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Review of cloud computing models in education and the unmet needs

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ABSTRACT

This article thoroughly examines recently proposed cloud computing (CC) models used within the higher educational institutions (HEI) field, scrutinizing their objectives, structures, and incorporated requirements. Each model's unique architecture and functionality are analyzed to understand their potential educational contributions. Beyond technical considerations, the study explores nuanced requirements essential for successful integration in educational settings. The review exposes diverse aims pursued by the models, such as enhanced scalability, collaborative learning, and resource management, emphasizing their capacity to reshape traditional educational paradigms. However, a notable gap emerges-the absence of cultural and requirement elicitation models within the frameworks. Despite growing cultural diversity and varied educational needs, most models lack components addressing cultural nuances and robust requirement elicitation. In conclusion, the paper identifies a pressing need for a transformative shift in developing CC models for education. The absence of dedicated cultural and requirement elicitation models challenges the holistic effectiveness of these frameworks. Future efforts should prioritize integrating culturally sensitive components and comprehensive requirement elicitation strategies to create adaptive, universally applicable, and inclusive CC educational environments. Addressing these gaps will pave the way for a nuanced and responsive integration of CC technologies in diverse educational settings.

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1. INTRODUCTION

In today's rapidly evolving educational landscape, integrating technology has become not just a trend but a necessity, fundamentally reshaping how students and educators interact, collaborate, and access information [1]. At the forefront of this technological revolution lies cloud computing (CC). A paradigm that offers unparalleled scalability, accessibility, and efficiency to the educational process [2].

CC offers innovative solutions with the potential to transform educational content delivery, access, and management [2], [3]. From enhancing remote learning to enabling global collaboration, CC can redefine the boundaries of education [4]. However, it is essential to emphasize that the educational sector has undergone substantial transformations since the emergence of the COVID-19 pandemic. Various strategies and innovative technologies have been adopted to facilitate a smooth transition [5], [6]. Scholars actively engage in dialogues regarding establishing a robust education system capable of enduring crises, stressing the significance of a flexible learning framework accessible across different times and locations [6].

Therefore, there is a pressing need to analyze proposed models within this context to identify those that align with the current educational requirements and to address potential gaps for future research. This study aims to provide insights for informed decision-making in adopting CC solutions in education. CC is a technology that has attracted significant attention from several researchers [1], [2], [7], [8] and major corporations such as Amazon, Google, Oracle, IBM, and Microsoft. These companies heavily invest in CC to improve cost-efficiency and resource utilization [9], making it widely utilized within higher educational institutions (HEI) [10].

The National Institute of Standards and Technology (NIST) defined CC as enabling ubiquitous, on-demand network access to scalable resources, such as applications, storage, servers, networks, and services [3]. Aligning with John McCarthy's vision of CC as a future public utility [11], [12] characterizes CC as an IT-related capability offered as services in different data center types, aiming to provide users with improved performance, availability, scalability, and cost-effectiveness. Moreover, like traditional utilities, CC computing allows users to access resources as needed and pay for actual consumption [4], [12], [13].

Researchers categorized CC into three service models: IaaS for managing hardware resources, PaaS for a platform without dealing with infrastructure, and SaaS for user subscription to licensed software. IaaS providers include Amazon, Savvis, and GoGrid; PaaS providers are Google Apps and Microsoft Azure; and SaaS providers include Google NetSuite and Apple iCloud [14]. Studies suggest that HEI should choose IaaS, PaaS, or SaaS based on specific needs and financial capacity to minimize costs [1]. In educational settings, there's a preference for SaaS when integrating CC computing [14]. On the other hand, research categorizes CC into deployment models as public, private, community, and hybrid CC models. The public cloud offers open access on a pay-as-you-go basis, the private cloud is exclusive for authorized personnel, the community CC serves multiple users with shared interests, and the hybrid cloud combines elements of all models for flexibility [2]. Studies show a preference for the hybrid cloud model in HEI due to its cost-effectiveness, simplified resource sharing, and secure access to instructional materials from any location [12]. The hybrid cloud seamlessly integrates the benefits of both private and public cloud models, making it adaptable and advantageous for HEIs [15].

