Indian Journal of Science and Technology, Vol 10(36), DOI: 10.17485/ijst/2017/v10i36/117641, September 2017
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Adoption of Cloud Computing in Higher Learning Institutions: A Systematic Review

Rashidah F. Olanrewaju[1], Burhan ul Islam Khan[1]*, M. Mueen Ul Islam Mattoo[1], Farhat Anwar[1], Anis Nurashikin Bt. Nordin[1], Roohie Naaz Mir[2] and Zainab Noor[3]

[1]Department of ECE Kulliyyah of Engineering IIUM, Malaysia; frashidah@iium.edu.my, burhan.iium@gmail.com, mueenmattoo@gmail.com, farhat@iium.edu.my, anisnn@iium.edu.my
[2]Department of CSE National Institute of Technology Srinagar - 190006, Jammu and Kashmir, India; naaz310@nitsri.net
[3]ASET (Amity School of Engineering and Technology), Amity University, Noida - 201313, Uttar Pradesh, India; zainabnoor97@gmail.com

Abstract

Objectives: The goal of this paper is to comprehend the significance of adopting Cloud Computing (CC) in establishments of higher learning. This paper plots a portion of the advantages that can be conveyed to advanced education using cloud computing, analyzes probably the most imperative difficulties that can be faced by the academia due to its adoption, and proposes some early strides towards its adoption while alleviating the risks involved. **Methods/Statistical Analysis:** This paper recognizes an expansiveness of institutional variables and CC appropriation procedures by including the diverse perspectives of sources from various backgrounds and contexts on a single phenomenon. The different aids and contributions in this paper are based on the consolidation of research works available in various papers. **Findings:** The discoveries from this analysis demonstrate that the adoption of CC in establishments of higher learning can be comprehended through a few factors that have an essential impact on CC adoption methodologies like administrative bodies and governments, internal stakeholders, cloud suppliers, firm attributes, socio-political changes, IT framework, and so on. **Applications/ Improvements:** This investigation offers open doors for future research besides giving an understanding into how cloud suppliers, advisors, governments, and scholastics see several market requests, and how they react to these demands while advancing services offered by CC in higher learning institutions. The consequences for practice can help decision makers in adopting services provided by CC legitimately.

Keywords: Cloud Based Education, Cloud Computing, Cloud Computing Adoption, Cloud Pedagogy

1. Introduction

The investigation of technology acceptance and its implementation in the IT environment has intrigued researchers for quite a while. Hypotheses and techniques have been worked out that permit deducing behavior of a consumer and even anticipating it, in spite of the fact that the principal driver has been to confirm or foresee failure or success of a project related to Information Technology. The idea of cloud computing is not considered to be new-fangled anymore. Since 2012, the level of cloud computing technology adoption is by all accounts achieving an attractive state[1]. Nonetheless, the innovative advancement of CC administrations is outgrowing its rates of adoption. Various applications based on cloud computing are now generally employed in different facets of human endeavor, education not proving to be an exception. Cloud computing is changing the manner organizations work together and assist their related elements. For advanced education, it offers the capacity to be beneficial not only to administrators and educators, but also students, who have their own technology-based gadgets, needs, and desires to be taken into account[1,2].

The fundamental concern of Higher Education (HE) is the process of knowledge discovery and its dispersal,

*Author for correspondence

either face to face, or from remote locations or a mixture of both. The IT framework for the said purpose ought to be made simple-to-utilize, simple-to-scale and absolutely consistent. Unlike the situation for the services offered by local IT service providers, it is legitimate to buy infrastructure (IaaS: Infrastructure-as-a-Service) and a third party (PaaS: Platform-as-a-Service) platform, in this way passing on the danger of issues, for example, equipment letdowns, programming designs and patching to the cloud supplier inside an e-Learning system for HE to guarantee that it is fit reason and within suitably arranged Service Level Agreements (SLAs)[3].

In a report[4], Canadian Higher Education Lead and Principal, Louise Upton, stated that higher learning institutions were in the midst of a perfect storm. This is because of the decline in government funding, reduction in the value of endowments by market conditions, waning of private backing and the escalating costs. This report is fortified by the outline of Gartner Group. In a document[5], it is guaranteed that two of the best needs confronting advanced education Chief Information Officers (CIOs) today are diminishing enterprise costs and enhancing technical infrastructure. Offering an adaptable versatile framework and reducing costs, are the most regular guarantees and offering contentions of cloud computing service providers. They guarantee that cloud computing may possibly empower improvements in these important zones[6].

A report by Educause[7] gives additional proof that advanced education CIOs are keen on lessening costs and upgrading infrastructure as administrative/ERP frameworks and funding IT issues take the top two positions. Apparently, many advanced education CIOs are enduring the weight to lessen costs and institutionalize frameworks and assets through shared administrations activities. It is quite difficult to achieve both of these with the legacy technology that is being used on numerous grounds today[5,8].

With the unabated development of Web 2.0 and mobile technologies, establishments need further propelled innovation arrangements that can keep up with the circumstances and advancements. Higher learning establishments are dynamically switching to cloud computing for bringing down cost and exploiting the most recent innovation[8]. The advantages of cloud applications on the educational part are huge. The cloud rearranges and upgrades IT, empowers IT to release minor procedures, and enables IT to relocate its focus on driving the essential mission and targets of higher learning establishments. Utilizing the cloud enormously raises IT flexibility and enables institutions to pay for just the IT related services they use, tracking resources, more predictable costs, enhanced assessment of budget, and quicker degree of profitability[6].

Regardless of the capacities that the CC model can convey to associations such as versatility, adaptability, simplicity, agility, and proficiency[9], there are in any case a few elements critical to its adoption. These variables are concerned with business conditions, the technology, the potential of the organization adopting CC, and the connection between the potential adopting association and its business conditions[10-13].

The paper is organized as: Section 2 gives the description of the cloud computing technology and its benefits followed by the description of education based on this technology in Section 3. The details about the adoption of cloud computing in higher learning institutions have been provided in Section 4. Section 5 and 6 discuss various issues concerning cloud adoption in educational institutions and the measures to overcome those barriers, respectively. Finally, the concluding remarks have been given in Section 7.

2. Cloud Computing - The Concept

As per authors of a document[14], "Literature on cloud computing suffers from hype and divergent definitions and viewpoints". A wide range of writers have thought of different meanings of this term, with some contending that it is only another name for a service that has been active for quite a while. Authors[14] referred to a report by McKinsey and Co. that provided 22 particular cloud computing definitions in detail. Cloud computing has been defined as the "new term for the long-held dream of computing as a utility"[15].

Cloud computing characterizes to not just an adjustment in how business is done and IT assets are kept up more proficiently[9], but also transforms the way the IT business works, since "Nothing in IT lasts forever, and that technological evolution and economic factors can rapidly alter the trajectory of the industry"[16].

Out of all the definitions of cloud computing, the one set forward by NIST is broadly utilized. As per NIST, Cloud computing is defined as "A model for enabling ubiquitous, convenient, on-demand network access to a

shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction"[17]. From the definition of CC, it is obvious that cloud computing offers an adaptable IT framework that adjusts IT to business needs. NIST has additionally put forward the five qualities of CC model: (1) on-demand self-service: where the customer association can subsequently self-arrange abilities of computing as required without human cooperation with the Cloud Service Provider (CSP); (2) access to a broad network: where the computing capacities are made available over the entire network by heterogeneous customer platforms; (3) pooling of resources: where the virtual and physical computing resources of the CSP (i.e., network bandwidth, storage, memory and processing) are pooled and utilized by multi-tenants, to whom only the data center location is known, with no idea about the location of the VM being used in the cloud; (4) rapid elasticity: where processing abilities can be scaled in and out naturally at whatever point required; and (5) consistent service: where the cloud frameworks usually control, monitor, report and optimize the resource usage, subsequently making CSPs transparent to customers[13].

Along these lines, cloud computing may be defined as a method of computing wherein enormous adaptable IT-related abilities are given as a service to outside structures by means of internet technologies[18]. As a technology, cloud computing is viewed as the joining together of utility computing, virtualization and services using software which can be availed through the Internet. The technology has driven associations to rethink better approaches for utilizing IT assets auxiliary to their businesses. Associations have the chance to use outside suppliers and on-request services using a very versatile framework which is available via the Internet. Additionally, the on-request services can be made accessible by means of shared computing resources, e.g., networks, servers, applications, services and storage[18,19]. The cloud computing services can be sorted into Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS)[20]. Not quite the same as the former computing models, the requirements viz. broad network access, multi-tenancy, elasticity, economics, scalability and abstraction are met by cloud computing[21]. The institutions of higher learning have the chance to implement distinctive sorts of information and data cloud that they find suitable for their necessities.

