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Cloud Computing Adoption in Higher Education Institutions: A Systematic Review

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ABSTRACT Cloud computing (CC) is a recently developed computing paradigm that can be utilized to deliver everything-as-a-service to various businesses. In higher education institutions (HEIs), CC is rapidly being deployed and becoming an integral part of institution experience. CC adoption in HEIs is accompanied by numerous scientific contributions that address the topic from different perspectives. A systematic review of these heterogeneous contributions, which provide a coherent taxonomy, can be considered interesting for HEIs to identify opportunities to use CC in its own context. Therefore, this systematic literature review aims to analyze existing research on adopting and using CC in HEIs, review background research to develop a coherent taxonomy and provide a landscape for future research on CC in HEIs. The outcomes of this paper include a coherent taxonomy and an overview of the basic characteristics of this emerging field in terms of motivation and barriers of adopting CC in HEIs, existing individual and organizational theoretical models to understand the future requirements for extensively adopting and using CC in HEIs, and factors that influence the adoption of CC in HEIs at individual and organizational levels. Considerable information is available in relation to adopting and using CC in HEIs. This review will enhance this information by offering an in-depth analysis of the existing data to bridge any gap and expand on existing literature.

INDEX TERMS Cloud computing, adoption, higher education institutions, systematic literature review, taxonomy.

I. INTRODUCTION

Cloud computing (CC) is considered the next generation of computing. It has become the main paradigm of resource and service delivery. CC is extensively adopted in private and public organizations given its flexibility, collaboration, cost-effectiveness, and scalability. These features make CC essential among users and organizations, such as higher education institutes (HEIs). A CC tracking poll [1] reported that the number of HEIs that implemented or maintained CC reached 43% until 2012. A 10% increase has been observed from 2011 to 2012. This growth is expected to escalate in the following years. International Data Corporation predicted that the amount of CC in the industrial field, including the education sector, will become $210 billion by 2019 or an increase of 23.8% over 2018, thereby reaching $370 billion in 2022 or an increase of 22.5% in a five-year compound annual growth rate. Over the next 5 years, cloud platforms and ecosystems will serve as the launchpad for an explosion in the scale and pace of digital innovation [2]. According to [3], CC is considered the fifth utility after the four essential utilities, namely, water, electricity, gas, and telephone.

CC stems from the traditional hosting idea that the Internet can be used to store software applications, data, or both. A client can access these services through the Internet from any place [4]. However, the standard definition of CC is presented by the National Institute of Standards and Technology (NIST) in the United States. NIST defined CC as a model used to enable convenient, ubiquitous, and on-demand network access to a shared configurable computing resource pools, such as networks, storage, servers, services, and applications, that can be provisioned and released rapidly with minimal management effort and interaction with the service provider [5]. A technical definition describes CC as computer clusters, such as vast data centers and server farms, which provide a client with on-demand services and resources through a medium in the network, typically the Internet [6]. In addition, providers of CC can offer users a dynamic

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scale-up or scale-down service usage depending on their requirements; moreover, they can use the metering capability to charge subscribers in accordance with their actual usage [5]. The dynamic optimization of shared resources among multiple users is achieved by CC. For example, a CC resource (such as email) is allotted to a Western user based on his/her time zone. Through CC, the same resource is allotted to an Asian user based on his/her time zone [7].

CC is perceived as a new operation, rather than describing it as a new technology [8]. Thus, CC is a set of existing technologies, which operate businesses differently [8]. Another definition provides a new concept by describing CC as a computing utility, grid computing convergence, and software-as-a-service (SaaS). An objective of the applications of cloud technology is related to the design of next-generation data centers [9]. Users can access such applications from any place given the intentional design of data centers, including the virtual service network (hardware, database, user interface, and application logic) [9]. Therefore, CC provides the optimal built-in practice for IT organization capability and business processes [10].

HEIs face many problems, such as an increase in participants, requirement of infrastructure and IT, providing affordable education services, and improving education quality [11], [12]. Thus, HEIs exert continuous efforts to manage sources and provide improved services [6]. Advantages that support cost reduction and improve education quality make CC a favorable option for students and educators [13]. Another advantage is related to educational sustainability because CC provides the required infrastructure, software, and storage [6], [14], [15]. The adoption of CC in HEIs is increasing in popularity but is considered lagging behind the commercial sphere and even government organizations in this market [16]. However, it is becoming a necessary part, rather than a choice, of HEI offer, thus leading to increased competition in the higher education marketplace [17].

Existing literature falls into two main camps, namely, traditional literature review (TLR) and systematic literature review (SLR). TLR tends to view the topic of research on a general perspective and looks at the overall trends and shifts. By contrast, SLR is more specific and tends to ''address a precise set of formulated research questions'' following a systematic approach [18]. CC adoption in HEIs is accompanied by numerous scientific contributions that address the topic from different perspectives. A systematic review of these heterogeneous contributions that provide a coherent taxonomy can be interesting for HEIs to identify opportunities to use CC in its own context. Several attempts have been made to empirically research the phenomenon, but none has provided a coherent picture or sufficient analysis taxonomy. Ibrahim *et al.* [19] limited their study to the empirical evidence of CC adoption in the education system; [20] reviewed the literature on using CC in education. Table 1 compares this study with the existing work. Many benefits can be gleaned from developing a taxonomy from existing literature,

TABLE 1. Comparison of this study with existing work.

	Ibrahim, et al. [19]	González-Martínez, et al. [20]	This Study
Review methodology	Kitchenham and Charters [18]	Kitchenham and Charters [18]	Kitchenham and Charters [18], Okoli [21]
Year of publication	2015	2015	-
No. of search engines	5	5	7
The final set of articles	27	112	206
Type of reviewed articles	Empirical Studies	* Empirical and Non-empirical Studies	Empirical and Non-empirical Studies
Taxonomy	×	×	√
Benefits & Concerns	×	×	√
Theoretical Models	**√	×	√
Influencing Factors	×	×	√

*[20] reviewed the literature on the general use of CC in any educational organization.
**[19] partially mentioned some specific outcome/product/framework or implementation of CC model or technology, but the study did not list used models and frameworks.

especially on a relatively new subject area with scattered and diverse contributions. Despite the absence of a standard and absolute taxonomy, creating a coherent taxonomy provides a landscape for future research to identify relevant issues, challenges, and research lines. Literature taxonomy can organize numerous publications. For example, researchers can understand the research trends, aspects, and activities in a specific field of research by structuring research papers because comprehensive taxonomy depicts gaps in the research area. In addition, this review reflects the theoretical models and factors used to assess the state of CC adoption and practice in HEIs at individual and organizational levels. This review can also be useful for researchers in this emerging field to identify the key characteristics of CC adoption in HEIs based on the desire to adopt CC services and the barriers to their extensive usage in HEIs. Furthermore, this review offers a recent picture of the current status of CC adoption in HEIs.

To address these gaps, this study follows the SLR method provided by [18], [21] to analyze existing literature. This method is suitable for pinpointing the main characteristics of CC adoption and use in HEIs and providing a landscape for future research to identify relevant issues, challenges, and research lines.

This study aims to bridge the current gap with evidence regarding the adoption of new technological innovation of CC in HEIs based on the following ideas:

1) Quantifying existing research and expanding upon it to form a new taxonomy and provide a landscape for future research on CC in HEIs.

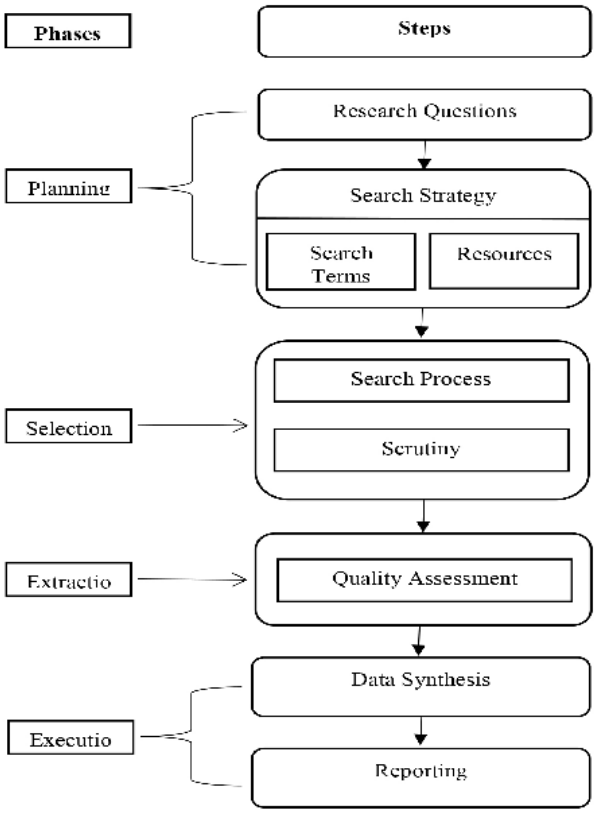

FIGURE 1. Phases and steps of the review protocol.

2) Surveying the basic characteristics of this emerging field represented on:
   a. motivation and barriers of adopting CC in HEIs,
   b. existing individual and organizational theoretical models to understand the future requirements for extensive adoption and use of CC at individual and organizational levels,
   c. and factors that influence the adoption of CC in HEIs at individual and organizational levels.

II. RESEARCH METHOD

The research methodology advocated by [5] and [8] was selected for this study (Fig. 1). It consists of four main phases, and each stage contains several steps. The first stage, planning, is composed of two main entities, namely, research questions and search strategy, which are created to complement the extensive theoretical questions of any existing research. The second stage, selection, involves sorting and extrapolating the data. This data processing exercise is composed of data collation followed by data refinement. The third stage, extraction, evaluates the data by applying rigorous assessment criteria. Finally, the fourth stage, data synthesis, involves a step-by-step analysis of data to produce a concluding set of subsequent procedures.

