

## **Online Teaching and Learning Within the Context Of Covid-19: Exploring the Perceptions of Postgraduate Mathematics Education Students**

**Jayaluxmi Naidoo<sup>1</sup>, Asheena Singh-Pillay<sup>2</sup>**

<sup>1</sup>Mathematics and Computer Science Education, School of Education, University of KwaZulu-Natal, South Africa

<sup>2</sup> Science and Technology Education, School of Education, University of KwaZulu-Natal, South Africa

<sup>1</sup>Email: [naidooj2@ukzn.ac.za](mailto:naidooj2@ukzn.ac.za)

### **Abstract**

The COVID-19 pandemic has resulted in education institutions using online pedagogy instead of face to face pedagogy to limit the virus's spread. This study aimed to explore postgraduate mathematics education students' perceptions of online teaching and learning within the context of COVID-19. For this qualitative, interpretive case study, forty-seven participants were purposively selected from one university in South Africa. The theoretical lens of Virtual Communities of Practice was used to generate data via three interactive online discussion forums. All data were analysed thematically, and the results revealed two main findings. These findings are that the participants perceived strengths and challenges to online teaching and learning within the ambits of COVID-19. Further in-depth analysis of these two main findings reveals the sub themes of unequal access to data and devices, limited connectivity, access to recordings of lectures and resources at any time and support provided by the virtual communities of practice. This study concludes with suggestions and implications for online teaching and learning for universities in developing countries. These suggestions include that to avoid the challenges of online teaching and learning, the lecturer needs to verify that students have equal access to technology-based devices, data and students require stable Internet connections to participate equally in online teaching and learning. The strengths of collaboration and accessing uploaded content, resources, and material conveniently were also revealed in this study

**Keywords:** COVID-19; Developing Country; Fourth Industrial Revolution; Mathematics; Virtual Communities of Practice

### **INTRODUCTION**

The Fourth Industrial Revolution (4IR) is depicted as integrating the physical and online domain, creating a transformed and globally connected society (Schwab, 2016). Within the Fourth Industrial Revolution's ambitions, on a global level, technology is being used in all spheres of life (Hoosain et al., 2020). However, there has been criticism of the 4IR whereby research (Gera & Singh, 2019) maintains that society is becoming compliant with machine learning, technological changes, artificial intelligence and robotics. Research has also been done on the anxiety that people are exposed to due to the need to accomplish more because of rapid technology advancements (Coldwell, 2019).

Moreover, there has been some critique of the 4IR and the impact of this era on underdeveloped and developing countries. Many countries that are underdeveloped or developing do not have access to technological devices, stable Internet services, or sufficient infrastructure to ensure that all society can access the basic and essential devices to participate equally within a technologically advanced community (Zervoudi, 2020). Apart from access to the necessary devices and infrastructure to be successful within the 4IR, an essential prerequisite is training and development in the use of technology (Hoosain et al., 2020; Zervoudi, 2020). Students and lecturers need to practice using technology within educational contexts, and they need to be exposed to and encouraged to participate in online teaching and learning. However, in most developing countries, for example, South Africa, preparing lecturers and students for online teaching and learning is barely underway, and we now find ourselves amid an unparalleled global pandemic-COVID-19.

The COVID-19 pandemic has changed our everyday routines, and we are undergoing a new normal of social distancing, sanitising frequently and wearing a fabric face mask in public. The learning environment for the COVID-19 pandemic is mainly online and remote. Hence, in these global lockdown settings, Higher Education Institutions (HEIs), which are also tasked with encouraging graduates to transform and improve society (Belaineh, 2017), are endeavouring to complete the academic year via online teaching and learning (Valverde-Berrocoso et al., 2020).