There are four models in which cloud computing can be arranged: i) public, ii) private, iii) community and iv) hybrid. In public cloud arrangement, the IT administrations are exterior to the association or IT division. On the other hand, the IT services in a private cloud are set inside the association however singular units of business recompense the IT office for utilizing institutionalized services under change back systems of the association. Community cloud bolsters sharing of framework among numerous associations using the arranged resources of IT and every association has particular shared objectives and missions. Hybrid cloud comprises of a framework which has at least two clouds, e.g. private, public and community cloud[21-23].

From a service provider's point of view, public cloud, with the multiple occupancy hardware services, provides the most efficient utilization of the outlay. Because of the shared services (hardware as well as software), multiple occupancies and restricted control permitted to be practiced by the subscribing organization, this execution is more vulnerable to issues in comparison to private cloud. This cloud is regularly utilized by prominent organizations, for example, boards and corporate which need an expansive number of clients using standard software applications inside an exceedingly advanced security system. Inside the setting of a University with students more than 20,000 in number, it can be thought of as countless users needing an almost similar desktop interface and application and additionally similar processing power. An application set and a standard interface that can be altered as needed, with insignificant local input shall be invited by IT offices because of reduction in cost[24].

Since the Hybrid Cloud is a combination of private and public clouds, it is the most suitable arrangement required. So, on account of e-Learning training, the general applications and information, for example, information related to modules or courses can be kept in a public cloud while the applications and information of students can be stored in the private one. Ordinarily, certain applications that need meticulous control and examination are run locally and other applications are kept running on a public cloud. A hybrid arrangement gives the adaptability when additional processing resources are required for brief periods rapidly, for example, at the time of exams, the public cloud can carry the burden for additional computing or capacity. This wasn't possible speedily in private cloud because of the purchase timescales[3].

2.1 Benefits

The surge in cloud computing is basically because of various outstanding advantages:

2.1.1 Economic

The primary economic benefit is that it acts like the subscription model utilized by the cloud suppliers[25,26]. The development of a new association is undoubtedly facilitated by the adoption of cloud, considering that by adopting the cloud an association could spare as much as three months of time and money generally expended on power, floor space, IT operations and time which would then be able to be utilized in increasing the business value[27]. Monetary advantage can likewise be attained using decreased utilization of energy; those businesses making a complete move to the cloud eventually become the end clients of an expansive pool of resources and in this manner, don't consume their particular energy in running their hardware[28]. Research conducted by Forbes highlights that by the year 2020, large American organizations can "realize energy savings of $12.3 billion per annum" and small-scale to medium-scale estimated organizations might diminish their utilization of energy by "90%" by adopting the cloud[29]. The greatest choice characterizing impact for organizations is the economic benefit. Out of the 800 IT experts overviewed in a report, "half" would embrace the cloud only for reduction in costs[30] and "35%" consider it to be an approach to accelerate their time to market[12].

2.1.2 Scalability

Another key advantage of the cloud is scalability, because of which resources, for example, the hard disk space can be scaled up or down in case the customer needs an expanded workload[31]. The flexibility of resources is an essential advantage but makes the clients deluded into believing that there are unlimited resources when in all actuality the limit of the data center will be governing this[32].

2.1.3 Service Availability

The accessibility to cloud services is the most critical factor among a variety of other factors; continuous availability, regardless of whether the cause of downtime be issues related to infrastructure or attacks on security, is critical to associations, particularly to those who are in the financial sector needing coverage at all times[33]. The possibility of outages is a recognized issue; the apparent recognition is that by cloud adoption, the 'single point of failure' is wiped out, no doubt the provider disseminates crosswise over numerous data centers even then there will be a common software framework hence the supplier itself can be said to be a 'single point of failure' alongside the likelihood that shall stop to exist[10]. A provider with possibility arrangements of resource pooling is fundamental; the main answer for ensuring all time availability is to adopt numerous suppliers.

2.1.4 Security

Intel investigation came to find out that among the 800 IT experts assessed, "65%" stated they had endured more security attacks than when utilizing an infrastructure on-premise[34]. This investigation additionally features the major worries for organizations while considering the adoption of public cloud. It apparently appears that there is an obvious absence of certainty in regards to provider's safety efforts. Data protection is viewed as the biggest hindrance for organizations[35]. Two other principal issues that deter organizations to adopt are; how the sensitive information is exposed to the cloud providers and how a few suppliers are "not willing to permit auditing of their network or physical security measures". The absence of transparency and security affirmations results in a basic issue of mistrust[36]. It is evident that for organizations to exploit the many advantages cloud adoption offers, they should have the capacity to confide in their cloud provider, who must form a persuading standing consequently[3].

2.1.5 Flexibility

In coordinating IT assets to business capacities, cloud computing provides added flexibility (often called elasticity) than the previous computing strategies. It can likewise build staff versatility by empowering access to business data and applications from a more extensive scope of services and locations[37].

2.1.6 Redeployment of Staff

By decreasing or taking out repetitive updates to the server and other issues related to computing and by reducing consumptions in terms of time and money or development of application, associations can concentrate IT on undertakings of higher value.

2.1.7 Focusing on Core Competencies

Apparently, for most of the organizations, the capacity to oversee and develop software application and run data centers is not really a center competency. Cloud computing can make it considerably less demanding to decrease or completely obliterate these capacities, enabling the association to focus on core issues, for example, the policy and planning for continually enhancing the learning environment.

2.1.8 Sustainability

Because of wasteful resource utilization or poor design, the energy efficiency of most of the data centers is reduced and is presently comprehended to be naturally and monetarily unsustainable. Cloud service providers can expend much less on energy and different resources as compared to the customary data center operators, by utilizing cost-saving strategies and their ability to oversee computing resources all the more proficiently[38].

Taking all the above-mentioned factors into consideration, for the higher learning institutions, the services offered by cloud computing may be appropriate and may incorporate hosting the cloud, storage of data, software services and infrastructure. HLIs may utilize virtual services facilitated by a cloud, e.g., calendars, file storage, creating websites, email, contact list, and sharing of archives[18,22]. The advantages of cloud computing adoption in the setting of HLIs incorporate better access to content and infrastructure (24*7 access), for services pay as you go, insignificant cost on upgrades and maintenance, internal resource freeing up, flexibility and enhanced reliability[19,20,23].

3. Cloud based Education

The seriously aggressive pressure situations faced in the system of education, combined with the yearning to be the top-notch establishment view the cutting edge universities continually sourcing approaches to end up plainly more self-proficient while keeping up with the deliverance of the best learning practice. The key drivers in this change are the government changes in the appropriation of financing and assets[39]. Since there is an ascent in educational cost expenses, universities as opposed to accepting the lion's share of subsidizing from the government must work as an independent entity whereby extra funds must be naturally created. Besides the current sponsorship subsidizing, universities are currently starting to take a gander at 'cloud based e-learning' or 'Education as a Service' (EaaS) as an approach to decrease the cost, enhance proficiency and learning quality. There are numerous third-party e-learning arrangements based on cloud like Docebo and CloudLearn however many battle to have a recognizable effect in the sector of education[3].

Distance Learning (DL), otherwise called e-learning, has assumed an essential part of the process of education, particularly for individuals who have work, health, disability or location issues making it troublesome for them to go to a conventional classroom. Notwithstanding tending to these worries, distance learning likewise gives elasticity in time, place, and scheduling[40-42]. An e-learning framework facilitated on the cloud would make new learning conditions where exams and lectures are conducted over a cloud system using the idea of virtualization[43]. Information can be made accessible to students via cloud-based arrangements which can be availed anytime, irrespective of the location, via any web-empowered gadget. Numerous universities and schools have just started to progress such activities[15,42,44].

E-learning frameworks have little effect in the academic world because of the accompanying reasons[45]; the absence of adequate infrastructure, the lack of assets for training, the absence of 'e-content' and insufficient, unengaging design of interfaces. The faulty design of interface specifically ruins numerous frameworks[46]; they prescribe an effective framework that ought to include: intuitive components, for example, tests, quizzes, simulations and video, navigation that is coherent, consistent, straightforward elements of design, like size of text, color and type, memorable content, uncluttered pages, community oriented components, viz., forums created by students and support and easy access to staff. Lacking of IT infrastructure is the real problem[47]. Numerous present frameworks, for example, Moodle are run and kept up on campuses with inadequate infrastructure, such as, slow hardware and networking; this can deliver a terrible experience of learning, demotivation and absence of retention to learn. The resolution is cloud deployment so that the previously mentioned issues can be annihilated[3].

A few services from the cloud are as of now being adopted in the educational sector[48], the most pervasive one being the SaaS item 'Microsoft live@edu' giving students access to email, Skydrive and office package based on their browsers. It provides access from anywhere to the most recent Microsoft items without buying[3,49]. Of late,

this service has been modified to Microsoft Office 365 and now incorporates PowerPoint, Access, Word, Excel, Outlook, Publisher and OneNote. The offer integrates shared coordinated effort storage in the cloud to allow sharing archives among representatives in their projects[50,51]. Another one of many cloud-based services for education is Google App Education (GAE). Google components, for example, Talk, Docs, and Mail offer similar rich advantages as its Microsoft partner, upgrading the experience of learning and online student joint efforts[3,52].

