



Prospective Teachers' Online Learning Mathematics Activities in The Age of COVID-19: A Cluster Analysis Approach

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Abstract

The learning situation in the Zambian education sector has changed in the age of COVID-19 when the first two cases of COVID-19 infection were detected in the country rising to 45 local and at least 1.8 million infections globally by 13th April, 2020. Zambia became one of the many countries globally that has prematurely closed all schools. This study examines prospective teachers' online learning mathematics activities in the age of COVID-19 pandemic. Cluster analysis results revealed that online learning mathematics activities have significant mean differences in clustering. Cluster 2 recorded the best performance, implying that students in this cluster exhibited excellent online learning skills for mathematics in technology-rich environments in which they will be forced to study and work in the future. The study reviews various available online platforms and indicates the one that will be opened by the government which is the Educational Channel on TV.

Keywords: COVID-19, online learning, virtual teaching, mathematics education, prospective teachers, Zambia

INTRODUCTION

The entire world has been brought down to its knees by the deadly coronavirus that has claimed masses of lives. We are not sure what will happen next with COVID-19. It is clearly a serious challenge to all especially health providers and governments worldwide. However, what we can be certain of is that COVID-19 will continue to spread and cause disruption and even when COVID-19 resolves and the vaccine is found, there is likely to be a next virus or pandemic which may affect the world. Subsequently, many countries in Europe (e.g., Italy, Spain, United Kingdom, France, Germany and the United States of America) have been on either partial or complete lockdown following the cumulative number of death tolls reported on daily basis. While this is happening elsewhere, Africa too has been affected and Zambia has not been spared by the virus. In addition, jurisdictions around the world have closed schools, colleges and universities because the rate at which COVID-19 is spreading and killing people is alarming. All these measures have been erected in order to combat and contain the outbreak of COVID-19. On the other hand, the COVID-19 outbreak has been a game-

changer in the way pedagogy is happening around the globe. Universities and colleges across Zambia and the world at large have been working to rapidly move their face-to-face classes to online delivery. Therefore, online learning has been an overwhelming response to these closures. In other words, online learning is a way of combating the spread of a communicable virus like COVID-19.

About COVID-19 in Zambia and Online Learning

The education system in Zambia is based on traditional and physical classroom education and requires the pupils and students to attend the school classes every day. This is also the case in many other countries like Georgia (Basilaia & Kvavadze, 2020). The situation in general and higher education in Zambia has changed in the rain season of the academic year, March 2020 when the first two cases of COVID-19 infection were detected in the country. Unfortunately, COVID-19 has infected 1,864,629 and killed 115,286 people worldwide by 13th of April 2020; among these there are 45 cases in Zambia, 30 recovered, 2 deaths and 13 active cases quarantined in the health facility as reported by

Contribution to the literature

- This study has highlighted that mathematics education in the context of digitisation or online learning is the best response in the age of the global pandemic.
- This study recognises that online learning in mathematics can offer personalised education for all, maximising the potential of every student, but may also feel some sense of freedom during the COVID-19 isolation period.
- This study has highlighted that differentiated mathematics instruction is one of the key aspects while delivering online lessons.
- The study proposes that CBU management should implement a comprehensive and advanced pedagogic design to render lessons through virtual classrooms during and beyond the COVID-19 age.

Johns Hopkins University of Medicine, interactive map (J. H. Uni. 2020).

The learning process in Zambia was later on suspended following the premature closure of all learning institutions from 20th of March 2020 by the recommendation from the Ministry of Health until the global pandemic evolves. While the situation in Zambia seems to be contained with just 13 active cases and 2 cumulative deaths at the time of writing, the Ministry of Health has highlighted that circumstances can change quickly. Thus, all higher learning institutions were advised to shift to online-learning.

