to be more empirical research on using cloud computing within educational institutions. The paper highlights the need for more empirical studies in this research area. [19] It aims to review and analyze the literature on cloud-based learning adoption in educational institutions and identify the most frequent factors affecting its adoption. The study found 32 suitable articles from sources such as Science Direct, Emerald, and IEEE and identified ease of use, usefulness, and security as the most frequent factors. TAM, TOE, and UTAUT were the most commonly used theories for adoption, and students were the majority of respondents. The study recommends future research to investigate adoption using UTAUT and to incorporate security and trust.

TABLE 1. A comparison between the current study and previous studies.

Context	[3] 2018	[10] 2021	[11] 2017	[12] 2019	[13] 2018	[14] 2016	[15] 2019	[16] 2018	[17] 2015	[18] 2016	Current study
Comparison based year	X	X	X	X	X	√	X	√	X	X	√
Cloud development model	X	X	X	X	X	X	X	X	X	X	√
Cloud services	X	X	X	X	X	X	X	X	X	X	√
Taxonomy	X	√	X	X	√	√	X	X	X	X	√
Affected area in e-learning	√	√	√	√	√	√	√	√	√	√	√
Graphic representation	X	X	√	√	X	√	X	√	X	√	√
Summarizing previous studies	X	X	X	X	√	√	X	X	√	X	√
Open issue	X	X	√	X	√	X	X	X	X	X	√
Future trends	X	X	√	√	√	X	√	X	X	X	√
Limitations	X	X	X	X	X	X	√	X	X	√	√

Covered Uncovered

These studies collectively provide a comprehensive overview of the challenges, benefits, and opportunities associated with the intersection of e-learning and cloud computing in education, offering valuable insights for readers and researchers.

Table 1 provides an overview of recent review studies on e-learning and cloud computing, which have been discussed in this section. It presents information on the main topics, publication year, and the years covered in each study. The varying perspectives in these reviews suggest that a more thorough and methodical literature review is needed to address some of the common shortcomings.

III. SYSTEMATICAL REVIEW METHODOLOGY

For a broader understanding of the interaction of e-learning with cloud computing and to clarify the gap in this field, we have provided the literature survey to be a guide for researchers in this field to offer new additions and give a larger picture to educational institutions, including the advantages that cloud computing technology provides. Therefore, the systematic review study was used to define, analyze, and synthesize the evidence related to explicit research questions. It is divided into three phases: planning, conducting, and reporting the review [10]. Fig. 2 describes the general phases.

The activities in the planning phase are to collect the necessary documentation for the study, develop a study protocol, define study questions, and evaluate the review protocol. The review phase activities include primary research, data extraction, quality assessment and monitoring, and data synthesis. Finally, the reporting phase involves identifying dissemination mechanisms, structuring the main report, and assessing the information.

A. PLANNING THE REVIEW

Planning the review step is an essential stage in the systematic review methodology, which involves developing a comprehensive plan for the review process. The planning of the review stage contains basics and activities for summarizing the subject of study, defining objectives, selecting appropriate search terms and databases to search for primary information, inclusion/exclusion criteria, screening and selecting studies, extracting data, and analyzing and synthesizing the data.

FIGURE 2. General phases of systematic literature review.

1) IDENTIFYING THE NEED FOR A REVIEW

Identifying the need for a review is the first step in the systematic review methodology. It involves assessing the existing literature to determine if a review is necessary, defining the research question, and conducting a preliminary search to determine the feasibility of the evaluation. This step explores the importance of education and the search for ways to spread it. Cloud computing offers additional benefits for e-learning and systematic review publications in the field to examine the limitations of this track. This step is essential in the systematic review methodology.

2) REVIEW PROTOCOL

The review protocol step provides a detailed plan for the research question, search strategy, inclusion and exclusion

criteria, data extraction and analysis, and dissemination of results. It ensures the review's transparency, rigor, and reliability, beginning with defining the research question, developing a search strategy, establishing inclusion and exclusion criteria, and creating a data extraction and analysis plan. Ultimately, the review protocol ensures a thorough and transparent systematic review, which others can replicate. Therefore, we need to understand current cloud computing in e-learning environments and define a classification for all research in this field to analyze, compare, and discuss the results.

3) RESEARCH QUESTIONS

Formulating research questions is crucial to a research study's success as it provides direction and focus. Research questions create a structure for the study and help the researcher develop the research design and methodology. Poorly crafted research questions can lead to a lack of focus and unclear objectives in the study. Moreover, research questions are essential for assessing the study's success, serving as the basis for the research hypothesis, which is the initial explanation of the research question. The researcher can determine whether the survey accomplished its goals by answering the research question and testing the hypothesis. This research gives the ability to set the edge for aims review, allowing for the reference inclusion and exclusion measures to be followed in this research. The research questions of this study are as follows:

- **RQ 1:** What is the distribution of the selected studies regarding the year of publications, publication source, type of papers, deployment, service type, and e-learning elements?
  Description: Definition of publication distribution for the papers included in this study regarding years, publication source, cloud environment, and the impact on e-learning.
- **RQ 2:** What is the current research on e-learning-based cloud computing environments?
  Description: Focus on previously published studies on e-learning in the cloud computing environment.
- **RQ 3:** Which areas of e-learning are most commonly used in cloud computing environments?
  Description: Defining the impact of cloud computing in terms of services and development models and which one is more appropriate or used in e-learning.
- **RQ 4:** Which cloud computing models (deployment, service type, e-learning element) are suitable for use in e-learning areas?
  Description: More clarification of the interaction of the cloud environment in terms of services and development models with e-learning and the suitability of the cloud environment for e-learning.
- **RQ 5:** What cloud computing service models (IaaS, PaaS, and SaaS) are most regularly used in e-learning?
  Description: The services and development models are mainly used and reflect their effects on e-learning.
- **RQ 6:** What are the present study's potential future research directions and limitations?
  Description: Identification of research gaps, areas of future research, and limitations of this study.

4) STUDY SELECTION CRITERIA

We prioritize quality assessment and precise article selection criteria. Our selection process involves carefully examining titles, keywords, and abstracts to identify relevant articles in e-learning-based cloud computing. We apply various publication types for comprehensive coverage and tailor search queries to digital libraries' guidelines. Inclusion criteria demand reliability, focus on e-learning elements, and relevance to e-learning and cloud computing. Exclusion criteria filter out unrelated, non-English, and short papers. These rigorous criteria ensure our review relies on credible, pertinent, and methodologically sound sources, enhancing the credibility and validity of our findings in e-learning-based based-cloud computing. Table 2 presents the origins and search strings for primary studies. A broad query is created by joining the terms. We have developed unique strings for each digital library as the string formation guidelines of different libraries vary. In this process, we followed the recent study [19], which aimed to analyze software development practices in cloud computing systematically. This research explores perceptions and insights about the software development process within cloud computing environments.

- ***INCLUSION CRITERIA***
  - Papers must be reliable in the field.
  - Papers must be based on e-learning environment elements.
  - Papers must be in e-learning and cloud computing.
- ***EXCLUSION CRITERIA***
  - Papers must not relate to ''cloud'' and ''e-learning.''
  - Papers that must not be in English are excluded.
  - Papers with less than five pages.

B. CONDUCTING THE REVIEW

First, define a set of keywords to be retrieved and begin the search in the IEEE, Scopus, Springer, A.C.M., and Science Direct databases. All papers related to cloud computing and e-learning environments are retrieved. For full query, we use ''e-learning environment'' or ''framework'' AND ''cloud computing.''

1) SELECTION OF PRIMARY RESEARCH

After the initial search that collects a set of papers, an automatic search from four sources, and a manual search of the mentioned sources, we stop giving 50 unrelated results.

To improve the quality of the study, a set of tools is used to analyze the survey according to a standard method. It consists of three stages: the first is the definition and extraction of articles; the articles are explored; and the last stage is the

TABLE 2. Sources and formulated searches string.