Despite widespread adoption, institutions and individuals encounter persistent challenges with CC [4], particularly security issues spanning privacy, single points of failure, and implementation concerns [1]. Studies highlight the need for guidance and support, especially in developing countries, where security and cultural considerations are paramount [16], [17]. Also, cultural influences pose challenges in integrating collaborative environments with CC, affecting academic staff, student experience, finances, and learning resources [2]. In the Omani context, technology training and cultural factors are critical for efficient adoption [1]. Furthermore, Trust issues abound, including concerns about data storage, maintenance, and the use of student data by CC service vendors in education [9]. In Saudi Arabia, challenges include legal interception, regulatory implementation, and data protection [18]. On the other hand, success factors in CC adoption encompass securing infrastructure, assessing technological maturity, and evaluating institutional readiness to mitigate financial risks [19].

CC emerges as a viable solution for educational institutions grappling with financial constraints and technical complexities, operating on a 'pay-as-you-go' model to reduce costs during low service demand [2], [15], [20]. North American and European universities embrace CC for its flexibility, extensive resource sharing, and facilitation of IT infrastructure setup and maintenance, driven by streamlined updates, monitoring, and security testing [2], [21], [22]. Large storage capacity allows tailored resource access, enhancing virtual labs, fostering collaboration, and encouraging innovative teaching methods to enrich student learning experiences [1], [2], [8], [23], [24].

The preceding introduction emphasized the importance of CC in education. To fully grasp how to capitalize on these innovations, the upcoming section will initially delineate the methodology used to gather previous proposed models and frameworks from diverse countries, aiming to leverage CC with e-learning platforms. Subsequently, the paper will critically discuss and evaluate these models. By doing so, educators and stakeholders can harness the full potential of CC to foster a transformative educational landscape. Through a comprehensive review, this paper aims to elucidate the strengths and limitations of CC models, ultimately facilitating their effective integration in education for positive outcomes.

2. METHOD

This study conducts a systematic investigation, including a comprehensive literature search, to analyze studies proposing or developing CC frameworks within HEI. The review follows the reporting checklist specified by the preferred reporting items for systematic reviews and meta-analyses (PRISMA) extension, which serves as a framework to search, identify, and select pertinent articles for inclusion in the study [17], [25], [26]. PRISMA principles facilitate the reading, extracting, and managing secondary data

from selected studies, ensuring an unbiased and impartial synthesis of the gathered data [27]. Analysis of existing data employs a qualitative deductive and inductive coding approach [28]. The review focuses on articles published from 2018 to 2023 to capture the ongoing significance of CC as a rapidly emerging technology and exclude outdated information. This timeframe aims to capture the latest developments by focusing on recent publications, ensuring transparency through comprehensive methodological details.

2.1. Search strategy

The study begins by identifying research articles for inclusion and defining study parameters, including the components, influencing factors, and requirements of the CC e-learning frameworks in each study. The researchers later conducted a Boolean search across chosen databases and journals. Retrieved publications undergo thorough evaluation against pre-defined criteria to determine final analysis eligibility. The researchers extracted and coded relevant data related to the research questions from the selected studies.

The data retrieval process employed manual and electronic search methods [27]. Notable databases such as IEEE, Scopus, Springer, ACM, and Google Scholar were employed for electronic search. Within these databases, the researchers conducted a comprehensive full-text search using a Boolean search strategy related to the questions and topic of the research, focusing on CC, education, e-learning, HEI, university, framework, model, and requirements. While the specific Boolean search terms varied across databases, Table 1 provides a complete list of applied search terms. Filtering options were applied during the investigation, considering database availability within the past six years and relevance to education and CC research in English.

During the systematic review process, a total of 493 articles published between 2018 and 2023 were initially identified through keyword-based and manual searches, focusing on proposed or developed frameworks for CC within the educational sector. After removing duplicate and non-related entries, the researcher conducted a thorough manual screening of the remaining 82 articles, initially assessing titles and abstracts. Subsequently, the researchers examined the full text to determine eligibility based on pre-defined inclusion and exclusion criteria, resulting in the compilation of 10 articles in an Ms. Excel spreadsheet, which included relevant data on research methodologies, theories or models, participants, purposes, requirements, and contributions.