The change to online teaching and learning is based on many assumptions, such as all members of society have access to numerous devices (for example, desktop computers, laptops, tablet computers and cell phones), efficient and unlimited Internet connectivity. Bolton (2019) indicated that technologies, such as E-Learning and M-Learning, combined with current content material for mathematics, need to be used in developing countries like Kenya, Ethiopia, Malawi, Rwanda, Nigeria, South Africa, Uganda, Zimbabwe and Zambia. E-Learning refers to learning that incorporates technology-based tools to work with educational content beyond a traditional face-to-face educational context. M-learning is also known as mobile learning, refers to the learning of educational content by using personal devices, for example, cell phones, tablets, laptops and I-Pads. This may be considered as a means of remote or online learning where m-learners can use mobile devices at any time and at a location that is convenient for them. This is a change from the traditional face-to-face learning approach. However, in the South African context and the contexts of many other developing countries, the reality is that due to poverty, many members of society do not have access to the Internet, data and devices (United Nations, 2019) to participate equally within an online environment. Furthermore, many people do not have stable Internet connectivity, especially those who live in rural areas (Woolley et al., 2020). Hence, in this article, the focus is on a study that sought to respond to the question: What are postgraduate mathematics education students' perceptions of online teaching and learning within the context of COVID-19?

### **Online Teaching and Learning**

Research (Harris et al., 2016) revealed that using technology for teaching and learning has enhanced student performance. Online teaching and learning using the Internet is perceived to circumvent the spread of COVID-19 (Murgatrottd, 2020). Thus, substantial national strategies that promote the use of technology-based devices (for example, desktop computers, laptops, tablet computers and cell phones) to support online teaching and learning in South Africa during the global COVID-19 pandemic are evolving quickly.

Within this study, technology-based devices include online platforms and Internet-based tools used with computers or portable devices that transmit text, audio-visuals and images to support online teaching and learning (Peachey, 2017). Thus, many HEIs are proceeding to incorporate technology-based devices (for example, tablet computers, laptops, cell phones, netbooks and collaborative online platforms such as Zoom, Google Meet and Google Drive/Classroom) within online teaching and learning. Zoom is a software application (app). This app allows one to network virtually with colleagues, family, friends, and students when communication through face-to-face means is impossible.

However, while online teaching and learning strategies have existed for many years (Gillett-Swan, 2017), to succeed with online teaching and learning requires that both students and lecturers access the Internet, data and technology-based devices. Additionally, they need to be adequately trained to use these technology-based devices (Johnson et al., 2016).

### **Online Mathematics Teaching and Learning**

Technology has led to advancements in society; however, many students are not competent users of technology (Johnson et al., 2016) or do not have access to the required technology-based devices essential to participate in online teaching and learning. Moreover, in a developing country like South Africa, students' access to technology-based devices is diverse, and problems endure as students continually learn new skills in a technologically advanced society (Ng'ambi et al., 2016).

For online mathematics teaching and learning, Pope and Mayorga (2019) maintain that numerous websites and a large number of technology-based applications can support students' learning and performance. In addition, the beneficial effects of using technology-based devices for mathematics education have been supported by other research (Fabian et al., 2018; Mlotshwa & Chigona, 2018). Also, for the teaching and learning of mathematics, technology-based devices can provide access to numerous problem-solving approaches compared to using the traditional paper and pencil method (Umugiraneza et al., 2018). Moreover, mathematics teacher education within the era of the 4IR requires that teachers be sufficiently prepared to incorporate technology-based devices effectively within their educational contexts (Naidoo, 2020).

## **Inequality in Opportunities and Outcomes in South Africa**

Online teaching and learning have consequences for students living in contexts that are not conducive to online learning. For example, using a generic online teaching and learning approach can affect learning outcomes, and the level of student performance reached. All South African students do not have access to technology-based devices, the Internet, data, and other resources required to participate equally in online teaching and learning. In addition, a student's social background may influence achievement in mathematics (Panthi, 2016) due to the unequal educational opportunities available to members of South African society (Ndimande, 2016).

Most South African university students are from rural contexts and have limited access to essential services such as water, housing, sanitation, electrification, and Internet connectivity (The World Bank, 2018). Thus, students who live in rural contexts are hindered from participating equally in online learning. Some of these inequalities experienced by students in rural contexts are presented in Table 1 that follows.