TABLE 2. Research questions and their reasons.

Research questions	Reasons
RQ1: What research evidence indicates the adoption of CC in HEIs [19]?	To collate existing research findings into a coherent taxonomy to organize and classify the existing research into an ordered format, thereby providing a clearly defined overview of existing research. The nature of the taxonomy provides all researchers with important viewpoints of the subject in many ways. (See Discussion)
RQ2: What inspires HEIs to adopt CC technology in their institutions [20]?	This question is designed to reveal the positive elements behind the adoption of CC technology along with any interesting motivations in the existing research.
RQ3: What are the barriers that may prevent the extensive adoption of CC in HEIs [20]?	This question aims to reveal any issues faced by HEIs when introducing CC into their institutions.
RQ4: Which theoretical models are used to assist in adopting CC in HEIs?	These responses enlighten researchers in terms of methods that can be effective in any future adoption recommendations.
RQ5: Which factors influence the adoption of CC in HEIs?	Can be used to create an appropriate model by highlighting the enabling factors behind the adoption of CC in HEIs, which are obtained from empirical evidence.

A. PHASE 1: PLANNING

1) RESTRICTED ISOMETRY PROPERTY

The research questions focus on the following criteria: population, intervention, comparison, outcomes, and context structure [18], as described in Table 2 [22]. The questions here are presented in no particular order and can be asked simultaneously.

2) SEARCH STRATEGY

Detailed analysis of the search strategies used in this study is described in search terms, literature sources, and the search process as follows:

a: SEARCH TERMS

The search terms were devised using a set of pre-defined definitions and methods [18], [21]. They were then used to construct the following search strings: (a) extrapolation of the most common themes from the key questions, (b) list of possible alternative spellings, (c) extrapolation of keywords and terminology from existing research papers, (d) incorporation of the Boolean operator "OR" to include alternative terms or spellings, and e) use of the Boolean operator "AND" to ensure any combination of the terms that can be searched is cloud OR computing. All research terms were obtained from the topic being investigated. These terms are cloud

computing, adoption, usage, and higher education. The final search terms were as follows: ([''cloud'' OR ''cloud computing''] AND [''adoption'' OR ''usage''] AND [''education'' OR ''teaching OR learning'']).

b: LITERATURE RESOURCES AND EXISTING RESEARCH

The research investigation used by seven research databases, namely, Web of Science (WoS), ScienceDirect, IEEE Xplore, ACM Digital Library, Scopus, Springer, and Emerald. Various existing research articles were also searched for their ''title,'' ''abstract,'' and ''index'' terms and were used to run further search terms to locate published journals or papers, conference proceedings, workshops, symposiums, books chapters, and IEEE bulletins.

B. PHASE 2: SELECTION

1) SEARCH PROCESS

The SLR methodology requires a comprehensive interrogation of all existing literature under investigation. Fig. 2 outlines the steps of this process.

Search stage 1: The seven electronic database resources were systematically searched, and the results were returned.

Search stage 2: The existing research papers were sorted, and a final definitive list of 461 papers was shortlisted through elimination. The titles were examined to remove duplications, thus leaving a shorter list of 342 papers.

Researchers applied the quality and assessment criteria to these papers, and 206 were selected because they were well-matched to the research questions.

2) SCRUTINY AND FILTERING PROCESS

The initial list of 461 studies (as illustrated in Fig. 2) was filtered and analyzed to ensure relevance. Several steps were involved in this process. Initially, the titles were assessed for relevance, and the contents were briefly scanned to ensure relevance to the issues under investigation. They were further assessed against the following requirement; written in English, conference references, workshops, symposiums, excerpts from books, and articles. If two copies of the same paper were found, only the most recent and up to date were included. The SLR was conducted on articles published between January 1, 2009, and May 31, 2017, as summarized in Table 3.

C. PHASE 3: EXTRACTION

STUDY QUALITY ASSESSMENT

The original study was whittled down with the use of a scoring system. The papers were given a score based on their capability to provide answers to specific questions. The process involved allocating a score based on how closely the answers matched the research questions. The guidelines provided in [18] and [21] are summarized in Table 4. The scoring system was ''Yes = 1,'' ''Partly = 0.5,'' or ''No = 0.'' A total relevance score was produced at the end. An ''acceptable quality'' score was then allocated, and other studies must fall within this range to be accepted. The qualifying studies were also required to have a score greater than 2 (50% of the percentage score). The authors calibrated their scores on a few sample studies based on similar quality assessment scores. This system excluded 40 papers given their lack of adherence to the minimum quality assessment score, thus leaving 206 research papers, which could be used as a base to the study questions (see Fig. 2).

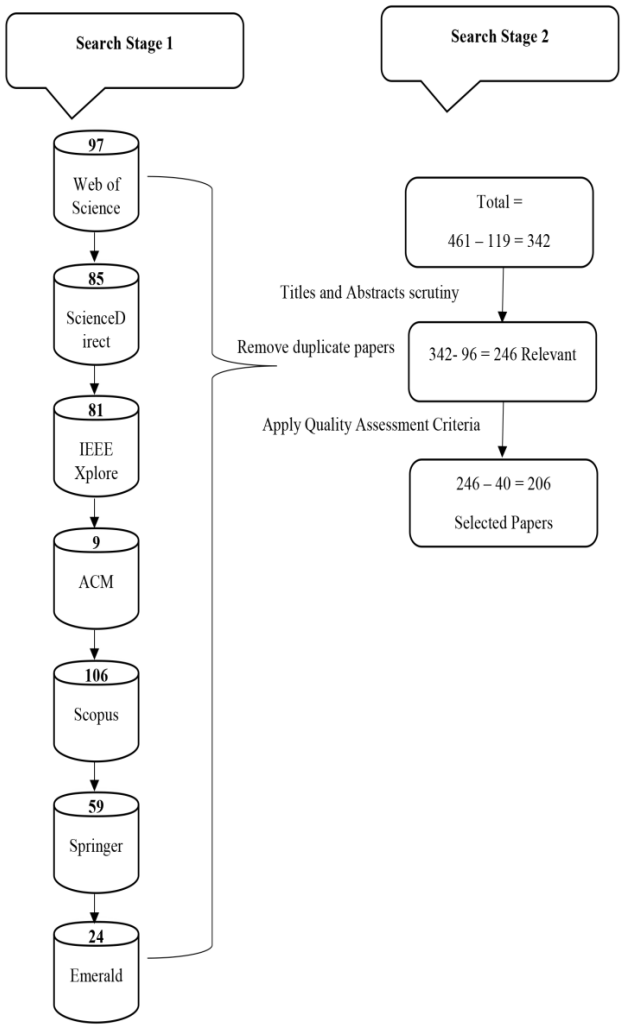

FIGURE 2. Search process.

D. PHASE 4: EXECUTION

DATA SYNTHESIS

The final stage of our study was article filtering, a process, which involved the application of further validation, to ensure the quality of our final list. This list was then assessed against further qualifying criteria, as outlined in Table 5. The qualifying criteria reviewed quantitative (numerical outputs) and qualitative data, such as the strong and weak points in the results.

TABLE 3. Inclusion/exclusion criteria.

	Inclusion criteria	Exclusion criteria
A.	English papers	Any other language papers
B.	All papers discussing CC in HEIs	Papers that did not have any link with the research questions
C.	Matching papers published between 2009 and 2017	Gray papers; papers, excluding CC, with no relevance to research questions or incomplete papers
D.	Papers that can potentially answer at least one research question	Any outdated papers or papers with the same author because this information tended to be duplicate
E.	For Research Question 5 (RQ5), only empirical studies, which examined the relevant factors, were included	Publications whose text was not accessible through search engines or the authors themselves, that is, authenticity cannot be verified
F.	Papers (≥3 pages).	Short papers (<3 pages)

TABLE 4. Study quality checklist – success criteria.

QA ID	Checklist questions	Answer
QA 1	Are the aims of the study clearly stated?	
QA 2	Is the proposed theory/model/framework clearly described?	Yes = 1/ Partially = 0.5/
QA 3	Is the methodology (research approach) used appropriately for the subject?	No = 0.5
QA 4	Is the research information useful for extensive academic research or employers?	

TABLE 5. Content assessment criteria.

Selected study	Description
Confirmation of bibliographic references	Unique identification number for the study, publication year, title, and source
Type of study	Journal and conference papers, IEEE bulletins, and book chapters
Study focus	Subject of the study, problems, scope, reasons, and objectives
Research methodology	Case study, survey, experiment, interview, observation, and questionnaire
Data analysis	Quantitative/qualitative analysis
Constraints	Analysis of research limitations with recommendations for future research

III. RESULTS

A. OVERVIEW OF SELECTED STUDIES

The initial query returned 461 articles: 97 from WoS, 85 from ScienceDirect, 81 from IEEE Xplore, and 9 from ACM. Additional 106 articles were returned from Scopus, 59 from Springer, and 24 from Emerald, all of which were obtained between Jan-2009 and May-2017. Based on the original output, 119 articles were duplicated. After scanning the titles and abstracts, 96 additional articles were excluded, thereby reducing the output to 246. An in-depth reading further excluded 40 irrelevant articles, thereby leaving 206 articles as the final study sample.

TABLE 6. Numbers and percentages in relation to the filtering process.

Reference type	Number	Percentage
Journal Articles	81	39%
Conferences	71	71%
Book Sections	54	54%

Table 6 lists a full breakdown of the numbers and percentages in relation to the filtering process. Fig. 3 depicts the breakdown of the database sources. Fig. 4 demonstrates a breakdown of papers per year. Fig. 5 exhibits a breakdown of articles per year in different categories.