Concerning secondary schools, the Ministry of General Education gave a directive that the Zambia National Broadcasting Corporation (ZNBC) will open an Educational Channel on April 13, 2020 dedicated to the provision of education during the closure of schools and beyond. Furthermore, for those pupils who cannot access television, the government will introduce other programmes on the radio. To crown it all, the Zambian government will further introduce e-learning platforms and effect other measures like printing of education materials on CDs to be distributed countrywide for the pupils in rural areas who may miss out on the e-learning opportunities. This is consistent with Roy (2020), who posited that in Australia, some private schools have moved to online classes pre-emptively. It is envisioned that this online shift will allow pupils access education regardless of the COVID-19 outbreak period. This has come as a positive response to the closure of schools due to coronavirus. It is the desire of the Zambian government also to ensure that education continues despite the coronavirus crisis and the Ministry of General Education is consulting on how to handle this year's General Certificate of Education -GCE-Examinations. This initiative by the Zambian government is consistent with the study conducted by Basilaia and Kavadze (2020), whose findings revealed that online portal, TV School and Microsoft Teams for public schools and the alternatives like Zoom, Slack and Google Meet, EduPage platform that can be used for online education and live communication were supported by the government.

Related Literature

The main purpose of the current study is to investigate how mathematics prospective teachers participate in online learning activities in the age of COVID-19 pandemic. Both authors of this paper have a deep enthusiasm in the advancement and innovative use of Information and Communication Technologies (ICT) in mathematics education and an awareness of the current and future trends in the use of technology to enhance mathematics teaching and learning. Therefore, to appreciate this study, we examine some other related works in the literature which exclusively focused on online learning and mathematics related activities. For example, China was the first country to experience the virus as well as to undergo a lockdown. Therefore, in the wake of the COVID-19 crisis, the Chinese Ministry of Education launched the "Disrupted classes, Undisrupted Learning" initiative, providing flexible online learning to over 270 million students from their homes (Huang et al., 2020). The idea was to have undisrupted learning in the middle of the viral outbreak which had already disrupted many things in China including its economy. In the area of Mathematics Education, a study by Perienen (2020) investigated which factors significantly contributed to technology usage by mathematics teachers. This study confirmed that mathematics teachers were regular users of technology and participated in online activities more in order to learn well. Another study by Niess (2006), highlighted that "if technology is used to improve the learning of mathematics at all levels, students will be well prepared to use technology appropriately, fluently, and efficiently to do mathematics in technology-rich environments in which they will study and work in the future." Similarly, a study by Zekowski, Gleason, Cox and Bismark (2013), reported on the collection of international research disclosing that students learn mathematics better when effective and appropriate technological tools are utilized. Again, a study conducted in Georgia found that resolutions and recommendations for universities and colleges to quickly change the study form from face-to-face to online with minimal expenditures was the only way out in the age of the COVID-19 pandemic (Basilaia et al.,

2020). Meanwhile, a research by Bigirwa et al. (2020), conducted in Uganda sought to establish whether school financing role was essential to e-learning adoption, and the salient traits of school financing role to be focused on by midwifery schools.

In another study (Burke, 2020) the authors posited that online learning and teaching require skills that need to be developed; we are on a steep learning curve and, from this report, we are doing well. We are being forced to think in different ways, to solve problems together, to collaborate and to communicate in different ways, to educate and be educated in a different way. Due to COVID-19 global crisis, there is an increasing number of recent studies focusing on educational technology and technology in education (e.g., Agnoletto & Queiroz, 2020; Demuyakor; Mulenga & Marbán, 2020; Poh-Sun Goh & Sandars, 2020; Smith, 2020; Zhao & Xu, 2020); this is because researchers around the world are trying to find possible alternatives that can work for students to have a paradigm shift from the face-to-face method of learning to online education due to the closures of schools in many parts of the world. A few other studies have been focused on the impact of COVID-19 on the performance of students (Keefe, 2020; Schiariti, 2020; Sintema, 2020).

While this is happening in education, every other sector has been affected by the impact of COVID-19. For instance, it is not surprising that many research scientists and preventive medicine specialists in the medical field (e.g., Abdulmir & Hafidh, 2020; Paterson, 2020), are also in the laboratories trying to investigate a medical solution to this global pandemic. Economists are calculating and predicting models which are sending shocks through the global economy (Kraemer et al., 2020).