Google additionally has put forward a program for the purpose of education using its Google Apps for Education Suite that incorporates applications for productivity, for example, Google Docs. This suite also includes classroom management system, email service, shared storage like Google Drive, site creation, hosting, and tools for collaboration[53]. A contextual analysis at the University of Westminster expounded the advantages and savings realized by the utilization of services offered by Google Apps by the university. The chief role of this service is to make use of email, storage services and collaboration of Google Apps for data that is not sensitive. An estimated sustentation of £1,000,000 was observed[54]. IBM Cloud Academy is a group cloud computing program that gives consultation services and best practices other than cloud services offered to advanced education establishments. These arrangements incorporate infrastructure computing, collaboration solutions, virtual desktop solutions, integration solution and so forth[51,54,55].

In this manner, cloud computing can assume a fundamental part of education. It can provide direct access to an extensive variety of various scholarly assets, educational tools and research applications. This is a huge part of the rapidly developing innovative services on the web[56]. Working in collaboration with HLIs, the cloud computing suppliers are making global forums (for example, IBM formed the IBM Academy in 2009) for teachers, analysts and other IT faculty for them to meet up and share thoughts. These activities serve to enhance the quality as well as access to educational data at minimal working costs[57]. As indicated by IBM, "Cloud computing makes it possible for educators and learners to get access to a range of research tools and applications and a large collection of learning material"[15,57].

Same as that in the industry, the key advantage as indicated by researchers[58] is somewhat money related. Institutions will find saving funds in the upkeep of IT framework including utilization of energy; licensing, hardware and specialized workforce coming about because of cloud virtualization. The improvement in the learning experience of students is perceived as another key advantage as content ends up noticeably being brought together in a single archive that may be accessed rapidly and effortlessly at any time and at any place as opposed to being spread crosswise over local servers; therefore administration and content management are streamlined. The staff can focus on providing an improved learning experience as all the content is centralized instead of dawdling in engaging in a wasteful framework[59]. They additionally recognize the potential for Mlearning utilizing cell phones to advance research as online worldwide teamwork will be conceivable over the environment shared by all, adding to the achievement and creation of excellent work[3].

Obviously, with benefits come trials; again like the businesses, in cloud-based education, information security, privacy along with an inadequate framework are problems that should be dealt with. The privacy laws of the data and its accompanying handling ought not to be messed with[60], they likewise talk about another issue, that is: acceptance. Migration to the cloud and far from the customary pattern of teaching shall be a major transformation for organizations. Some may grasp it while others repulse it. There is the feeling among teachers that such e-learning frameworks could supplant them; however researchers[61] contend that this won't be the situation; educators shall dependably assume a crucial part in education and the regular contact time of lectures can never be supplanted[3].

3.1 The Cloud Pedagogy

In 2014, The Education Endowment Foundation expressed that, "There is positive substantiation showing the vital role that technology plays in accelerating and deepening learning". The combination of learning and teaching and cloud computing will improve the educational programs and make an environment of embedded learning called cloud pedagogy.

Cloud pedagogy has been characterized as "the art of teaching while encouraging omnipresence learning via cloud-based applications"[62]. The author additionally alluded to it as the utilization of web 2.0 tools and web-based tools where the resources for computing are collectively used for upgrading the learning and teaching process[62].

In basic terminology, cloud pedagogy alludes to any type of learning and teaching achieved utilizing cloud-based learning technologies; or in other words, any type of teaching and learning utilizing a cloud-based platform or cloud-based applications. At times, it is alluded to as internet learning, or eLearning that is accessible in the cloud implying that assets are kept in a virtual domain at a different location and availed from various types of web-empowered gadgets like portable PCs, tablets, and cell phones[63]. Different depictions take into consideration anything that is availed external to an association's firewall since this incorporates customary outsourcing being on the cloud.

The investigation of cloud pedagogy is however in infancy, with very little research conducted on it and novel models of teaching and learning are as yet being settled[62]. There are many types of cloud-based learning developments. As of now, students and teachers utilize cloud applications such as Dropbox, YouTube or email in their regular exercises. These applications provide numerous inventive and capable methodologies for the transmission and dispersal of educational information. It provides a perfect stage for upgrading innovative and creative thinking, multi-media, problem solving and ICT (Information and Communication Technology) education[62].

Basically, the cloud alludes to a gathering of PCs acting as one; that is PCs linked with an infrastructure (World Wide Web) and they shape a processing model that takes into consideration scaling of assets in the light of real-time needs[64]. Cloud pedagogy takes the thought of an all-around available, versatile and simple network of PCs and applies it to electronic learning[64]. This consolidates everything from online classrooms present at certified learning establishments to diminutive modules of learning to be utilized inside private associations or other private endeavors.

By virtue of cloud applications, it is possible that lectures can be conducted from any place on the planet, the applications help evacuate the impediment of classroom limits and as long as the student has a working internet connection, it enables learning from any place in the world. Various educational institutes across the world can regulate a similar educational module synchronously; pupils from different nations can cooperate utilizing the learning platform like electronic boards and work in study groups. They can utilize platforms for virtual learning to team up and share information[62]. With this innovation, students can get to their learning tools from any computing gadget, paying little heed to the platform, as long as the gadget can link with the cloud. Further, the framework consequently adapts to the client's necessities, in case of an upsurge in traffic or the measure of resources accessible to the clients of the framework, guaranteeing that the client's experience remains generally even.

Cloud-based pedagogy can likewise supplant course books with the program based delivery of content, and this as a service would be putting forth the organization substantially more than merely just the content. The resources may be conveyed as databases, spread sheets or word processors. A decent case was identified in California in 2009, where the State Governor Arnold Schwarzenegger acquainted a program which had the State quit purchasing reading material rather give students free digital gadgets[15,65].

4. Adoption in Educational Institutions

With the steady expansion in cloud computing adoption, the educational sector has not been left untouched. The institutes of education have additionally joined the drive to embrace the technology of cloud into their operations. The utilization and adoption of services offered by the cloud are spreading all around, the educational sector being no exception, despite the fact that the rate and scale differ with area and the monetary condition of areas[66]. Large companies like Microsoft have started activities to give free cloud services to universities. Services that are incorporated are document storage, email, formation and sharing of reports and the capacity to form sites[66]. In a typical institute of higher learning[54], distinguished lecturers, students, developers, administrative staff, researchers and analysts among others are the fundamental clients of IT assets. Generally, HLIs own an in-house IT administrations office where all their ICTs are overseen. It has been demonstrated that these administrations can be migrated to the cloud where the web can be employed to avail them.

By virtue of cloud computing frameworks, the development and adoption of different technologies in the scholarly world have accelerated. A few advancements have been made conceivable using the assets and frameworks of the cloud[67]. Researchers[68] analyzed that the University of California embraced cloud computing to empower them to viably meet conference and

research due dates viably, and allot assets productively, while staying away from the expensive traps of under or over-provisioning. In the United States, Marist Colleges implemented the cloud computing technology into their maneuvers. This implementation of cloud computing has lessened expenses by sharing a data center with other establishments of education[69]. They decided to link up with what is ordinarily alluded to as community cloud. North Carolina State University (NCSU) likewise embraced cloud computing for their entire ICT operations. They decided to house their cloud arrangement in-house. This has accelerated the output of their information technology workforce and students, and brought about technological and educational cost savings[69]. Besides, proficiency factor was perceived by particular institutes of higher education that embraced cloud computing. Effectiveness was accomplished by Washington State University by implementing an environment of virtualization that is viewed as an agent empowering cloud computing. Saving was realized by the utilization of email services in Google Apps. Cloud computing was additionally employed by a variety of advanced education organizations in poor African nations, such as, Rwanda, Ethiopia and Nairobi[51,54].

Cloud computing is the answer for some issues that the advanced education in Africa and other developing countries confront when incorporating ICTs into their educational modules[70]. The authors recognized problems like the shortage of ICT infrastructure, inconsistent and lacking electrical power supply and high cost of ownership as elements that are constraining the adoption of ICT in the advanced education in Africa. They asserted that the cloud's pay-as-you-use and on-request access trademark can enable toppling the capital consumption of establishments[15,71].

Cloud computing might be seen as being counteractive to several issues of the higher educational institutions in developing nations. There is a developing collection of literature that demonstrates HEIs have begun implementing cloud computing with regards to African nations such as, Kigali Institute of Education in Rwanda, National University of Rwanda, University of Mauritius, Kenyan Methodist University in Kenya and University of Nairobi[54,72]. Likewise, it was noticed that the likings and difficulties of cloud computing in HEIs of Tanzania[73]. An investigation led in South Africa features security concerns in the implementation of cloud computing in higher educational institutions[74]. Several services of cloud computing that have been embraced in HEIs are Google Cloud administrations that incorporate Google Talk, Gmail Calendar, Google spreadsheets and Google Docs. IT costs are being diminished as a result of these services and the IT services are being enhanced as well in various associations. Notwithstanding increasing number of HEIs embracing cloud computing in the developing nations, it is needed to comprehend contextual problems that may change from nation to nation[20,23,75].