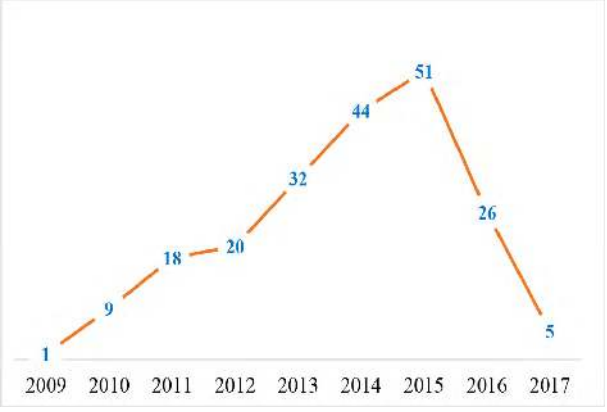

FIGURE 3. Breakdown of database sources.

B. RQ1): WHAT RESEARCH EVIDENCE INDICATES THE ADOPTION OF CC IN HEIS?

To address the above question, a literature taxonomy aimed at summarizing the existing research was created (see discussion). The final sample of 206 papers was read and studied to obtain a detailed picture of the existing research into this subject area. The research papers had several different forms: (34%; 70/206) were survey and review studies for the previous studies in an exploratory manner, (25%; 52/206) were proposals or frameworks that aim to seek answers to the practical application of CC in HEIs, the next (21%; 43/206) comprised findings from previously attempted implementations, and the smallest and significant group (20%; 41/206) represented different investigations into HEIs, which intended or managed to successfully adopt and maintain CC within their institutions (see Fig. 5). This study observed each research category and studied the findings to produce the taxonomy displayed in Fig. 6. Several subcategories could be distinguished in the main classes, although many of the

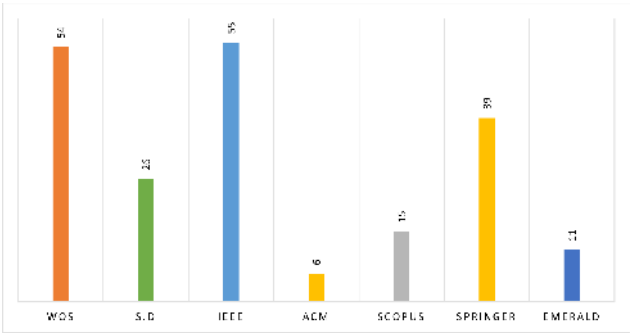

FIGURE 4. Breakdown of papers per year.

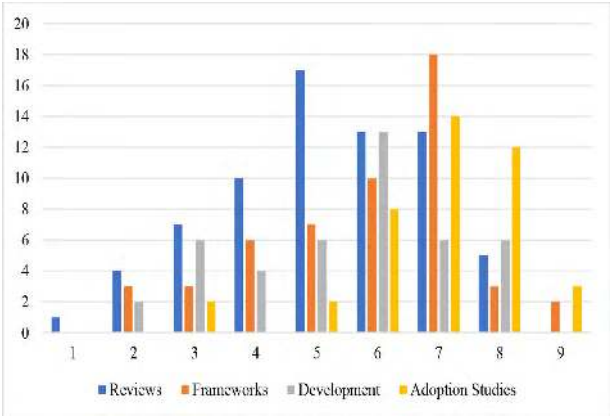

FIGURE 5. Number of articles per year in different categories.

different papers were not as clearly defined as suggested, and some overlapped into different subcategories that the readers should be aware of. Overall, the results of RQ1 demonstrated that the adoption of CC in HEIs is a current topic, which has attracted many researchers.

1) REVIEW AND SURVEY ARTICLES

Extensive research on CC is conducted at the beginning of our study. The improved overview will be given about the operation of technology and its introduction to HEIs. By first analyzing the extensive statistics aimed at informing the reader of any complications, which may arise throughout the process, specific specialties can be addressed. The largest category of this study is concerned with a specific specialty [23]–[51] (29/70 articles). The following articles referred to reviews on cloud-based e-learning [30], [32]–[34], [36]–[38], [44]–[46], [48], mobile learning [39], [40], [50], [51], c-learning [24], x-learning [42], collaborative learning [43], learning environments [41], and libraries [25], [27], [49]. These articles also offered scientific research (e-Science) [23], teaching and learning [28], knowledge-as-a-service [31], SaaS [26], and smart and intelligent classrooms [29]. Other kinds of articles offered an overview of CC in HEIs with numerous benefits, effects, challenges, or concerns [6], [20], [52]–[69] (20/70); and they were all classified as ''general'' articles. Despite the generality of some of these articles, they contained some specific elements, such as cloud-based e-learning systems [66], strategy and recommendations for effective adaption [64], CC infrastructure for universities [60], [62], or co-word analysis of CC in education [59]. Other papers, including [19], [70]–[89] (21/70), were written with a specific purpose, and they were related to the effectiveness of CC that has been adopted by HEIs [19], [79].

Some studies have been interested in the economic effects of implementing CC technology [86], disaster recovery [82], or cloud-in-cloud setups [68]. Other studies may have included the use of SaaS by students [73], CC for implementing core elements of the curriculum [74], [77], or automation of CC operations of HEIs [78]. Other studies have referred to distance collaborative teaching and research [84], clouded and ''ubiquitous'' learning environments [80], and CC for students with attention deficit hyperactive disorder (ADHD) [89]. Finally, varied categories include working in a library setting [70], rural e-learning sustainability [87],cloud-based e-learning security measures and management standards [83], teaching resource application [88], university business processes [81], CC for knowledge centers [85], teaching assistant systems [75],e-learning application design [71], and CC for faculty members [76].

As a result of the review and survey articles, specific specialty articles [23]–[51] (41.4%) are the largest searched category while the smallest one is the 'general' articles [6], [20], [52]–[69] (28.5%).

2) STUDIES CONDUCTED ON THE ADOPTION OF CC IN RELATION TO HEIS

The lack of research on CC in the higher education sector compared with other areas, such as business and finance, has been criticized. The studies tended to fall into two brackets: individual and organizational, as in our small study sample [14], [15], [90]–[128]. To assess these studies further, the brackets were broken down into the following subcategories: ''individual'' category studies (25/41) [14], [90], [91], [93], [99], [100], [104]–[106], [108], [109], [111], [114], [115], [119], [120], [123]–[129] and a small category of ''organizational'' category studies (14/41)[94]–[98], [101]–[103], [107], [110], [116]–[118], [121], along with other miscellaneous criteria that did not fit neatly into our classifications (2/41) [116, 122]; Table 7 summarizes the full breakdown. Fewer studies were concerned with the organizational category dimensions of CC compared with other concerns.

Innovation adoption research is divided between individual concerns as opposed to studies examining the individual adoption of innovations and organizational concerns centered upon a wide group of people [130]. The following articles were based on the individual approach, and they examined the acceptability and adoption of CC by HEIs, as presented in Table 7. The following articles fell into this category [90], [91], [93], [99], [106], [109],

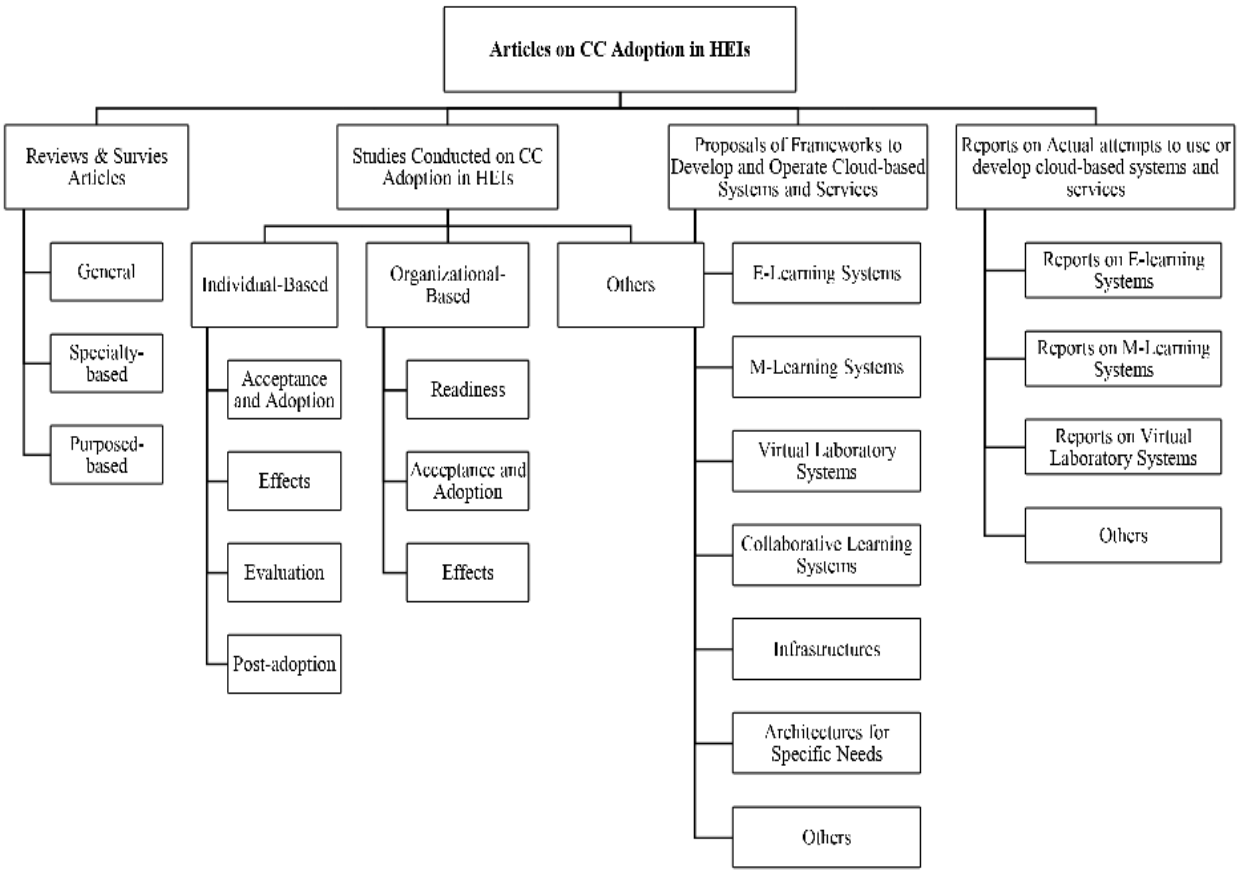

FIGURE 6. Taxonomy of research literature on CC adoption in HEIs.

