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Online Teaching and Learning of Mathematics in Higher Education: Post- Covid 19 Lecturer Perspectives

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ABSTRACT
Online learning offers excellent chances for both students and teachers because it is flexible, affordable, and convenient in terms of time and space. This paper examined the perspectives of lectures on online teaching and learning mathematics in higher education after COVID-19. This paper adopted the Technology Acceptance Model (TAM) as a theoretical framework. The theory was used in the study to understand the lecturers' viewpoints on how they embrace the use of technology in their teaching of mathematics. This was a qualitative study that used a case study as a design. The study's participants were ten (10) mathematics lecturers at the Mathematics Department in one rural university in the Eastern Cape Province purposefully selected as information-rich participants. Data was collected using face-to-face, semi-structured interviews which were analysed through thematic analysis. The findings of the study revealed that lecturers saw the importance of teaching mathematics using technology to close the resource gap as universities steadily shift to 21st-century learning environments. At the same time, lecturers in rural universities are impacted by the challenges they face, which include a lack of technology skills, teaching practical work online, classroom control during online teaching, shortage of resources such as poor internet connections and electricity load shedding in the country which had strained the smooth running of online mathematics classes especially while teaching mathematics online. Based on the findings the study recommended that lecturers should be provided with technology professional development in mathematics, strengthening of internet access points, and methods for monitoring and controlling mathematics classes.

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INTRODUCTION
According to Stankous and Buibas, technology is an intellectual tool that offers ways to radically change mathematics and mathematics education in students' lives.[1] In addition, the use of technology in mathematics education transforms how mathematics is viewed and taught. The study therefore explores the perspectives of lecturers on online teaching during the COVID-19 era. The United Nations Educational, Scientific and Cultural Organization (UNESCO) has stated that the virus has caused a global pandemic which affected teaching and learning in schools and tertiary institutions worldwide.[2] In the wake of the COVID-19 pandemic, a lot has changed in the process of teaching and learning in higher education and this has also affected the interaction between students and teachers.[3] Hence, institutions have made an effort to keep the education process around

[1] Nina Stankous and Martha Buibas, "Math Online: Student's Perspective Based on Survey," *European Scientific Journal* 14, no. 34 (2018): 336–51.
[2] UNESCO. "COVID-19 Educational Disruption and Response". UNESCO. https://en.unesco.org/themes/education-emergencies/coronavirus-school-closures.(2020)
[3] Juliana Ahmad, Siti Fairos Saffardin, and Kok Ban Teoh, "How Does Job Demands and Job Resources Affect Work Engagement towards Burnout? The Case of Penang Preschool," *International Journal of Psychosocial Rehabilitation* 24, no. 02 (2020): 1888–95.

the world going by using online learning to supplement in-person teaching.[4] As a result of this pandemic, universities are limited in carrying out exclusive activities which has led to the acceptability of hybrid learning and the enthusiasm for online programs among students and teachers.[5] The shift in learning is driven by technologies, which can empower the needs of the new generations of learners, that rapidly have become an integral part of society.[6] Online teaching and learning approaches provide many opportunities for lecturers and students to teach and learn through their student-centred settings. Online teaching and learning are, however, affected by several challenges, especially in rural areas. Dube indicates that in the South African rural context, learning is hampered by the absence of network connections and the shortage of devices for virtual learning.[7] In this paper, the researchers explore how mathematics lecturers in rural higher education institutions perceive the quick switch from the traditional mode of lesson delivery to online teaching and learning during the initial response to the pandemic. It thus explores the views of lecturers on the use of online teaching and learning after COVID-19 in rural universities through the following objectives:

- To discover the views of mathematics lecturers regarding the use of technology as a method of instruction during the COVID-19 pandemic.
- To examine factors that affected the use of technologies in the teaching and learning of mathematics during the COVID-19 pandemic.

LITERATURE REVIEW

Lecturers' Beliefs About Using Technology As A Mode Of Instruction During The Covid-19 Pandemic

According to Borba et al., online teaching and learning challenged the traditional view of mathematical knowledge, which includes information being transmitted from lecturers to students.[8] Additionally, approaches like the flipped classroom have also changed the roles of lecturers and students. Furthermore, integrating technology into mathematics teaching and learning typically entails adjustments to the curricula, teacher training programs, and assessment techniques.