The cloud applications have been adopted in various forms in HEIs and are utilized for various assignments in these institutions. Some are utilized specifically in the process of delivering knowledge while others are utilized for different exercises that help the process of teaching. According to a study, the respondents showed that they use cloud applications for different assignments that help them in their teaching such as posting lecture notes, posting assignments, posting continuous evaluation marks and as gatherings to help discuss with students. Other uses include submission of articles to journals, data sharing, doing research, or arranging meetings with students[15]. This is explained in Figure 1.

4.1 Levels of Technology Adoption

Similar to any other development of technology, cloud computing experiences a series of stages for development[76.] The cloud computing development level over some time period in associations can be clarified by the diffusion of the innovation curve. The innovation curve's diffusion has five phases to be specific[76,77]: i) innovators, ii) early adopters, iii) early majority, iv) late majority and v) laggards. These are defined as:

- Innovators: associations or individuals who are occupied with the technology and hold uplifting disposition towards the novel innovation
- Early adopters: associations or individuals with enthusiasm for the novel innovation and can take risks in adopting the same
- Early majority: larger part of organizations and individuals who are realists and concentrate on the procedural model for the novel innovation
- Late majority: associations or individuals who are pretty much incredulous towards the novel innovation and have negative demeanors towards it
- Laggards: associations or individuals with outrageous states of mind towards the novel innovation and frequently don't consider adopting it as the standard

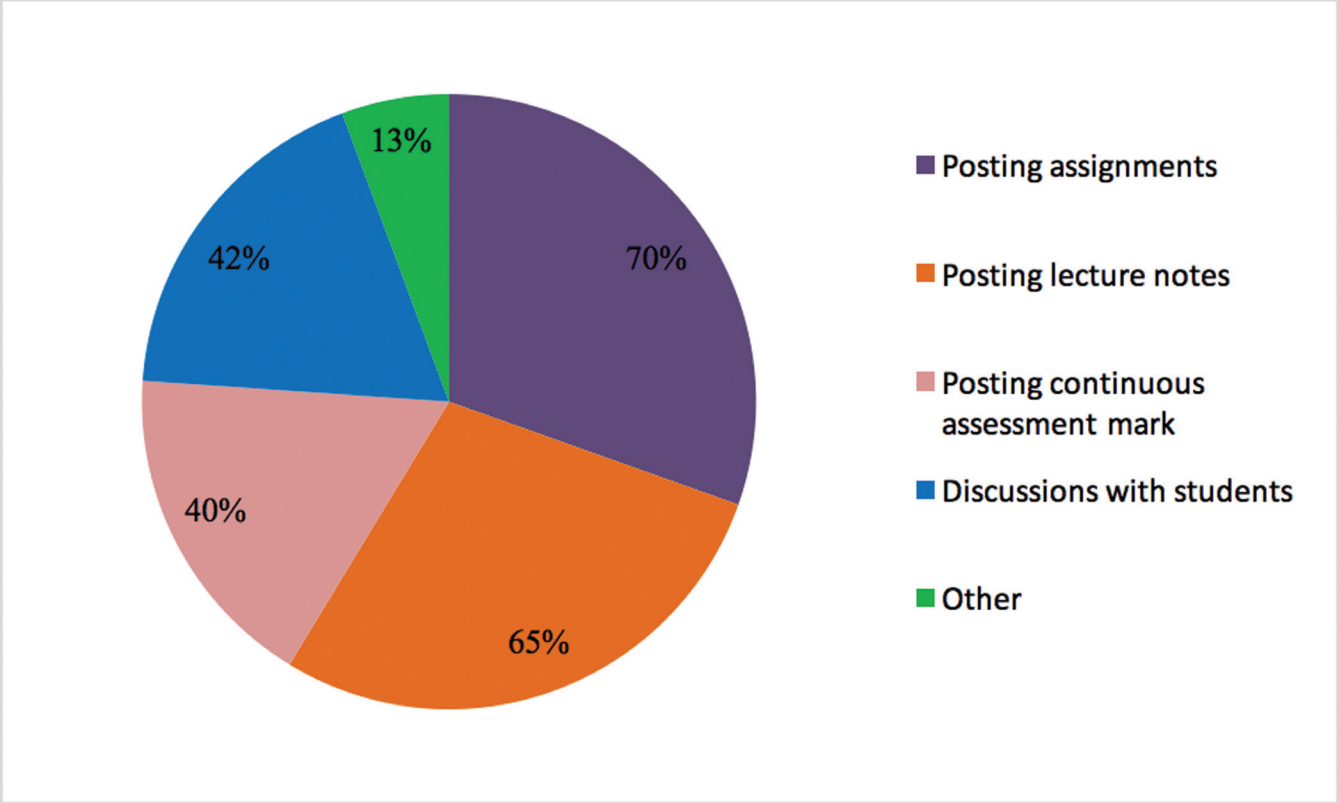

Figure 1. Usage of Cloud Computing in Higher Education.

It is important to pay attention to the diverse adoption levels for cloud computing with regards to HEIs. The levels of adoption differ particularly with regards to developing nations where cloud computing is new in comparison to developed nations[54]. Comprehension of the development level may likewise bolster top administration and IT managers to choose proper cloud computing services in the higher educational institutions. IT Managers may comprehend the advancement stages in which the novel innovation shall take place and prepare for the change accordingly[23].

4.2 Current Trend of Cloud Computing Adoption

Authors[78] analyzed the part of three factors in the proper implementation of Cloud Computing. By employing Partial Least Squares examination, they expounded that two elements (experience and age) play an important role in a man's aim to use cloud computing. Junior colleges have turned out to be early adopters of the technology of cloud computing. Experts employed the Technology Acceptance Model to analyze whether students of junior college would adopt the technology of cloud computing. Their investigation came to the conclusion that students would probably choose the technology of cloud computing if it is not difficult to use and does not require elaborate training procedure[79,80].

As of now, in North America, about 70% of HEIs have adopted (or are adopting) their email frameworks to the cloud. Nearly 50% have taken up a cloud-based framework of collaboration to enhance sharing of data across the campuses. Technavio's statistical surveying investigators have anticipated that the worldwide cloud computing market in advanced education will develop stunningly in the stipulated period and will post a CAGR of over 24% by the year 2020. This industry investigation report recognizes the rising interest for online substance improvement and digitization to be one of the central points that will positively effect the development of this market in the forthcoming years. The utilization of e-learning devices, for example, Learning Content Management System (LCMS) and Learning Management System (LMS) are essential in making content for training and educating learners. The high expenses related

to the use of e-learning instruments will drive the interest towards cloud computing in the education sector. Furthermore, cloud computing kills the need to introduce LMS on singular servers and also the necessity of specialists for dealing with the product[81].

As far as topographical areas are concerned that this report evaluates, North America represented around 43% of the aggregate share of the market in the year 2015. The expanding adoption of the services offered by cloud computing by institutions of higher education to enhance the educational quality, in email frameworks, and information sharing over the campus will drive the development of the market. Thus, the area will keep on dominating the market in the time frame of observation. The adoption of various devices, for example, tablets, e-readers, and portable PCs and the accessibility to internet will likewise increase the market development in the geographical area[81].

The investment in cloud technology is anticipated to develop in advanced education this year; 81 percent of IT pioneers or experts said their establishments would be expanding investing on cloud computing in 2017. 60% are of the view that they are incorporating cloud technology in their IT techniques. In any case, it will take a couple of more years before the majority of applications in universities are operating in the cloud. As of now, 39 percent of applications are cloud-based; by 2021, it could be more like 62 percent[82].

