

A Review of COVID-19's Digitalisation of Built Environment Education

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Abstract: The coronavirus pandemic that unexpectedly took over the world in early 2020 has resulted in the rapid digitalisation of education in the built environment. The closure of higher education institutes due to the global shutdown instituted by authorities significantly impacted the academic realm. As a result, traditional face-to-face teaching and learning in engineering education programs had to transform to a completely online learning pedagogy. However, a seamless shift to an online pedagogy in a developing country such as South Africa was difficult as it exposed several challenges. These challenges have since become the 'new normal' in higher education institutes of developing countries including engineering programs. A comprehensive traditional literature review focusing on online learning due to the pandemic was conducted. This study provides an overview of the various pedagogical approaches adopted from research databases. The keywords 'Online learning', 'E-Learning', 'Construction education' and 'Online pedagogy' were used to search the databases. Findings from the study revealed that various pedagogies were implemented online to assist students to adapt to the online mode of instruction. However, it was further identified that students in developing countries faced technical challenges accessing digital work, challenges accessing online learning platforms, internet connectivity, adequacy of technology and challenges adapting to a student centred approach.

Keywords; Academic, Built environment, Coronavirus, Higher education institutes, Online pedagogy, Pandemic.

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1. INTRODUCTION

1.1 Background

There are compelling conditions that can negatively impact the education sector and potentially disrupt the right of students to quality education such as disasters, student protests and pandemics like COVID -19 (Toquero, 2020). The World Health Organisation (WHO) declared COVID-19 a global pandemic on March 11th 2020 and in South Africa on March 18th 2020, the president instituted a nationwide lockdown in order to curb the spread of the virus. This resulted in a shutdown of all sectors including the closure of higher education institutes (HEI's). In order to still accommodate the academic program without prejudicing the students who now no longer could be on campus, HEI's had to consider alternatives and develop plans to ensure minimum interruption to the academic program as far as possible. To achieve this objective necessitated

transforming traditional face-to-face teaching and learning on the university campus to the virtual off campus and remote environment (Dube, 2020; Mhlanga, 2020; Peimani, 2021). In a developing country such as South Africa where the nation faces serious socio-economic inequalities, online learning presents several challenges. These challenges include the lack of suitable infrastructure and in some HEI's both instructors and students lack the necessary skills and equipment to fully utilize a virtual platform (Dube, 2020; Mpungose, 2020, World Bank Group, 2018, Du Plessis and Mestry, 2019).

2. ONLINE LEARNING AS A METHOD OF ACADEMIC INSTRUCTION

The sudden closure of educational institutions and suspension of academic programs around the globe as a result of the COVID-19 pandemic catalysed the conversion of traditional face-to-face instruction to alternative online platforms at an exponentially rapid rate (Mhlanga & Molo, 2020). As a result, academic institutions that focused solely on traditional face-to-face instruction modes of instruction in a physical classroom space encountered various challenges in the virtual migration (Baticulon et al., 2021; Rotas & Cahapay, 2020; Sundarasan et al., 2020). Students in South Africa faced many challenges due to the switch to online learning platforms such as both planned and unplanned electrical power cuts by ESKOM, poor network connectivity, insufficient data and lack of personal electronic devices (Du Plessis & Mestry, 2019; Dube, 2020; Mpungose, 2020; Shafiei Sarvestani et al., 2019).

2.1 Technology required during online learning

Online learning platforms are primarily dependent on the use of technology and the internet. The need for technical devices such as laptops and data provision for instructors and students was a challenge for HEI's in South Africa (Dube, 2020). Students from low-income households were suddenly faced with the added financial burden of having purchase data packages which in South Africa are not as inexpensive as is the case elsewhere in the world. Additionally, students that owned or used an outdated device identified that most features were unavailable as the device was not compatible with the online platforms such as MOODLE and MSTEAMS. In addition, instructors and students that resided in locations with poor network connectivity such as in the rural areas of the country may not be able to access the online platforms (Abel Jr, 2020). The unstable internet connectivity is one of the greatest challenges that negatively affects the online learning experience especially in developing countries where telecommunications have not been adequately developed (Aboagye et al., 2021) or where coverage is limited. Furthermore, students may reside in locations that have limited or no network terminals or devices that cannot navigate to the internet (Baticulon et al., 2021).