**Table 1: Inequalities experienced by students living in rural contexts**

---

Factors that limit students who live in rural contexts from participating equally in online learning
Limited access to essential services
Limited access to water
Limited access to food
Limited access to housing
Limited access to electricity
Limited access to sanitation
Limited access to technology-based devices
Limited access to data
Limited access to the Internet
Unstable Internet Connectivity

---

While research (Schuck, 2016) has been focused on using technology-based devices within mathematics education, limited research has been done focusing on the implications of online teaching and learning strategies for mathematics within unequal social contexts.

## **Virtual Communities of Practice**

The Communities of Practice (CoP) theory is a social theory of learning, whereby the fundamental unit of enquiry is the CoP (Farnsworth et al., 2016). Communities of Practice progress around meaningful experiences of members within the CoP (Wenger, 2009). Wenger's (1998) CoP theory is established on four principles: people are social beings; knowledge includes significant initiatives; knowing revolves around engaging in the world, and learning supports constructing meaning. The theory upholds that CoP is shaped by individuals who participate in the process of shared learning within a community realm. Thus, CoP comprises individuals sharing a common interest in a phenomenon, and by collaboration, they

learn to develop and construct in-depth meaning concerning what they undertake (Wenger & Wenger-Trayner, 2015).

Virtual Communities of Practice are different from Communities of Practice (CoP) because of their technological element and online platform (Peñarroja et al., 2019). Through collaboration via the Internet, technology-based devices and online platforms, CoPs become progressively Virtual Communities of Practice (VCoPs). This VCoP diminishes space and time constraints for collaboration, participation, and communication. Thus, members of VCoP and members of CoP experience different settings and different realities due to the environment through which they predominantly communicate. Virtual Communities of Practice may be described as cohorts of professionals who come together by common aims and shared interests concerning participation or exchanging ideas, thereby adding to their knowledge base, meaning-making, and improving their professional practice (Mohajan, 2017). In addition, virtual Communities of Practice within formal education settings support members of the communities of practice with both professional and content development (Ekici, 2017).

As the VCoP under focus collaborated virtually, they created knowledge and developed a community that supported learning and development (Schieffer, 2016). Also, VCoP proposes a flexible structure for collaboration with peers, sharing ideas, knowledge and best practice (Mohajan, 2017). The link between VCoP theory and this study is explained as follows: VCoP has a shared area of interest; in this study, the shared interest focuses on the participants' perceptions of online teaching and learning. Within VCoP, community members engage in shared activities and critically reflect on, think and discuss the presented content (Ekici, 2017). In the study under focus, members of the VCoP used the Internet and technology-based devices to interact and collaborate via Moodle, Zoom and WhatsApp. The Learning Management System (LMS) that is being used at the participating university is Moodle. This LMS is an open-source e-learning/online platform. WhatsApp is a free messenger application (app) that uses the Internet to receive and send calls and messages. WhatsApp was unofficially used as an online platform at the university under study. This app was used as an online platform to send images, messages, video and audio files during the COVID-19 era. In addition, members of a VCoP are professionals; in this study, the members of the VCoP were mathematics teachers. Thus, this study which focused on postgraduate mathematics students' perceptions of online teaching and learning within the context of COVID-19, was framed adequately by the theory of VCoP.

## **RESEARCH METHOD**

This qualitative, interpretive case study was conducted during the first semester (15 weeks) of the 2020 academic year within the context of COVID-19. The population for the study were 47 Bachelor of Education Honours students registered at the participating university. Ethical clearance and gatekeeper access were obtained from the participating university's research office. Also, each participant was provided with an informed consent sheet explaining the study's process and purpose. This information sheet also included the participants' right to withdraw from the research. In addition, the participants provided consent for the

recording of the online discussion forums. Only students who volunteered were included in the pilot and main study selection.

