| RESEARCH ARTICLE

A Literature Review of E-Learning Technology in Higher Education

Purwono Hendradi[1] ✉ **Mohd Khanapi Abd Ghani[2] and S.N Mahfuzah[3]**
[1]Technical Information, Universitas Muhammadiyah Magelang, Indonesia
[2]Biomedical Computing and Engineering Technologies (BIOCORE) Applied Research Group, Faculty of Information and Communication Technology, Universiti Teknikal Malaysia Melaka, Malaysia
[3]Department of Interactive Media, Faculty of Information and Communication Technology, Universiti Teknikal Malaysia Melaka, Malaysia
Corresponding Author: Purwono Hendradi, **E-mail**: p_hendra@ummgl.ac.id

| ABSTRACT

The increase in the use of E-learning during the COVID-19 pandemic as a consequence of the call for Work From Home (WFH) is increasingly massive. In contrast to regular times, E-learning during the COVID-19 pandemic depends on available home resources. Technology plays an essential role in supporting the implementation of e-learning which must consider the resources available at home. This research is a systematic literature review using database sources from ScienceDirect and Emerald. The inclusion criteria are research that discusses e-learning in higher education during the COVID-19 pandemic (2019-2020) from a computer science perspective. An exclusion criterion is research examining e-learning in higher education from sources outside ScienceDirect. The search results from ScienceDirect obtained 518, and Emerald got 66 relevant articles. The next stage is reviewing abstracts and titles that focus on technology in e-learning on the lecturer and student side; We obtained 23 articles and then checked them in full text. This literature study shows that technology as a support for e-learning systems during the COVID-19 period in universities needs to consider the resources available at home, namely infrastructure and applications for students and teachers, for future work in the research of friendly e-learning technology to the availability of resources at home.

1. Introduction

E-learning, which was initially an electronic-based learning tool, developed into computer-based learning (CBL) and is now learning using information and computer technology (ICT), also known as distance learning [Simanihuruk, 2019]. Since then, we have discussed e-learning as inseparable from web development [Dominic, 2014]. The Industrial Era 4.0 also influenced the development of e-learning with the emergence of the term Education 4.0. This era is identified by mixed and highly interactive learning with personalized learning types, adaptability, learning analysis, electronic assessment, Chabot, and virtualization [Ciolacu, 2017]. Furthermore, e-learning technology in the Education 4.0 era involves the role of students, teachers, educational institutions, and cloud service providers [Masud, 2012]. The cloud service provider in question for this last role is educational content and applications.

During the COVID-19 pandemic, the Government of the Republic of Indonesia urges to carry out activities from home, known as Work from Home (WFH), following the recommendations of the World Health Organization (WHO) (WFH)[Djalante, 2020]. Thus, the role of e-learning becomes very strategic because it is forced to become a learning tool during the WFH period. E-learning will act as a substitute for face-to-face teaching and learning activities, so it must meet all learning processes' demands. There was a significant change in readiness and interest in student learning with the implementation of integrative e-learning [Resdasari, 2021].

Refers to the type of e-learning, namely telementoring and e-coaching, namely the use of the internet and the web to master the knowledge and monitor the development of skills and attitudes. Applications that are teleconference, instant messaging, and chat [Horton, 2023].

Different from the implementation of e-learning in ordinary times is the location or the place of access. The e-learning system regularly recognizes the term anyone, anywhere, and anytime [8]. In particular on the terminology from anywhere to be at home [Rubens, 2021][Lopez-Leon, 2020].

This creates a need for infrastructure that must be provided in the area around the house for both teachers and students, and currently, what is popular is cellular service provider infrastructure[APJII, 2018]. The use of mobile technology (mobile technology) as infrastructure and social media received a positive response in Thailand [Ngampornchai, 2016]. Universiti Teknologi Malaysia (UTM) established the Center for Teaching and Learning (CTL) for e-learning and supported technology-based educational materials. The result is a significant relationship between satisfaction, perceived benefits, and intention to use e-learning [Al-Rahmi, 2018]. Australian University using Critical Success Factor (CSF), found that technology awareness factors and instructor characteristics affect effectiveness. E-learning system [Xaymoungkhoun, 2012]. The three countries above can represent developed and developing countries around Indonesia.