[113], [115], [120], [124]–[128] (14/25). Some individual studies scrutinized specifically at the application of cloud services to e-learning in universities [90], [99], [128], the cloud-based collaboration tools in a university setting [90], [115], and the inspirational behaviors and influences of CC usage in HEIs [126].

The following papers highlighted the effect of CC adoption and usage on HEIs [100], [104], [105], [112], [114], [119], [123] (7/25). The following papers evaluated CC and outlined the extent of using CC in HEIs [14], [108], [111] (3/25). Only one study was concerned with predicting the factors that influence the post-adoption of CC technology for undergraduate students at a mid-sized university [15] (1/25).

The wide organizational studies examined the acceptability and adoption of CC by various types of HEIs [94], [95], [101]–[103], [110], [117], [121] (8/13), as displayed in Table 7. Some organizational studies have empirically investigated the adoption of CC in different developing countries, including Saudi Arabia [59], [94], [110], sub-Saharan Africa [96], [101], [102], and Malaysia [98]. Some studies have focused on adopting CC in academic libraries [103], [121] while improving the general awareness of CC migration issues [110]. Further organization-based categories investigated the readiness of HEIs to adopt CC in their institutions [96], [107], [118] (3/13). Other studies have explored the extensive effects of technology on HEIs [97], [116] (2/13). In addition to the individual and organizational studies highlighted above [116], [122] (2/13), one article aimed to propose a method that maximizes platform utilization for HEI environments [116]. The other article offered a specific business model, which outlined the optimum IT infrastructure setup [122] and raised the concern about high-level IT performance and CC services.

TABLE 7. CC adoption studies in HEIs by different categories.

Subcategory	Main category		
	Individual	Organizational	Others
Readiness	-	3	
Acceptance and Adoption	14	8	
Effects and Output	7	2	
Evaluation	3	-	
Post-adoption (Continuance use)	2	-	
Total	25	13	2

Table 7 indicates that little research attention has been paid to the adoption and usage of CC at the organizational level comparing to the individual level. Furthermore, a gap in the literature still exists in the post-adoption phase in both the individual and organizational levels.

3) EXISTING PROPOSALS OF FRAMEWORKS TO DEVELOP AND OPERATE CC APPLICATIONS AND SERVICES

Existing research on adopting CC in HEIs aimed to offer suggestive frameworks for models to follow (52/206) [132-183], as presented in Table 8. These articles (13/52) have tended to focus on either implementing CC in HEIs or developing e-learning systems [141], [145], [148], [150], [156], [158], [159], [161], [164], [171], [172], [178], [181], and other studies have tended to focus on developing mobile learning systems (3/52) [167], [175], [182]. One or two articles have introduced the concept of distance and virtual education "laboratories" (8/52) [132], [137], [140], [146], [147], [151], [169], [173]. Some papers have proposed tailor-made or bespoke architectures for specific requirements, (5/52) [143], [144], [162], [163], [165]. Other papers have outlined general infrastructure ideas in education (5/52) [142], [154], [166], [168], [170], whereas other researchers have discussed the ideas of collaborative learning and use of application software to support these ideas (5/52) [131], [150], [153], [179], [180]. In addition to studies highlighted above (14/52) [133]–[136], [138], [139], [146], [149], [152], [155], [157], [160], [176], [177], certain articles have included an "evaluation model" [134], sustainable ICT provisions [149], and an information management system structure based wholly on CC technologies [136]. Articles have outlined the issue of resource sharing [176] and lab assignments [177] along with the exploration of educational SaaS, configuration steps [160], intelligent learning (i-Learning), system architecture [152], and dual-cloud technology to build the C-learning environment [135]. One research paper has outlined a framework designed to inspire educational practitioners in areas of u-learning [133], and another one has advocated "the design and evaluation of inquiry-based learning activities to enhance students' critical thinking skills" [157]. Another paper has proposed "parallel and distributed computing." Other papers have highlighted a cloud-based framework to manage university systems [155] and a cloud-based learning environment [139]. Finally, frameworks and models have included an architecture for education systems such as massive open online course (MOOC) and their expectation in working together [146] or a framework for scrutinizing the operation of users in a CC environment [138].

To sum up, Table 8 shows that there are few upbeat studies conducted on m-learning systems as well as collaborative learning systems comparing to e-learning system studies.

4) FINDINGS FROM PREVIOUS ATTEMPTS TO DEVELOP AND IMPLEMENT CC TECHNOLOGY IN HEIS

Previous researchers have recorded their experiences after attempting to develop and implement CC technologies over the years. The last category in our taxonomy relates to these specific reports and trends and analyzes these attempts to develop CC systems, services, or applications (43/206) [125], [182]–[223], as displayed in Table 9. The first implementation documented in 2010 offered an enhanced e-Learning ecosystem based on the integration between CC and Web 2.0 [212]. Other researchers have documented their experiences when developing e-learning systems (5/43) [183], [188], [207], [212], [215], m-learning systems (mobile) (5/43) [196], [200], [203], [206], [208], and virtual laboratory systems (4/43) [184], [185], [199], [202]. In addition to these studies (30/43) [186], [187], [189]–[195], [197], [198], [201], [204], [205], [209]–[211], [213], [214], [216], [217], [219]–[224], other researches have shared considerably in common and highlighted issues, such as computer-supported collaborative learning platform [222], ontology-driven systems [201], SaaS platform [195], and private clouds [213]. Others have documented teaching and learning networked systems [223],cloud-based web application with integrated robotics [189],cloud-based content cooperation system [218],cloud-based open-test

TABLE 8. Frameworks of cloud-based systems and services.

General classification criteria	Specific classification criteria	Studies
Proposals of frameworks to develop and operate cloud-based systems and services	e-Learning Systems	[142, 146, 149, 151, 157, 159, 160, 162, 165, 172, 173, 180, 183]
	m-Learning Systems	[168, 177, 184]
	Virtual Laboratory Systems	[133, 138, 141, 147, 148, 152, 170, 175]
	Collaborative Learning Systems	[132, 151, 154, 181, 182]
	Infrastructure	[143, 155, 167, 169, 171]
	Architectures for Specific Requirements	[144, 145, 163, 164, 166]
	Others	[134-137, 139, 140, 147, 150, 153, 156, 158, 161, 178, 179]

TABLE 9. Reports on cloud-based systems and services.

General classificati on criteria	Specific classification criteria	Studies
Reports on actual attempts to use or develop cloud-based systems and services	Reports on e-learning Systems	[185, 190, 209, 214, 217]
	Reports on m-Learning Systems	[198, 202, 205, 208, 210]
	Reports on Virtual Laboratory Systems	[186, 187, 201, 204]
	Others	[188, 189, 191-197, 199, 200, 203, 206, 207, 211-213, 215, 216, 218, 219, 221-226]

database system [197], and e-Meeting system [217]. Further innovations include management training system [214], personal learning environment system [209], cloud-based knowledge management system [190], and cloud-based social network application [193].

Many works have discussed the adaption of their approach to suit their university [194]. Some researchers have discussed the usage of blogs, Wikis, Google Docs, and interactive whiteboards as part of their day-to-day teachings or to help with course preparation [196], [224]. A specific case study highlighted the implementation of CC at University Sorbonne Paris Cite [220] or the adoption of CC for a private teaching school [213]. A study in Taiwan examined the application of big data analytics to Taiwan's Edu Cloud [191], and others have shared their experiences of blended learning from the learning management system ''Moodle'' [204]. The basic hypothesis was formed; that is, teaching is evolving from a once passive mode of teaching to a currently active cloud-based approach. This theory was applied to a specific engineering–physics course for first-year students [216]. One study focused on a technical model designed for the input-output place–transition Petri net models and its adoption through a digital design course [221]. Further studies have explored collaboration between industry-smart universities [210]; a study investigated the case of a university-based CC service provider [192]. The University of Rijeka [186] conducted a study of cloud migration, and another focused on how the University Cloud had ''helped to organize student internships at the Wroclaw University of Technology'' [205]. Another study [197] investigated the use of cloud-based applications to enhance ''instructional'' teaching methods, which have focused on constructivism and cooperative learning [211]. A study examined engineering students' IT processing requirements based on their own internal iStar methodology [198]. Sullivan University reported their findings on the ''transition to the complex cloud environment'' [219].

To conclude, the current investigation shows that there are few reports on virtual laboratory systems [184], [185], [199], [202] (9.3 %),m-learning systems (11.6%) [196], [200], [203], [206], [208], and e-learning systems (11.6%) [183], [188], [207], [212], [215].

C. (RQ2): WHAT INSPIRES HEIS TO ADOPT CC TECHNOLOGY IN THEIR INSTITUTIONS?

This section presents the benefits, which inspire HEIs to adopt CC, as highlighted by research papers [6], [14], [20], [28], [30], [43], [49], [54], [61], [86], [89], [125], [139], [146], [204], [207], [209], [211], [225], [226]. The reasons to adopt CC in HEIs are illustrated in Fig. 7).