Chen et al. conducted a study in China on how K-12 teachers addressed challenges during the transition to online education due to the COVID-19 pandemic.[9] The results of their study showed that teachers applied live video streaming on multiple social media platforms and repurposed different entertainment features to deliver online teaching for better student engagement while students developed a better sense of intimacy with their teachers after experiencing certain online interactions. Furthermore, in Lebanon, a study conducted by Farah et al. investigated high school teachers' perceptions of online learning during the pandemic period.[10] The findings revealed that teachers seemed to have a high sense of comfort with online teaching; even though they valued face-to-face instruction more, they perceived themselves as efficient in creating positive learning environments. Rodríguez-Muñiz, Burón, Aguilar-Gonzálezand Muñiz-Rodríguez in Spain examined secondary school mathematics teachers' perceptions of their readiness for emergency remote teaching, their previous training in digital teaching tools, their level of digital competence for teaching mathematics, and their adaptation to remote teaching.[11] Despite the differences observed in the hours of training received, no significant age differences were detected in the effort perceived for adapting to remote teaching. The research cited above talked a lot about how teachers had positive views and how online teaching and learning had an advantageous effect on them. However, less is stated about the perspectives of lecturers about online teaching during COVID-19, especially in mathematics in rural disadvantaged universities.

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[4] Inayat Ali, "The Covid-19 Pandemic: Making Sense of Rumor and Fear: Op-Ed," *Medical Anthropology* 39, no. 5 (2020): 376–79; Kok Ban Teoh and Daisy Mui Hung Kee, "Psychosocial Safety Climate and Burnout among Academicians: The Mediating Role of Work Engagement," *International Journal of Society Systems Science* 12, no. 1 (2020): 1–14.

[5] Abu Elnasr E Sobaih, Ahmed M Hasanein, and Ahmed E Abu Elnasr, "Responses to COVID-19 in Higher Education: Social Media Usage for Sustaining Formal Academic Communication in Developing Countries," *Sustainability* 12, no. 16 (2020): 6520.

[6] Keith S Taber, "The Role of New Educational Technology in Teaching and Learning: A Constructivist Perspective on Digital Learning," *Handbook on Digital Learning for K-12 Schools*, 2017, 397–412.

[7] Bekithemba Dube, "Rural Online Learning in the Context of COVID 19 in South Africa: Evoking an Inclusive Education Approach," *REMIE: Multidisciplinary Journal of Educational Research* 10, no. 2 (2020): 135–57.

[8] Marcelo C Borba et al., "Digital Technology in Mathematics Education: Research over the Last Decade," in *Proceedings of the 13th International Congress on Mathematical Education: ICME-13* (Springer International Publishing, 2017), 221–33.

[9] Xinyue Chen et al., "' I Was Afraid, but Now I Enjoy Being a Streamer!' Understanding the Challenges and Prospects of Using Live Streaming for Online Education," *Proceedings of the ACM on Human-Computer Interaction* 4, no. CSCW3 (2021): 1–32.

[10] Mireille Farah and Nemer Frayha, "Lebanese Teachers' Perceptions of Online Learning," *Int. J. Adv. Res. Sci. Eng. Technol* 8 (2021): 16539–47.

[11] Luis J Rodríguez-Muñiz et al., "Secondary Mathematics Teachers' Perception of Their Readiness for Emergency Remote Teaching during the COVID-19 Pandemic: A Case Study," *Education Sciences* 11, no. 5 (2021): 228.