The ten selected articles were coded systematically using grounded coding methodology [29] to analyze and synthesize findings from multiple research studies. Grounded theory in a literature review allows for identifying patterns, themes, and theoretical insights from reviewed data, offering a comprehensive understanding of the topic. The coding process involved extracting information from the articles about utilizing CC models and frameworks within HEIs.

3. RESULTS AND DISCUSSION

This study reviewed previous CC e-learning proposed models, exploring their primary purposes, requirements, and layers. While prior studies have introduced frameworks and models for diverse purposes. they have often lacked a thorough investigation into requirements elicitation models, neglecting to comprehensively assess all user requirements before proposing their models.

The review findings identified several purposes for the proposed models to address various challenges. These include addressing issues of availability and security, as noted by [7], [29], [30]; conversely, challenges such as financial costs, a one-size-fits-all content approach, passive student roles, and the lack of content relevance were highlighted by [31]. Additionally, concerns regarding resource provisioning were raised by [2], [31], while Ahmed and Hussain [32] emphasized the importance of low costs and technical barriers.

Furthermore, Elmasry and Ibrahim [15] developed a model specifically tailored to address challenges faced by developing countries, while Khan *et al.* [6] underscored the necessity for a model capable of mitigating challenges arising from pandemics and wars. Table 1 provides a comprehensive summary of the reviewed proposed models, outlining each model's architecture, layers, and purposes. This table serves as a valuable reference point for understanding the structure and objectives of each model, facilitating comparison and analysis to inform further research and decision-making processes.

An essential aspect distinguishing between models proposed for CC e-learning is the inclusion of requirements and factors specific to each study, underscoring the importance of highlighting these requirements to uncover gaps in the literature of proposed models for CC e-learning. For instance, security has emerged as a paramount concern, prompting researchers to propose innovative frameworks and models that address security and privacy issues. The works of [7], [29], [30], [32] collectively underscore the imperative of fortifying CC education against potential vulnerabilities, emphasizing the need for comprehensive security measures, efficient system management, and adherence to regulatory protocols.

Developing these dimensions offers insights that can inform the development of robust security protocols and best practices within the CC e-learning landscape.

For instance, Ahmed *et al.* [29] proposed a framework emphasizing SaaS-level security and privacy, ultimately promoting the acceptance of CC e-learning systems through enhanced surveillance consciousness. Alghamdi [7] presents an integrated CC model for an intelligent e-learning system, ensuring availability and security. The model leverages web 4.0 and CC service delivery to enhance system efficiency and mitigate e-learning challenges. Chatterjee *et al.* [30] introduce an architectural CC virtual learning platform model that integrates the latest security features. The model fosters a secure and user-friendly personal learning environment supported by various technologies, exhibiting cost-effectiveness. Ahmed and Hussain [32] also developed an e-learning embracing the CC model, encompassing essential components for effective implementation. This model effectively addresses obstacles related to e-learning, with a specific focus on security, privacy, access methods, and compliance with government regulations.

Table 1. Proposed models aim and layers

Article	Output	Overcome challenges	# Layers/main elements
[29]	SaaS security framework for cloud-based e-learning systems (CBES).	Security	i) cloud management system, ii) virtual machines, and iii) physical hardware
[6]	Proposes a futuristic cloud-based educational model for the next generation of learning and teaching.	Pandemic, war	na
[15]	Proposes a hybrid CC model, wherein the HEI's services and systems are distributed between a private cloud on-premises and a public cloud.	Developing countries	i) public cloud and ii) private cloud
[1]	Propose a cloud-based collaborative virtual learning environment (CBCVLE).		i) cultural influences, ii) ICT infrastructure and services, iii) users' acceptance, iv) users' experience and expectations, and v) operational environment
[2]	Propose a conceptual framework for a cloud-based collaborative environment	Course provision	i) quality, ii) legal, iii) educational, iv) operations, and v) security
[30]	Propose a cloud-based learning management system model focusing on security enhancements.		i) infrastructure, ii) software resource, iii) resource management system, iv) service, v) application, and vi) security
[33]	Propose a hybrid CC solution with a cloud-based virtual learning environment (CBVLE) model.		i) infrastructure, ii) data, iii) application, and iv) presentation
[31]	Propose personal cloud-based e-learning environment (CB-SALF)	Provisioning, cost, all size fits all content, passive role, contents relation lacks	i) transaction manager, ii) social/ collaborative manager, iii) adaptivity/personalization manager, iv) CB-SALF is the data layer
[7]	Propose a model offering solutions to enhance the effectiveness of e-learning systems by utilizing Web 4.0 technologies.	Security, availability	i) E-learning CC, ii) E-learning 4.0, and iii) applications
[32]	Propose an e-learning embracing cloud computing model (ELECCM)	Cost, technical barriers	i) infrastructure, ii) platform, iii) services, iv) clients-access, and v) user