2.2 Socio-economic inequalities

As a result of the socio-economic inequalities in South Africa students rely on access to computers in computer laboratories and free Wi-Fi at HEI's (Guarner, 2020). Consequently, due to the closure of HEI's as a result of the pandemic, the transition process to the virtual world of these students occurred at a much slower pace severely prejudicing their academic performance. Undoubtedly, students that came from a low socio-economic background faced challenges since they were unable to attend HEI's due to the closure of institutes and suspension of academic programs (Gates, 2020; Mouton, 2013). In addition, most students in South Africa only have access to a basic smartphone. The online platform presents tool and features that is more suited for use on a laptop/

desktop therefore, as students did not receive devices from HEI's most were unable to access all features of the platform via their smartphone device (Pete and Soko 2020).

2.3 Digital literacy for online learning

Despite the general growth of information technology and the increased exposure to technology, instructors and students struggled to use unfamiliar technology (Minichiello, 2022). Digital literacy is the competence, skills and knowledge required when using Information and Communication Technology (ICT) and electronic devices to perform tasks in a virtual environment (Morze et al., 2021). Due to the rapid digital transformation of academic instructional delivery as a result of the pandemic, HEI libraries were forced to follow the digital trend in order to provide instructors and students with resources during online teaching and learning. However, instructors and students with a lack of digital literacy faced difficulties in the optimal utilization of digital library resources having been used to accessing physical printed resources.

3. THE ADOPTION OF ONLINE LEARNING IN THE BUILT ENVIRONMENT

The traditional face-to-face engineering education mode of instruction has been largely syllabus-driven, content- and instructor-centred and design-orientated focusing on the development of critical thinking and problem-solving skills (Bourne et al., 2005). There are various pedagogies such as flipped classrooms, project- and problem-based learning, inquiry-based and active constructivist learning that enhanced higher built environment education. Recently, access to online built environment study has become attainable but not necessarily achieved in all sub-fields of built environment careers. The use of online learning in the built environment has been limited to basic functions such as a tool for students to access course notes uploaded by the instructor (Mushtaha, 2022; Adhikari, 2021; Arif, 2022 and Saw, 2020).

The rapid transition to completely full time online teaching and learning in a short transitional time as a result of the pandemic necessitated a need to discover alternative and unfamiliar teaching and learning strategies within the entire educational spectrum (Abdulkareem, 2022). Consequently, HEI's with a traditional face-to-face teaching and learning background and focus faced severe challenges with the conversion to a completely virtual environment (Besser, 2020; Svatos, 2022; García-Alberti, 2021). Table 1 highlights key findings of studies in the built environment sector and the use of virtual tools and platforms adopted.

Table 1: Systematic literature review of related studies

#	Authors/ Year	Title of Study	Study Findings
1	Mohammed, Zoghby and Elmesalawy, 2020	Remote Controlled Laboratory Experiments for Engineering Education in the Post-COVID-19 Era: Concept and Example	Remote-controlled experimentations were implemented thereby providing students with the practical work required in a way that is achieved in traditional face-to-face physical laboratories.
2	Asgari, 2021	An observational study of engineering online	The implementation of ZOOM breakout rooms were utilised to encourage group