Source	Search strings	URL
Springer	"e-learning based on cloud computing" /"cloud computing" OR "platform" OR "environment" AND "e-learning" OR "lab"	www.springerlink.com
Elsevier	"e-learning based on cloud computing" / "cloud computing" AND "e-learning"	www.elsevier.com
A.C.M.	"e-learning in cloud computing environment" OR "e-learning based on cloud computing" / "cloud computing" AND "e-learning"	www.acm.org
IEEE Explore	"e-learning in cloud computing environment" OR "e-learning based on cloud computing" / "cloud computing" OR "platform" OR "environment" AND "e-learning" OR "lab"	www.ieee.org

TABLE 3. Search query result.

Database	Initial hits	By Title	By Abstract	Full text
IEEE	1,730	117	98	71
ACM	481	56	50	25
Springer	58,490	69	47	43
Science Direct	15,434	64	48	15
Total				154

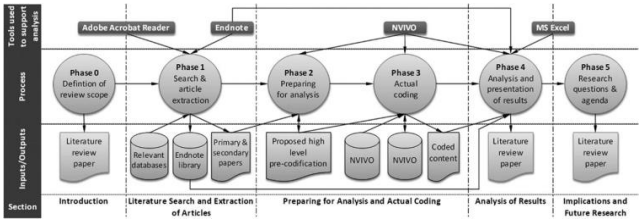

FIGURE 3. Summarizing the steps of conducting the methodology [20].

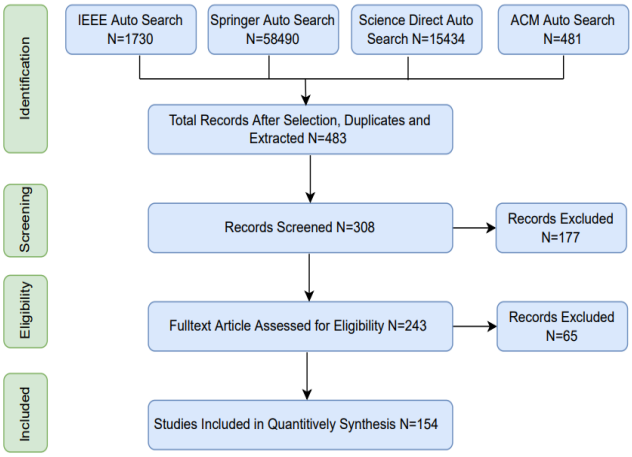

FIGURE 4. Process of study selection.

extraction of reports. Fig. 3 describes the phases of conducting the methodology.

The tools include EndNote, NVIVO, and Microsoft Excel. These tools were pivotal in facilitating the research process, notably enhancing our ability to manage, organize, and analyze data effectively. By leveraging these tools, we aimed to elevate the overall quality of our study, ensuring that it met rigorous academic standards.

For the subject of the study, as shown in Table 3, after the manual search, the studies are sorted based on the title and abstract. The investigation is conducted according to the criteria previously clarified in Fig.3 and Fig.4, showing the Study selection process. The number of studies is then defined based on the three stages. In Table 4, we explain the types of studies that were included.

2) STUDY QUALITY ASSESSMENT

The study relies on reliable sources to collect scientific papers, such as Springer, IEEE, A.C.M., and Science Direct. And filter the documents to ensure their relevance to the subject of the study and read the full text.

3) DATA EXTRACTION AND MONITORING

We selected one paper after determining the relevant scientific papers relevant to the topic. The chosen studies contain information about the articles, such as authors, years, countries, paper type, and publication source, to answer the recognized questions. The applicable abstract standard to conduct a systematic study to supply answers to a stated study question Fig. 5 illustrates the classification scheme for data synthesis.

The paper selection process represented in Fig.5 follows a systematic approach to curate a relevant and representative collection of papers for analysis in this study. The main objective is to identify scholarly publications offering insights into integrating cloud computing and e-learning environments. This selection process is critical for ensuring the quality and validity of the data used for analysis.

The process begins with the central focus on the main item, "Cloud Computing E-Learning Environment." This represents the overarching theme of the study, emphasizing the intersection of cloud computing and e-learning.

The primary item branches into two sub-items (level two), "Cloud Computing" and "E-Learning Environment," which serve as the primary categories for paper selection.

Under the "Cloud Computing" sub-item (level three), papers are sought that provide information and insights into different aspects of cloud computing relevant to e-learning. This includes (Level four) cloud models (such as public, private, hybrid, and all related models) and cloud service (SaaS, PaaS, IaaS, SOA, and all services) that impact the delivery and management of e-learning content.

Under the "E-Learning Environment" sub-item, a diverse range of elements related to the e-learning landscape are considered. These include the architectural design of e-learning platforms, software applications used for content delivery and

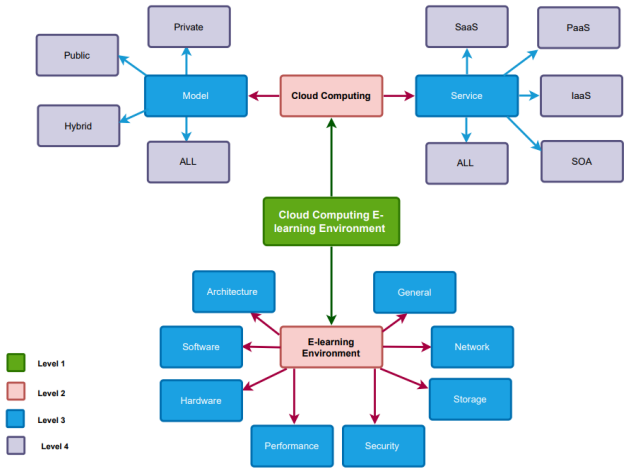

FIGURE 5. Classification Scheme Data synthesis.

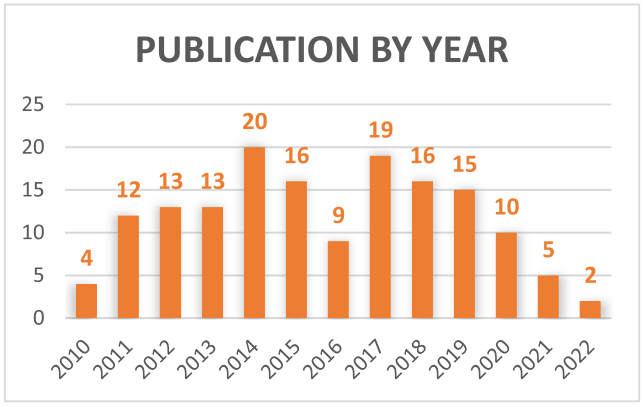

FIGURE 6. Publication by year.

interaction, hardware infrastructure supporting e-learning, performance optimization strategies, security protocols, storage solutions, network connectivity, and overarching general aspects of the e-learning environment.

C. REPORTING THE REVIEW

At this stage, the results are presented in graphs, through which we can answer the questions posed above and discuss and analyze the results.

Fig.6 shows the distribution number of papers published from 2010 to 2022; we can note that the lowest number of articles was published in 2022, with only two articles. This is due to the difficulty of accessing new papers. Most of the articles are from 2014 to 20202, which is evidence of a recent interest in this area of research.

Fig.7 shows the distribution of the selected articles by database sources. We find 71% in the IEEE database, 43% in the Springer database, 25% in the A.C.M. database, and 15% in the Science Direct database.

Fig.8 shows the distribution of the publication sources. A variety of research data sources were used, including journals (24%), conferences (66%), workshops (2%), and book

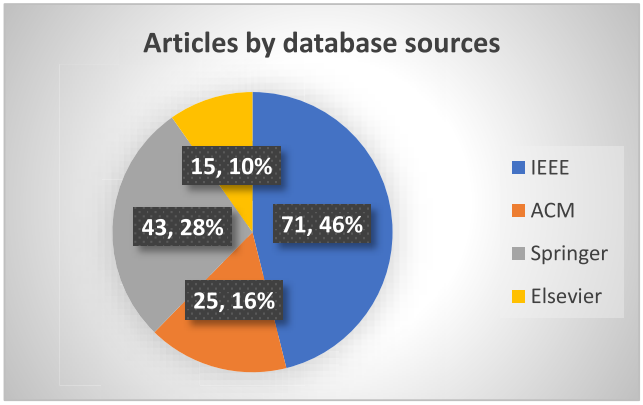

FIGURE 7. Distribution of articles by database sources.

chapters (12%). Table 4 shows the variety of publications per specified sources.