The study was an in-depth qualitative case study, and 33 Postgraduate Mathematics Education (PME) students agreed to participate in the study. Ten participants (10 PME students) were selected randomly to participate in the pilot study. Through the pilot study, the research instruments were revised. Although 23 PME students agreed to participate in all three discussion forums, due to personal reasons, only 15 of the 23 PME students participated in all three discussion forums. To ensure the reliability of the data analysis, only the analysed data generated from the 15 PME students who participated in all three discussion forums are presented and discussed. To assure participants of their anonymity and confidentiality, pseudonyms, as shown in Table 2, were used.

**Table 2: Pseudonyms used for the PME students who participated in three online discussion forums for the main study**

PME student #	Pseudonym	PME student #	Pseudonym
1	Judy	9	Nozipho
2	Vusi	10	Anne
3	Cephu	11	Msizi
4	Bongani	12	Rani
5	Lerato	13	Owen
6	Thulani	14	Pranesh
7	Khethiwe	15	David
8	Sandile		

The discussion forums were randomly staggered during the semester to explore Postgraduate Mathematics Education (PME) students' perceptions of online teaching and learning during COVID-19. The reason for selecting interactive online discussion forums was so that responses for each question could be probed for clarity. The online discussion forums focussed on the following key question:

What were the participants' perceptions of online teaching and learning within the context of COVID-19? The discussion forums included the following sub questions:

*What are some of your experiences of online teaching and learning in the context of COVID-19?*

*Are there any issues that affected your participation in online teaching and learning during COVID-19?*

*Do you think that online teaching and learning is beneficial for you in the context of COVID-19?*

*Do you have possible suggestions for improving students' experiences of online teaching and learning in the context of COVID-19?*

All discussion forum responses were transcribed before conducting a thematic analysis of the generated data. Data analysis that encompassed coding and categorising themes was established on the research's conceptual framework, i.e., Virtual Communities of Practice. During the data analysis process, codes for describing participants' responses to questions on the discussion forum were identified. These codes were carefully reviewed and noted as themes. Thus,

inductive coding was used to generate themes. The two main themes identified within the context of COVID-19 were the challenges of online teaching and learning and the strengths of online teaching and learning. The data and themes were analysed further to determine sub themes within each central theme. The sub themes included unequal access to data and devices, limited connectivity, access to recordings of lectures and resources at any time and support provided by the virtual communities of practice. The main themes and sub themes are discussed in detail in the results and discussion section that follows.

## RESULTS AND DISCUSSION

While the participants engaged interactively within the online educational context, they did indicate that they experienced both challenges and strengths with online teaching and learning. The participants' responses for each main theme and sub theme are described as follows.

### *The Challenges of Online Teaching and Learning*

Although the participants did participate in this study within their Virtual Communities of Practice, all 15 PME students who participated in all stages of the main research indicated that they experienced challenges of various complexity with online teaching and learning in the context of the COVID-19 pandemic. The participants' perceptions concerning the challenges they experienced have been categorised in two sub themes as follows.

#### *Unequal access to data and devices*

Participants indicated that they experienced challenges with online teaching and learning due to unequal access to data and devices in this study. This is reflected in the following discussion forum transcripts.

**Cephu:**...the university said we students would get data for online lectures...I still did not get my data...I don't have a computer...I am struggling to cope...

**David:**...I don't have a computer, so I use my phone...hard to write assessments using the phone...

**Msizi:**...I use my phone most of the time...I don't have a computer...I used the computers at university...hard now...university is closed...

**Owen:**...I didn't receive my data until the end of the first month of online lectures...I used my home Internet...very expensive because we have online lectures on most days...

**Sandile:**...I received my data late from the university...I was buying data and using my phone... it's costly...online lectures take lots of data...

It was evident that the unequal access to data and devices influenced Postgraduate Mathematics Education (PME) students' equal participation in online teaching and learning. The participants believed that they need to have the essential supplies for online teaching and learning (for example, technology-based tools, access to data and stable Internet connectivity) to participate actively and equally in online teaching and learning (Johnson et al., 2016). Also, access to the necessary resources for teaching and learning is important for promoting independent learning (Belaine, 2017). Furthermore, the participating PME students indicated that the

Virtual Communities of Practice (VCoP) fostered active interaction (Langley et al., 2017) and supported and promoted new knowledge using different online platforms.