Dhawan sheds light on online teaching as a necessity, explaining that this is no longer an option, but a certainty caused by the pandemic.[12] Additionally, the pandemic motivated both teachers and students to use innovative communication technologies and e-learning methods in mathematics classrooms.[13] Dick and Hollebrands mention that in a balanced mathematics program, the strategic use of technology strengthens mathematics teaching and learning.[14] Furthermore, they emphasized that just having access to technology in the classroom is not sufficient; the teacher and the curriculum have to play critical roles in mediating the use of technological tools. Digital learning during the pandemic had good results in people who can self-motivate and understand the ultimate goal of learning.[15] This model has been effective in higher education because it gives students the chance to continue the learning process.[16] Therefore, lecturers' knowledge and skills have a significant impact on the way they integrate technology into their teaching. Additionally, the technological knowledge, skills and experience gained by lecturers during the pandemic process will help to integrate technology into the mathematics classroom.[17]

In online learning, students' interaction and involvement in the learning environment are supported as they are provided with opportunities to learn from each other through discussions and the exchange of resources, experiences, and ideas.[18] Furthermore, Voskoglou highlighted that the use of technology in the teaching and learning of mathematics benefits the students as animated figures and mathematical representations could help students better understand mathematical concepts and solve mathematical problems.[19] Nevertheless, there is little or no mention of how lecturers in rural universities should create technological learning environments that should support and allow students to make mathematical representations.

Pedro, Piedale, and Matos revealed that technology is becoming more deeply integrated into the institution curricula thereby creating learning and innovation that empowers educators to enhance student learning through the integration of contemporary technologies and digital learning.[20] Although online learning has proven to help maintain students' and faculty's health amid the COVID-19 pandemic, it is not as effective as conventional learning.[21]

Factors Affecting the Use of Technologies in the Teaching and Learning of Mathematics

According to Basilaia and Kvavadze, in Indonesia, there are still many areas that are far from the reach of the Internet.[22] Every individual does not necessarily have the tools for virtual learning. Therefore, for people who live in rural locations in particular, the lack of access to reputable web associations is a barrier to internet connectivity. As COVID-19 arrived without adequate planning, it was difficult for lecturers to understand the various ways to access the internet. Gqoli conducted a study on integrating technology into mathematics teaching and learning in early childhood development.[23] The findings of the study revealed a lack of confidence in their abilities to use technologies; lack of technical skills; lack of technological equipment; physical environment constraints and infrastructure as the challenges impeding the integration of technology in mathematics teaching. This indicates that although some mathematics lecturers supported the idea of online teaching enforced by the COVID-19 pandemic, there were some challenges that they experienced.

Ardiç mentions that it has been observed that the problems encountered especially in assessment and evaluation make it difficult to understand the actual impact of teaching mathematics on student learning during

[12] Shivangi Dhawan, "Online Learning: A Panacea in the Time of COVID-19 Crisis," *Journal of Educational Technology Systems* 49, no. 1 (2020): 5–22.
[13] Dhawan, "Online Learning: A Panacea in the Time of COVID-19 Crisis."
[14] Thomas P Dick and Karen F Hollebrands, *Focus in High School Mathematics: Technology to Support Reasoning and Sense Making* (National Council of Teachers of Mathematics Reston, VA, 2011).
[15] Daria Shcherbakova, "Дистанционное Обучение в Период Кризиса: Возможности и Недостатки Online-Технологий (Distance Learning During the Crisis: Opportunities and Disadvantages of Online Technologies)," *Available at SSRN 3584481*, 2020.
[16] John Vandivier, "New Digital Education as the Market Solution to the Student Debt Crisis," *Available at SSRN 3530647*, 2020.
[17] ChanMin Kim et al., "Teacher Beliefs and Technology Integration," *Teaching and Teacher Education* 29 (2013): 76–85.
[18] Javier Bravo-Agapito, Sonia J Romero, and Sonia Pamplona, "Early Prediction of Undergraduate Student's Academic Performance in Completely Online Learning: A Five-Year Study," *Computers in Human Behavior* 115 (2021): 106595.
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[20] Ana Paula Pedro, João Piedade, and João Filipe Matos, "Technology Enhanced Learning," *Sisyphus: Journal of Education* 7, no. 1 (2019): 6–8.
[21] Muhammad Adnan and Kainat Anwar, "Online Learning amid the COVID-19 Pandemic: Students' Perspectives.," *Journal of Pedagogical Sociology and Psychology* 2, no. 1 (2020): 45–51.
[22] Giorgi Basilaia and David Kvavadze, "Transition to Online Education in Schools during a SARS-CoV-2 Coronavirus (COVID-19) Pandemic in Georgia.," *Pedagogical Research* 5, no. 4 (2020).
[23] Neliswa Gqoli, "Integrating Technology Into Mathematics Teaching and Learning in Early Childhood Development," In *South Africa International Conference On Education*, 2022, 116.