It was classified based on a study conducted in collaboration with IEEE that explained a set of criteria for categorizing scientific papers related to computer science. Fig. 9 and Table 8 refer to the primary study classification; it was organized into six types of research:

> Evaluation research: (survey, case study, experiment, and field study).
> Validation research: (mathematical proof of properties, experiments, simulation, mathematical analysis, prototyping).
> A proposal of a solution: discussing a new technology solution or an improvement to an old technology.
> Philosophical papers: such as frameworks, new concepts, etc.).
> Opinion paper: clarifies the author's opinion on some things, good or bad.

> Personal experience: it discusses a topic of concern without focusing on research methods and contains the results of experiments.

Fig.10 shows the distribution service of cloud computing. The results show that in the percentage of the paper that discusses all benefits in general (53%), software as a service (18%), infrastructure as a service (17%), service-oriented architecture (2%), and platform as a service (10%).

Fig.11 depicts the outcome of keywords for a research question: "Cloud computing models used with an e-learning environment." Public cloud (74%), hybrid cloud (3%), private cloud (12%), and all (11%) are the most popular models.

Fig.12 illustrates that most studies focus on architecture (27%). Most of the studies have reviewed a structure of e-learning in cloud computing consisting of three layers, and there are also proposals for five and seven layers. The general (21%) statement represents some of the studies that discussed the definition, advantages, and challenges of e-learning on cloud computing without going into the details of the environment. Software 19% of many studies have been applied as a software process for e-learning that works on cloud

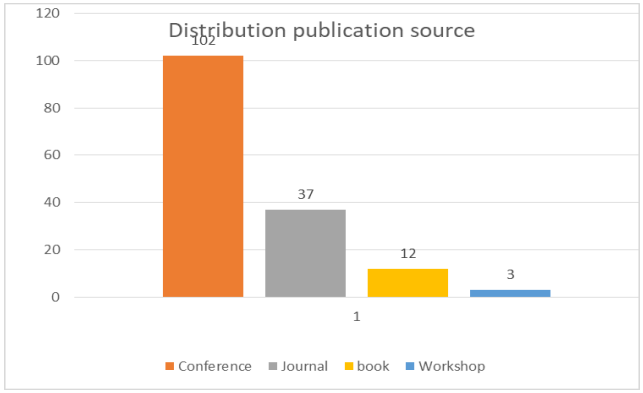

FIGURE 8. Distribution publication source.

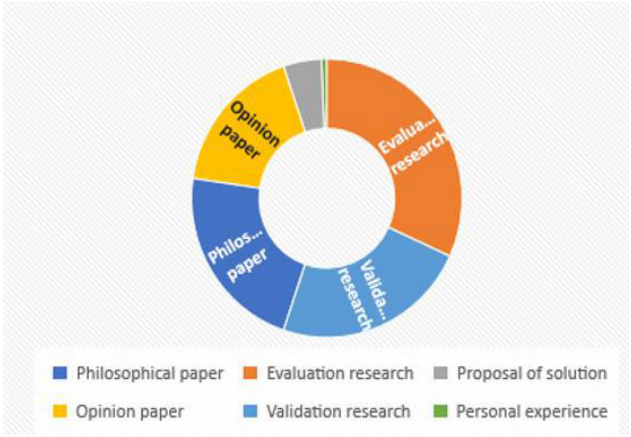

FIGURE 9. Distribution of papers by classification.

computing, such as learning management systems and others listed under the section Software. Some studies discussed other factors of the e-learning environment, such as improving performance, monitoring programs and increasing the speed of the performance (18%), the virtual (6 %) environment, and less on security (4%) following it in storage (2%) following it in the network (2%) following it in Hardware (1%). The results in Tables 3 and 4 showed that the selected primary studies in Fig.10 showed a map of focus areas in research on e-learning in cloud computing environments by e-learning elements and cloud computing models. Table 7 refers to the primary study classification, and Table 9 summarizes all included studies.

IV. DISCUSSION

In this section, we will discuss e-learning and its interaction with its cloud computing environment, review the services provided and their impact on e-learning, and present and discuss the results of the studies. In this study, we clarify the interaction between e-learning and cloud computing through a survey of studies from 2010 to 2022, including e-learning and cloud computing. The summary of all selected studies is shown in Table 9.

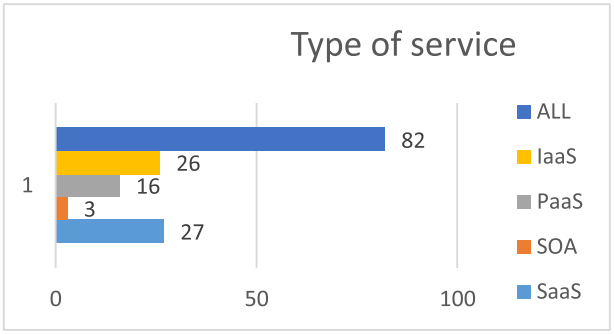

FIGURE 10. Distribution of type of service.

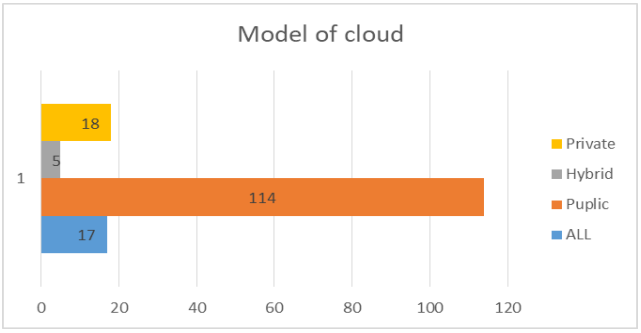

FIGURE 11. Distribution of model of cloud.

A. CLOUD COMPUTING SERVICE

In answer to the question of cloud service, in terms of services, it was found that most of the studies dealt with all the services in the study because there was an overlap between the services. The studies included proposals or a framework that consists of all services with the highest percentage (53%), followed by software as a service (18%), then infrastructure as a service (17%), Platforms as a Service (10%), and finally, Service Architecture (2%) as shown in Fig. 10.

B. CLOUD COMPUTING DEVELOPMENT MODEL

In answer to the question of cloud development models, the public cloud was the most common (74%), and the private cloud (12%), followed by all the models (11%), and then the hybrid cloud (3%), as shown in Fig. 11.

C. IMPACT ON E-LEARNING

To answer the third question, which is about the impact of e-learning, we discovered that most studies challenged the architecture or structure (27%), followed by a study that was published in general about e-learning in cloud computing (21%), followed by studies of software development in education (19%), and another on performance (18%), followed by the virtual with (6%), then security with (4%), then storage and networks with (2%) studies for each, and the last in hard disk storage.

TABLE 4. Distribution of primary studies by the publisher's type.

Publisher	Number of Publications	%	Type of publication					
			Evaluation	Opinion	Philosophical	Validation	Proposal solution	Personal experience
Springer	43	28%	17	11	6	9	-	-
IEEE	71	46%	24	9	16	17	4	1
A.C.M.	25	16%	4	5	10	6	-	-
Elsevier	15	10%	4	2	2	4	3	-
Total	154	100%	49	27	34	36	7	1

TABLE 5. Distribution of deployment Cloud computing model.