Therefore, the aim of this study is to explore how prospective teachers at the Copperbelt University (CBU) engage in online learning mathematics activities in the age of COVID-19. This study is primarily important to the Copperbelt University as it offers relevant information to transition from physical classroom based mathematics learning to online learning as a potential response to COVID-19. The results of this study could be used to propose that CBU management should implement a comprehensive and advanced pedagogic design to render mathematics lessons through virtual classrooms during and beyond the COVID-19 age. On a broader perspective, this study contributes to existing literature in the field of Mathematics Education which other scholars could use in relation to the global pandemic. This study might also be interesting for the Ministry of Higher Education as it provides relevant information to the ministry to prepare to combat and contain the impacts of COVID-19 on the Zambian education in general. It is hoped that when COVID-19 resolves, transition is likely to take place in the way e-

learning will be used in Mathematics Education, particularly with the utilization of digital devices.

CONCEPTUAL FRAMEWORK

The research framework adopted in this study uses the constructs of Activity Theory (AT). Authors use AT as a conceptual framework in the field of computer and mobile technologies for describing and analyzing the structure, development and context of online learning activities mediated by computers, mobile technologies, and so on (Edwards & Daniels, 2004; Jonassen & Rohrer-Murphy, 1999; Miettinen, 1999). Activity Theory is also used to describe and analyze the factors that influence user participation in online discussions. Therefore, AT is a suitable framework through which to design, understand and improve learning through online learning communities (Gedera & Williams, 2016; Kapetlinin, 1996; Kuutti, 1996).

RESEARCH METHODS

The current study is a subset of a bigger ongoing research-project which utilized a mixed-methods sequential explanatory design. This is because a mixed-methods approach is a technique used for gathering, interpreting and “mixing” or coordinating both “quantitative” and “qualitative” data at some phase of the research process within one study in order to increase a superior comprehension of the statement of the problem (Creswell, 2005; Tashakkori & Teddlie 2003). The essence of combining two types of data in one study is based on the fact that neither quantitative nor qualitative methods are enough by themselves to depict the manner or describe the circumstance under study. In solving issues to do with which method will be appropriate for the current study, our decision-making process was guided by the purpose of the study and its research questions, as well as the methodological discussions in the literature. However, only part of the quantitative results has been reported in this paper which matches a cluster analysis approach with a post hoc follow-up by means of survey technique.

Participants and Instruments

Purposive sampling technique was used to sample prospective secondary school teachers of mathematics at the Copperbelt University (CBU) in Zambia. The sample was formed by 102 participants from undergraduate school of Mathematics and Science Education in 3rd and 4th year cohorts who must complete four years of training to receive a university degree in Mathematics Education. To measure participants’ online mathematics behaviors in the context of social media applications via online learning in mathematics activities, the authors administered an adapted and validated scale by Moll & Nielsen (2017), via a quantitative and qualitative survey system. Thus, within each science learning context, the

Table 1. Number of Cases in each Cluster

Cluster	1	27.000
	2	46.000
	3	29.000
Total		102.000
Missing		.000

authors of the current paper adapted the validated scale within each mathematics learning context and went through all the processes of validation to make the instrument reliable and valid before administering it. Delivery mode was face-to-face in lecture room setting and in the presence of the lecturer. This was possible because at the time of data collection, the country had not recorded any COVID-19 case and schools had not closed yet. The authors’ role during participants’ answering was restricted to responding to participants’ questions in order to clarify the items under study. This was done to ensure that all questions involved in the questionnaire were clearly understood and the data collected was the intended one. Survey completion took at least 30 minutes.

Data Analysis

SPSS 24.0 software was used to analyse data. K-means cluster analysis was used to organize data into clusters. Our goal was to find out how many groups the data will be clustered into and explore the patterns in the data. To describe the different patterns in the data, the authors used the guide by Hartigan (1979). A one-way analysis of variance within the cluster analysis tools was then performed to examine the difference between the extent of prospective teachers’ online mathematics behaviors in the teaching and learning of mathematics activities. Finally, the Post Hoc test was conducted to determine where the actual mean differences in the online learning activities lie between the specific

clusters. Results were tabulated and presented in the next sections.