1) READILY ACCESSIBLE ONLINE APPLICATIONS

Students are already familiar with the concept of CC to some degree and are probably already used in cloud-based technologies, such as Google Apps and Dropbox, which are free, easy to use, and highly accessible. Software is typically

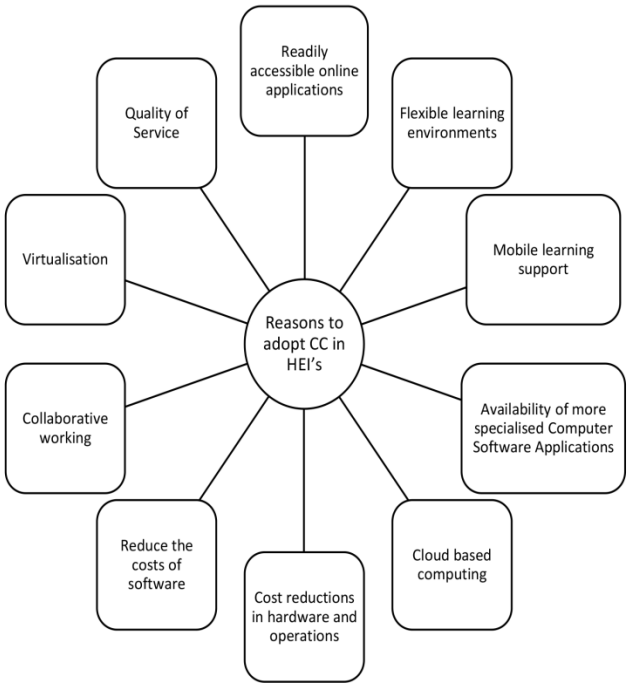

FIGURE 7. Reasons to adopt CC in HEIs.

built on the latest technological infrastructure and constantly being developed and enhanced. Cloud-based systems are attractive to the education sector because they are readily available, quick to respond, and easy to roll out to numerous audiences. However, occasional issues with performance can arise. Some applications, such as Google Apps for Education or Microsoft Office 365, can be used in an online capacity for the classroom. Specialist software packages, such as (AutoCADWS), can be used by teachers or lecturers to assist them with their lessons [204]. Built-in collaboration and community technology can be exploited by educators because this software simplifies teaching certain disciplines, including certain pedagogical methods, such as constructivism or collaborative learning [211].

A study by [28], which advocated the use of cloud collaboration tools for teachers, and other studies, such as [139], showed the improvements caused by these technologies on various disciplines, such as science and technology or even advance teaching of certain courses (i.e., MBA courses on e-learning, physics, computer science, and programming). These improvements can be helpful with CC technologies, such as Google docs, blogs, and Wikis.

2) FLEXIBLE LEARNING ENVIRONMENTS

The highly configurable nature of cloud technologies enables teachers to create a whole new teaching and learning environment [20]. A study [146] tested this theory by integrating three cloud tools, such as Google Apps, Facebook, and mind-mapping applications, to help teachers present their e-learning course. The model received a mixed response

with some students who struggle to adapt initially, but the benefits were noticed over time. Other examples included the configuration of personal learning environment [209] for long-term education. A powerful feature of CC is that the teacher has relative freedom on configuring the computers for specific students. They can provide virtual desktops with pre-installed software and can re-clean, configure, and then reuse the computers for different teaching purposes [14]. This feature is invaluable for computing and technology classes where specific network and IT infrastructure setups can be replicated in the classroom environment [207]. Some teachers may prefer to use the tools to build developing environments, such as Google App Engine or Windows Azure [20]. Vaquero [14] compared three working environments for Computer Science students and with a traditional environment based on Google app technology. The results indicated that the pre-configured environment can maintain students' interests for a long time despite no evidence of improved results. Teachers should not take learning away from students by making the process very easy for them.

3) MOBILE LEARNING SUPPORT

Cloud technologies have much greater capacity than other network infrastructures because they can overcome other computing limitations by offering great processing capability and data storage capacity given the servers where they are stored [114]. A research paper [61] stated that cloud and mobile computing are the technology of the present and the future in the workplace and within education. Students can benefit from ''augmented reality,'' which is used by students with ADHD because they may need to perform many complex operations simultaneously in the cloud [89]. A study [225] undertaken at Khalifa University used the mobile technology ''Moodle'' to analyze the enhancement of CC on the traditional mobile learning experience.

4) AVAILABILITY OF SPECIALIZED CLOUD-BASED SYSTEMS

CC applications can be relied on when other technologies fail. They can be established to run applications in a short period [20] and on any environment. [204] studied the highly intensive engineering process and architectural drawing software AutoCADWS, which runs in a cloud environment. This processing and memory-eating application can be accessed by engineering students in a cloud environment, such that it can be made available to everyone.

5) SCALABILITY OF SPECIALIZED CLOUD-BASED SYSTEMS

CC can react to changing requirements on its resources [207]. The CC technology is scalable and can satisfy increased demand. CC is incredibly powerful, especially during peak times in the academic calendar (e.g., exam times, during enrolment, and assignment deadlines) [43]. This behavior also tends to occur at other times, such as during MOOCs when numerous students must access the technology simultaneously [30].

6) COST REDUCTIONS IN HARDWARE AND OPERATIONS

HEIs can save money in many ways if they adopt cloud technology. Cloud technologies include on-demand services, scalability, and pay-per-use technology; the largest cost saving comes from reduced hardware and networking costs [20], [49].

Other cost savings include IT maintenance, telecommunication services, power consumption, cooling requirements [6], fire suppression, and storage. These savings can also be matched by not having to spend on infrastructure or the staffing required to operate and maintain the systems [6] because they can be alleviated by introducing cloud technology. Universities can also benefit from using private cloud technology if they are reluctant to adopt public clouds. Virtual environments in private clouds also mean reduced energy usage and the costs associated with it [207].

7) REDUCE THE COSTS OF SOFTWARE

HEIs can make considerable cost savings [3] by accessing the free software available in a cloud environment. A study conducted at the University of Westminster [3], which advocated the use of Google mail and Google apps, obtained dramatic cost-saving results. The cost of using applications is zero. Nevertheless, when the same technologies are run on paid software, the cost is £1,000,000, which is the cost of this incorporated software purchase, maintenance, and required infrastructure. The study also showed the production of license fee savings by using virtual learning environments, which were used for geometry and algebra lessons, and they were applied over several school environments [226]. [204] highlighted that Civil Engineering students can benefit from free (normally very expensive) software, such as AutoCADWS.

8) COLLABORATIVE WORKING

CC can significantly enhance the way students work, particularly collaboration. Teachers can benefit from the tools provided by cloud technologies, such as Google, Box, Podio, and Microsoft online applications. Such technologies can be used to familiarize students with modern technological practices. Collaborative working is essential for students. For example, a student can begin a project on Google Drive or Microsoft SkyDrive, and fellow students can view and edit the same document simultaneously. This activity is a huge technological step. The ability to access these technologies enables teachers to produce lesson plans around the knowledge because they will have access to these resources [61].

9) VIRTUALIZATION

Virtual computing denotes that any computer can be cleaned, set up, re-cleaned, and reinstalled cheaply and easily in a short period [54]. This process can be performed remotely by engineers or the off-site IT department, thereby dramatically

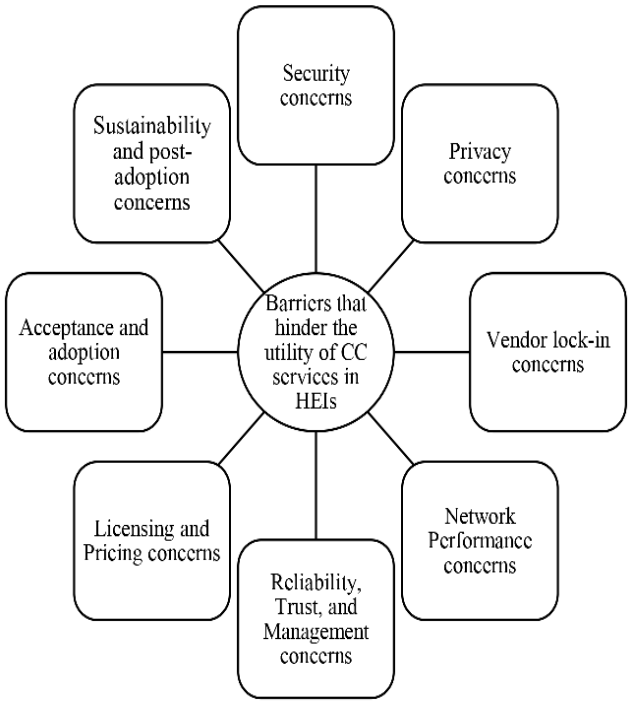

FIGURE 8. Barriers which hinder the utility of CC services in HEIs.

reducing any effect on the student. This process also reduces downtimes due to technical software problems because the software can be quickly and easily fixed or re-installed [86].

10) QUALITY OF SERVICE (QOS)

Copies of the quality of service (QoS) agreements can be obtained from software suppliers. QoS guarantees a certain level of quality from the provider, thereby outlining the SLA to which they must adhere [51].

D. (RQ3): WHAT ARE THE BARRIERS THAT MAY PREVENT THE EXTENSIVE ADOPTION OF CC IN HEIs?

Despite many unquestionable advantages of CC in HEIs, some barriers may prevent the complete adaptation of CC in HEIs. This section examines the barriers, which may hinder the utility of CC, as highlighted by research papers [6], [20], [52], [54], [56], [91], [93]–[98], [101], [102], [109], [110], [113], [122], [127], [226] (see Fig. 8).

1) SECURITY CONCERNS

The most pressing concern for education decision makers and many other industries is the security of CC. Cloud software producers must provide confidentiality, integrity, and availability in all software applications. The most significant factor is verifying users where the administration of passwords themselves may compromise security. At times, the correct permissions must be given to the correct staff members, depending on their specific role within the organization. This condition must be understood and managed correctly. The software must not only control accessibility but also use the most advanced and correct encryption methods, especially in protecting crucial or sensitive data, such as personal information and exam grades. HEIs must ensure that security is maintained constantly. HEIs may also be required to use non-repudiation technologies occasionally, thereby indicating that processes cannot be prevented given time stamps or digital signatures [6], [20], [22], [52].