Cloud computing Deployment model	Acronym	Number of publications	%	References
Public cloud	Public cloud	114	74%	[21],[22],[23],[24],[25],[8],[26],[27],[28].[29],[30],[31],[32],[33],[5],[34],[35],[36],[37],[38],[39],[40],[41],[42],[43],[44],[45],[46],[47],[48],[49],[50],[1],[51],[52],[53],[54],[55],[56],[57],[58],[59],[60],[61],[62],[63],[64],[65],[66],[67],[68],[69],[70],[71],[4],[72],[73],[17],[74],[75],[76],[77],[78],[7],[79],[80],[81],[82],[83],[84],[85],[86],[87],[88],[89],[9].[90],[91],[92],[93],[94],[95],[96],[97],[98],[99],[100],[101],[102],[103],[104],[105],[106],[13],[50],[107],[107],[108],[109],[110],[111],[112],[113],[114],[115],[116],[117],[118],[119],[120],[121],[122],[123], [124]
ALL model	ALL	17	11%	[125],[126],[127],[128],[129],[130],[131],[132],[133],[134],[135],[136],[137],[138], [139],[140]
Privet cloud	Private cloud	18	12%	[141],[142],[143],[144],[145],[146],[147],[148],[149],[150],[151],[138],[120],[152],[153],[154],[50],[155],[156]
Hybrid cloud	Hybrid cloud	5	3%	[157],[158],[159],[160] ,[161]

TABLE 6. Distribution of cloud computing service type.

cloud computing service	Acronym	Number of publications	%	References
ALL service	ALL	82	53%	[21],[157],[8],[26],[27],[158],[29],[32],[33],[5],[34],[35],[36],[38],[40],[41],[42],[43],[44],[45],[125],[49],[126],[127],[128],[129],[1],[51],[52],[53],[54],[55],[56],[58],[59],[60],[61],[62],[63],[64],[65],[65],[68],[70],[4],[72],[73],[77],[7],[143],[80],[81],[84],[86],[88],[89],[9],[90],[91],[92],[93],[95],[161],[96],[99],[100],[162],[131],[132],[107],[108],[109],[119],[121],[122],[135],[136],[137],[124],[138],[126],[140],[139]
software as a service	SaaS	27	18%	[24],[28],[30],[37],[47],[57],[66],[69],[74],[75],[76],[79],[83],[145],[146],[94],[101],[102],[104],[130],[13],[110],[112],[114],[115],[116],[123]
platforms as a service	PaaS	16	10%	[23],[163],[46],[159],[78],[97],[98],[147],[105],[106],[133],[111],[118],[134],[151],[153]
infrastructure as a service	IaaS	26	17%	[25],[31],[39],[48],[50],[160],[67],[142],[82],[85],[87],[144],[103],[50],[113],[117],[120],[148],[149],[150],[138],[120],[152],[154],[50],[155],[156],
Service Oriented Architecture	S.O.A.	3	2%	[141],[22],[71],

D. INTERACTION OF CLOUD SERVICES AND THE IMPACT ON E-LEARNING

The interaction of cloud services and the impact on e-learning is shown in Fig. 13, and Table 6 refers to the primary study. The highest percentage of cloud computing services was about architecture, which includes all services, followed by performance, and there needs to be more practical and interactive applications of e-learning, recommendation systems, artificial intelligence, and business intelligence. Platforms as a Service reported the highest performance among others,

TABLE 7. Distribution of e-learning element environment.

E-learning effect	Number of publications	%	References
Architecture	42	27%	[21],[22],[157],[25],[33],[35],[37],[163],[41],[45],[1],[51],[52],[55],[59],[60],[61],[62],[63],[68],[70],[71],[4],[72],[73],[142],[7],[81],[89],[90],[161],[96],[97],[131],[148],[135],[136],[124],[138],[156],[140]
General	33	21%	[8],[26],[158],[29],[32],[5],[36],[43],[44],[125],[126],[127],[128],[53],[56],[17],[77],[80],[84],[86],[88],[9],[91],[92],[93],[95],[99],[100],[13],[108],[109],[121],[126],[139]
Software	30	19%	[24],[28],[30],[42],[46],[47],[57],[58],[66],[69],[74],[76],[79],[143],[83],[144],[145],[146],[94],[98],[101],[102],[104],[162],[130],[110],[112],[113],[114],[115],[116],[119]
Performance	27	18%	[34],[38],[40],[49],[50],[129],[160],[64],[65],[65],[75],[82],[105],[106],[132],[133],[107],[111],[117],[122],[123], [149],[137],[150],[151],[138],[120]
Virtual	10	7%	[23],[159],[147],[50],[118],[120],[152],[153],[154],[50],[155]
Security	5	3%	[39],[54],[78],[87],[134]
Network	3	2%	[48],[67],[103]
Storage	3	2%	[27],[31],[85]
Hardware	1	1%	[141]

TABLE 8. Distribution studies by the publisher's type.

Type of publication	Number of publications	%	References
Evaluation research	49	32%	[141],[23],[24],[32],[163],[39],[40],[46],[47],[159],[127],[129],[56],[57],[63],[66],[69],[73],[17],[142],[75],[76],[143],[80],[83],[85],[88],[9],[144],[145],[146],[164],[162],[106],[13],[133],[110],[112],[114],[115],[116],[117],[119],[121],[123],[153],[154],[155],[156]
Opinion paper	27	17%	[8],[30],[5],[43],[44],[125],[1],[52],[53],[55],[58],[70],[72],[7],[79],[84],[90],[91],[95],[161],[96],[99],[100],[108] ,[113],[124]
Philosophical paper	34	22%	[21],[22],[25],[26],[28],[158],[33],[35],[37],[45],[48],[50],[128],[160],[51],[59],[60],[61],[62],[64],[65],[68],[4],[77],[81],[89],[94],[97],[130],[50],[148],[135],[136],[138]
Proposal of solution	7	5%	[157],[126],[147],[103],[131],[132],[107]
Personal experience	1	1%	[49]
Validation research	36	23%	[27],[29],[31],[34],[36],[38],[41],[42],[54],[71],[74],[78],[82],[86],[87],[92],[93],[98],[101],[102],[105],[109],[111],[118],[120],[122],[149],[134],[137],[150],[151],[120],[152],[50],[140] ,[139]

followed by virtual infrastructure, labs, virtual machines, and programs for development on them, such as programming languages and others, have a dearth of matching software that does not run on the cloud, enhancing security, measuring quality, and evaluating performance. Infrastructure as a service has the highest performance percentage, followed by networks, security, and storage. There needs to be a more practical experience to measure service stability with increased demand and migration of virtual machines and green computing.

E. INTERACTION OF CLOUD COMPUTING MODELS AND IMPACT ON E-LEARNING

In the interaction of cloud computing models and their impact on e-learning, the highest percentage was for software and infrastructure in the public cloud. There needs to be more private and hybrid clouds, as shown in Fig. 14 and Table 5, referring to the primary study. We rely heavily on the public cloud in most studies in order to reduce costs and the ability to connect with distributed and remote places, but the public cloud is less secure than the hybrid and private clouds. The hybrid cloud represents a solution to reduce costs and enhance security where the educational institution is linked from the inside with a private cloud, connects with other institutions, and provides services through the public cloud.

V. APPLICATIONS AND SYSTEMS USED IN CLOUD COMPUTING BASED ON E-LEARNING

In the world of e-learning based on cloud computing, several typical applications and systems are widely used to facilitate online education and training. These applications and systems allow institutions and educators to deliver content, engage

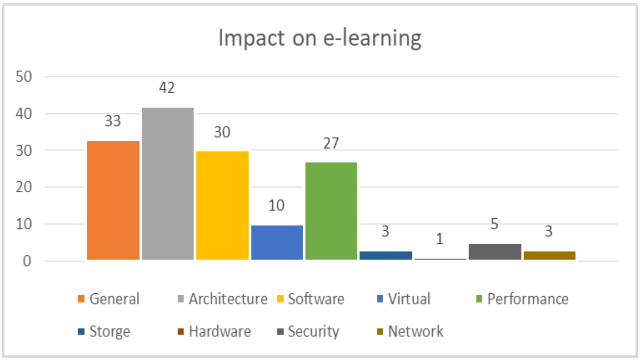

FIGURE 12. Distribution of papers discussing the effect of e-learning.

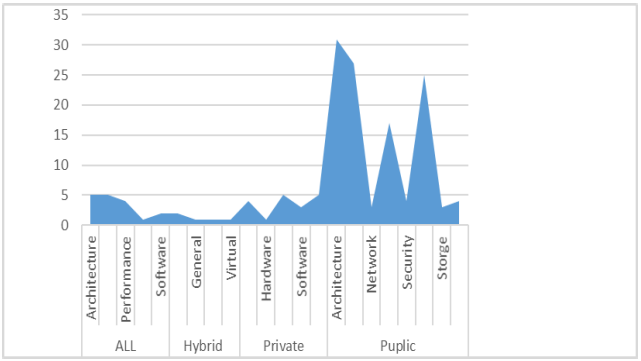

FIGURE 13. The interaction of cloud service with e-learning.

with learners, and effectively manage various aspects of e-learning.