Reviewing several literature articles published during the COVID-19 pandemic, namely 2019-2020, discussing the readiness of lecturers in online classes, taking advantage of e-learning challenges, and reviewing e-learning and e-teaching. The first article aims to evaluate the preparedness of lecturers as well as the weaknesses and obstacles that must be overcome [Junus, 2021]. The study results show that lecturers have solid basic skills in e-learning and can adapt to the Learning Management System (LMS), and have tactical solutions in implementing learning.

Another article reviews the literature review on the challenges of e-learning during the COVID-19 pandemic [Aini, 2020], where the analysis results divide the challenges into student challenges, challenges for lecturers, and challenges for institutions. For students, the challenges are connectivity, e-learning system support, technology issues, and self-regulation. Meanwhile, the challenges for lecturers are competence, operational problems, self-regulation, and isolation. The final challenge for institutions is financial support and change management.

The following article reviews e-learning and e-teaching during the covid-19 pandemic to obtain evidence of the challenges and opportunities of e-learning and e-teaching [Mseleku, 2020]. The article uses a literature search from 16 databases for relevant studies published in 2020 using Covid-19, coronavirus, online learning, E-learning, E-teaching, and higher education. As a result, the literature presents learning and teaching challenges, such as the inability to access or use online learning and teaching tools and difficulty adapting, especially for students living in rural areas with low incomes.

The three literature review articles above found that the challenges of implementing e-learning during the pandemic include three roles, students, lecturers, and institutions. Two of the three roles have technological challenges, namely in infrastructure technology, such as connectivity and access capabilities, and application technology in the form of a Learning Management System (LMS) and other supporting applications. The current discussion of e-learning systems is about computer and information technology (ICT) [Ghosh, 2020]. The writing of this literature study will then focus on the role of students and lecturers.

Finally, the research question (RQ) is how to implement the e-learning system during the covid-19 pandemic and what best technology to use. The aim is to present an overview of designing an e-learning system by considering each role's technological capabilities as a reference in writing this paper, using a literature review with keywords on relevant and reputable sources from 2019 to the present.

2. Methods

Solving the research questions above requires a method that directs the research steps in a structured and systematic way. The first step is to determine the keywords to be searched for in the scientific article journal database. There are two databases of scientific article journals in this writing, namely ScienDirect and Emerald. These keywords can be explained into two main words: e-learning technology and the covid-19 pandemic, which were later developed into similar sentences. E-learning can be developed into: "electronic learning," "online learning," and "web-based learning." As for the ruling, the Covid-19 pandemic remains. The publication period is determined to refer to the covid-19 pandemic period starting in 2020. In searching the Science Direct database, the following script is used: (E-learning OR "electronic learning" OR "online learning) AND Technology AND Covid-19.

The following is an explanation in the table for the search criteria:

Table 1 Limitations of searching criteria

No	Searching Criteria	Limitation
1.	Database	ScienceDirect and Emerald
2.	Search within	Article title, Abstract
3.	Search document	E-learning, Technology, Covid-19
4.	Type of access	ScienceDirect = All , Emerald = Open Access
5.	Year	2020 – present
6.	Subject area	Computer Science
7.	Source type	Journal
8.	Language	English
9.	Data akses	May 18 2021

The next step is refining the article, divided into several stages, namely the first stage by separating the year of publication, namely 2019 to 2021, and the type of article; Review articles, Research articles, and subject areas; computer science.

In the ScienceDirect database, 518 articles were obtained (on May 18, 2021), consisting of 45 reviews and 473 research articles. Next is the selection stage for the article's content by reviewing the abstract and title, which focuses on the combination of e-learning or online learning keywords and the word covid-19. In this step, 14 articles were obtained. Meanwhile, in the emerald database using the same query in the search facility and limited to articles from 2019 to 2020, 66 reports were obtained, consisting of 34 and 32 Earlycite pieces. Furthermore, the selection was carried out by reading abstracts focused on science directly, getting nine articles relevant to the discussion.