### ***Limited connectivity***

To ensure success with online teaching and learning, the lecturer needs to ensure that all students have an equal opportunity to succeed within the online setting. Unfortunately, this was not the case in this study since participants indicated that they experienced online teaching and learning challenges due to limited Internet connectivity. This was evident in the following excerpts from the discussion forums.

**Anne:** ...we have poor network in my area...I couldn't attend all the online lectures...

**Khethiwe:** ...I don't have Internet at home...I use my phone for the Internet...it is expensive, and sometimes the reception is not good...

**Msizi:** ...in my area, we only have a café for the Internet...but because of lockdown, I have to use my phone now...

**Owen:** ...I have Internet, but the connection is not stable...I am logged out of online lectures most times...takes time to reconnect...I miss important information...

**Sandile:** ...I need to buy data for my phone to have Internet...gets finished quickly in online lectures...we don't have good Internet connections in my area...

**Thulani:** ...my home is far out of town...rural...no Internet connection...I can only look at recordings sometimes using my phone...can't attend online lectures most of the time...

Participants were inhibited by limited Internet access and connectivity, which hindered their equal participation in online teaching and learning. Research (Johnson et al., 2016) maintains that access to a stable Internet connection is important to participate equally in online teaching and learning. However, many developing countries have inadequate infrastructure, which creates obstacles for regular Internet access and connectivity (United Nations, 2019).

### ***The Strengths of Online Teaching and Learning***

In the main study, 11 PME students (73%) indicated that they perceived online teaching and learning's specific strengths. The main theme of strengths of online teaching and learning have been categorised into two sub themes as follows.

#### ***Access to recordings of lectures and resources at any time***

The participants valued the uploaded recordings of classes and resources, as reflected in the following discussion forum excerpts.

**Bongani:** ...I don't have space at home to study...so I don't attend all my online lectures...but I can look at the recordings anytime to catch up...

**Judy:** ...I can view the lectures at any time...if I don't understand, I can go back to the lecture or ask the group...



**Lerato:** ...I use the resources all the time to help me...I can catch up with the lectures at night when my children are asleep...it is better this way for me...

**Pranesh:** ...I can't attend all my online lectures, so I view the recordings... which helps me keep up...

**Sandile:** ...we don't have good Internet connections where I live...I can't connect to all my online lectures...seeing the recordings when I have time and when the Internet is good works for me...

**Vusi:** ...my home is noisy...so I look at the recordings at night when the house is silent...the videos and worksheets help me...

The recording and uploading of lectures and resources (for example, worksheets, examples of good practice and teaching notes) did provide support to the participants as they engaged with online teaching and learning. The participants in this study were comfortable viewing the uploaded material when it was convenient for them. It was evident in this study that the PME's were engaging with content, material and resources online at different times. It was apparent that online platforms encouraged and established helpful interactions within the VCoP in this study (Mlotshwa & Chigona, 2018).

#### ***Support provided by the virtual communities of practice***

The participants valued the online interaction and support provided by members of the Virtual Communities of Practice. This was evident in the following discussion forum excerpts.

**Anne:** ...I can only study late at night...if I have problems solving maths questions, I can talk to the group at any time...someone responds and helps me...

**Cephu:** ...I struggled, but the group supported me...they sent me data on my phone...this was a lifesaver to me...

**David:** ...I don't have a computer...I rely on my phone...but sometimes I miss things...I can always ask the group...instead of looking at the recordings which cost lots of data...also I need to practice the maths examples...the group checks and gives me pointers...

**Judy:** ...sometimes I need to speak to someone...I can count on the group...they help me all the time with maths and other problems I am having during lockdown...

**Khethiwe:** ...sometimes it's hard to follow the maths questions and solutions...so I chat to the group, and they can explain to me...maths must be taught face to face...I am struggling to cope with online learning for maths...sometimes, they call me to explain...