A. LEARNING MANAGEMENT SYSTEMS

Many companies and e-learning platforms have moved to provide their services through cloud computing, such as Google Educational Cloud, Microsoft Education Cloud, Moodle, Blackboard, Sakai, Cisco Collaborative Knowledge, Braidio Collaborative Learning Platform, Echo 360 Active Learning Platform, N2N Illuminate Services Student Engagement Platform, rSmart OneCampus, WizIQ, Engrade, Wiggio, Edmodo, Wikispaces, Classdojo, Snapwiz, and Docent-EDU and GoClass [163].

B. MOBILE LEARNING APPLICATIONS

Popular mobile learning applications like Coursera, edX, Khan Academy, and Duolingo enable learners to access educational content on smartphones and tablets, promoting flexible and on-the-go learning. In addition, there are educational game apps for children, professional development apps like LinkedIn Learning, and university-specific apps for course management and resources.

C. VIDEO CONFERENCING TOOLS

Many tools can be used for synchronous learning system applications, including Zoom, Microsoft Teams, Google Meet, and Adobe Connect, to facilitate real-time video

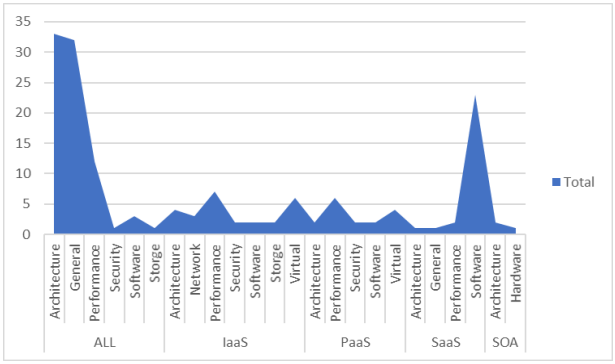

FIGURE 14. The interaction of the cloud model with e-learning.

conferencing, allowing educators to conduct virtual lectures, webinars, and interactive sessions.

D. CLOUD-BASED LEARNING ANALYTICS

Some analytics platforms can help educators make data-driven decisions to improve courses. These include Learning Locker and Watershed, which collect and analyze learner performance, engagement, and behavior data.

E. OPEN EDUCATIONAL RESOURCES REPOSITORIES

Platforms like MERLOT, OER Commons, and OpenStax host a vast collection of free and open educational resources that educators can incorporate into their courses. The analysis revealed significant variations among these repositories in terms of metrics. These platforms attract millions of users monthly, with visitors worldwide, while others have a more localized audience [164].

F. CLOUD STORAGE AND FILE SHARING

Cloud storage and file sharing are essential components of modern digital life, offering convenient and secure ways to store, access, and share files and data over the internet. Cloud storage services, including Google Drive, Dropbox, and Microsoft OneDrive, store, share, and collaborate on documents, presentations, and other course materials. They ensure easy access to resources from anywhere.

G. E-LEARNING RECOMMENDER SYSTEM

A cloud-based e-learning platform aims to implement a recommender system utilizing Google Cloud services. This system's primary function is to suggest suitable courses to students based on their individual needs and preferences, ultimately motivating them to make informed course selections [165].

VI. OPPORTUNITIES, OPEN ISSUES, AND CHALLENGES

With the increasing sources of information, the Internet of Things (IoT) is attaining its scope daily in the near future. Data generated by such an extensive set of dissimilar machines stored in massive data, the appearance of fog Computing goals to less data that needs for conveyed in a cloud

for the procedure plus storage on fog computing, for generally improved system efficiency a resource is transferred to the network border. Technological evolution supports several learning organizations. 2018 University of Parma, Riccardo Pecori showed a new e-learning structure that joined Cloud Computing over fog computing plus big data. It develops the cloud on the e-learning stage by the fog computing competencies over inner APIs wherever the cloud appearance a primary function in sequential back up with a big storage operator in adding the mining mechanism requiring broad time.

The fog mechanism emerges light dole out NoSQL storage services, which are used to realize interim predictions above the light mining mechanism.

Utilized the outer APIs to compute architecture and give layout with the learning cloud users such as educators, teachers, and learners to attain the rise interactivity and give beneficial proposal [33].

Despite the effectiveness of cloud computing in education, its application has some challenges. The most important of these challenges are technical, bandwidth, and security. And non-technical, such as Charge, user concept, educational forms and methods, management rules for education, and resource development [124]. Organizations face some challenges when converting from a traditional e-learning system to a system that works in a cloud environment, and the challenge is how to convert. Is it to go to a payment service provider or switch through the available resources? Also, students and users may suffer from problems of delays in accessing cloud education systems, and therefore, the dimension of cloud centers and problems of delays in the network. Among the most critical challenges are some lectures and laboratory materials unsuitable for the cloud computing environment, which is challenging to implement. The cloud is inappropriate for some programs that need special devices or tools, such as robots, digital forensics, and other programs. The presence of packages and programs that do not fit the cloud environment and the fact that there are no versions of them suitable for the cloud environment could be improved in some of the interaction tools in the cloud. Vendor lock-in problems are a concern for everyone who deals with cloud computing.

VII. FUTURE TRENDS

Cloud computing has contributed to finding solutions to many e-learning problems. For example, there were limitations in practical application and access to remote laboratories and a need to adapt some materials in practical application. During the survey, many studies provided feasible and practical solutions.

A. BUSINESS INTELLIGENCE AND ARTIFICIAL INTELLIGENCE

Business intelligence in e-learning can be through dashboards for reports to help decision support and manage the data in the cloud, recommendation systems, and artificial intelligence techniques such as facial recognition and natural language

TABLE 9. Summary of included studies.

NO	Ref no	Summarized	year	type of paper
1.	[21]	It provides the integration of e-learning reality with cloud computing and the design of a framework consisting of the learner, mixed reality, learning tools, and methods, and finally, management using easy tools	2017	Philosophical paper
2.	[141]	We are implementing cloud computing technology for four universities upon request and providing many services, such as laboratory resources and a dedicated work environment.	2012	Evaluation research
3.	[22]	Explore the benefits of cloud computing for Improving the learning environment through a set of integrated virtual technologies	2012	Philosophical paper
4.	[157]	A proposal to use electronic materials in the educational community through cloud computing in an effective manner and at a lower cost	2014	Proposal of solution
5.	[23]	It discusses the implementation of simulation-based education for students of engineering, energy, and technology who face problems in practical application over the Internet	2019	Evaluation research
6.	[24]	Proposal for integrating e-learning standards with the cloud computing platform	2011	Evaluation research
7.	[25]	A directed model based on cloud computing and electronic learning systems based on smart engine management and Scrum standards	2017	Philosophical paper
8.	[8]	Present the challenges and benefits of cloud computing in e-learning	2014	Opinion paper
9.	[26]	A model for ensuring the success of using the cloud computing environment in education and defining the most critical standards in the education system	2013	Philosophical paper
10.	[27]	Provides a storage service for educational platforms via cloud computing	2014	Validation research

TABLE 9. *(Continued.)* **Summary of included studies.**

11.	[28]	A proposal for a scrum standard-compliant model offering consistent content management and lower storage cost	2011	Philosophical paper
12.	[158]	An e-learning model based on a hybrid cloud with the integration of educational, technical, and general requirements	2013	Philosophical paper
13.	[29]	It reviews an experiment to convert a web-based educational system to cloud computing. The experiment involved 500 participants	2017	Validation research
14.	[30]	Developing a model for providing educational programming services through cloud computing	2013	Opinion paper
15.	[31]	model suggests cloud computing for semantic-based content storing of E-Learning materials	2013	Validation research
16.	[32]	Use the collaborative Google platform as a case study for applying cloud computing in an e-learning environment	2010	Evaluation research
17.	[33]	An illustration of the current state of e-learning in cloud computing and existing technologies, such as fog computing	2018	Philosophical paper
18.	[5]	Explain some of the solutions provided by cloud computing in terms of scalability and security for e-learning advantages and disadvantages	2013	Opinion paper
19.	[34]	Clarify the current state of e-learning in the cloud computing environment and provide recommendations for improvement	2016	Validation research
20.	[35]	Analyze essential requirements and technologies and build a standard architecture for educational cloud computing	2014	Philosophical paper
21.	[36]	A model using cloud computing that allows universities and schools to share educational resources at the lowest cost	2016	Validation research
22.	[37]	The importance of using cloud computing for organizations and learners illustrates the benefits and design offerings	2016	Philosophical paper
23.	[38]	Clarify and solve e-learning problems using cloud computing to participate in lifelong learning	2012	Validation research