Furthermore, 14 and 9 articles were read in-depth, considering the review results in the introduction section. The final results were 19 articles. The following is an image that explains the process:
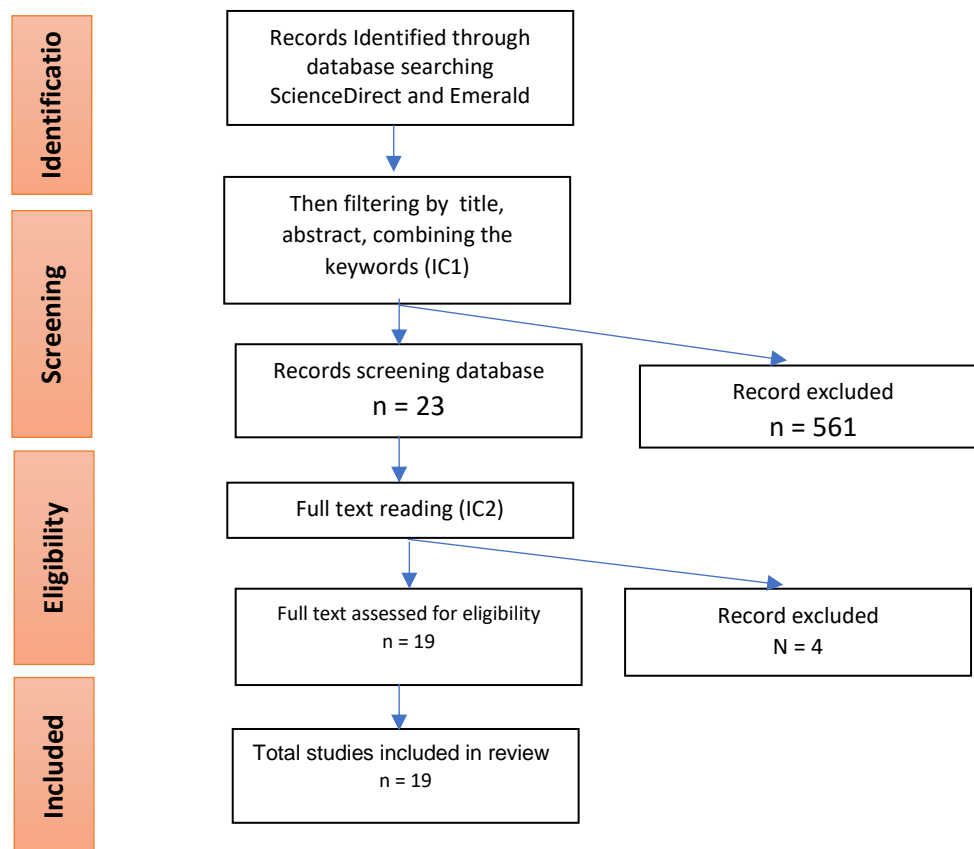

Figure 1 Article search and selection process

The generated table refers to the basic information needs of an article (theme, authors, objectives, discussions and conclusions) coupled with a review that refers to the formulation of the problem, namely regarding technology in e-learning on the side of lecturers and students. The technology field is divided into two things [18], namely infrastructure and computer applications. The following is the generated table:

Table 2. Review of data synthesis from Role and Technology of e-learning

Technology	Role	Ref
Infrastructure	Teacher	[20], [21], [23], [24], [25], [26], [27], [28], [29], [33], [36], [37]
	Student	[20], [21], [23], [24], [25], [26], [27], [29], [32], [33], [35], [36], [37]
Application	Teacher	[19], [20], [21] , [23], [24], [25], [26], [27], [28], [29], [30], [31], [32], [33], [34], [35], [36], [37]
	Student	[19], [20], [21], [22], [23], [24], [25], [26], [27], [29], [31], [32], [33], [34], [35], [36], [37]

3. Results and Discussion

Referring to the explanation of the research method above, the author analyzes it based on two things: technology review and user role review. Of the 23, four articles are not relevant to RQ. The final results are 19 articles used as discussion material in the sub-sections consisting of Infrastructure for teachers and students and Applications for teachers and students.

3.1 Infrastructure for teachers and students

From the literature review results on the infrastructure in the e-learning system, both for students and teachers, it can be distinguished in two ways: Infrastructure as an internet access point and supporting Infrastructure for e-learning applications. Infrastructure as an internet access point is divided into two: those provided by the Internet Service Provider (ISP) and those offered by cellular phone operators. Meanwhile, Infrastructure as a support for e-learning applications or e-learning access tools can be described as a server device and a personal access device.