**Lerato:** ...I need someone to explain only for me at my level...the group helps me with problem-solving...they show me step by step...they send photos of the steps...

**Pranesh:** ...sometimes I need help, so I ask the group...they help me...I can't attend all the online lectures...the group fills me in if I don't understand something in the lecture recording...

**Rani:** ...maths problems need to be taught with many examples and explanations...in the recordings, we can't see the step by step explanations...the group helps me and we talk about each step...

Based on the data analysed from the discussion forums, it was apparent that the participants received support from members of the VCoP under focus. It was through shared interests and collaboration (Wenger, 1998) that the PME's interacted virtually. The participants encompassed the ideas of a VCoP by sharing thoughts and giving assistance to other VCoP members. When the participants had difficulties, they did pursue support from the VCoP, as was evident in the discussion forums. As a result, the discussion forums created an additional level of mathematics assistance for the VCoP members.

## **CONCLUSION**

This research study aimed to explore postgraduate mathematics education students' perceptions of online teaching and learning during the COVID-19 pandemic era. The participating postgraduate mathematics education students' perceptions indicated both challenges and strengths to online teaching and learning.

The article concludes with possible ideas for lecturers wanting to use online teaching and learning. These thoughts are based on the participants' perceptions as elicited in this study. The challenges of online teaching and learning within the COVID-19 pandemic era are essential for lecturers to note. To avoid these challenges, the lecturer needs to confirm that students have equal access to technology-based devices and data for using the Internet. The participants also indicated that they required stable Internet connections to participate equally in online teaching and learning.

The participants in this study were comfortable accessing the uploaded content, resources, and material conveniently. Also, they valued the collaborative and supportive online discussions and reflected on and discussed their challenges with members of their VCoP. Through this collaboration, participants were supported during online teaching and learning.

Due to the study's importance, opportunities for further research on a larger scale based at other universities nationally and globally could provide different perceptions on the topic. Future research opportunities may also help determine additional noteworthy perceptions of postgraduate students in general and perceptions of mathematics students specifically on online teaching and learning. The results, implications and limitations as discussed in this article add new knowledge to the field. This new knowledge is of value to lecturers globally as we embrace online pedagogy within the context of the COVID-19 pandemic era.

## **ACKNOWLEDGEMENTS**

The authors are grateful to the South African National Research Foundation, which partially funded this study: NRF Grant Number: TTK170408226284, UID: 113952.