the COVID-19 pandemic.[24] Furthermore, at the beginning of the pandemic, universities gave various instructions including various training on distance education to their lecturers. However, these instructions were usually technical in scope and insufficient to overcome the difficulties encountered in the process. Therefore, mathematics instruction was carried out with an understanding of "emergency distance education" rather than formal distance education.[25] On the other hand, Ardiç states that the experience of distance education gained during the pandemic process had a positive influence on the views of a significant proportion of the lecturers on the integration of technology in mathematics education.[26]

Prasojo, et.al., studied school principals' perceptions and found that the major external barriers to integrating technology are lack of funding and lack of professional development.[27] Other researchers have also revealed various challenges in incorporating technology in the classroom.[28] Additionally, these researchers have pointed out that the number of technological tools, maintenance services, technical support, and training for new tools are also external factors. Moreover, Hur, Shannon, and Wolf noticed that lack of funding, lack of technical support, lack of administrative support, poor training, lack of equipment, and lack of access to the equipment reduced the level of teachers' technology use.[29] Furthermore, Hur, Shannon, and Wolf also reported that the lack of technological equipment, insufficient computer labs, and Internet connection problems are some factors that affect technology integration in the classroom negatively.[30] The literature revealed that the lack of in-service training, lack of equipment, lack of technology plans, lack of appropriate software, and lack of computer labs are some barriers reported by teacher educators, prospective teachers, and deans.[31] Furthermore, Kilinc, Tarman, and Aydin found that according to in-service teachers, lack of technology, lack of access, and lack of administrative and technical support are major barriers to integrating technology. [32]

According to Adolphus, one of the problematic topics that lecturers struggled to teach in mathematics is Euclidian geometry using technology because of the technicalities related to the language, visualization of objects for better identification of properties, and inadequate conceptual understanding.[33] The researchers revealed that professional development influenced teachers' technology use positively and in the end, significantly affecting technology integration.[34] However, Hur, Shannon, and Wolf found that professional development does not have a significant effect on technology use and teachers' self-efficacy; instead, it affects teachers' perceptions regarding the benefit of technology integration and their self-confidence significantly.[35] Accordingly, self-confidence in technology use positively affects technology integration.[36] Nevertheless, Duhaney found that some teachers are unwilling to integrate technology into their classrooms due to a lack of

[24] Mehmet Alper Ardiç, "Three Internal Barriers to Technology Integration in Education: Opinion, Attitude and Self-Confidence.," *Shanlax International Journal of Education* 9 (2021): 81–96.
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[28] Eric C Sheninger, *Digital Leadership: Changing Technology for Change-Savvy School Leaders* (Corwin, a SAGE Company, 2014); Peggy A Ertmer and Anne Ottenbreit-Leftwich, "Removing Obstacles to the Pedagogical Changes Required by Jonassen's Vision of Authentic Technology-Enabled Learning," *Computers & Education* 64 (2013): 175–82; Kleopatra Nikolopoulou and Vasilis Gialamas, "ICT and Play in Preschool: Early Childhood Teachers' Beliefs and Confidence," *International Journal of Early Years Education* 23, no. 4 (2015): 409–25.
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[35] Hur, Shannon, and Wolf, "An Investigation of Relationships between Internal and External Factors Affecting Technology Integration in Classrooms."
[36] Joyce H L Koh and Theodore W Frick, "Instructor and Student Classroom Interactions during Technology Skills Instruction for Facilitating Preservice Teachers' Computer Self-Efficacy," *Journal of Educational Computing Research* 40, no. 2 (2009): 211–28.

interest and motivation.[37] The literature states several impediments to technology integration in teaching and learning. However, little or nothing is stated about the various challenges impeding technology integration in rural universities of South Africa. This has piqued the researchers' curiosity in exploring various barriers to the use of technology in teaching mathematics in rural universities during the COVID-19 pandemic.