		education during the COVID-19 pandemic.	discussions, problem-solving, critical thinking activities and reflective analysis among students. Additionally, “home lab kit” methods was introduced by recording hands-on experiments and availing this to students.
3	Kapilan, Vidhya, and Gao, 2021	Virtual Laboratory: A Boon to the Mechanical Engineering Education During Covid-19 Pandemic.	A method was implemented whereby Students attended theoretical training on virtual fluid mechanics (FM) laboratory. Students further conduct virtual experiments in a hypothetical environment on a digital device based on the demonstration given by the instructors. Instructors additionally recorded real experiments giving students the ability to reflect and discuss their findings.
4	Malhotra, 2020	Paradigm Shift in Engineering Education During COVID 19: From Chalkboards to Talk Boards.	The study identified the implementation of interactive webinars provided a positive feedback from students therefore providing an opportunity to reflect and discuss topics. Students agreed that learning outcomes was successfully achieved through the online teaching method.
5	Rassudo and Korunets, 2020	COVID-19 Pandemic Challenges for Engineering Education	A Digital Twin concept was implemented for laboratory installation to simulate the work of the properly working equipment. Some changes were implemented into the experimental setup and the students were to diagnose it and discuss and reflect the results online. Therefore, enabling students to operate real hardware not available at home.
6	ElSary, 2021	Using a Reflective Practice Model to Teach STEM Education in a Blended Learning Environment	The implementation of the STEM curriculum during online learning allowed student engagement in an experiential learning environment (Inquiry based learning and project based learning) this provided several check points to reflect on their learning and obtain constructive feedback. This indicated a positive outcome as it created a differentiated learning environment where individual goals and needs are met.

4. METHOD

4.1 Research approach

This study identified Science direct and Scopus as a source of data due to their widespread coverage of global research publications (Hosseini, 2018). The databases were considered as a primary scientific research database (Olawumi, 2018). A comprehensive selection process was adopted to sieve pertinent publications on the database and centred only on relevant publications

in English. A retrieval of publications was undertaken on the 13th of July 2022, with 546 publications identified. In addition, a keyword search was undertaken to filter out unrelated publications, with keywords such as “COVID-19”, “Engineering education”, “Built Environment education”, “Online Learning”, “Online pedagogies”, “Construction Instructors”, “E-Learning”. Various combinations of the keywords were used in order to validate the range of the search results. The results of a search on different platforms reviewed 5,100 publications that were further filtered to 126 and 11 relevant publications were eventually referred to for the literature review.

5. CONCLUSION

The paper provided a systematic traditional literature review on the transition of face-to-face teaching and learning to an online instructional mode within the built environment and engineering sector. Existing literature on the adoption of online engineering education in particular in South Africa as a result of the pandemic is limited, and there is no thorough (qualitative and quantitative) analysis on the online adoption procedures and strategies. This study adds to the developing body of knowledge on the adoption and implementation of online engineering education as opposed to traditional instruction in a physical classroom space on campus. Literature has identified the use of reflective practice as a positive outcome to the few programmes that have adopted it therefore, it is suggested that the use of reflective practice ought to be emphasised and integrated into online engineering education. Reflective practice in particular to engineering education assists in the analysis and understanding of real life concepts and theories enabling graduates to identify and recognise events thereby create new distinctions and advancement in the world of work. The unanswered question is whether reflective practice is indeed possible in a complete virtual and digital instructional environment where there is no largescale interaction between students and instructors. The pandemic had a significant influence on and the pace of the digitalisation of teaching and learning practices within HEI’s with both negative and positive outcomes. However in a developing country such as South Africa, where smartphones are used as a primary source to access online learning it is suggested that HEI’s ensure the tools and features used on online platforms are more readily available, accessible and compatible for use on a smartphone. The measures and practices implemented might be here to stay, including the use of digital devices, recorded instructor videos, innovative course content, podcasts, questionnaires and quizzes and virtual laboratories therefore, HEI’s should ensure infrastructure is compatible with online learning requirements as well as provide instructors with adequate support and training to allow instructors optimal use and familiarity of the online platforms. The novel pandemic has additionally allowed developing countries an opportunity to rectify the socio-economic inequalities within HEI’s perhaps by providing students with laptops or set up home desktop stations for students to enable students to have access to online learning and ensure a seamless transition and adoption under the ‘new normal’.

6. REFERENCES

6.1 Reference List

Adhikari, S., Langar, S., & Mosier, R. (2021). *Construction Educators’ Challenges during COVID-19 Transition from F2F to Online Setting: A Case Study in the Southeastern United States*. In 2021 ASEE Southeastern Section Conference.