2) PRIVACY CONCERNS

Current legislation, such as the Data Protection Act in the United Kingdom and the European Union in Europe, require that all personal and private data remain protected and private consistently. To comply with these requirements, universities must protect student, staff, and research data at all times, all of which must be 100% secure. This requirement extends to any information held on the cloud, which is a serious concern for businesses and education providers. Thus, large companies, such as Amazon offer EU-based cloud storage to comply with the legislation. Considering these strict policies, some HEIs may be reluctant to utilize cloud technologies [6], [20], [52], [56].

3) VENDOR LOCK-IN CONCERNS

The vendor lock-in problem in CC is the situation where customers depend (i.e., locked in) on a single CC provider and cannot easily move in the future to a different vendor without substantial costs, legal constraints, or technical incompatibilities. If a university uses one particular application, then the data entered into the system can only be released by that software provider. The software supplier may effectively lock access to the data, thereby requiring the university or institution to specifically request them. This arrangement can incur a cost when extracting the data from the old system and migrating them to a new one [6], [20], [56].

4) NETWORK PERFORMANCE CONCERNS

Some cloud-based computing services require high bandwidth and Internet performance to run efficiently and in real time. They depend on a good network and Internet connection to run services optimally (high-performance computing) [20], [122], [155].

5) RELIABILITY, TRUST, AND MANAGEMENT CONCERNS

Cloud-based applications are not constantly reliable because systems can ''go offline'' or fail. When these situations occur, the user or the university IT department cannot perform much. For example, Salesforce.com went offline for 6 h in 2008, followed by a disruption to Amazon's SSS and EC2 services in July for 8 h. Studies have indicated that Google and Amazon have experienced disruptions to their service at some point [6], [20], [56].

A study at a Malaysian University in 2013 has documented that 89% of university researchers mistrust cloud services [52], [54], [56]. Lack of trust in the services is a primary concern for university decision makers. Risks can

also be attributed to education management, which differs between traditional software platforms and cloud-based technologies, thus denoting that decision makers must re-assess their whole academic infrastructure process [54], [56].

6) LICENSING AND PRICING CONCERNS

Stein, et al. [226] demonstrated risks attached to the pricing of CC services. The relative infancy of the technology indicates that HEIs must consider the costs of licensing fees when adopting new technology. The supplier may opt to change its licensing structure to the point where any savings made by using CC are minimal in comparison with the cost of the licenses.

7) ACCEPTANCE AND ADOPTION CONCERNS

The way that teaching staff and academics respond to the introduction of CC within their institution affects the readiness of others in accepting and using it in the long term. University academics and administrative staff must be in favor of the technology prior to its adoption. [91], [93], [102], [109], [113], [127]. Researchers have empirically investigated the acceptance and adoption concerns of CC by HEIs in different developing countries; these concerns include lack of user awareness, risk, network bandwidth, infrastructure, sociocultural, SLA requirements, disaster recovery, Ministry of Education policies, management support, regulatory policies, job loss and sabotage, and lack of experience [13], [94]–[96], [98], [101], [102], [110].

8) SUSTAINABILITY AND POST-ADOPTION CONCERNS

The continuance use of CC helps sustain its use and ensures the long-term success of the innovation in HEIs. This expansion, which will potentially influence the institutions' subsequent decisions on continuous adoption intention, was discussed by [15] and [129]. The authors investigated the factors that influence and predict the post-adoption of CC technology for undergraduate students at a mid-sized university.

E. (RQ4): WHICH THEORETICAL MODELS ARE USED TO ASSIST IN ADOPTING CC IN HEIs?

In an education environment, CC can provide teachers and students with numerous advantages. When the decision-making unit or individual (the adopter) goes through the process of beginning to consider a new product, idea, or service, this process is known as adoption. This process has several phases, and the outcome is the decision of whether or not to adopt the new item. This decision is made by an entity about a certain object within a particular context. This outcome or decision is based on theoretical models; therefore, the entity is the HEI, and the object is the adoption of CC. Existing literature was analyzed in this review; several studies have considered the adoption of CC based on theoretical models at an individual level [15], [90], [91], [93], [99], [105], [106], [109], [111], [113], [115], [120], [124]–[128], [112]

TABLE 10. Theoretical models used for the adoption of CC in HEIs at the individual level.

Code	Theory/Model	Source
1	Social Cognitive Theory and the TAM	[109]
2	Six theoretical models:	[112]
3	QoS, self-efficacy (SE), motivational model (MM), TAM, the theory of reasoned action or theory of planned behavior (TRA/TPB), and innovation diffusion theory (IDT)	[113]
4	Extended TAM	[126]
5	TAM framework	[99]
6	Recursive Intelligent Learning model	[128]
7	TAM	[105]
8	TAM	[125]
9	TAM3	[115]
10	Expectation Confirmation Model (ECM)	[91]
11	Theory of Planned Behavior (TPB)	[90]
12	Task-Technology Fit (TTF) model	[129]
13		[111]
14	TAM	[106]
15	TAM	[93]
16	Extended Unified Theory of Acceptance and Use of Technology (UTAUT2) and consumer innovativeness	[126]
17	Theory OF Motivation	[99]
18	Duo-theme DEMATEL (decision-making trial and evaluation laboratory) with TAM (technology	[128]

TABLE 11. Theoretical models for the adoption of CC in HEIs at the organizational level.

Code	Theory/Model	Source
1	DOI and TAM	[102]
2	TOE framework	[94]
3	Institutional theory and capability approach	[96]
4	Control objectives for information and related technologies (COBIT) 5 framework	[107]

(18/22), but few articles on CC were written at the organizational level [94], [96], [102], [107] (4/22).

Therefore, technology acceptance model (TAM) is most extensively used for CC adoption studies in HEIs at the individual level, but the TOE is the most dominant theoretical model in organizational studies. Existing research theories and models have aimed to highlight these facts, as summarized in Tables 10 and 11.

F. (RQ5): WHICH FACTORS INFLUENCE THE ADOPTION OF CC IN HEIs?

''Factors'' throughout this study refer to variables, which are likely to ease adoption, and CC offers mean that having favorable professionals and practices may improve the quality of education and research. These factors were extrapolated from the examined studies and were segregated into individual- and organizational- based considerations.

We conducted a process of filtering, matching, collaborating, and consolidating of ideas from the research studied [213]. The information was collated and organized by a specific factor. Thus, we examined the source, subject

TABLE 12. Key previous studies examining the individual-based category factors that affect the adoption of CC in HEIs.

N.	Source	Subject studied	Methodology	Model	Variables		Key findings
					Dependent Variables	Independent Variables	
1	[103]	library professionals in Indian academic libraries	Descriptive survey research method	-	Perceptions of librarians engaged in Indian academic libraries towards cloud computing	- Security - Reliability - Regulatory compliance Complexity - Privacy - Connection dependence - Service provider dependence - Technology dependence - Data management - Skills - Integration - Lock-in (switching costs) - Loss of IT control and ownership - Cost uncertainty - Lack of awareness - Lack of suppliers with satisfactory credentials - Lack of standards - Lack of liability of providers - Internet congestion - Over-subscription of services - The unclear scheme in Pay-per-use approach - Data center location	- "Library professionals are using CC tools in their daily works and want to adopt CC in the libraries to improve library services and avoid redundancy of works". - "Ubiquitous availability, economy and the various service layers are the core drivers of its adoption in the libraries". - "Security and data privacy in cloud are the most concern factors among all".
2	[127]	Users of a CC classroom (college students in a medium-size university in Taiwan)	Survey and structural equation modeling	Six models/theories: - Service quality (SQ), - Self-efficacy, - The motivational model, - TAM, - TRA/TPB, - and IDT theory	Behavior intention toward a CC classroom	TRA/TPB: - Perceived behavioral control - Subjective norms - Attitude TAM: - Perceived ease of use - Perceived usefulness MM: - Perceived usefulness - Perceived playfulness SE: - Cloud self-efficacy - Computer self-efficacy SQ: - Cloud service quality - Application service quality IDT: - Trialability - Visibility - Result demonstration - Voluntariness - compatibility	- "All the six theoretical models (the MM, the TAM, IDT, the TPB, SE, and SQ) exhibited strong explanatory power of intention to use CC classroom". - "All the factors of the theoretical models, except CSE and trialability, exert significantly positive effects on the intention to use a CC classroom". - "variance explanation, Chi-squared statistics, effect size, and predictive relevance results revealed the ranking importance of the theoretical models". - "The united model provided a comprehensive understanding of the factors that significantly affect the college students' BI toward a CC classroom".
3	[120]	IT professionals	Multiple linear regression and neural network modeling	Extended (TAM)	motivators of CC adoption	TAM: - Perceived usefulness - Perceived ease of use Additional Factors: - Computer self-efficacy - Trust - Job opportunity	- "The best predictor of CC adoption are job opportunity, trust, perceived usefulness, self-efficacy, and perceived ease of use". - "There is a need to extend the fundamental TAM when studying a recent technology like CC".
4	[112]	Stakeholders in mobile cloud learning (MCL) (Students, teachers, and parents)	Qualitative and quantitative approach	Recursive intelligent learning model	learning experience and outcome of the learners	- Learning - Assessment - Communication - Analysis	- "All students, teachers, and parents have a positive attitude towards implementing MCL in teaching and learning purposes". - "There is a significant increase in GPA and learning performance of students, increase in engagement in learning activities, flexibility in learning, and increase in accessibility to relevant learning contents of materials". - "All the parents had a positive attitude towards using MCL in their kids' learning process". - "Majority of the students and teachers preferred the ratio for face-to-face and online learning in Blended learning to be face-to-face and online".
5	[113]	University students of CC (two Universities in Thailand)	Quantitative method (questionnaire)	(TAM)	Usage behavior	- Intention to Use - Perceived Ease of Use - Perceived Usefulness - Subjective Norm - Perceived Convenience - Trust - Computer Self-Efficacy - Software Functionality	- "perceived ease of use, perceived usefulness, intention to use, perceived convenience, trust, and software functionality have a statistically positive relationship towards the adoption of CC".
6	[126]	Undergraduate students	Survey and structural equation model (SEM)	(TAM)	Intention to use mobile cloud storage services	- Perceived usefulness - Perceived ease of use - Perceived ubiquity - Trust - Perceived security - Perceived privacy - Subjective norm - Attitude	- "Perceived usefulness, subjective norm, and trust have a significantly positive effect on the attitude, which in turn is a significant predictor of behavioral intentions". - "The research model has a strong predictive power".
7	[99]	Undergraduate students [two Saudi universities]	Quantitative approach	(TAM3)	BI (University students' intention to adopt cloud services)	- Output Query - PU - PEOU - Anxiety	- "perceived usefulness and perceived ease of use are the main determinants of students' behavioral intention to adopt the