Simultaneously, literature reflects studies concentrating on cultural elements and their corresponding models. Such as the works of [1], [2], which emphasize the alignment of technology with specific cultural requirements. Notably, Nasser and Hajri [1] has tailored a CC collaborative e-learning framework for Omani HEIs, a testament to the imperative of aligning technology with specific cultural requirements. Similarly, Aldoayan *et al.* [2] had woven a rich conceptual framework for collaborative environments integrating CC legal, quality, security, educational, and operational aspects, which are meticulously addressed. At the same time, the emphasis on the teaching and learning culture adds depth to their work. Additionally, the importance of adaptability and responsiveness in education is highlighted by [31], who introduced a CC self-adaptive learning framework to address the limitation of "one size fits all" learning methods.

Furthermore, the works of [6], [15], collectively underscore the significance of continuous improvement, technological adaptability, and efficient management practices. In the context of CC e-learning by proposing strategic models and frameworks for HEI. Offering a roadmap for optimizing educational processes, and harnessing the transformative potential of CC technologies.

Hence, Mulyawan *et al.* [33] emphasized the perpetual enhancement of higher education's business processes in response to stakeholders' increasing demands. They proposed a CC model for higher education and an IT governance framework for adopting CC models. Elmasry and Ibrahim [15] suggested a CC architecture for HEI in developing countries, including student information systems, assessment and question bank systems, project management systems, university management systems, learning management systems,

video on demand, virtual classrooms, and university mailing systems. Khan *et al.* [6] bring the narrative to Bahrain's educational landscape, post the COVID-19 pandemic, gathering data from 956 participants. They aimed to comprehend the adaptability of recent technologies, including CC computing services and artificial intelligence, within the educational sector. The research outlined various modules utilized within the proposed CC educational models, including the training module for institution members, the course development module, and the virtual computer lab module.

Based on the literature review, Table 2 briefly outlines the requirements and factors identified by studies proposing models or frameworks related to CC computing and e-learning platforms. The table notably emphasizes the necessity for integrating e-learning platforms and e-resources in most models, followed by a focus on security requirements. On the contrary, there was minimal discussion regarding legal issues and regulations despite their significance in establishing collaboration rules among various HEIs [2]. Moreover, only one study addressed the functions of Chatbots, e-stores, and finance. Each article examines and discusses the necessary requirements from diverse perspectives. Highlighting the need for an ideal CC e-learning model, including overall system requirements.