TABLE 9. *(Continued.)* **Summary of included studies.**

24.	[163]	Demonstrates a range of innovations that can be applied to current cloud computing to accommodate cloud-based education platforms	2012	Evaluation research
25.	[39]	Use simulation software such as Cloudsim. This is for students to gain practical experience and understanding of aspects of cloud computing	2016	Evaluation research
26.	[40]	It demonstrates the success of the open learning experience based on cloud computing in terms of file sharing and ease of access	2014	Evaluation research
27.	[41]	The Education Everywhere Proposal The study included all previous studies in Indonesia and then proposed an open learning environment based on cloud computing	2016	Validation research
28.	[42]	Submit a proposal for open education in Indonesia that relies on cloud computing to reduce educational disparities and bridge the technological gap	2014	Validation research
29.	[43]	The possibility of adopting cloud computing services in education is discussed and called "Teaching and Learning as a Service."	2012	Opinion paper
30.	[44]	It studies an e-learning ecosystem that supports the modern era, the integration of web technologies and cloud computing	2011	Opinion paper
31.	[45]	It studies an e-learning ecosystem that supports the modern era, the integration of web technologies and cloud computing	2015	Philosophical paper
32.	[46]	Providing a cloud desktop for engineering students that supports their requirements	2014	Evaluation research
33.	[47]	Providing software as a service for education and supporting the economy through service pricing	2010	Evaluation research
34.	[48]	Providing a virtual environment for universities through cloud computing, providing mobile and decentralized	2014	Philosophical paper

TABLE 9. *(Continued.)* **Summary of included studies.**

35.	[125]	A descriptive analysis to determine the importance of e-learning and its factors in cloud computing	2020	Opinion paper
36.	[49]	The use of cloud computing in co-education through an educational platform and performance evaluation	2017	Personal experience
37.	[50]	A framework for improving performance in virtual laboratories and quality of services	2015	Philosophical paper
38.	[159]	Hybrid cloud design in e-learning and the use of programs such as C.M.S., WordPress, and programming languages such as PHP	2019	Evaluation research
39.	[126]	A proposal for higher education in Nigeria based on a cloud computing infrastructure using the theory of DOI and T.O.E.	2019	Proposal of solution
40.	[127]	The results of a questionnaire for classroom learners on the Google platform, which included 255 learners, are discussed and analyzed using S.P.S.S.	2020	Evaluation research
41.	[128]	A proposal that allows increased cooperation creates a basis for building an intelligent system and contributes to innovation	2020	Philosophical paper
42.	[129]	A proposal for intelligent modeling of cloud computing resources in e-learning systems through the MS2CRAE algorithm	2020	Evaluation research
43.	[160]	Experimenting with a hybrid cloud application in e-learning and costing, where 30% of the cost is saved	2011	Philosophical paper
44.	[1]	The study presents the pros and cons of cloud computing in education, health, and agriculture	2018	Opinion paper
45.	[51]	Integration of an educational web environment with cloud computing using a tool called JBraindead	2013	Philosophical paper
46.	[52]	A partial learning platform designed to support lifelong learning that uses mass cloud storage	2011	Opinion paper
47.	[53]	The benefits and limitations of Cloud Computing in the education sector are presented	2014	Opinion paper

TABLE 9. *(Continued.)* **Summary of included studies.**

48.	[54]	A survey of historical studies and a questionnaire on the factors of confidence in cloud-based e-learning	2017	Validation research
49.	[55]	the implementation of new technologies for education, such as cloud computing with teacher training to contribute to improving education	2017	Opinion paper
50.	[56]	Obstacles and solutions for full implementation of cloud computing	2016	Evaluation research
51.	[57]	A collaborative intelligent learning management system called a smart cloud to support resource management	2018	Evaluation research
52.	[58]	Transitioning from traditional learning management systems to learning management systems operating in the cloud computing environment	2019	Opinion paper
53.	[59]	Concepts for applying cloud computing in the education sector in India	2016	Philosophical paper
54.	[60]	A proposal to apply cloud computing and big data technologies in education, discovering the advantages and disadvantages	2017	Philosophical paper
55.	[61]	Clarify the steps needed to create a quality virtual learning environment and use Moodle to study the case	2014	Philosophical paper
56.	[62]	essential factors affecting users in accepting classroom computing and use of cloud computing in Thailand	2018	Philosophical paper
57.	[63]	Building a Bridge Connecting Learning Analytics Dashboards (L.A.D.s) and Open Learner Models (OLMs) to conduct a study and present the results	2018	Evaluation research
58.	[64]	An online platform for the Malaysian government (MOOC) called ArmadaNet uses the Moodle model	2011	Philosophical paper
59.	[65]	it reviews the G.O.D. project for managing educational data in a cloud computing environment	2013	Philosophical paper
60.	[66]	I put forward a system called Protus that works on cloud learning systems that identify learners' behaviors and	2017	Evaluation research

TABLE 9. *(Continued.)* **Summary of included studies.**

		learning styles using classification mechanisms and make use of them in recommendations		
61.	[67]	Provide a model for the application of cloud computing in the university system in terms of structure and environment for implementation	2020	Opinion paper
62.	[68]	It offers a cloud service provider architecture that enables the efficient and effective provision of educational services to improve education	2014	Philosophical paper
63.	[69]	A proposal that supports the exchange of knowledge and the creation of a community to exchange information and educational experiences in the cloud environment	2014	Evaluation research
64.	[70]	It raises some of the advantages and challenges of cloud computing in the field of education and solutions for its application in higher education institutions	2019	Opinion paper
65.	[71]	A training model that aims to provide educational materials in short periods that suit workers through micro-education and integrating them with learning management systems	2020	Validation research
66.	[4]	A framework of six layers that can be implemented in educational institutions located in developing countries	2019	Philosophical paper
67.	[72]	A detailed illustration of the shared infrastructure for e-learning systems in the cloud environment with actual examples	2012	Opinion paper
68.	[73]	Applying the virtual learning environment in three stages and displaying the results for each stage	2015	Evaluation research
69.	[17]	Clarify the actual experiences of applying cloud computing in education. The study included 27 studies	2015	Evaluation research
70.	[74]	Implementing a SaaS presentation platform called E.D.I.S.O.N. that provides computerized design software	2018	Validation research
71.	[142]	Developing a private cloud that allows sharing the university's resources and linking the various systems with each other	2017	Evaluation research

TABLE 9. *(Continued.)* **Summary of included studies.**

72.	[75]	Directing cloud computing in education to solve some companies' problems, such as lack of resources and knowledge gaps	2014	Evaluation research
73.	[76]	Courses covering cloud computing concepts ten years ago explored the existence of shortcomings compared to the impact of cloud computing	2017	Evaluation research
74.	[77]	It demonstrates the importance of integrating and combining educational components with cloud computing technology to reduce costs and increase storage and security	2015	Philosophical paper
75.	[78]	This study presents descriptive census results to clarify the advantages and limitations of using cloud computing services as a commodity in educational platforms.	2019	Validation research
76.	[7]	It provides an analysis of the limitations facing e-learning and provides some solutions to suit the cloud computing environment	2017	Opinion paper
77.	[79]	It explains cloud computing in universities and how information and resources are managed	2012	Opinion paper
78.	[143]	Providing a private cloud that meets the needs of universities and the requirements of e-learning	2011	Evaluation research
79.	[80]	The use of cloud computing in higher education in developing countries such as Thailand. The study included collecting data from two universities and analyzing and presenting the results.	2015	Evaluation research
80.	[81]	Showcasing online educational platforms and explaining how they can contribute to educational efficiency and sustainability	2012	Philosophical paper
81.	[82]	Enhance security in the cloud by encrypting messages before storing them and saving encrypted messages in the storage center for e-learning systems	2018	Validation research
82.	[83]	A study about Armangarayan Company in Iran is providing e-learning services: cloud computing was used in Ayandeh Bank. The study aimed to find out the results of this experiment.	2017	Evaluation research