THEORETICAL FRAMEWORK

The theoretical framework that underpins the study is the Technology Acceptance Model (TAM) by Fred D. Davis.[38] According to Davis, TAM is a model that is designed to measure the adoption of new technology based on customer attitudes. Furthermore, TAM is an information systems theory that models how users come to accept and use technology and is applied to determine the acceptance, adoption, and utilization of information technology. According to Davis, TAM represents individual attitudes and subjective choices for using technology for teaching and learning. TAM consists of two attitude constructs namely, Perceived Usefulness (PU) and Perceived Ease of Use (PEOU).[39] These attitude constructs are utilised to frame the lecturers' attitudes toward engagement in the usage of technology. Additionally, Davis also claims that PEOU and PU are the two fundamental determinants of user acceptance of technology.[40] PEOU is defined as the degree to which a person believes that using a particular technology would be free from effort and PU is defined as the degree to which a person believes that using a particular system would enhance his or her job performance. Additionally, according to the TAM, PEOU will have an impact on PU when consumers regard technology as useful and find that it is easy to use. Therefore, the TAM proves that both PEOU and PU influence the users' attitudes toward using a technology.

METHODOLOGY

The qualitative research approach was used in the study to collect and work with non-numerical data that seeks to interpret meaning to understand social life through the study of targeted populations or places. [41] A case study was used as a design for the study. The study's population was mathematics lectures at a rural university in South Africa. The participants were ten (10) mathematics lecturers purposefully selected as information-rich participants. Data was collected using face-to-face, semi-structured interviews. During data collection, the researcher respected the autonomy of the lecturers involved, and the authority of the department, which included the Head of the Mathematics Department. An interview guide with questions related to the phenomenon of the study, which was online teaching and learning mathematics, was used.[42] During the interviews, a tape recorder was used to collect data, and probes were made for participants to provide further information. The study used thematic analysis to identify patterns or themes within qualitative data.[43] The data for the study were transcribed into segments followed by codes, categories, and themes.

FINDINGS

This part of the study focused on the presentation of results obtained from the data collected through semi-structured interviews to explore the perceptions of lectures on the use of online teaching and learning. The data generated focused on the aim of the study: *To explore lecturer's perspectives on online teaching and learning in higher education after COVID-19 in OR Tambo Inland District, Eastern Cape Province.* The findings are thus presented according to themes emanating from the objectives of the study. To maintain confidentiality and anonymity, pseudonyms have been used, like, L1, L2, L3, etc.

Theme 1: Lecturers' Beliefs About Using Technology As A Mode Of Instruction During The Covid-19 Pandemic

The findings of the study revealed that lecturers saw the importance of using technology in teaching mathematics to close the resource gap as universities steadily shift towards 21st-century learning environments.

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[37] Devon C. Duhaney and Allan E. Young, "Retooling For Teaching And Learning: Focus On Educational Technology," in *The Caribbean in a Changing World: Surveying the Past, Mapping the Future*, ed. Stephanie Fullerton-Cooper, Erica Gordon, and Livingston Smith (Cambridge: Cambridge Scholars Publishing, 2017).
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[43] Virginia Braun and Victoria Clarke, "Using Thematic Analysis in Psychology," *Qualitative Research in Psychology* 3, no. 2 (2006): 77–101.

It is critical to prepare for the future

When lectures were asked about their views on the use of technology in their teaching of mathematics, these were some of their responses:

L3*: "The world is changing technologically. So, as lecturers and transferers of knowledge, it is our obligation to make sure that we integrate technology is our teaching to prepare our students to fit in the globally competitive world. Our students have to be equipped for the 4th industrial revolution world."*

L6: *"I didn't have a problem with teaching mathematics using technology as I understand that technology is essential for preparing the students to fit in a global competitive 4th industrial revolution world."*

Positivity concerning technology

L2*: "Before, I had a negative attitude, thinking that technology could not be used in Mathematics. But after the COVID-19 pandemic, I noticed the real situation was different, and technology is an essential element for mathematics education."*

L5*: "Before COVID-19, I used to go to class even if I didn't prepare because the mathematics content was in my head. But, after COVID-19 I experienced some difficulties. I also noticed that, whenever I prepare my online lesson well and performed computer-aided activities, my students get motivated. The lesson becomes interesting and enjoyable. But if I don't prepare the lesson well the students are not motivated to study."*

A call for more in-service technological training

Some lecturers supported the use of technology in their mathematics teaching. They felt that their knowledge of technology had increased. However, they were not fully equipped with some aspects of technology which included some activities that involved drawings like Euclidean geometry.