RESULTS AND DISCUSSIONS

This section presents the research results and interpretations to the research question and the hypothesis of the study. When a *k*-means cluster algorithm was run in SPSS multiple times with different starting conditions, 3 clusters were formed as shown on **Table 1**.

Figure 1 shows the visual representation of clusters with the highest scores recorded in cluster 2, followed by cluster 3 with a relatively small difference recorded in cluster 1. The figure also helps us to explore the patterns in the data.

In order to understand the differences between the extent of student teachers’ online learning mathematics activities in each cluster in relation to the 9 item/variables, that the study endeavoured to answer the research question below:

Is there a significant difference between the extent of prospective teachers’ online learning mathematics activities and each of the following 9 variables?

1. When completing mathematics assignments, I work in front of my computer so that I can chat online with my friends when I am stuck.
2. When completing mathematics assignments, I work in front of my computer so that I can search the Internet and/or Google.
3. I search the Internet for the answers to particular assignment questions. When I find the answer I stop looking.
4. I search the Internet for information that will help me to understand mathematics concepts better.

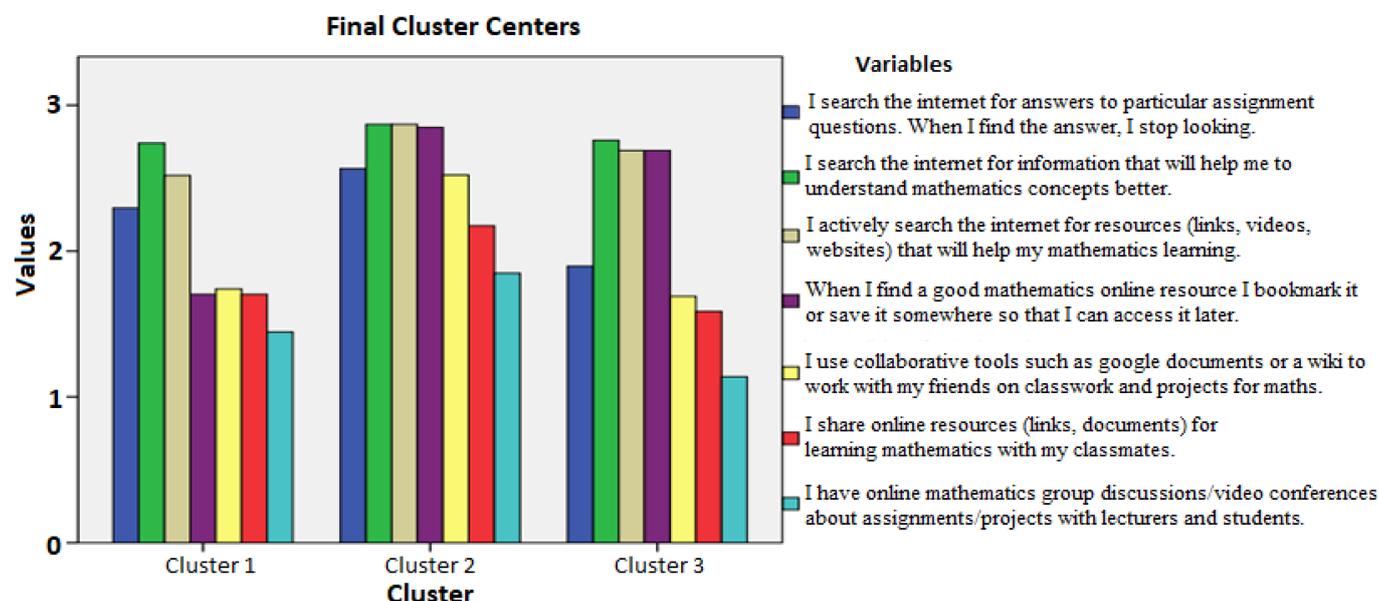


Figure 1. Final Clusters generated

Table 2. Auto-clustering of prospective teachers in ANOVA

Online Activities	Cluster		Error		F	Sig.
	Mean Square	df	Mean Square	df		
1.	5.823	2	.313	99	18.585	.000
2.	4.521	2	.307	99	14.739	.000
3.	3.977	2	.360	99	11.053	.000
4.	.183	2	.159	99	1.151	.320
5.	1.074	2	.183	99	5.855	.004
6.	11.864	2	.180	99	66.094	.000
7.	8.251	2	.413	99	19.987	.000
8.	3.658	2	.296	99	12.370	.000
9.	4.647	2	.384	99	12.090	.000

The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.