TABLE 9. *(Continued.)* **Summary of included studies.**

83.	[84]	Providing the infrastructure for cloud computing and using it in the educational field, specifically in universities	2013	Opinion paper
84.	[85]	Focuses on using cloud computing in developing countries in the field of education and making use of cloud storage and storing educational materials	2015	Evaluation research
85.	[86]	A survey of 282 participants in cloud-based education systems was analyzed by structural equation modeling (S.E.M.)	2014	Validation research
86.	[87]	The study aimed to clarify the security issues in the field of e-learning in the cloud, to clarify the gaps, and to find some solutions	2013	Validation research
87.	[88]	The effect of cloud computing on education and the importance of cloud computing services in the field of education	2011	Evaluation research
88.	[89]	Development of a model to support e-learning in cloud computing and model analysis using C.S.P. and evaluation	2012	Philosophical paper
89.	[9]	Includes a set of studies in cloud computing in the field of education, determining what has been implemented, analyzing, and clarifying future challenges.	2019	Evaluation research
90.	[90]	Clarify the basic concepts of cloud computing in the field of e-learning and suggest a five-layer model for implementation	2013	Opinion paper
91.	[91]	Using cloud computing platforms to increase the effectiveness of e-learning	2019	Opinion paper
92.	[92]	Encouraging the transition to cloud computing in the education sector and analyzing using SWOT to illustrate strengths and weaknesses	2013	Validation research
93.	[93]	Examine the factors affecting the adoption of cloud computing in higher education using SmartPLS and present the results	2015	Validation research
94.	[144]	Development of an IaaS e-learning system infrastructure to equip the private cloud and operate the learning management system	2014	Evaluation research
95.	[145]	A prototype for building an e-learning environment in cloud computing with emergency and disaster alert	2017	Evaluation research
96.	[146]	A prototype for building an e-learning environment in cloud computing, a content management system, and using the phone to display an emergency and disaster alert	2015	Evaluation research
97.	[94]	Explain how cloud computing can be used in the educational process and its essential characteristics	2012	Philosophical paper
98.	[95]	Moving to cloud computing in universities through six stages and discussing policy change, security, and reliability issues	2010	Opinion paper
99.	[161]	A mixed private and public cloud to implement the proposed five-unit learning system	2012	Opinion paper
100	[96]	Discuss the concept of cloud learning by explaining the idea of the virtual environment and providing a platform for learning from the ground up	2014	Opinion paper
101	[97]	Developing a framework based on A.R. for collaborative product design and Cloud platform assistance for file exchange and storage	2020	Philosophical paper
102	[98]	It aims to provide a virtual learning lab that uses a set of cloud-based learning models	2014	Validation research
103	[99]	A study on the barriers to using cloud computing in higher education included 69 universities in Kenya,	2018	Opinion paper
		and the results were statistically		
104	[100]	E-learning standards and their contribution to cloud computing and the most important current issues: a comparison between e-learning before the transition to the cloud environment	2015	Opinion paper
105	[147]	Improving the educational process through cloud computing and reducing complexity. It also aims to develop virtual laboratories	2014	Proposal of solution

TABLE 9. *(Continued.)* **Summary of included studies.**

106	[101]	Design and evaluation of educational activities in a cloud computing environment that rely on inquiry and social networks and support critical thinking skills	2014	Validation research
107	[102]	Using artificial intelligence mechanisms in cloud learning platforms to evaluate the user and recommend additional education for him	2014	Validation research
108	[103]	Using two models of SaaS and PaaS cloud computing to teach networking to graduate students, this experience affected the extent of students' learning and participation.	2011	Proposal of solution
109	[104]	A software-as-a-service application in the education field with a user interface	2015	Evaluation research
110	[162]	survey gamification techniques in cloud computing to increase the effectiveness of education with clarification of current and future requirements	2019	Evaluation research
111	[130]	Framework It contains services such as recording activities, exercises, and others, and providing C ++ Workbook as a software service in the cloud	2013	Philosophical paper
112	[131]	It discusses e-learning in the cloud computing architecture divided into five layers, as well as the advantages and disadvantages	2015	Proposal of solution
113	[105]	Analysis of student activity data in the English language through a classroom built in the cloud environment	2021	Validation research
114	[106]	The CLEM cloud learning project for mechatronic students enables access and use of their virtual laboratories and interact with them via the cloud	2015	Evaluation research
115	[13]	A survey of learning management systems and interaction with social networking platforms, including 29 studies	2018	Evaluation research
116	[132]	A proposal to reduce complexity in the cloud computing environment through agent and virtual resource management tools	2020	Proposal of solution

TABLE 9. *(Continued.)* **Summary of included studies.**

117	[133]	It aims at cooperative and interactive education through behavioral analysis	2015	Evaluation research
118	[50]	A framework that aims to ensure the quality of services, specifically infrastructure as a service, by measuring services and performance with what has been agreed upon by the service provider.	2015	Philosophical paper
119	[107]	A proposal for a smart system that aims to share content such as photos and videos and access them via smart devices	2017	Proposal of solution
120	[108]	Clarification of cloud computing in e-learning, the benefit, and the cost-effectiveness	2018	Opinion paper
121	[109]	A comprehensive survey of cloud computing in the field of e-learning and the most important factors affecting its success for stakeholders	2019	Validation research
122	[110]	The use of cloud services in teaching engineering students: the study included 10 Cloud Services from Amazon and Google Firebase	2021	Evaluation research
123	[111]	Experience using the Google platform to collaborate and teach subjects in the College of Engineering, such as industrial neural networks, that need expensive devices and high specifications	2020	Validation research
124	[112]	Discusses cooperation between students in the development of a software engineering project and remote interaction between students	2020	Evaluation research
125.	[113]	Adaptation of the cloud computing environment for courses distributed through the T.A.M. model and the use of open-source software	2018	Opinion paper
126	[114]	Design and implementation of a collaborative educational system based on cloud computing. The experiment includes two groups of students	2018	Evaluation research
127	[115]	A proposal to develop a cloud-based educational system using educational media to deliver lessons focused on writing code, storage size, and server simulation	2019	Evaluation research
128	[116]	A cloud-based learning management system with new features that support interaction between teacher and learner	2021	Evaluation research

TABLE 9. *(Continued.)* **Summary of included studies.**

129	[117]	Cloud performance monitoring in case of increased demand from beneficiaries and load distribution	2018	Evaluation research
130	[118],	A survey of a group of students and their views on the use of cloud-based virtual laboratories to apply information technology courses	2018	Validation research
131	[119]	Develop a cloud-based education system, data science techniques, and recommendation systems that work in real-time	2021	Evaluation research
132	[120]	Designing a virtual lab and applying the networking course to it using the OpenNebula cloud operating system and evaluating the performance of the lab	2017	Validation research
133	[121]	A survey of e-learning in Malawi during the Corona period and a proposal for some technologies that support e-learning	2022	Evaluation research
134	[122]	A cloud computing architecture that integrates with physiological systems that analyzes images and behavior of students during distance learning	2022	Validation research
135	[123]	Development of ingredient management software in pharmacy by developing a cooperation program to support resource sharing and communication	2011	Evaluation research
136	[148]	A proposal for a prototype for private cloud infrastructure in universities, colleges, and research centers	2010	Philosophical paper
137	[149]	Improving performance in scheduling using the fairy algorithm by applying to a private cloud designed for e-learning	2012	Validation research
138	[134]	Improving security in platforms as a service by isolating devices and using more than one algorithm to determine which devices are close to each other in terms of location and scheduling tasks, and then the algorithm was compared with three different algorithms to evaluate performance	2017	Validation research
139	[135]	A proposal for a national framework for e-learning that includes a set of layers of applications, services, databases, and networks	2016	Philosophical paper