Table 3 Teacher and Student Infrastructures

Infrastructure	Description	Ref
Internet Access	Internet Service Provider (ISP)	[19],[20],[21]
	Cellular Operator	[19],[20],[21]
Access device	Server	[22]
	Personal device	[20],[23]

Infrastructure as a means of internet access has a strategic role in implementing e-learning during the COVID-19 pandemic. There are two kinds of infrastructure for internet access: infrastructure provided by ISPs and infrastructure for cellular telephone operators [Favale, 2020]. The infrastructure of the ISP sometimes has a narrow reach, so there are often differences in the quality of internet access between students and teachers. Meanwhile, the infrastructure of cellular operators depends on the quality of service and the quality of mobile devices [Kulal, 2020], such as smartphones. This affects the quality of learning using audio and video [Rizvi, 2021].

Two things support the infrastructure of e-learning applications as servers, namely those provided by institutions and applications provided by third parties, namely following cloud computing service providers termed Cloud Computing Environment (CCE) [Alashhab, 2020]. CCE could save on infrastructure needs, especially for big data technology applications with Artificial Intelligence (AI). On the other hand, CCE can make old, reused devices.

The above illustrates that both teachers and students must carry out activities from their respective homes, so they require personal infrastructure known as Work From Home (WFH), which can be adapted into Teach From Home (TFH) and Learning From Home (SFH). There are many infrastructure options for those living in urban areas, unlike those living in rural areas. In addition, the lack of infrastructure for online classes, such as the availability of smartphones or laptops and network problems, are the main problems or reasons for the lack of online courses [Cardullo, 2021.

3.2 Applications for teachers and students

For applications for teachers and students in the e-learning system during the covid-19 pandemic, the literature can be explained in two ways. That is a learning management application, often termed a Learning Management System (LMS), and learning applications. Besides, in terms of use, it is also divided into synchronous and asynchronous.

Table 4 Teacher and Student Application

Application	Description	Ref
Learning Management	LMS	[23]**,**[24]
	Cloud LMS	[25]**,**[19]**,**[22]**,**[24]
Learning Application	Synchronous	[26]**,**[19]**,**[27]**,**[28]
	Asynchronous	[29]**,**[30]**,**[31]**,**[27]

Learning management applications (LMS) provide features that can be adapted to the needs of an educational institution in implementing e-learning; however, it requires a teacher's skills to explore this platform[Cardullo, 2021]. Besides, there are currently developing cloud-based Learning Management application services providers, such as Google Classroom [Saidi, 2019] and Microsoft Teams [Favale, 2020], which can increase cost-effectiveness and efficiency [Alashhab, 2020]. In its development, the LMS is also equipped with an Intelligent Tutoring System, an interactive application program that applies methods in artificial intelligence [Marciniak, 2020]. LMS applications and cloud-based LMS must consider users who often use mobile devices [Klimova, 2020]. In addition, there is also a Virtual Learning Environment (VLE) which is similar to an LMS but has several different functions [Rizvi, 2021]

Next is the application related to the implementation of learning, which can be divided into two, namely synchronous and asynchronous learning. Synchronous learning is where teachers and students can interact directly, usually using video conferencing applications such as zoom [Alkhowailed, 2020], BigBlueButton application [Favale, 2020], etc. In addition, synchronous learning can use social media applications such as Whatsapp [Alkhowailed, 2020].

During the COVID-19 pandemic, synchronous video conferencing learning increased by two-thirds [Santiago, 2021].

Asynchronous applications are used to develop learning materials prepared by teachers, which can be a combination of images, videos, audio tracks Etc [De Notaris, 2021]. For learning videos, teachers can design their own or use other available videos adapted to the structure of digital lesson work [Hrastinski, 2021]. In digital learning, three levels of teacher-initiated learning activities can be explained, namely low level (Powerpointers), moderate level (Clickers), and high level (Digital pros), so that they can be described in three general types of learning settings, namely lectures, seminars and online courses [Lohr, 2021].

A survey that exploits learners' experience, needs, expectations, and challenges in the online learning environment explains that using synchronous and asynchronous applications correlates with high student satisfaction [Chen, 2021]. Besides, the level of success in online learning is also influenced by personal teachers and students [Sailer, 2021].

3. Conclusion
The purpose of this article is to present an overview of designing an e-learning system by considering the technological capabilities of each role involved and the functions that have technology challenges are teachers and students. For technology in the implementation of e-learning, the preliminary study refers to infrastructure technology and application technology.