5. Challenges/Issues in Cloud Computing Adoption in HLIs

Regardless of the enormous advantages of cloud computing; uncertainties on the security and confidentiality of information stored in the cloud, location of data, privacy and regulatory compliance, vendor lock-in, reliability and legal jurisdiction of the cloud vendor have been distinguished as the obstructions to the adoption of cloud in advanced education[20,83], which resemble the findings of the investigation completed by the analysts of Carnegie Mellon University. The review additionally found that for institutions of higher learning, the difficulties in adoption of cloud are not confined to the dangers mentioned above, rather the relative underdevelopment and novelty of services offered by the cloud is likewise one of the significant worries for the adoption of cloud[54,84]. In a whitepaper[85], four primary concerns and worries for cloud computing in advanced education have been perceived: security and integration, compliance and risk issues, IT staffing implications and governing questions[6]. For cloud adopters, privacy and security are outstanding issues since important information is stored outside the firewalls of institutions; consequently, any hacking or different types of assaults on the cloud seller's framework shall influence all customers whose information was saved on that framework[86]. As indicated by researchers[87], failure to show consistence with SLA (Service Level Agreements) by the providers of cloud service is yet another cause for the moderate rate of adoption, since if cloud sellers don't meet the necessities of the SLA and take care of downtimes promptly, performance shall be significantly influenced. Jurisdiction and legal concerns additionally cause worries in light of the fact that legal issues can tie an establishment into undesirable or inadmissible conditions, prompting legal disputes that can keep running for years because of laws of the land where the information is found. The institutions never again gain control over the physical framework where their information is gathered, once the services of cloud vendors are utilized; the normal client may not be worried about where their information is located, yet colleges hold extremely imperative data of thousands of individuals and procedures, for example, results of researches and discoveries that require very high amount of privacy and confidentiality[88]. A case of an organization confronting legal issues because of the adoption of public cloud by Google is the Lakehead University, Canada. The faculty union of the university documented a complaint that the email framework outsourced to Google does not ensure the protection of their academic freedom and privacy since Google is a U.S. organization and along these lines answerable to the American law that makes Google to handover information to the U.S. Government when needed, even without the permission of the concerned university[89]. Such problems endanger the protection of privacy of information and wedge the enthusiasm of HLIs to adopt the cloud. However, in developing nations, the adoption rate of the cloud technology is meager even now; subsequently, in this part of the world, universities shall, for the most part, operate with copyright laws of the selected cloud sellers and that of the area where the vendors' frameworks are found; thus, one of the measuring standards of selecting vendors shall be founded on how promising the copyright laws emerge for the universities[84].

As in other low-pay status economies, HEIs in Malawi are facing issues bringing about low quality of teaching, learning and a constrained output of research. A portion of the issues identified with ICTs are deficient transfer speed, the absence of software and hardware assets, lack of IT systems inside the establishments, inadequate skills and consciousness of ICTs among the individuals of the staff in the associations[90]. In addition to this, there are other socio-economic issues in Malawi which in a roundabout way influence the selection and utilization of ICTs in HEIs. These are the poor economic performances that influence the foreign direct investment, powerless internal administration of frameworks and inappropriate structures of governing inside the organizations. Another concern is the absence of energy supply in provincial regions, uncertain power supply (frequent power outages) and ICT framework vandalism that influences operations of ICT users and service providers[23,90,91].

By and large, the primary hurdles that impede the cloud computing adoption in SADC region have been given as follows:

- **Poor Network Infrastructure**
  The absence of adequate network infrastructure has dependably been a noteworthy impediment to the utilization of ICTs in developing countries. Network infrastructure alludes to every single technological device, technique and access model that is utilized to encourage the effective administration and exchange of data. The SADC region, for the most part, comprises of developing countries; these nations are still undergoing development in many sectors of their economies. There is an extremely constrained framework for telecommunications in most of the developing nations and costs are exceptionally huge[92]. The restricted accessible framework is for the most part found in bigger urban territories, in this way dismissing and denying whatever remains of the populace in other, more rustic ranges.
- **High cost of ICT**
  The excessive cost related with setting up and maintenance of the ICT framework and equipment is again an issue in the developing nations[92]. PCs, portable PCs, cell phones and some ICT hardware are costly and unreasonably expensive to most of the populace in developing nations. This chops down the populace who can purchase ICT hardware. Subsequently, a lot of potential clients is banished from utilizing the internet due to high expenses.
- **Lack of Cloud Awareness**
  Majority of the people in the region of SADC don't know about the presence of cloud application and cloud computing. This is fundamentally credited to the higher rate of lack of education in developing nations. A poor e-readiness score is observed for most countries in Sub-Saharan Africa except for South Africa and its neighbors[93,94,95]. This is confirmed by a general absence of community awareness regarding the potential advantages and abilities of the cloud. Such a high scale of ignorance is a participating element in the low rate of cloud computing adoption in the region.
- **Unreliable Internet**
  One of the principal challenges preventing the widespread cloud adoption in Southern Africa is the internet reliability. For services of the cloud to be effective, it is a precondition that the internet ought to be dependable as the cloud calls for quick and reliable internet[96,97]. In any case, as indicated by the researcher[15], the adoption of cloud in Southern Africa is still low on the grounds as the area does not have quick and dependable fast access to the internet. Researchers[15,57] state that the absence of dependable internet access has led to most developing countries not embracing the cloud. They brought to light a great deal of elements including the region's poor infrastructure, absence of information coupled with a negative attitude, poverty, deficiency of resources, absence of IT know-how among the teachers, lack of ICT assets with respect to students, unresponsive to change, poor network connectivity, ignorance, shattering economy and absence of resolution from the leaders of institutions[15].

5.1 Factors affecting Adoption of Cloud Computing in HLIs

Most of the colleges and universities (about 69 percent) refer to savings of cost as their essential reason for the adoption of cloud. An increase in flexibility, versatility and speed are the following most well-known causes behind the migration of operations to the cloud, each referred to by about 40 to 50 percent of respondents. Actually, seven out of every 10 (71 percent) revealed that they had observed cuts in costs of the application upon migration to the cloud-based computing. Different other bonuses include enhanced service to the client, as said

by 77 percent of advanced education respondents and an increase in productivity, mentioned by 76 percent. The most widely recognized concern was identified as security and privacy, determined by 55 percent of respondents[82]. Various factors that influence cloud computing adoption in HLIs have been discussed below:

5.1.1 Performance

A new technology is often embraced by people assuming that it may help them to achieve their tasks quickly and enhance the nature of their output. Performance expectation is one of the principal elements that impact a person's choice to embrace a new technology[92,98,99]. With a poor network infrastructure and low levels of bandwidth in many nations in the region of SADC[92], cloud clients are very prone to encounter poor performances while accessing applications of the cloud. Poor cloud execution is typically observed when the network connection between the consumer and the cloud server is poor[100]. Researchers perceive performance as being both an opportunity and a risk for the adoption of cloud.

5.1.2 Ease of Use

As indicated by an investigation[101], a critical factor while assessing cloud computing technology is the ease of use. This is because while utilizing an application, the user experience is critical in evaluating the success of that application[102]. Past research on cloud computing adoption has demonstrated ease-of-use or effort expectancy as one of the principal elements considered when settling on the choice whether to adopt cloud applications[103,104].

5.1.3 Integration with other Services

For different uses around the campus, HEIs need to embrace many different applications. A need of these applications is to associate with each other. The absence of communication between these applications represents an enormous hurdle to cloud providers and adopters. An investigation conducted by researchers[102] noticed the main consideration affecting cloud computing adoption in an organization of education as "Support and integration of institution services". They stressed that this element assumed a major part when institutions needed to settle on a choice whether or not to adopt cloud computing.

5.1.4 Reliability

Despite the fact that providers of cloud services guarantee 99.9% SLA to their clients, cloud customers are as yet worried about the dependability of cloud services. Any association doing business would want to stay away from a circumstance where their operations are ceased because of a blackout of services offered by the cloud. As indicated by authors[105], at times an outage is inevitable and cloud clients ought to keep that in mind while deciding about embracing solutions that are cloud-based. Reliability exhibits itself as a risk and is subsequently taken as the main consideration in the adoption of cloud computing. It determines the sort of application that is able to be relocated to the cloud[15,105].

When building up a strategy for cloud, some general standards can be drawn for higher education in comparison to the business group. A powerful and tough cloud system plan for establishment in learning education will require: making a framework based upon the necessities of the various partners involved – from faculty to students, alumni to members of board; closing in all partners prior to schedule; and putting up an organization-wide cloud methodology that meets IT challenges specific to campuses and advanced education[2].

6. Recommendations/Overcoming Barriers to Cloud Adoption

As enunciated from the primary and secondary collection of data, regulatory compliance issues, privacy, reliability of service provider and confidentiality, as well as security of data, have been found to be the major obstacles in the cloud computing adoption[106]. Thus, the requirement is the recommendation of an approach that is futuristic as well as proactive besides being an immediate and preventive solution. Thus, several measures have been suggested in the proposed study that helps to overcome the challenges to cloud computing.

6.1 Strategic guidelines for overcoming Privacy and Security Concerns

The concerns related to privacy and security are the two main challenges that arise in cloud computing adoption[107]. To overcome these issues, the below-mentioned guidelines and techniques should be employed for safeguarding educational data:

6.1.1 Encryption

It has been found to be the most popular technique for ensuring the security of cloud data. It is the process in which information is transformed or changed in such a manner that it cannot be comprehended by anyone without authorization. Thus, anyone who does not possess the password or code for decrypting the encrypted data is unable to comprehend the data being transmitted when this technique is employed. In this way, the data is safeguarded by ensuring its integrity as well as authenticity by preventing the confidential educational data to be disclosed improperly[108].

6.1.2 Digital Signature

Digital signatures can also be employed for overcoming privacy and security issues. A digital signature is an electronic signature that is used for authenticating the users who access the cloud services. In this technique, users ought to provide their proper access/login credentials in order to access the applications or information they require. As a result, the integrity, accountability and authenticity of data stored on the cloud are ensured[109].