## REFERENCES

- Belaineh, M. S. (2017). Students' conception of learning environment and their approach to learning and its implication on quality education. *Educational Research and Reviews*, 12(4), 695-703. <https://doi.org/10.5897/ERR2017.3258>
- Bolton, L. (2019). *Foundational mathematics education in developing countries*. Institute of Development Studies Retrieved on April 10 2020. [https://resourcecentre.savethechildren.net/node/16285/pdf/657\\_foundation\\_al\\_mathematics\\_education\\_in\\_developing\\_countries.pdf](https://resourcecentre.savethechildren.net/node/16285/pdf/657_foundation_al_mathematics_education_in_developing_countries.pdf)
- Coldwell, D. A. L. (2019). Negative influences of the 4th industrial revolution on the workplace: Towards a theoretical model of entropic citizen behavior in toxic organizations. *International Journal of Environmental Research and Public Health*, 16(2670), 1-13. <https://doi.org/10.3390/ijerph16152670>
- Ekici, D. I. (2017). The effects of online communities of practice on pre-service teachers' critical thinking dispositions. *EURASIA Journal of Mathematics Science and Technology Education*, 13(7), 3801-3827. <https://doi.org/10.12973/eurasia.2017.00759a>
- Fabian, K., Topping, K. J., & Barron, I. G. (2018). Using mobile technologies for mathematics: Effects on student attitudes and achievement. *Educational Technology Research and Development*, 66(1), 1119-1139. <https://doi.org/https://doi.org/10.1007/s11423-018-9580-3>
- Farnsworth, V., Kleanthous, I., & Wenger-Trayner, E. (2016). Communities of practice as a social theory of learning: A conversation with Etienne Wenger. *British Journal of Educational Studies*, 64(2), 139-160. <https://doi.org/https://eprints.whiterose.ac.uk/92950/3/repository11.pdf>
- Gera, I., & Singh, S. (2019). A critique of economic literature on technology and fourth industrial revolution: Employment and the nature of jobs. *The Indian Journal of Labour Economics*, 62(1), 715-729. <https://doi.org/10.1007/s41027-019-00191-8>
- Gillett-Swan, J. (2017). The challenges of online learning supporting and engaging the isolated learner. *Journal of Learning Design*, 10(1), 20-30. <https://files.eric.ed.gov/fulltext/EJ1127718.pdf>
- Harris, J. L., Al-Bataineh, M. T., & Al-Bataineh, A. (2016). One to one technology and its effect on student academic achievement and motivation. *Contemporary Educational Technology*, 7(4), 368-381. <https://files.eric.ed.gov/fulltext/EJ1117604.pdf>
- Hoosain, M. S., Paul, B. S., & Ramakrishna, S. (2020). The impact of 4IR digital technologies and circular thinking on the United Nations sustainable development goals. *Sustainability*, 12(10143), 1-16. <https://doi.org/10.3390/su122310143>
- Johnson, A. M., Jacovina, M. E., Russell, D. E., & Soto, C. M. (2016). Challenges and solutions when using technologies in the classroom. In S. A. Crossley & D. S. McNamara (Eds.), *Adaptive educational technologies for literacy instruction* (pp. 13-29). Taylor & Francis.
- Langley, A., Patel, H., & Houghton, R. J. (2017). Fostering a Community of Practice for Industrial Processes. In S. Grösser, A. Reyes-Lecuona, & G.

- Granholm (Eds.), *Dynamics of Long-Life Assets* (pp. 151-168). Springer.  
[https://doi.org/10.1007/978-3-319-45438-2\\_9](https://doi.org/10.1007/978-3-319-45438-2_9)
- Mlotshwa, N., & Chigona, A. (2018, 15-18 October 2018). *Using Moodle to enhance Mathematics learning in Grade 10 classrooms in South Africa*. E-Learn 2018 Conference, Las Vegas, United States.  
[http://digitalknowledge.cput.ac.za/bitstream/11189/6936/1/Mlotshwa\\_N\\_Chigona\\_A\\_Edu\\_2018.pdf](http://digitalknowledge.cput.ac.za/bitstream/11189/6936/1/Mlotshwa_N_Chigona_A_Edu_2018.pdf)
- Mohajan, H. K. (2017). Roles of communities of practice for the development of the society. *Journal of Economic Development, Environment and People*, 6(3), 1-23. [https://mpra.ub.uni-muenchen.de/82954/1/MPRA\\_paper\\_82954.pdf](https://mpra.ub.uni-muenchen.de/82954/1/MPRA_paper_82954.pdf)
- Murgatrot, S. (2020). *COVID-19 and online learning*. Retrieved on April 14 2020.  
[https://www.researchgate.net/publication/339784057\\_COVID-19\\_and\\_Online\\_Learning](https://www.researchgate.net/publication/339784057_COVID-19_and_Online_Learning)
- Naidoo, J. (2020). Postgraduate Mathematics Education Students' Experiences of Using Digital Platforms for Learning within the COVID-19 Pandemic Era. *Pythagoras*, 41(1), 1-11. <https://doi.org/10.4102/pythagoras.v41i1.568>
- Ndimande, B. S. (2016). School choice and inequalities in post-apartheid South Africa. *Global Education Review*, 3(2), 33-49.  
<http://africainequalities.org/wp-content/uploads/2016/04/203-1134-1-PB.pdf>
- Ng'ambi, D., Brown, C., Bozalek, V., Gachago, D., & Wood, D. (2016). Technology enhanced teaching and learning in South African higher education-A rearview of a 20 year journey. *British Journal of Educational Technology*, 47(5), 843-858. <https://doi.org/10.1111/bjet.12485>
- Panthi, R. K. (2016). *Socially just pedagogy in the mathematics classroom*. First International Conference on Transformative Education Research and Sustainable Development (p.140), Dhulikhel, Nepal.  
<https://files.eric.ed.gov/fulltext/ED573754.pdf>
- Peachey, N. (2017). *Digital tools for teachers*. PeacheyPublications.Com.
- Peñarroja, V., Sánchez, J., Gamero, N., Orenge, V., & Zornoza, A. M. (2019). The influence of organisational facilitating conditions and technology acceptance factors on the effectiveness of virtual communities of practice. *Behaviour & Information Technology*, 38(8), 845-857.  
<https://doi.org/10.1080/0144929X.2018.1564070>
- Pope, S., & Mayorga, P. (2019). Enriching Mathematics in the Primary Curriculum. In *Exploring the Primary Curriculum*. Sage.
- Schieffer, L. (2016). The benefits and barriers of virtual collaboration among online adjuncts. *Journal of Instructional Research*, 5(1), 109-124.  
<https://files.eric.ed.gov/fulltext/EJ1127636.pdf>
- Schuck, S. (2016). Enhancing teacher education in primary mathematics with mobile technologies. *Australian Journal of Teacher Education*, 41(3), 125-139. <https://doi.org/10.14221/ajte.2016v41n3.8>
- Schwab, K. (2016). *The Fourth Industrial Revolution: What it means, how to respond*. <https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond>