5. I actively search the Internet for resources (links, videos, and websites) that will help my mathematics learning.
6. When I find a good mathematics online resource, I bookmark it or save it somewhere so that I can access it later.
7. I use collaborative tools such as Google documents or a wiki to work with my friends on class work and projects for mathematics.
8. I share online resources (links, documents) for learning mathematics with my classmates.
9. I have online mathematics group discussions/ video conferences about assignments/ projects with lecturers and students.

This research question intended to determine the difference of each cluster between variables. Therefore, it called to test the null hypothesis which states:

Ho: There is no significant difference between the extent of prospective teachers' online learning mathematics activities and the stated 9 variables.

In testing the hypothesis, the authors employed k-means cluster analysis with a one-way ANOVA to determine whether there were any significant mean differences between two or more clusters on 9 dependent variables. The independent variable, cluster membership, included 3 clusters ($n = 102$, see Figure 1).

Table 2 shows statistically significant mean differences of each cluster in terms of the 8 variables [online learning mathematics activities] prospective teachers engage in. Since $p \leq 0.05$, in all cases except for activity 4 with ($p > 0.05$), all the other 8 variables [online learning mathematics activities] have significant mean differences in clustering. Thus, we reject the null hypothesis and conclude that there is a significant mean difference between the extent of prospective teachers' online learning mathematics activities and the stated 8 variables while there is no statistical significant mean difference in terms of the way students search the Internet for information that will help them understand mathematics concepts better [variable 4].

Although there was a performance difference between the three clusters, examining the results, we see that the general extent of student teachers' online learning mathematics behaviors in the teaching and learning activities were very high on activity 4, 5 and 6 (see Figure 1) across the clusters with cluster 2 positing the best performance and the least being activity 9 in cluster 3. It can also be argued that cluster 1 and 3 comprised of prospective teachers with relatively low scores on mathematics related learning activities while online (Figure 1). On comparison, specifically activity 7, 8 and 9 recorded lower scores in both clusters.

Therefore, in the age of COVID-19, prospective teachers display positive attitudes towards embracing online learning behaviors and are likely to adopt e-learning during the coronavirus outbreak. As most of the schools announced their closure in the age of COVID-19, it is necessary for mathematics prospective teachers at CBU to explore new methodologies for online education. Now since everyone is both together and separated by the threat of the COVID-19, a key issue in these times of pandemic is to provide all students with access to the Internet, adequate supply of electricity, reliable internet connectivity to online learning platforms and the necessary tools (Agnoletto & Queiroz, 2020). Therefore, authors recommend to the university management that a comprehensive and advanced pedagogic design should be implemented to render lessons through online mode. However, a follow up Post Hoc test was conducted to determine where the actual mean differences in the online learning activities lie between the specific clusters. For this purpose, the Tukey HSD test (see Table 3) was performed.