TABLE 12. *(Continued.)* **Key previous studies examining the individual-based category factors that affect the adoption of CC in HEIs.**

						- Result Demonstrability - Subjective Norm - Internal Experience Image - Perceived Enjoyment - Perception of External Control - Playfulness - Trust - Self-Efficiency		provided CC service".
8	[128]	MBA students (university in the Northeastern USA)	- Structural equation modeling SEM - A case of Google Docs	ECM	-	Intention to continue use	- Satisfaction - Confirmation with expectations - PU of SaaS Collaboration Tool Moderating factor: - Experience with SaaS Collaboration Tool - IT Skills	- "Users' confirmation with expectations positively affect their perceived usefulness and satisfaction level". - "Users' perceived usefulness and satisfaction positively affect their intention to continue using such collaboration tools". - "Users' prior experience with such tools and their IT skills have a moderating effect on the relationships among confirmation, perceived usefulness, satisfaction, and continuance intention".
9	[108]	University stakeholders' (teachers and students)	experimental research method	-	-	The Usability evaluation of these cloud-based services (Google site)	- ease of learn and use - satisfaction - efficiency - memorability - Error	-
10	[105]	Undergraduate students [Faculty of Education-Turkey]	Structural Equation Model	TPB	-	Educational use of cloud services	- Security and privacy - Attitude - Behavioral Intention	- "Security and privacy have a strongly significant influence on the students' attitudes towards using cloud services in educational settings".
11	[125]	Undergraduate students [UTM]	questionnaire	Task-Technology Fit (TTF) model	-	User adoption	Task characteristics: - Non-routineness - Interdependence Technology characteristics: - Personalization - Collaboration - Mobility - TTF	- "Inconsistent with past studies, task Interdependence positively influences Task-Technology Fit (TTF)". - "Task non-routineness has a negative influence on (TTF)". - "There is a significant effect of Mobility and Personalization and collaboration as technology characteristics on (TTF)". - "There are significant relationships between Task-Technology Fit (TTF) and User adoption".
12	[115]	Higher education students	Paper-based questionnaire	TAM	-	Attitude towards using	- PEU (required effort) - PEU (usability) - PU	- "The perceived ease of use of cloud file hosting services is above that of LMS tools and services". - "Cloud file hosting services presented higher levels of perceived usefulness than standard learning management tools". - "Attitude toward using cloud file hosting services is well above that of using LMS tools".
13	[91]	Universe professionals and students	Online questionnaire with closed quantitative questions	TAM	- Intention for use - use		- PEOU - PU	- "The perceived ease of use of CC systems affects positively the perceived usefulness. - The perceived usefulness impacts positively the intention to use CC systems and therefore the use of those same systems".
14	[90]	Respondents who have used or intend to use cloud-based e-learning in Vietnam	Survey and structural equation modeling (SEM)	(UTAUT2) and customer innovativeness	- Cloud-based e-learning Intention - Cloud-based e-learning Usage		- Performance expectancy - Effort expectancy - Social influence - Facilitating conditions - Price value - Hedonic motivation - Habit - Innovativeness	- "The adoption of cloud-based E-learning is influenced by performance expectancy, social influence, hedonic motivation, and habit". - "Innovativeness is not significant to use intention; it has a positive effect on E-learning usage".
15	[129]	University students (KMITL, Thailand)	Survey questionnaire	Theory of motivation	-	Intention to use cloud-based e-learning	- Intrinsic motivation - Extrinsic motivation - Availability - Collaboration - Notification	- "The factors that influence the intention to use cloud-based e-learning are the availability, collaboration, cloud-based e-learning notifications, intrinsic motivation, and extrinsic motivation".
16	[111]	Case University (China)	Case study	Duo-theme DEMATEL and TAM	-	Acceptance of internal cloud	- PEOU - PU - Cause-effect factors of PEOU - Cause-effect factors of PU - PEOU-PU matrix	- "Clear understanding and operational ease under the theme of perceived ease of use (PEOU) are more imperative". - "Improved usefulness and productivity under the theme of perceived usefulness (PU) are more urgent to foster the usage of internal clouds".
17	[106]	Survey approach	Undergraduate students (two universities in Korea)	Two-factor theory	-	Intention to switch toward cloud	- Expected switching benefits - Expected switching costs Switching enablers: - Omnipresence - Collaboration Expected switching benefits: - Satisfaction with incumbent IT - Breadth uses of incumbent IT Control variables: - Personal innovativeness - social influence	- "Users' switching intention to cloud services was not only positively influenced by expected switching benefits whose antecedents are omnipresence of cloud services and collaboration support, but also negatively influenced by expected switching costs whose antecedents are satisfaction with incumbent IT and breath use of inclement IT". - "The impacts of switching benefits

TABLE 12. *(Continued.)* **Key previous studies examining the individual-based category factors that affect the adoption of CC in HEIs.**

										and costs on switching intention are positively moderated by end users' personal innovativeness".
18	[93]	Experiment	Community college students	TAM3	- Intentions for future use - Actual use - Future use -	-	Usefulness Ease-of-use Future utility Technology anxiety Instructor support Reliability Access to software Ease of travel Personal innovativeness	-	"Background characteristics such as the student's ability to travel to campus had influenced the usefulness perceptions, while ease of use was largely determined by first-hand experiences with the platform, and instructor support".
19	[230]	Survey	Undergraduate students (Southeast Michigan)	TAM and Determinants of Perceived Ease of Use framework	- Cloud perceived usefulness	-	Computer self-efficacy Internet self-efficacy Information technology self-efficacy Computer anxiety PEOU	-	"Significant correlations between each measured variable and support the interaction between perceived ease of use, computer anxiety, computer self-efficacy, and internet self-efficacy with the perceived usefulness of cloud applications in a higher education setting".

studied, methodology, model, variables, and research key findings. Table 12 presents key previous studies that have examined the individual-based category factors affecting the adoption of CC in HEIs, whereas Table 13 summarizes the key previous studies examining the organizational-based category factors affecting the adoption of CC in HEIs.

To incorporate the factors from our original search and filter them down to 17 individual factors (Table 14) and 8 organizational considerations (Table 15), we adhered to the following processes:

1) All easily recognizable factors from the research were recorded by the author and study (eight individual- and six organizational-based category studies).
2) The factors were sorted and concatenated to remove any duplications because some areas from different studies emphasized the same information but with a different name.
3) The concatenated information was logged and classified with the details of all the authors who identified such a particular factor.
4) Specific groups, classifications, or relationships of interest during the research were made available to the readers.
5) Any re-occurring themes were consolidated into 8 organizational- and 17 individual-based factors.
6) By using the classifications outlined in Step 4, the factors were then transferred into categories.

1) INDIVIDUAL-BASED CATEGORY FACTORS

Based on a systematic approach [228], we determined the following individual-based category factors from the featured empirical studies (Table 14). Table 14 shows that researchers have studied many individual-level factors that address the adoption of CC in the context of HEIs.

2) ORGANIZATIONAL-BASED CATEGORY FACTORS

Based on a systematic approach [228], we derived the following organizational-based category factors from the featured empirical studies (Table 15). The current level of investigation shows the need for more academic attention to investigate the factors that influence the adoption of CC in HEIs at the level of organizations.

IV. DISCUSSION

This study aimed to offer an up-to-date picture of the current status of CC adoption and use in HEIs, as highlighted in Section 1. The purpose was to outline current trends within the existing research projects in a new and exciting manner. The focus was on studies that consider the adoption of the technology side in HEIs, thus forming the basis of a taxonomy from which universities may benefit in the future. In addition, this review might be useful for researchers in this emerging field to identify the key characteristics of CC adoption based on the desire to adopt CC technology into HEIs, highlight practical and technological barriers, explore existing theoretical research models used to advise and advocate the adoption of CC, and identify the factors that influence the complete adoption of CC in HEIs. This review reflected the theoretical models and the factors used to assess the state of CC adoption and use in HEIs at the individual and organizational levels. The research used the findings from 206 studies: 80 were found in journals, 71 were obtained in minutes taken from conferences, and 54 were from chapters in existing books. All published numbers and percentages are presented in Table 6, whereas the number of papers by year is plotted in Fig. 4.

Many benefits can be gleaned from developing a taxonomy from existing literature, especially on a relatively new subject area [229], [230]. The taxonomy forced the creator to organize and classify the existing research into an ordered format, thereby providing a clearly defined overview of the existing research. Any person interested in this area can refer to this succinct summary of the subject area, which can provide a landscape for future research to identify relevant issues, challenges, and research lines. Many articles have examined the subject area from an introductory viewpoint, several studies have explored existing technologies, and other works may have selected to focus on the real applications themselves. A taxonomy of the related literature helps organize these different perspectives into am easily digested, manageable,

TABLE 13. Key previous studies examining the organizational-based category factors that affect the adoption of CC in HEIs.