Arif, M. T., & Shafiullah, G. M. (2022). *Exploring Teaching and Learning Experience during COVID-19 Pandemic in Engineering Education*. Sustainability, 14(12), 7501.

Abdulkareem, Z. O., Abdulkareem, S. A., & Mustapha, I. B. (2022). *Engineering Students' Perception of Online Learning During the Emergency Nationwide Lockdown in Nigeria*. SN Computer Science, 3(4), 1-8.

Abel Jr, A. (2020). *The phenomenon of learning at a distance through emergency remote teaching amidst the pandemic crisis*. Asian Journal of Distance Education, 15(1), 127-143.

Aboagye, E., Yawson, J. A., & Appiah, K. N. (2021). *COVID-19 and E-learning: The challenges of students in tertiary institutions*. Social Education Research, 1-8.

Asgari, S., Trajkovic, J., Rahmani, M., Zhang, W., Lo, R. C., & Sciortino, A. (2021). *An observational study of engineering online education during the COVID-19 pandemic*. Plos one, 16(4), e0250041.

Baticulon, R. E., Sy, J. J., Alberto, N. R. I., Baron, M. B. C., Mabulay, R. E. C., Rizada, L. G. T., Tiu, C. J. S., Clarion, C. A., & Reyes, J. C. B. (2021). *Barriers to online learning in the time of COVID-19: A national survey of medical students in the Philippines*. Medical science educator, 1-12.

Besser, A., Flett, G. L., & Zeigler-Hill, V. (2020). *Adaptability to a sudden transition to online learning during the COVID-19 pandemic: Understanding the challenges for students*. Scholarship of Teaching and Learning in Psychology.

Bourne, J., Harris, D., & Mayadas, F. (2005). *Online engineering education: Learning anywhere, anytime*. Journal of engineering education, 94(1), 131-146.

Du Plessis, P., & Mestry, R. (2019). *Teachers for rural schools—a challenge for South Africa*. South African Journal of Education, 39.

Dube, B. (2020). *Rural online learning in the context of COVID 19 in South Africa: Evoking an inclusive education approach*. Multidisciplinary Journal of Educational Research, 10(2), 135-157.

ElSayary, A. (2021). *Using a Reflective Practice Model to Teach STEM Education in a Blended Learning Environment*. Eurasia Journal of Mathematics, Science and Technology Education, 17(2).

García-Alberti, M., Suárez, F., Chiyón, I., & Mosquera Feijoo, J. C. (2021). *Challenges and experiences of online evaluation in courses of civil engineering during the lockdown learning due to the COVID-19 pandemic*. Education Sciences, 11(2), 59.

Gates, B. (2020). *Responding to Covid-19—a once-in-a-century pandemic?*. New England Journal of Medicine, 382(18), 1677-1679.