Table 2. Proposed models needed factors and requirments

Items	[29]	[6]	[15]	[33]	[30]	[1]	[2]	[31]	[7]	[32]
Academic standards							X			
Access management			X		X	X	X		X	X
Accreditation							X			
Assessments & questions bank system			X		X		X	X		
Authentication & verification	X				X		X	X		X
Authorization	X		X							
Availability			X	X		X			X	
Backup and recovery system			X		X					
Chatbot		X								
CC servers					X				X	
Collaboration systems				X		X	X	X		
Compatibility						X				
Confidentiality			X	X	X		X		X	
Content customization							X	X		
Cost-saving						X				
Courses development							X			
Cultural considerations						X	X			
Data base management system				X	X				X	X
E-resources (materials, e-library collections, publication data)		X	X	X	X	X	X	X	X	X
E-store									X	
Gamification									X	
Governance software				X						
Government rules and regulations										X
Human resource management				X		X				
Hybrid cloud			X	X						
Integrity	X							X		
Intelligent web									X	
Legal issues							X			
LMS - VLE		X	X	X	X	X	X	X	X	X
Mailing system			X					X		
Maintenance & technical support				X		X	X		X	
Management support			X	X		X	X		X	
Monitoring system								X		X
Operational issues				X		X	X			
Parents view						X				
Personalized approach						X	X		X	
Portability						X			X	
Privacy	X				X	X				
Quality issues		X	X			X	X			
Resource management system							X			X
Scalability			X							X
Security	X		X		X	X	X		X	X
Social networking with other HEI					X	X	X	X		X
Storage					X				X	
Student Information System			X			X	X	X		
Surveillance consciousness	X		X		X				X	
Technology and users' readiness			X			X				
Tracking performance									X	
Trust					X	X				
Users' awareness and training		X		X	X	X	X			
Video on demand and VCR					X					
Virtualization		X	X		X				X	

It is worth noting that four of the listed studies specified the country of research: India [30], Indonesia [33], Bahrain [6], Saudi Arabia [32], and Oman [1]. Additionally, Elmasry and Ibrahim [15] explicitly covers developing countries in general. This observation underscores that all these countries are classified as developing nations, highlighting that 60% of the listed studies pertain to developing countries. The predominance of studies from developing countries in this review highlights a potential gap in the representation of CC e-learning models from developed nations. This imbalance suggests that there may be insufficient insight into how CC is integrated into e-learning platforms in more developed educational contexts. Addressing this gap could provide a more holistic understanding of the global landscape of CC integration in education, offering valuable insights for both developing and developed nations.

In summary, this study comprehensively reviewed previously proposed CC e-learning models, uncovering their primary purposes, requirements, and layers. It highlighted a gap in the representation of models from developed nations, as the majority of studies focused on developing countries. While these models addressed various challenges, such as security and resource provisioning, their practical applicability and relevance limitations were identified, particularly across diverse educational contexts. The emphasis on cultural elements in model development underscored the importance of aligning technology with specific cultural requirements. Addressing these gaps requires a nuanced approach to model development, considering cultural nuances and institutional practices specific to various educational landscapes. Overall, this analysis provides valuable insights for both developing and developed nations, facilitating a more comprehensive understanding of CC integration in education and guiding future research endeavors.

However, despite the advancements in CC e-learning models, some limitations persist. A lack of understanding of the unique challenges and priorities within different educational contexts may undermine the practical applicability and relevance of the proposed models. Generic frameworks may fail to address the fundamental requirements of culturally diverse educational systems, particularly in developing countries' environments. Addressing these limitations would require a more nuanced approach to model development, considering cultural nuances, pedagogical preferences, and institutional practices specific to various educational landscapes.

4. CONCLUSION

In conclusion, this paper has identified a significant gap in integrating CC within the education sector: the lack of a robust requirements elicitation model for CC e-learning platforms. This gap may hinder platforms from delivering optimal functionality and user experiences, particularly regarding cultural sensitivity. Future developments should prioritize integrating comprehensive requirements elicitation models to address these gaps and align with the evolving needs of educators and learners. Additionally, future research could involve comparative analyses of different CC e-learning models in diverse educational settings, exploring the effectiveness of addressing specific challenges and requirements. Investigating the impact of cultural factors and integrating emerging technologies into CC e-learning frameworks could offer innovative solutions to enhance learning experiences and outcomes. Overall, advancing the understanding and application of CC technologies in education can address the evolving needs of modern learning environments. The research on CC e-learning has limitations such as scope constraints, gaps in literature coverage, data availability issues, and methodological constraints. These limitations may affect the generalizability and depth of the findings. However, the research also offers practical implications for educators, policymakers, and developers. It highlights the importance of comprehensive requirements elicitation models, cultural sensitivity, and suggests future research directions. The findings can inform policy decisions, strategic planning, and educational innovation in adopting and integrating CC technologies in education.

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