6.1.3 Direct contact with the Cloud Vendor

The chances that the data may be compromised increase with the growing number of intermediate stages or levels between the vendor and the user. Therefore, a direct contact ought to be established by the university with the cloud service provider with no interference from an intermediary. This shall ensure one-way movement of data from the cloud service provider to the higher learning institution.

6.1.4 Gradual Migration

Despite the cost benefits, efficiency and increased agility offered by the cloud, caution is a must while migrating to the cloud. It is recommended to migrate towards the cloud in a gradual manner and moving low-risk applications first. In this way, the university can get some time to analyze if the vendor chosen or the cloud project is worthy or not; if it is found to be worthy, then only rest of the applications should be moved in a stepwise manner. Furthermore, the compatibility between the systems of the cloud service provider and the university should be ensured to overcome the barriers of privacy and security concerns. This can be done by gradual migration since both the parties would have ascertained their compatibility before the migration of sensitive data to the cloud[110].

6.1.5 Investigation of Cloud Vendors

Before choosing any cloud provider, it is important to thoroughly investigate their security mechanisms, type of configuration and security measures for ensuring the security of data on their cloud. Furthermore, the details about the measures to be followed in case a security breach occurs should be analyzed, understood and warranted to be in harmony with the standards laid down by CSA (Cloud Security Alliance) and NIST (National Institute of Standards and Technology). This shall make sure that the security level offered by the cloud service provider is apt and proper backups are in place to thwart the effects of disasters such as flood, fire, or earthquake or other problems[111]. Such an investigation is, therefore, mandatory for the cloud service adoption in the educational sector for ensuring confidentiality as well as availability due to the privacy level which is required for preserving the results of researches or other confidential data.

6.1.6 Data Splitting

This technique involves the storage of data on diverse clouds in such a way that maintains availability, integrity and confidentiality of data. So, it requires the services of many service providers[86]. Such a technique helps in reducing the risks of downtime and data loss, avoiding vendor lock-in and improving the performance by employing fault-tolerant protocols to control the security issues like intrusion, data integrity and service availability across different clouds. Splitting data across clouds provides the educational institutions with an opportunity to employ a different cloud for a different purpose since one cloud may perform better than the other for some application such as, the usage of Microsoft Azure for providing IaaS as well as PaaS services and the Google public cloud has been found to be the best for providing email services. With the advancements in cloud technology, the services offered by the cloud vendors and the migration solutions have made the synchronization of data across different clouds easier, for example, the countability provided by cloud vendors makes it convenient for the users to manage different cloud providers simultaneously. In the same way, the costs implicated by different cloud service providers vary based on the pricing schemes; the applications that are kept running for a longer duration of time and

used quite frequently may have lesser costs as compared to those that are utilized for a shorter span of time. Thus, the clients should carefully analyze the costs of data splitting across different clouds. Although it is emphasized to guarantee that the most appropriate model for service delivery and deployment together with a reputable cloud vendor is chosen for a reliable and secure cloud, failure may still occur; thus the use of multiple clouds is a more reliable and better approach for handling failures since it is very uncommon that the services from various providers may be down simultaneously. This technique offers the educational institutions the provision to migrate in a convenient manner which proves beneficial in case the service provider changes its business terms or hikes the prices. In such a case, the institutions may shift to other cloud service providers with favorable business terms and pricing[84].

In order to prepare for the cloud pedagogy adoption and achieve an improvement in the same, the below-mentioned steps should be taken:

- All the advantages and potential opportunities in shifting to cloud services from the traditional computing arrangements should be identified.
- It should be ensured that the in-house infrastructure is complementing the services offered by the cloud vendor. The migration to cloud is not all or nothing process and the extension of an in-house IT to some clouds may be supported by several cloud services like infrastructure services to provide additional storage and computation facility. Virtualization shall thus be an important part of a compatible infrastructure.
- A risk evaluation and cost/benefit framework should be developed for supporting decisions concerning when, how and where the cloud services can be adopted. A roadmap should be developed to optimize the current IT infrastructure for the adoption of private and public cloud services. It should be identified which type of data cannot be stored in public clouds for security or legal reasons.
- In-house competencies vital for managing the effective cloud service adoption should be identified and safeguarded.
- While transferring current applications or information to the cloud (even to a private cloud), technical challenges to be addressed should be evaluated. Various internal as well as external services should be experimented with for identifying the problems that may arise.
- It should be ensured that the networking environment is apt for cloud computing[38].
- To improve the speed of internet, internet service providers should make enhancements in their networks besides making it accessible in remote locations which are devoid of any connection.
- A uniform application for cloud learning should be adopted by institutional leaders that shall be used by everybody in the institutions.
- Workshops should be conducted for raising the awareness about cloud computing together with its applications which can be employed for educating in the institutions.
- The enhancements in ICT infrastructure should be facilitated by stakeholders and governments of different countries. The assistance from governments may be in the form of availability of funds for boosting such developments.
- Teaching with technology approach should be encouraged by institutional leaders. Some policies should be put in place to promote the use of technology while teaching.
- Subsidies should be provided to learners by stakeholders and governments so that they can acquire the required equipment for accessing cloud applications[15].

7. Conclusion

An exploratory study has been presented in this paper which was carried out for better understanding the cloud computing shift and the changing significance of its decisive factors. The current status of cloud pedagogy has also been studied for highlighting the challenges and determining how the e-learning environment can be improved for higher learning institutions. After the identification of the limitations and challenges, this study shows that majority of the problems can be overcome for improving the Virtual Learning Environment (VLE). Therefore, feasible solutions like usage of IaaS for overcoming resource constraints and the usage of SaaS for enhancing the learning environment with the addition of valuable and interactive tools can be employed to harness the services offered by cloud vendors in educational institutions. However, this study found a dearth of research in the field of cloud computing adoption in educational institutions. As a result, it was concluded that cross-country investigations should be used for revealing more information

about the factors that affect cloud computing adoption in educational institutions.

8. Acknowledgment

This work was partially supported by Ministry of Higher Education Malaysia (Kementerian Pendidikan Tinggi) under Research Initiative Grant Scheme (RIGS) number RIGS 16-357-0521.

9. References

1. Olanrewaju RF, Mir RN, Khan BU, Baba AM, Gannie MR. RAED: Response analysis of educational data for leveraging knowledge dissemination system. 2015 IEEE Conference on e-Learning, e-Management and e-Services (IC3e). 2015 August; p. 1-6.
2. The cloud: a smart move for higher education. Date Accessed: 2017: Available from: http://www.ellucian.com/emea-ap/Insights/The-Cloud--A-Smart-Move-for-Higher-Education/
3. Smith A, Bhogal J, Sharma M. Cloud computing: adoption considerations for business and education. IEEE International Conference on Future Internet of Things and Cloud (FiCloud). 2014 August; p. 302-07. Crossref.
4. Making the grade 2011 A study of the top 10 issues facing higher education institutions. Deloitte. 2011; p. 1-33.
5. Lowendahl J. 2016 CIO Agenda: A Higher Education Perspective. Date Accessed: 19/02/2016: Available from: https://www.gartner.com/doc/3218417/-cio-agenda-higher-education.
6. Jenhani A. Cloud computing in German higher educational institutions. Institut für Wirtschafts- und Verwaltungsinformatik. 2011; p. 1-71.
7. Agee AS, Yang C. Top-ten IT issues, 2009. EduCause Current Issue Committee. EducausE review. 2009 July; 44(4):44-59.
8. Workday for Higher Education™. 2012; p. 1-4.
9. Venters W, Whitley EA. A critical review of cloud computing: researching desires and realities. Journal of Information Technology. 2012 September; 27(3):179-97. Crossref.
10. Armbrust M, Fox A, Griffith R, Joseph AD, Katz R, Konwinski A, Lee G, Patterson D, Rabkin A, Stoica I, Zaharia M. A view of cloud computing. Communications of the ACM. 2010 April; 53(4):50-8. Crossref.
11. Garrison G, Kim S, Wakefield RL. Success factors for deploying cloud computing. Communications of the ACM. 2012 September; 55(9):62-8. Crossref.
12. Marston S, Li Z, Bandyopadhyay S, Zhang J, Ghalsasi A. Cloud computing—The business perspective. Decision support systems. 2011 April; 51(1):176-89. Crossref.
13. El-Gazzar R. Understanding the Phenomenon of Cloud Computing Adoption within Organizations. Doctoral Dissertation, Faculty of Social Sciences, University of Agder. 2016; p. 1-371.
14. Katz R, Goldstein P, Yanosky R. Cloud Computing in Higher Education. 2008; p. 1-8.
15. Chibaro N. Adoption of cloud pedagogy by higher learning institutions in Southern Africa. Cape Peninsula University of Technology. 2015; p. 1-159.
16. Campbell-Kelly M. The rise, fall, and resurrection of software as a service. Communications of the ACM. 2009; 52(5):28-30. Crossref.
17. Mell P, Grance T. The NIST definition of cloud computing, 2011; p. 1-2.
18. Ercan T. Effective use of cloud computing in educational institutions. Procedia-Social and Behavioral Sciences. 2010 January; 2(2):938-42. Crossref.
19. Khmelevsky Y, Voytenko V. Cloud computing infrastructure prototype for university education and research. Proceedings of the 15th Western Canadian Conference on Computing Education. ACM. 2010 May; p. 8. Crossref.
20. Low C, Chen Y, Wu M. Understanding the determinants of cloud computing adoption. Industrial management & data systems. 2011 August; 111(7):1006-23. Crossref.
21. Arasaratnam O, Halpert B. Introduction to cloud computing. Auditing Cloud Computing: A Security and Privacy Guide. 2011; September; p. 1-3.
22. Mathew S. Implementation of cloud computing in education-A Revolution. International Journal of Computer Theory and Engineering. 2012 June; 4(3):473. Crossref.
23. Makoza F. Cloud computing adoption in higher education institutions of Malawi: An exploratory study. International Journal of Computing & ICT Research. 2015 December; 9(2):1-18.
24. Hurwitz J, Kaufman M, Halper F, Kirsch D. Hybrid cloud for dummies. John Wiley & Sons; 2012 May; p. 1-360.
25. Rao NM, Sasidhar C, Kumar VS. Cloud computing through mobile-learning. International Journal of Advanced Computer Science and Applications. 2012 April.
26. Kim W. Cloud computing: Today and tomorrow. Journal of Object Technology. 2009 January; 8(1):65-72. Crossref.
27. Gupta P, Seetharaman A, Raj JR. The usage and adoption of cloud computing by small and medium businesses. International Journal of Information Management. 2013 October; 33:861-74. Crossref.
28. Baliga J, Ayre RW, Hinton K, Tucker RS. Green cloud computing: Balancing energy in processing, storage