Table 3. Tukey HSD's Multiple Comparisons of mean differences

(I) Cluster Number of Case	(J) Cluster Number of Case	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	.137	.136	.573	-.19	.46
	3	.825*	.150	.000	.47	1.18
2	1	-.137	.136	.573	-.46	.19
	3	.688*	.133	.000	.37	1.00
3	1	-.825*	.150	.000	-1.18	-.47
	2	-.688*	.133	.000	-1.00	-.37
1	2	-.477*	.134	.002	-.80	-.16
	3	.198	.148	.379	-.15	.55
2	1	.477*	.134	.002	.16	.80
	3	.675*	.131	.000	.36	.99
3	1	-.198	.148	.379	-.55	.15
	2	-.675*	.131	.000	-.99	-.36
1	2	-.269	.145	.159	-.61	.08
	3	.400*	.160	.038	.02	.78
2	1	.269	.145	.159	-.08	.61
	3	.669*	.142	.000	.33	1.01
3	1	-.400*	.160	.038	-.78	-.02
	2	-.669*	.142	.000	-1.01	-.33
1	2	-.129	.097	.380	-.36	.10
	3	-.018	.107	.985	-.27	.24
2	1	.129	.097	.380	-.10	.36
	3	.111	.094	.471	-.11	.34
3	1	.018	.107	.985	-.24	.27
	2	-.111	.094	.471	-.34	.11
1	2	-.351*	.104	.003	-.60	-.10
	3	-.171	.115	.298	-.44	.10
2	1	.351*	.104	.003	.10	.60
	3	.180	.102	.185	-.06	.42
3	1	.171	.115	.298	-.10	.44
	2	-.180	.102	.185	-.42	.06
1	2	-1.144*	.103	.000	-1.39	-.90
	3	-.986*	.113	.000	-1.26	-.72
2	1	1.144*	.103	.000	.90	1.39
	3	.158	.100	.261	-.08	.40
3	1	.986*	.113	.000	.72	1.26
	2	-.158	.100	.261	-.40	.08
1	2	-.781*	.156	.000	-1.15	-.41
	3	.051	.172	.952	-.36	.46
2	1	.781*	.156	.000	.41	1.15
	3	.832*	.152	.000	.47	1.19
3	1	-.051	.172	.952	-.46	.36
	2	-.832*	.152	.000	-1.19	-.47
1	2	-.470*	.132	.002	-.78	-.16
	3	.117	.145	.699	-.23	.46
2	1	.470*	.132	.002	.16	.78
	3	.588*	.129	.000	.28	.89
3	1	-.117	.145	.699	-.46	.23
	2	-.588*	.129	.000	-.89	-.28
1	2	-.403*	.150	.023	-.76	-.05
	3	.307	.166	.159	-.09	.70
2	1	.403*	.150	.023	.05	.76
	3	.710*	.147	.000	.36	1.06
3	1	-.307	.166	.159	-.70	.09
	2	-.710*	.147	.000	-1.06	-.36
Dependent	Variable:	Overall	online	mathematics	learning	behaviours

*. The mean difference is significant at the 0.05 level.

In terms of variable 1, tests revealed that there are significant pairwise differences between the mean scores of prospective teachers in cluster 1 and cluster 3, cluster 2 and cluster 3 ($p < 0.05$) while cluster 2 does not differ significantly from cluster 1. Moving down to variable 2, significant pairwise differences between the mean scores of prospective teachers in cluster 1 and 2, cluster 2 and 1 and finally 2 and 3 existed ($p < 0.05$) but not between the pairs of cluster (1 and 3) and (3 and 1). Variable 3 shows that the mean scores of prospective teachers between the pair of clusters (1 and 2) and (2 and 1) are not statistically significant while (1 and 3), (2 and 3) and vice-versa are significant ($p < 0.05$). Variable 4 indicates that the pairwise differences between the mean scores of prospective teachers among the three clusters are not significant ($p > 0.05$). This is consistent with the results on the ANOVA table on the dependent variable 4 ($p > 0.05$). Variable 5 shows significant pairwise differences between the mean scores of student teachers in cluster 1 and 2 or 2 and 1 while there are no significant differences in the combination of the remaining clusters as $p > 0.05$. Variable 6, shows that there is no significant pairwise differences between the mean scores of prospective teachers in cluster 2 and 3 or 3 and 2 while they differ significantly between different arrangements of cluster (1 and 2), (2 and 1), (1 and 3) and (3 and 1) since $p < 0.05$ respectively. Variable 7 indicates significant pairwise differences between the mean scores of prospective teachers who are in cluster 1 and 2 and cluster 2 and 3. Prospective teachers in cluster 1 and 3 do not differ significantly from the other two groups $p > 0.05$. Variable 8 shows significant pairwise differences between the mean scores of student teachers in cluster (1 and 2) and (2 and 3) as $p < 0.05$ while cluster 1 does not differ significantly from cluster 3. Finally, variable 9 highlights significant pairwise differences between the mean scores of students who are in cluster (1 and 2) and (2 and 3) since $p < 0.05$, showing that our findings are significant while students in cluster 1 do not differ significantly from those in cluster 3.