- Guarner, J. (2020). *Three emerging coronaviruses in two decades: the story of SARS, MERS, and now COVID-19*. *American journal of clinical pathology*, 153(4), 420-421.
- Hosseini, M. R., Maghrebi, M., Akbarnezhad, A., Martek, I., & Arashpour, M. (2018). *Analysis of citation networks in building information modeling research*. *Journal of Construction Engineering and Management*, 144(8), 04018064.
- Kapilan, N., Vidhya, P., & Gao, X. Z. (2021). *Virtual laboratory: A boon to the mechanical engineering education during covid-19 pandemic*. *Higher Education for the Future*, 8(1), 31-46.
- Malhotra, S., Dutta, R., Daminee, A. K., & Mahna, S. (2020, September). *Paradigm Shift in Engineering Education During COVID 19: From Chalkboards to Talk Boards*. In 2020 12th International Conference on Computational Intelligence and Communication Networks (CICN) (pp. 287-293). IEEE.
- Mhlanga, D., & Molo, T. (2020). *COVID-19 and the Digital Transformation of Education: What Are We Learning on 4IR in South Africa?* *Education Sciences*, 10(7), 180.
- Minichiello, A., Lawanto, O., Goodridge, W., Iqbal, A., & Asghar, M. (2022). *Flipping the digital switch: Affective responses of STEM undergraduates to emergency remote teaching during the COVID-19 pandemic*. *Project Leadership and Society*, 3, 100043.
- Mohammed, A. K., El Zoghby, H. M., & Elmesalawy, M. M. (2020, October). *Remote controlled laboratory experiments for engineering education in the post-COVID-19 era: Concept and example*. In 2020 2nd Novel Intelligent and Leading Emerging Sciences Conference (NILES) (pp. 629-634). IEEE.
- Morze, N., Varchenko-Trotsenko, L., Terletska, T., & Smyrnova-Trybulska, E. (2021). *Implementation of adaptive learning at higher education institutions by means of Moodle LMS*. *Journal of Physics: Conference Series*,
- Mouton, N., Louw, G. P., & Strydom, G. (2013). *Critical challenges of the South African school system*. *International Business & Economics Research Journal (IBER)*, 12(1), 31-44.
- Mpungose, C. B. (2020). *Emergent transition from face-to-face to online learning in a South African University in the context of the Coronavirus pandemic*. *Humanities and Social Sciences Communications*, 7(1), 1-9.
- Mushtaha, E., Dabous, S. A., Alsyof, I., Ahmed, A., & Abdraboh, N. R. (2022). *The challenges and opportunities of online learning and teaching at engineering and theoretical colleges during the pandemic*. *Ain Shams Engineering Journal*, 13(6), 101770.
- Olawumi, T. O., & Chan, D. W. (2018). *A scientometric review of global research on sustainability and sustainable development*. *Journal of cleaner production*, 183, 231-250.

Peimani, N. and H. Kamalipour, *Online Education and the COVID-19 Outbreak: A Case Study of Online Teaching during Lockdown*. Education Sciences, 2021. 11(2).

Pete, J., & Soko, J. (2020). *Preparedness for online learning in the context of Covid-19 in selected Sub-Saharan African countries*. Asian Journal of Distance Education, 15(2), 37-47.

Rassudov, L., & Korunets, A. (2020). *COVID-19 pandemic challenges for engineering education*. In 2020 XI International Conference on Electrical Power Drive Systems (ICEPDS) (pp. 1-3). IEEE.

Rotas, E., & Cahapay, M. (2020). *Difficulties in remote learning: voices of philippine university students in the wake of COVID-19 Crisis*. Asian Journal of Distance Education, 15(2), 147-158.

Ryan, T. G., Toye, M., Charron, K., & Park, G. (2012). *Learning management system migration: An analysis of stakeholder perspectives*. The International Review of Research in Open and Distributed Learning, 13(1), 220-237.

Saw, G. K., Chang, C. N., & Lomeli, U. (2020). *Fall enrollment and delayed graduation among stem students during the COVID-19 pandemic*. The Network for Research and Evaluation in Education (NREED) Data Brief, (1).

Shafiei Sarvestani, M., Mohammadi, M., Afshin, J., & Raeisy, L. (2019). *Students' experiences of e-learning challenges; a phenomenological study*. Interdisciplinary Journal of Virtual Learning in Medical Sciences, 10(3), 1-10.

Sundarasan, S., Chinna, K., Kamaludin, K., Nurunnabi, M., Baloch, G. M., Khoshaim, H. B., Hossain, S. F. A., & Sukayt, A. (2020). *Psychological impact of COVID-19 and lockdown among university students in Malaysia: Implications and policy recommendations*. International journal of environmental research and public health, 17(17), 6206.

Svatos, J., Holub, J., Fischer, J., & Sobotka, J. (2022). *Online teaching of practical classes under the Covid-19 restrictions*. Measurement: Sensors, 100378.

Toquero, C. M. (2020). *Challenges and Opportunities for Higher Education Amid the COVID-19 Pandemic: The Philippine Context*. Pedagogical Research, 5(4).

World Bank Group. (2018). *Overcoming poverty and inequality in South Africa: An assessment of drivers, constraints and opportunities*. World Bank.