L7*: "I enjoy teaching mathematics using technology, but I experience problems when it comes to Euclidean geometry as it involves a lot of drawings. So, I just need to be equipped in some areas. I also noticed that students are also excited when we do mathematics activities online and we support each other."*

L10: "*I will not say now I am perfect in using online teaching applications such as Moodle, and Teams, but well, I will say that I have learned a lot. The COVID-19 pandemic has given us a chance to learn new things. But, as lecturers, we need a bit of training in some areas like using pictures in lessons like Euclidean geometry. We have had hands-on practices and our administration has helped us in this regard."*

Theme 2*:* Factors Affecting The Use Of Technologies In The Teaching And Learning Of Mathematics

The findings of the study showed that while lecturers were eager to employ online teaching and learning, there were some difficulties they encountered. They were also uncomfortable using online teaching and learning because of the challenges experienced when the COVID-19 pandemic forced them to interact with their students online. These are some of their responses when asked about the factors that might be the challenges:

Lack of technological resources

L1: "We were not used to online teaching and learning until the COVID-19 pandemic which forced us. Preparing mathematics lessons using technology needs a lot of work. Also, some students are not capable of using technology, so I spend most of the time dealing with technical problems they encounter. There is a need for computer lessons to teach software to the students in their mathematics lessons and make example studies every week, then, the students will not forget the software and repeat the subjects they learned."

L4 "Some lecturers are not familiar with the culture of online teaching and learning. We are also experiencing challenges caused by the load shedding and some of our students are staying in places where there is no internet connection. The COVID-19 pandemic forced us to use online teaching and learning, yet some of us as lecturers lack technical computer skills. We find difficulties in using Moodle, Teams, and Zoom for mathematics teaching and learning."

Difficulty in teaching practicals and lack of class control

L3: "As a mathematics lecturer I find it difficult to teach practical lessons especially those that include drawings like Euclidean geometry and graphs. Sometimes during the lesson, I find that students just connect and leave

the laptops with the hope that they will listen to the recordings. So, this online teaching and learning is not suitable for mathematics as it needs hands-on activities and active participation by the students."

L9: "Teaching mathematics online is frustrating because student's attendance is poor and they are not always cooperative; even when we ask questions, they don't respond. There is no class control and as the lecturer you just speak alone. During an assessment, there is also no monitoring tool for invigilation."

DISCUSSION OF FINDINGS

The findings of the study on the theme of lecturers' beliefs in using technology as a mode of instruction during the COVID-19 pandemic have indicated that mathematics lecturers supported the view of online teaching as it prepares their students to fit in the globally competitive world. Hence, Dick and Hollebrands mention that in a balanced mathematics program, the strategic use of technology strengthens mathematics teaching and learning.[44] Additionally, most mathematics lecturers seemed to be happy about the impact of COVID-19 which moved them from traditional ways of teaching and strongly introduced them to online teaching and learning. This view confirms that of Dhawan who mentions that the pandemic motivated both teachers and students to use innovative communication technologies and e-learning methods in the mathematics classroom.[45] Moreover, Davis also revealed that PEOU is the degree to which a person believes that using a particular technology would be free from effort and PU is defined as the degree to which a person believes that using a particular system would enhance his or her job performance.[46] Therefore, the mathematics lecturers believed that using technology in their teaching would ease their teaching stress. Additionally, lecturers felt that teaching mathematics online has increased their knowledge about technology, especially in using online sites like Moodle, Teams, and Zoom. This view also confirms the position of Matos et al. who believe that technology integration into the institution curricula creates learning and innovation that empowers educators to enhance student learning through the integration of contemporary technologies and digital learning.[47] Moreover, Voskoglou has highlighted that the use of technology in the teaching and learning of mathematics benefits the students as animated figures and mathematical representations could help students better understand mathematical concepts and solve mathematical problems.[48]