and transport. Proceedings of the IEEE. 2011 January; 99(1):149-67. Crossref.
29. McKendrick J. Cloud Computing's Hidden 'Green' Benefits. Date Accessed: 03/10/2011: Available from: https://www.forbes.com/sites/joemckendrick/2011/10/03/cloud-computings-hidden-green-benefits/#2c630fc72c9d.
30. Clarity in the Cloud: A Global Study of the Business Adoption of Cloud. Forbes Insights. Date Accessed: 11/2011: Available from: https://www.forbes.com/forbes-insights/kpmg_private_sector_cloud/.
31. Rader D. How cloud computing maximizes growth opportunities for a firm challenging established rivals. Strategy & Leadership. 2012 April; 40(3):36-43. Crossref.
32. Grobauer B, Schreck T. Towards incident handling in the cloud: challenges and approaches. Proceedings of the 2010 ACM workshop on Cloud computing security workshop. ACM. 2010 October; p. 77-86. Crossref.
33. Hanna EM, Mohamed N, Al-Jaroodi J. The cloud: Requirements for a better service. Proceedings of the 2012 12th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (ccgrid). IEEE Computer Society. 2012 May; p. 787-92.
34. What's Holding Back the Cloud? Date accessed: 05/2012: Available from: https://www.intel.in/content/dam/www/public/us/en/documents/reports/whats-holding-back-the-cloud-peer-research-report2.pdf
35. Mirashe SP, Kalyankar NV. Cloud computing. An in-depth look at the latest trends and issues in the space. 2010 March.
36. Khan KM, Malluhi Q. Establishing trust in cloud computing. IT professional. 2010 September; 12(5):20-7. Crossref.
37. Khan BU, Olanrewaju RF, Altaf H, Shah A. Critical insight for mapreduce optimization in hadoop. International Journal of Computer Science and Control Engineering. 2014 April; 2(1):1-7
38. Cloud Computing in Higher Education: A Guide to Evaluation and Adoption. Date accessed: 26/05/2017: https://www.cisco.com/web/offer/email/43468/5/Cloud_Computing_in_Higher_Education.pdf
39. Chang V, Wills G. A University of Greenwich case study of Cloud Computing. E-Logistics and E-Supply Chain Management: applications for evolving business. 2013 April; p. 232.
40. Blake R. Distance learning for second and foreign language teaching. Encyclopedia of language and education. Springer US. 2008; p. 1454-65. Crossref.
41. Aldakheel EA. A cloud computing framework for computer science education. Master of Science (MS), Bowling Green State University, Computer Science. 2011.
42. Olanrewaju RF, Khan BU, Mir RN, Baba AM, Anwar F. DFAM: A distributed feedback analysis mechanism for knowledge based educational big data. Jurnal Teknologi. 2016 January; 78(12-3):31-8.
43. Isaila N. Cloud computing in Education. Knowledge Horizons. Economics. 2014 April; 6(2):100.
44. Manro S, Singh J, Joshi A. Managing e-learning using clouds: A cost-effective boon in 21st century. International Journal of Computers & Distributed Systems. 2012; 1(1):11-3.
45. Aljenaa E, Al-Anzi FS, Alshayeji M. Towards an efficient e-learning system based on cloud computing. Proceedings of the Second Kuwait Conference on e-Services and e-Systems. ACM. 2011 April; p. 13. Crossref.
46. Mehlenbacher B, Bennett L, Bird T, Ivey M, Lucas J, Morton J, Whitman L. Usable e-learning: A conceptual model for evaluation and design. Proceedings of HCI International, 11th International Conference on Human-Computer Interaction. 2005 July; 4:1-10.
47. Kurelović EK, Rako S, Tomljanović J. Cloud computing in education and student's needs. 36th International Convention on Information & Communication Technology Electronics & Microelectronics (MIPRO). IEEE. 2013 May; p. 726-31.
48. Naik AB, Ajay AK, Kolhatkar SS. Applicability of cloud computing in academia. Indian Journal of Computer Science and Engineering. 2013; 4(1):11-5.
49. Alshuwaier FA, Alshwaier AA, Areshey AM. Applications of cloud computing in education. 8th International Conference on Computing and Networking Technology (ICCNT), IEEE. 2012 August; p. 26-33.
50. Office for Students, Teachers, & Schools | Office | Microsoft. Date Accessed: 2017: Available from: https://products.office.com/en-us/student/office-in-education
51. Tashkandi A, Al-Jabri I. Cloud Computing Adoption by Higher Education Institutions in Saudi Arabia: an exploratory study. 2015 December; 18(4):1527-37.
52. Lakshminarayanan R, Kumar B, Raju M. Cloud computing benefits for educational institutions. 2013 May.
53. Google for Education: Save time and stay connected. Date Accessed: 2017: Available from: https://edu.google.com/products/productivity-tools/
54. Sultan N. Cloud computing for education: A new dawn? International Journal of Information Management. 2010 April; 30(2):109-16. Crossref.
55. 10. IBM Cloud Academy - Getting started - United States. Date Accessed: 24/06/2017: Available from: Crossref.
56. Kumar BP, Kommareddy S, Rani NU. Effective ways cloud computing can contribute to education success. Advanced Computing: An International Journal. 2013 July; 4(4):1-16.
57. Le Roux J, Evans N, Bay R. South Africa: Richards Bay: University of Zululand: A Proposal for the Adoption