TABLE 9. *(Continued.)* **Summary of included studies.**

140	[136]	A proposal to move academic institutions to rely on cloud computing in education	2013	Philosophical paper
141	[137]	Analysis of e-learning in the previous period by collecting data from different education platforms to know the current situation and future requirements	2019	Validation research
142	[150]	Analysis of e-learning in the previous period by collecting data from different education platforms to know the current situation and future requirements	2017	Validation research
143	[151]	Developing an educational platform using and relying on Hadoop to analyze data to improve performance through feedback and student assessment	2018	Validation research
144	[124]	Discussing e-learning in cloud computing in terms of structure and challenges	2011	Opinion paper
145	[138]	A framework for e-learning in ways that suit the educational community, including individuals and organizations, in an effective manner with cloud computing	2012	Philosophical paper
146	[120]	Developing a cloud-based virtual lab to study networking through the Open Nebula program	2017	Validation research
147	[139]	Test strategies that help students with dyslexia in the e-learning environment on the Amazon platform	2019	Validation research
148	[152]	A virtual lab experience for a distributed I.T. course application using OpenStack	2017	Validation research
149	[153]	A virtual lab to apply some information technology materials, such as big data, which we find shortcomings in using in the cloud	2021	Evaluation research
150	[154]	A virtual laboratory for studying communication and networking courses	2016	Evaluation research
151	[50]	A framework to improve the quality of virtual laboratories and reduce time and delays in performance	2015	Validation research
152	[155]	An open-source private cloud for higher education	2019	Evaluation research
153	[156]	implementing the infrastructure for higher education in Oman on cloud computing using OpenStack	2018	Evaluation research

TABLE 9. *(Continued.)* **Summary of included studies.**

154	[140]	Evaluation of computer courses through cloud computing in platforms as a service and infrastructure as a service	2011	Validation research

processing that support more significant interaction with learning management systems.

Artificial intelligence techniques can help improve the online course content design because the course design is difficult and time-consuming and does not adapt to every employee's specific requirements. To overcome the limitations of educational systems, business intelligence and artificial intelligence techniques can be excellent choices to support e-learning systems.

B. PRIVATE CLOUD

Here, we discuss cloud computing as a specialization or subject within the field. Private clouds in educational institutions provide students with an environment for applying research and projects related to cloud computing as a path in information technology. A private cloud enables the actual application in the infrastructure and prepares containers for platforms as a service. The private cloud can provide and attain scalability, persistent storage, distributed access, effective resource utilization and management, and interoperability of the e-learning system. In addition, it can support maximizing the resource with more efficiency and control by avoiding bottlenecks and downtime, ensuring the stability of the e-learning system for a long time with reasonable control of the system. In addition, using a private cloud can offer a high-security environment instead of an unsecured internet connection.

C. PERFORMANCE

Improving performance in cloud computing would enhance the learning services provided through the cloud. Using machine learning algorithms to schedule tasks and distribute the load balance improves performance, response speed, and processing, whether parallel or multiple processing. This is a fertile field for study, research, and development.

D. QUALITY SERVICE

Service providers compete to provide quality service to keep customers and attract more trust in service level agreements (S.L.A.s). Conduct experiments to evaluate trials, service stability, and change factors. The quality of e-learning can focus on several aspects of quality service that lead to the satisfaction of the students, e-learning system quality, and loyalty of students to the e-learning system, e-learning instructor, and course materials. Quality and e-learning were administrative. These factors can increase and directly affect e-learning service quality and student satisfaction.

E. DEVELOPMENT

Harmonization of software and open-source cloud operating systems such as OpenStack competes with commercial companies in performance and is considered one of the best cloud operating systems. However, there are some areas for improvement, such as Internet of Things sensors and artificial intelligence.

F. GREEN INTERNET OF THINGS

IoT devices need massive Power for tremendous and effective performance to support a sophisticated environment for e-learning organizations. This primary concern has earned enormous attention in the forthcoming investigation research.

Green computing can help reduce Power and energy, which are the main points in designing and implementing the future computing system. Green computing solutions can provide the organization's e-learning system with friendly and less energy consumption.

The Green Internet of Things (GIoT) is a solution for the protection and sustainability of such issues. GIoT represents the framework of connecting smart sensors and devices and creating automation by enabling energy conservation methods. Sensors monitor students and control virtual classrooms and other tasks that help in education. Monitoring energy depletion and energy use variability is one of the priorities for the next stage. Integrating green Internet of Things (GIoT), technologies would be performed in the best potential manner and improve the e-learning system environment to be friendly and less energy-consuming.

G. BLOCKCHAIN AND METAVERSE

Blockchain is a distributed, unchanging record that enables recording transactions and tracking resources. On the other hand, the metaverse is a massive structure that has many digital aspects. There are several advantages to the Metaverse globe, such as interaction, authenticity, and portability. Using blockchain and the metaverse can benefit e-learning's future development, such as guaranteeing data security and privacy in the e-learning environment. Another thing can be ensuring the quality of the e-learning process and offering data Integrity in different backgrounds. This integration can promote a new feature to e-learning progress.

VIII. LIMITATIONS

In this study, we analyzed an e-Learning cloud computing environment. The study has some limitations, such as the selection of database sources. There are many sources for publishing scientific papers. However, this study focused on only four reliable sources to collect articles (Springer, IEEE Xplore, A.C.M., and Elsevier).

Many terms related to e-learning, such as mobile learning, massive open online courses (MOOC), continuing learning, micro-learning, and types of e-learning, are added to the techniques used with e-learning and are focused on the e-learning environment. Several factors may impact the findings, such

as whether the contents were only partially analyzed or the study's researchers.

The study's research questions focused on the impact of e-learning and cloud computing services and models in scientific papers related to the subject. This limited scope may have excluded other potential research questions that provided additional insights into the topic.

The study only analyzed papers written in English, which may exclude relevant research published in other languages. This could limit the generalizability of the findings or miss essential insights. While the study analyzed a range of topics related to e-learning and cloud computing, it may have overlooked specific topics or issues relevant to particular contexts or stakeholders. For example, the study did not mention the role of teachers or instructors in e-learning environments or the impact of e-learning on student outcomes.

We can give some suggestions to address the limitations:

To enhance the study's comprehensiveness, consider expanding the selection of database sources beyond the four mentioned (Springer, IEEE Xplore, A.C.M., and Elsevier). Additional reputable databases can help capture more relevant scientific papers and provide a more holistic view of the topic.

We are incorporating a broader spectrum of e-learning-related terms beyond those analyzed in the study, such as mobile learning, MOOCs, micro-learning, and continuing education. This expansion can offer a more comprehensive analysis of the subject matter.

To expand the scope of the study, explore additional research questions beyond the impact of e-learning and cloud computing services and models. This can uncover new dimensions and perspectives within the field and provide a more nuanced understanding of the subject.

Acknowledge that the impact of e-learning and cloud computing can vary across different educational contexts, and consider investigating specific issues or stakeholders, such as the role of teachers or instructors and the effects on student outcomes.

IX. CONCLUSION

Since the direction is now for online learning as the development of the technology, on the other hand, with its on-demand, metered access to computing resources (Process, Memory, Storage, etc.), cloud computing is a new paradigm that is fostering technical advancement and enabling dispersed applications across different geographies. Therefore, this study reviewed an e-learning-based cloud computing environment. The study extensively examined the integration of e-learning and cloud computing from 2010 to 2022, analyzing 154 scholarly works. The potential for remote engagement in education and employment is emphasized. The reliance on literature reviews signals a need for practical implementations and comprehensive integration of hardware, software, security, and other facets. While public cloud computing offers cost efficiency, data security remains pivotal, particularly for sensitive information like student grades. Cloud computing's role in shaping e-learning is recognized, yet challenges necessitate ongoing innovation for a comprehensive educational environment.

The primary finding of this study underscores the substantial role of cloud computing in enhancing the integration and effectiveness of e-learning, particularly concerning architecture, software, performance, and the potential of diverse cloud computing service models. Furthermore, this study offers recommendations for both researchers and readers. For researchers, it suggests a shift towards empirical validation to bridge theoretical concepts with practical applications, emphasizing the comprehensive integration of all e-learning elements, prioritizing practical implementations, and advancing research in data security. As for readers, the study advises them to seek studies that provide practical relevance through empirical insights, promote integrated approaches in e-learning, consider case studies, and maintain awareness of security measures within cloud-based educational systems.

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