Under the theme of factors affecting the use of technologies in the teaching and learning of mathematics, the findings indicated that lecturers in rural universities were impacted by the challenges they face especially while teaching mathematics online. Some lecturers mentioned the lack of technological skills in students as a challenge. This made them attend to these technical skills instead of teaching, which consumed their time for teaching. Kilinc, Tarman, and Aydin have also stated that major barriers to integrating technology experienced by in-service teachers include lack of technology, lack of access, and lack of administration.[49] Furthermore, Gqoli mentions various challenges impeding the integration of technology in mathematics teaching as a lack of confidence in their abilities to use technologies; lack of technical skills; lack of technological equipment; physical environment constraints, and infrastructure.[50]

Some of the lecturers stated that there was poor attendance of students during mathematics classes online. Additionally, the lecturers also mentioned challenges they were experiencing especially when teaching practical lessons and activities like Euclidean geometry. Adolphus stated that one of the problematic ideas that lecturers struggled to teach in mathematics using technology is Euclidian geometry because of the technicalities related to the language, visualization of objects for better identification of properties, and inadequate conceptual understanding.[51] Hence the lecturers suggested a bit of training in these areas. Additionally, lecturers also mentioned the shortage of resources such as poor internet connections and electricity load shedding in the country which had strained the smooth running of online mathematics classes. Dube has further indicated that in the South African rural context, learning was hampered by the network to connect and the shortage of devices for virtual learning.[52]

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[44] Dick and Hollebrands, *Focus in High School Mathematics: Technology to Support Reasoning and Sense Making*.
[45] Dhawan, "Online Learning: A Panacea in the Time of COVID-19 Crisis."
[46] Davis, "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology."
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[48] Voskoglou, "Comparing Teaching Methods of Mathematics at University Level."
[49] Kilinc, Tarman, and Aydin, "Examining Turkish Social Studies Teachers' Beliefs about Barriers ToTechnology Integration."
[50] Gqoli, "Integrating Technology Into Mathematics Teaching and Learning in Early Childhood Development."
[51] Adolphus, "Problems of Teaching and Learning of Geometry in Secondary Schools in Rivers State, Nigeria."
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SUMMARY

The COVID-19 pandemic forced institutions to use online teaching and learning and rural universities were also affected. According to the data gathered, both lecturers and students have had to move from traditional ways of teaching mathematics to online teaching. The findings have revealed that although lectures showed interest and positive attitudes toward online teaching, they experienced some challenges which included a lack of technological skills in students, the struggle to teach Euclidean geometry online, a shortage of resources and poor internet connections.

RECOMMENDATIONS

Based on the findings of the study the following recommendations are suggested:

- Interactive technology in the form of mathematics apps should be used as part of the learning environment for mathematics.
- Lecturers must be trained in technical skills.
- Mathematics lecturers must be empowered with the necessary resources to teach Euclidean geometry online.
- Electricity backup during the load-shedding and apps that will monitor the attendance of students during online classes should be provided by institutions.

CONCLUSION

COVID-19 presented several difficulties worldwide, and university teaching and learning were not excluded. The paper explored how mathematics lecturers in rural higher education institutions responded to the sudden shift from the traditional means of lesson delivery to online teaching and learning during the initial pandemic response. The researchers discovered that the mathematics lecturers were willing and excited to integrate technology into their teaching and learning. However, they experienced challenges that impeded the effectiveness of their teaching and learning of mathematics which included a lack of knowledge of how to teach Euclidean geometry using technology, a lack of technological knowledge among students, and load shedding. A lot of arguments have been made on how rural universities were affected by the COVID-19 pandemic, especially in teaching and learning. Various suggestions have been made on how rural universities might step in to support the lecturers of mathematics. These strategies if implemented will help lecturers teach mathematics effectively and generate positive results.

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