N.	Source	Subject studied	Methodology	Model	Variables		Key findings
					Dependent Variables	Independent Variables	
1	[102]	ICT experts and decision makers at universities in Sub Saharan Africa	A quantitative research approach was chosen over structured interviews for this study	DOI and TAM	- "Intent to adopt CC" and - "Actual usage of CC"	Innovation Factors: - Relative advantage - Complexity - Compatibility - Trainability - Observability - Results demonstrability Technology Factors: - Risk - Data Security Contextual Factors: - Infrastructure - Socio-Cultural - Awareness Economic Factors: - Cost Usability Factors: - Usefulness - Ease of use Demographic Factors: - University age - University size - University location - Individual age	- "(44.7%) of the variance of intent to recommend adoption of CC and 35% of the variance of actual usage of CC at universities in SSA". - "Data security is positively correlated with the intent to adopt CC". - "Results demonstrable is positively correlated with the intent to adopt CC". - "Usefulness is positively correlated with the intent to adopt CC Supported". - "Socio-cultural factors are negatively correlated with the intent to adopt CC Supported". - "Age of the university will influence the intent to adopt CC". - "Size of University will influence the intent to adopt CC". - "Age of ICT experts and decision makers will influence intent to adopt CC".
2	[121]	Library professionals in 28 central universities of India	Descriptive survey and constructive research method	DOI and its modification	-Behavioral intention to adoption vs. nonadopting	- PUOU - PU - Scalability - Availability - Return on time - Security risk - Privacy risk - Attitude towards the use of CC behavioral intentions	- "Perceived ease of use, usefulness and ubiquitous availability of the enabling technology are strong drivers of the adoption of CC technology in the libraries". - "Attitude is significantly correlated with the behavioral intention to adopt CC services". - "High level of correlation was obtained between the CC-perceived attributes and the librarian's intention to use CC technology". - "Security risk is the biggest issue that has been affecting the behavioral intentions".
3	[94]	The decision-making regarding IT (IT heads or their delegates)	- Development of survey instrument to test the hypotheses - Expert Review for the survey instrument - The research hypotheses were tested using the partial least square (PLS) method. - SEM method was used.	TOE	-CC adoption	Technological Factors: - Relative advantage - Complexity - Compatibility Organizational Factors: - Management support - Vendor lock - Data concern Environmental Factors: - Government regulation - Peer pressure	- "The most significant factors are Relative advantage, complexity, and data concern".
4	[97]	University Researchers (postgraduate students (Master and Ph.D.) in Malaysian Universities, which were UKM, UTM, UM, and UNITEN in specifying the field of computer science and technology study in 2013)	- Exploratory research using qualitative methodology. - Interviews with respondents	-	-Improve university researcher's productivity (Save time, effort and money of the researchers; Improve research productivity and Improve researchers' skills)	Independent Variable: - CC (Services AND Application) Mediating Variable: - Researchers use CC (Research Activities, Researcher's Activities, AND Researchers Life) Moderating Variables: Variables affecting productivity (Human factor) - Knowledge and understanding - Trust - Researchers needs	- "Perceived lack of knowledge had a substantial effect on the attitude towards trust and the usage of cloud services. Consequently, impacts on the ability to raise productivity".
5	[98]	Lectures from five different northern Malaysian polytechnics (MP) and other categories such as student, non-academic staff.	survey	-	-The acceptance of CC in Malaysian polytechnics	- Perception - Readiness - Knowledge - Security awareness	- "There is positive acceptance of CC in MPs in terms of readiness and perception". - "There is still a lacking on security awareness".
6	[107]	IT management unit at HE in West of Java	Several steps including Statistical approach of (SEM) Modelling by using smartPLS for testing the model and hypotheses, Case studies, questionnaires for data collection, etc.	COBIT 5 Framework	-Score of CC readiness	- Infrastructure - Information - Business process - Organizational structure - Culture - Human resource skills and competencies - Principles and policies	- "The application service infrastructure enabler and business process enabler, has a significant effect on the degree of IT readiness (e-Readiness) adoption of CC".

and useful format. Moreover, the nature of the taxonomy provides all researchers with important perspectives of the subject in many ways. Initially, it outlines the potential breadth of research in the subject area and highlights current gaps. Mapping the ideas about CC adoption in HEIs into distinct categories immediately shows the researcher where the strengths and weaknesses may lie in the research. The process of concatenating the research also shows where

TABLE 14. Individual-based category factors that influence CC adoption in HEIs.

Code	Factor name	Source
1	Security	[103, 105, 126]
2	Privacy	[103, 126]
3	Subjective norm	[99, 113, 126, 127]
4	Cost	[103, 106]
5	Internet self-efficacy	[15, 103]
6	Cloud self-efficacy	[15, 127]
7	Computer self-efficacy	[113, 120, 123, 127]
8	Behavioral	[105, 127]
9	Attitude	[105, 126, 127]
10	Ease of use	[91, 93, 99, 108, 111, 115, 120, 123, 126, 127, 130]
11	Usefulness	[91, 93, 99, 111, 113, 115, 120, 126-128]
12	Trust	[99, 113, 120, 126]
13	Anxiety	[15, 93, 99]
14	Experience	[99, 128]
15	Satisfaction	[106, 108, 128]
16	Social influence	[90, 106]
17	Collaboration	[106, 125, 129]

TABLE 15. Organizational-based category factors that influence the CC adoption in HEIs.

Code	Factor name	Source
	Innovation factors	
1	Relative advantage	[94, 102]
2	Complexity	[94, 102]
3	Compatibility	[94, 102]
	Technological factors	
4	Risk	[102, 121]
5	Security	[94, 102, 121]
	Contextual factors	
6	Infrastructure	[102, 107]
	Usability factors	
7	Usefulness	[102, 121]
8	Ease of use	[102, 121]

certain studies may have failed to highlight the non-functional aspects of the CC technology, including issues, such as security and privacy. All these aspects have considerable coverage in the literature in comparison with traditional educational technologies. In addition, the data were based on individual categories, thereby showing an ongoing and emerging trend. Finally, similar to all taxonomies, the researchers have created a new vocabulary to assist the process, investigated the results of all researchers and academics, and adopted and referred to this terminology, which facilitates all researchers to move along the subject matter. We can refer to ''a development paper, a comparative study, and a usage-based review'', and all researchers will be familiar with the terms.

Based on the SLR, the remaining questions were answered and presented along four specific themes: motivations (or reasons) behind the adoption of cloud technology in HEIs, challenges or barriers that may prevent the extensive use of CC technology in HEIs, theoretical models or alleviating any barriers or issues, and factors that may inhibit or prevent the adoption of CC in HEIs.

This SLR demonstrated that the adoption of CC in HEIs is a current topic, which attracts considerable attention from researchers. However, gaps in the research at the organizational level and some limitations with regard to the individual-based adoption remain. To study these gaps in HEIs, researchers have recommended to determine the level (individual or organization) and stage/s (i.e., intention [persuasion stage], adoption [decision stage], or routinization [implementation stage]) to propose an adoption model. Furthermore, research on investigating the CC sustained use in HEIs, which potentially influence institutions' subsequent decisions on continuous adoption intention, is lacking.

V. LIMITATIONS

The main limitation is the number and origin of some databases, but the selected sources provide a favorable solid illustrative collection. Second, the nature of this subject is fast-paced. Thus, revelations in this study may be quickly superseded by new emerging studies and technologies. Third, this study was restricted by a predefined search period. Hence, a feature separate review paper can be conducted. Finally, the secondary nature of this study only reflects the opinions of the researchers. Therefore, the research main focus is not on the technology use within universities or its successful or unsuccessful current state.

VI. CONCLUSION

A trend that has been revealed in this study was how CC technology leads to change in the way of work of teachers, educators, and HEIs. Some studies had attempted to investigate this trend, but it remains an ongoing and emerging subject, which requires further research. This study attempted to highlight some themes thoroughly by using the SLR to analyze and breakdown the existing research, thus enabling the current themes to be classified in the following ways: reviews/surveys, research studies on CC adoption, development attempts, and broad framework proposals. Some areas were given additional coverage by the researchers along with new and emerging technologies, thereby providing a general insight into the nature of the studies at present. Despite several CC studies in relation to HEIs, the researchers have tended to focus minimally on the organizational aspects and further on the individual perspectives. Thus, additional studies are required to investigate the phenomenon from the educational organizations' perspectives.

Many researchers have highlighted their concerns within their studies, and some researchers have developed models to counteract these concerns, thereby offering an extensive basis for further research into the field. The studies that investigated the subject of technology have frequently focused on the usefulness of the technology and have tended to exclude human aspects, such as adoption and diffusion. Considerable attention was accorded to the post-adoption stage of the technology at individual and organizational levels to ensure the successful adoption and sustainability of use. Most researchers have studied the new innovative technology

from the aspect of its use and disregarded its potential effect. Therefore, further studies have investigated the individual and organizational effects of the technology on the performance, productivity, innovation, efficiency, and effectiveness.

The nature of technology means that individuals and organizations will continue to adopt new technologies given that they appear endlessly. Researchers must remain ahead of these advancements at all times by anticipating future developments. Future predictions for the technology include the industry's fourth revolution (IR 4.0) connections to higher education (HE 4.0) as a dialectical, intricate, and intriguing opportunity, which can change society for the better. IR 4.0 is driven by the use of artificial intelligence and can change the work area from task-centered to human-based. With the IR 4.0 having CC, IoT, big data analytics, and mobile devices as the main technology enablers, a new type of HEI is placed into the limelight to change the way of teaching, research, and service. No empirical research has been available on the adoption and use of HE 4.0. Further investigation may overlap with extensive subject areas revealed in more scientific or technological fields.

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