Despite the different patterns between clusters, prospective teachers show different variations of online engagement in mathematics activities. The significant levels between clusters are observed. Based on the conceptual framework of this study, it can be argued that prospective teachers exhibited some skills to participate in online learning and had the necessary digital tools to facilitate their online interactions. While cluster 2 and 3 depict overall higher scores, results seem to suggest that through online learning activities, all prospective teachers are able to study from the comfort of their homes. Since COVID-19 has resulted in the widespread disruption of physical attendance of mathematics education and professional training classes, online learning as an educational response to COVID-19 would be the best alternative. In this context, our results seem to somehow agree with Poh-Sun Goh and Sandars (2020)

who disclosed that large group in-person lectures have been replaced by streamed online lectures, using technologies for screen capture and online dissemination. This is also possible among the prospective teachers as they endeavor to experience their mathematics activities through e-learning platforms as COVID-19 has and continues to decimate a lot of lives who physically gather in large numbers.

CONCLUSION

This study has provided further evidence that mathematics prospective teachers can also learn via online mode. The research question of the study has been answered. Results of the study reveals that online learning mathematics activities have significant mean differences in clustering (see Table 2). The reason for these differences could be due to prospective teachers' attitudes towards the use of technology in learning mathematics. Others lack the skill and knowledge on how to use online platforms. Hence, may be characterized by a negative attitude thereby recording low scores in cluster 1 and 3. Results also revealed that prospective teachers' online learning mathematics behaviours in the teaching and learning activities were very high on variable 4, 5 and 6 (see Table 3) across the clusters with cluster 2 recording the highest score. One reason for these high scores is that prospective teachers exhibited good tech-skills to engage in online mathematics learning activities and had the necessary technological tools to facilitate their online interactions. Results highlighted different patterns between clusters (see Figure 1) implying that prospective teachers show different variations of online engagement in mathematics activities. The reasons for these variations could be attributed to using unfamiliar technology by some prospective teachers, unstable electricity connections in Zambia, poor internet connections or unaffordable internet costs to sustain long hours of online learning connections.

Finally, authors have addressed the dangers head-on, notably the challenges to be undoubtedly encountered during the COVID-19 crisis. The realizations from this pandemic have gone further than anything else we have endeavored to report in our current paper, although the results and implications are quite too radical to allow their immediate reaction. To this end, there are many lessons drawn from the COVID-19 global pandemic. Further examples may be readily available from the pages of relevant journals. For example, a recent study by Basilaia and Kvavadze (2020) in an educational journal-pedagogical research, revealed that COVID-19 will force many countries and governments worldwide to be more prepared for the future. This would lead to the generation and reinforcement of new health laws, digital platforms and solutions for future pandemic outbreaks. However, we wish to recommend to the university management that a comprehensive and

advanced pedagogic design should be implemented to render lessons through virtual classrooms. In a nutshell, this study recognizes that online learning in mathematics can offer personalized education for all, maximizing the potential of every learner, but many also feel some sense of freedom during the COVID-19 isolation period.

Implications for Future Studies

The rationale behind this study is to give hope and perhaps solutions to both students and lecturers knowing that despite the premature closure of schools due to coronavirus (COVID-19) disease, mathematics students can still engage in virtual learning remotely using the digital platforms available. The published results of this study will serve as a basis for making a recommendation to the university management, the Ministry of Education and policy makers at large to re-examine the inclusion of online learning in the Zambian curriculum and its place in mathematics education during the pre and post pandemic age. While designing a lesson in online mode, online instructors and tutors need to consider various aspects to cater every student available online. For example, this study has highlighted that education in the context of digitization is the best response in the age of the global pandemic. Results of this study offer some insights into what a virtual classroom might look like. Hence, giving a good response to curbing the spread of the viral disease since measures to ensure social distancing have included closure of schools and working from home for both educators and students. The results of this study motivate new series of investigations. For example, one can carry out a study on the vision of digitalization of education now and beyond the age of COVID-19. Others could examine the impact of COVID-19 on global education, while others could conduct a qualitative study on the optimization of online learning in the age of COVID-19: A mathematics teachers' perspective.

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