and use of Cloud Computing in Secondary Education in South Africa. 11th DIS Annual Conference 2010, 2nd - 3rd September. 2010; p. 1-15.
58. Vishwakarma AK, Narayanan AE. E-learning as a service: A new era for academic cloud approach. 2012 1st International Conference on Recent Advances in Information Technology (RAIT). IEEE. 2012 March; p. 352-56. Crossref.
59. Fasihuddin H, Skinner G, Athauda R. A holistic review of cloud-based e-learning system. 2012 IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE). IEEE. 2012 August; p. H1C-6-HIC-11. Crossref.
60. Mokhtar SA, Ali SH, Al-Sharafi A, Aborujilah A. Cloud computing in academic institutions. Proceedings of the 7th International Conference on Ubiquitous information Management and Communication. ACM. 2013 January; p. 1-7. Crossref.
61. Masud MA, Huang X. An e-learning system architecture based on cloud computing. System. World Academy of Science, Engineering and Technology. 2012; 6:1-5.
62. Current Projects | Miri Barak. Date Accessed: 2015: Available from: http://barakmiri.net.technion.ac.il/cloud-pedagogy/
63. Boiros P. What is Cloud-Based Learning? Date accessed: 30/07/2014: Available from: http://blogs.skillsoft.com/learning-re-imagined/2014/07/what-is-cloud-based-learning.html
64. Oludipe O, Fatoki OK, Yekini NA, Aigbokhan EE. cloud-based e-learning platform: From the perspective of 'structure'and 'interaction'. International Journal of Innovation and Research in Educational Sciences. 2014; 1(1):1-6.
65. Hammer K. TDSB considers replacing textbooks with e-books. Date Accessed: 06/08/2012: Available from: https://www.theglobeandmail.com/news/toronto/tdsb-considers-replacing-textbooks-with-e-books/article4317788/
66. Muriithi G, Kotze E. Cloud computing in higher education: implications for South African public universities and FET colleges. Proceedings of the 14th Annual Conference on World Wide Web Applications Durban. 2012 Sep. PMCid:PMC3288012
67. Getso M, Ahmed R. Applications of cloud computing in academic institutions. International Journal of Information Systems and Engineering. 2014; 2(1):65-72.
68. Tout S, Sverdlik W, Lawver G. Cloud computing and its security in higher education. Proceeding ISECON, (Washington DC). 2009; 26:1-5.
69. Erenben C. Cloud computing: the economic imperative. ESchool News. 2009 March; 12(3): 13-9.
70. Gital AY, Zambuk FU. Cloud computing: Solution to ICT in higher education in Nigeria. Advances in Applied Science Research. 2011; 2(6):364-9.
71. Akin O, Matthew F, Comfort D. The impact and challenges of cloud computing adoption on public universities in Southwestern Nigeria. International Journal of Advanced Computer Science and Applications, IJACSA. 2014; 5(8):1-7.
72. Kihara T, Gichoya D. Use of cloud computing platform for e-learning in institutions of higher learning in Kenya. IST-Africa Conference Proceedings IEEE. 2014 May; p. 1-6. Crossref.
73. Mero R, Mwangoka J. Road map towards eco-efficient cloud computing adoption in higher learning institutions in tanzania. 2014 Pan African Conference on Science, Computing and Telecommunications (PACT). IEEE. 2014 July; p. 154-59. Crossref.
74. Schyff KVD, Krauss KE. Higher education cloud computing in South Africa: towards understanding trust and adoption issues. South African Computer Journal. 2014 December; 55 (1):40-55.
75. Kshetri N. Cloud computing in the global south: drivers, effects and policy measures. Third World Quarterly. 2011 July; 32(6):997-1014. Crossref.
76. Rodgers EM. Diffusion of innovations. Fourth Edition. THE FREE PRESS New York. 1995; p. 1-51. PMid:7833382
77. Moore GC, Benbasat I. Development of an instrument to measure the perceptions of adopting an information technology innovation. Information Systems Research. 1991 September; 2(3):192-222. Crossref.
78. Ambrose P, Chiravuri A. An empirical investigation of cloud computing for personal use. Proceedings of the Fifth Midwest Association for Information Systems Conference, Moorhead. 2010 May; p. 1-6.
79. Behrend TS, Wiebe EN, London JE, Johnson EC. Cloud computing adoption and usage in community colleges. Behaviour & Information Technology. 2011 March; 30(2):231-40. Crossref.
80. Taylor CW. Cloud Computing At The University Level: A Study Of Student Use Of Cloud Computing Applications. Zhurnal Eksperimental'noi I Teoreticheskoi Fiziki. 2011 May.
81. Global Cloud Computing Market in Higher Education 2016-2020 | Market Research Reports - Industry Analysis Size & Trends – Technavio. Date Accessed: 02/2016: Available from: https://www.technavio.com/report/global-education-technology-global-cloud-computing-market-higher-education-2016-2020
82. Schaffhauser D. Higher Ed Cloud Adoption on the Rise -- Campus Technology. Date accessed: 22/09/2016: https://campustechnology.com/articles/2016/09/22/higher-ed-cloud-adoption-on-the-rise.aspx

83. Mircea M, Andreescu AI. Using cloud computing in higher education: A strategy to improve agility in the current financial crisis. Communications of the IBIMA. 2011 January; p. 1-15.
84. Okai S, Uddin M, Arshad A, Alsaqour R, Shah A. Cloud computing adoption model for universities to increase ICT proficiency. SAGE Open. 2014 August; p. 1-10. Crossref.
85. Hignite K, Katz RN, Yanosky R. Shaping the higher education cloud. EDUCAUSE White Paper. 2010 May; p.1-29.
86. Khan BU, Baba AM, Olanrewaju RF, Lone SA, Zulkurnain NF. SSM: Secure-Split-Merge data distribution in cloud infrastructure. IEEE Conference on Open Systems (ICOS). IEEE. 2015 August; p. 40-45. Crossref. PMid:25524051
87. Rittinghouse JW, Ransome JF. Cloud computing: implementation, management, and security. CRC press. 2016 April; p. 1-340.
88. Cegielski CG, Allison Jones-Farmer L, Wu Y, Hazen BT. Adoption of cloud computing technologies in supply chains: An organizational information processing theory approach. The International Journal of Logistics Management. 2012 August; 23(2):184-211. Crossref.
89. Todd P. Switch to Google e-mail saves resources, raises privacy concerns | University Affairs. Date Accessed: 10/03/2008: Available from: http://www.universityaffairs.ca/news/news-article/switch-to-google-email-saves-resources-raises-privacy-concerns/
90. Gombachika HS, Kanjo C. Use of ICT in Science and Engineering: A case of University of Malawi. University of Malawi. 2008.
91. Kanjo C. Going beyond diagnostics and planning in ICT initiatives: Limitations in the context of Malawi. Proceedings on the 5th Plato Community Informatics and Development Informatics Conference on ICTs for Social Inclusion: What is the reality? 2008 October; p. 1-17.
92. Jorge SN. The economics of ICT: challenges and practical strategies of ICT use for women's economic empowerment. UN Meeting on ICTs and their Impact on and Use as an Instrument for the Advancement and Empowerment of Women, Seoul, Korea. 2002 November; p. 11-14.
93. Dutta S, Geiger T, Lanvin B. The global information technology report 2012. World Economic Forum 2012 November; p. 1-357.
94. Unit EI. Digital economy rankings 2010: Beyond e-readiness. The Economist, June. 2010 June; p. 1-26.
95. Ifinedo P. Measuring Africa's e-readiness in the global networked economy: A nine-country data analysis. International Journal of Education and development using ICT. 2005 March; 1(1): 53-71.
96. Maaref S. Cloud computing in Africa-Situation and perspectives. Geveva, International Telecommunication Union. 2012 April; p. 70.
97. Africa's cloud adoption challenges and opportunities. IT News Africa, Africa's Technology News Leader. 2013.
98. Changchit C. Students' perceptions of cloud computing. Issues in Information Systems. 2014 January; 15(1):312-22.
99. Wu YL, Tao YH, Yang PC. The use of unified theory of acceptance and use of technology to confer the behavioral model of 3G mobile telecommunication users. Journal of Statistics and Management Systems. 2008 September; 11(5):919-49. Crossref.
100. Benlian A, Hess T. Opportunities and risks of software-as-a-service: Findings from a survey of IT executives. Decision Support Systems. 2011 December; 52(1):232-46. Crossref.
101. Morgan L, Conboy K. Factors affecting the adoption of cloud computing: An exploratory study. ECIS Completed Research. 2013; p. 1-12.
102. Gupta N, Thakur S. The factors affecting adoption of cloud computing technology in education institutions. International Journal of Advanced Research in Computer and Communication Engineering. 2014; 3(6):7229-35.
103. AlAwadhi S, Morris A. The use of the UTAUT model in the adoption of e-government services in Kuwait. Proceedings of the 41st Annual Hawaii International Conference on System Sciences. IEEE. 2008 January; p. 219. Crossref.
104. Dhulla TV, Mathur SK. Adoption of cloud computing by tertiary level students–a study. Journal of Exclusive Management Science. 2014; 3(3):1-15.
105. Kim W, Kim SD, Lee E, Lee S. Adoption issues for cloud computing. Proceedings of the 7th International Conference on Advances in Mobile Computing and Multimedia. ACM. 2009 December; p. 2-5. Crossref. Crossref.
106. Olanrewaju RF, Khan BU, Baba A, Mir RN, Lone SA. RFDA: Reliable framework for data administration based on split-merge policy. 2016 SAI Computing Conference (SAI). IEEE. 2016 July; p. 545-52. Crossref.
107. Mir MS, Suhaimi B, Adam M, Khan BUI, Mattoo MUI, Olanrewaju RF. Critical security challenges in cloud computing environment: An appraisal. Journal of Theoretical & Applied Information Technology. 2017 May; 95(10):1-15.
108. Singh JP, Kumar S. Authentication and encryption in cloud computing. 2015 International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM). IEEE. 2015 May; p. 216-19. Crossref.

109. Rewagad P, Pawar Y. Use of digital signature with diffie hellman key exchange and AES encryption algorithm to enhance data security in cloud computing. 2013 International Conference on Communication Systems and Network Technologies (CSNT). IEEE. 2013 April; p. 437-39. Crossref.
110. Khan BU, Olanrewaju RF. QoS oriented MapReduce Optimization for Hadoop Based BigData Application. International Journal of Engineering Research and Applications. 2014; 4 (4):12-5.
111. Hubbard D, Sutton M. Top threats to cloud computing v1. 0. Cloud Security Alliance. 2010 March; p. 1-14.