- The World Bank. (2018). *Overcoming poverty and inequality in South Africa. An assessment of drivers, constraints and opportunities*. World Bank Publications Retrieved on September 10 2020. <http://documents.worldbank.org/curated/en/530481521735906534/pdf/124521-REV-OUO-South-Africa-Poverty-and-Inequality-Assessment-Report-2018-FINAL-WEB.pdf>
- Umugiraneza, O., Bansilal, S., & North, D. (2018). Exploring teachers' use of technology in teaching and learning mathematics in KwaZulu-Natal schools. *Pythagoras*, 39(1), 1-6. <https://doi.org/10.4102/pythagoras.v39i1.342>
- United Nations. (2019). *Digital Economy Report 2019. Value creation and capture: Implications for developing countries*. [https://unctad.org/system/files/official-document/der2019\\_en.pdf](https://unctad.org/system/files/official-document/der2019_en.pdf)
- Valverde-Berrocso, J., Garrido-Arroyo, M. d. C., Burgos-Videla, C., & Morales-Cevallos, M. B. (2020). Trends in educational research about e-learning: A systematic literature review (2009–2018). *Sustainability*, 12(5153), 1-23. <https://doi.org/10.3390/su12125153>
- Wenger, E. (1998). Communities of Practice. Learning as a social system. *Systems Thinker*, 9(5), 1-10.
- Wenger, E. (2009). Communities of practice a brief introduction. 1-5. Retrieved 25 September 2020, from <https://neillthew.typepad.com/files/communities-of-practice-1.pdf>
- Wenger, E., & Wenger-Trayner, B. (2015). Communities of practice: A brief introduction. 1-8. Retrieved 28 September 2020, from <https://wenger-trayner.com/introduction-to-communities-of-practice/>
- Woolley, S., Sattiraju, N., & Moritz, S. (2020). U.S. Schools trying to teach online highlight a digital divide. *Bloomberg Businessweek*, 1-6. Retrieved 24 October 2020, from <https://www.bloomberg.com/news/articles/2020-03-26/covid-19-school-closures-reveal-disparity-in-access-to-internet>
- Zervoudi, E. K. (2020). Fourth industrial revolution: Opportunities, challenges, and proposed policies. In A. Grau & Z. Wang (Eds.), *Industrial Robotics. New Paradigms*. (pp. 1-25). IntechOpen. <https://doi.org/10.5772/intechopen.90412>