Infrastructure Technology in the e-learning system, referring to the literature study, can be divided into Internet access and access devices. There is a choice of using an ISP or accessing through a cellular operator, while the required access devices are servers and personal devices for Internet access.

While in application technology, the use of LMS is either self-managed or through cloud computing service providers. Furthermore, synchronous applications can also be explained through video conferencing and applications used to develop learning materials.

The following work in continuing this research measures cost requirements in using resources during online learning. This is intended to be a recommendation for the development of the e-learning system in the future.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers.

References

[1]. Alkhowailed M.S. (2020). Digitalization plan in medical education during COVID-19 lockdown, *Inform Med Unlocked*, 100432, 2020, DOI: 10.1016/j.imu.2020.100432.

[2]. APJII. (2018) Penetrasi & Profil Perilaku Pengguna Internet Indonesia Tahun *Apjii*. 51

[3]. Al-Rahmi *W.M.* (2018). Use of E-Learning by University Students in Malaysian Higher Educational Institutions: A Case in Universiti Teknologi Malaysia, *IEEE Access*. 6, 14268–14276 DOI: 10.1109/ACCESS.2018.2802325

[4]. Aini, Q, Budiarto, M and Rahardja, U. (2020). Exploring E-learning Challenges During the Global COVID-19 Pandemic: A Review, *Jurnal Sistem Informasi*, 57–65, 2020, DOI: 10.21609/jsi.v16i2.1011.

[5]. Alashhab, Z.R, Anbar, M, Singh, Y.-B. Leau, Z. A. and Abu S. A. (2020). Impact of coronavirus pandemic crisis on technologies and cloud computing applications, *Journal of Electronic Science and Technology*. 100059, 2020, doi: 10.1016/j.jnlest.2020.100059.

[6]. Ciolacu, M, Svasta, P.M Berg, W and Popp, H. (2017). Education 4.0 for tall thin engineer in a data-driven society, *2 IEEE 23rd International Symposium for Design and Technology in Electronic Packaging, SIITME 2017 - Proceedings*, vol. 2018-Janua, pp. 432–437, 2018, DOI: 10.1109/SIITME.2017.8259942.

[7]. Cardullo, V., Wang, C., Burton, M and Dong, J. (2021). K-12 teachers' remote teaching self-efficacy during the pandemic, *Journal of Research in Innovative Teaching & Learning*. 32–45, 2021, doi: 10.1108/jrit-10-2020-0055.

[8]. Chen, C and Landa, S. (2021). A. Padilla, and J. Yur-Austin, "Learners' experience and needs in online environments: adopting agility in teaching, *Journal of Research in Innovative Teaching & Learning*, doi: 10.1108/jrit-11-2020-0073.

[9]. Djalante *R.* (2020) Review and analysis of current responses to COVID-19 in Indonesia: Period of January to March *Pros in Disaster Science*, 2020, DOI: 10.1016/j.pdisas.2020.100091.

[10]. Dominic, M, Francis, S and Pilomenraj, A. (2014). E-Learning in Web 3 . 0," *I.J. Modern Education and Computer Science*, 2 8–14 DOI: 10.5815/ijmecs.2014.02.02.

[11]. De Notaris, D, Canazza, S, Mariconda, C and Paulon, C. (2020). How to play a MOOC: Practices and simulation," *Entertain Comput*, 100395, 2021, DOI: 10.1016/j.entcom.2020.100395.

[12]. Favale, T, Soro, F, Trevisan, M, D and Mellia, M. (2020). Campus traffic and e-Learning during COVID-19 pandemic, *Computer Networks*, DOI: 10.1016/j.comnet.2020.107290.

[13]. Ghosh, S, Muduli, A and Pingle, S. (2020). Role of e-learning technology and culture on learning agility: An empirical evidence, *Human Systems Management*. 1–14 DOI: 10.3233/hsm-201028.

[14]. Horton, W. (2023). E-LEARNING TOOLS AND TECHNOLOGIES Planning your toolkit," no. September

[15]. Hrastinski, S. (2021). Digital tools to support teacher professional development in lesson studies: a systematic literature review, *International Journal for Lesson and Learning Studies*. 138–149, 2021, doi: 10.1108/IJLLS-09-2020-0062.

[16]. Junus, K, Santoso, H.B, Putra, P.OH and Siswantining, T. (2021). Lecturer readiness for online classes during the pandemic: A survey research, *Educ Sci (Basel)*, DOI: 10.3390/educsci11030139.

[17]. Kulal A and Nayak, A. (2020). A study on perception of teachers and students toward online classes in Dakshina Kannada and Udupi District, *Asian Association of Open Universities Journal*, vol. 285–296, 2020, DOI: 10.1108/aaouj-07-2020-0047.

[18]. Klimova, B. (2020). Benefits of the use of mobile applications for learning a foreign language by elderly population," *Procedia Comput Sci* DOI: 10.1016/j.procs.2020.09.255.

[19]. Lohr *A. (2021)*. On powerpoints, clickerers, and digital pros: Investigating the initiation of digital learning activities by teachers in higher education," *Comput Human Behav*, 106715, 2021, DOI: 10.1016/j.chb.2021.106715.

[20]. Lopez-Leon, S, Forero, D and Ruiz-Díaz, P. (2020) "Twelve Tips for Working from Home. Doi: 10.35542/osf.io/yndcg.

[21]. Lopez-Leon, S. F, and Ruiz-Díaz, P. (2020). Recommendations for working from home during the COVID-19 pandemic (and beyond), *Work*. 371–375 DOI: 10.3233/WOR-203187.

[22]. Mseleku, Z. (2020). A Literature Review of E-Learning and E-Teaching in the Era of Covid-19 Pandemic," *Int J Innov Sci Res Technol*, 5 588–597, 2020.

[23]. Masud M.A.H and Huang, X. (2012). An e-learning system architecture based on cloud computing," *System*. 74–78, DOI: 10.1.1.221.4704.

[24]. Marciniak J and Szczepanski, M. (2020). Individualized learning in a course with a tight schedule," *Procedia Comput Sci*, vol. doi: 10.1016/j.procs.2020.09.242.

[25]. Ngampornchai A and Adams, J. (2016). Students' acceptance and readiness for E-learning in Northeastern Thailand," *International Journal of Educational Technology in Higher Education*, DOI: 10.1186/s41239-016-0034-x.

[26]. Resdasari, P.A, Nurtjahjanti, H and Ardhiani, L.N. (2021). Impact of Changes in Teaching Methods During the COVID-19 Pandemic: The Effect of Integrative E-Learning on Readiness for Change and Interest in Learning Among Indonesian University Students," *International Review of Research in Open and Distributed Learning*, doi: https://doi.org/10.19173/irrodl.v22i2.5143.

[27]. Rubens, D. K and Okamoto, T. (2014). E-Learning 3.0: Anyone, Anywhere, Anytime, and, 171–172

[28]. Rizvi Y.S and Nabi, A. (2021) Transformation of learning from real to virtual: an exploratory-descriptive analysis of issues and challenges," *Journal of Research in Innovative Teaching & Learning*. 5–17, 2021, doi: 10.1108/jrit-10-2020-0052.

[29]. Saidi, R., Sharip, A.A and Zain, S.M. (2019). Evaluating Students ' Preferences of Open and Distance Learning Evaluating Students ' Preferences of Open and Distance Learning (ODL) Tools (ODL) Tools, *Procedia Comput Sci*, vol.955–961, doi: 10.1016/j.procs.2021.01.085.

[30]. Santiago, I.P, Ángel, H.G, Julián, C.P and Prieto, J.P. (2021). Emergency Remote Teaching and Students' Academic Performance in Higher Education during the COVID-19 Pandemic: A Case Study, *Comput Human Behav*, vol. doi: 10.1016/j.chb.2021.106713.

[31]. Simanihuruk *L.* (2019) E-Learning Dan Sejarahnya," in *E-Learning: Implementasi, Strategi dan Inovasinya*, Jakarta, 2. 6.

[32]. Sailer, M, Schultz-Pernice, F and Fischer, F. (2021). Contextual facilitators for learning activities involving technology in higher education: The C♭-model," *Computers in Human Behavior*, doi: 10.1016/j.chb.2021.106794.

[33]. Xaymoungkhoun, O, Bhuasiri, W, Rho, J.J, and Kim, M.G. (2012). The critical success factors of e-learning in developing countries, *Kasetsart Journal - Social Sciences*, 33(2) 321–332, 2012, doi: 10.1016/j.compedu.2011.10.010.