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GRADE 12 LEARNERS' EXPERIENCES AND PERCEPTIONS TOWARDS VIRTUAL LABORATORIES IN LEARNING OF EXPERIMENTAL PHYSICS DURING COVID-19 SCHOOL CLOSURE.

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Abstract: This study reports the results of a descriptive survey that explored grade 12 learners' experiences and perceptions about virtual labs used amid the COVID-19 school closure. The study involved 202 grade 12 students carefully chosen from 6 government secondary schools offering physics 5054 in Mufulira District of Zambia by means of homogeneous purposive sampling technique. A questionnaire with both closed-ended and open-ended questions was used to collect data. Research findings show that the minority (42.8%) of the students had experience of virtual labs during the COVID-19 school closure while the majority (57.2%) of students did not have experience of virtual labs during COVID-19 school closure due to lack of electricity and ICT gadgets. The students who had experience of virtual labs had positive perceptions about the virtual labs used and mentioned safety, flexibility and convenience as benefits associated with virtual labs. Students who had experience of virtual labs mentioned online simulations and digital simulated experiments on Zambia National Broadcasting Corporation Television (ZNBC TV4) as the most beneficial learning mode used when schools were shuttered due to COVID-19 pandemic. These findings

recommend a requisite for the educational providers in Zambia and other comparable environments to contemplate the social and economic standing of students when scheming virtual labs. Results also suggest that Physics educators should blend virtual labs with physical labs when teaching practical physics in secondary schools.

KEY WORDS: COVID-19, Experimental Physics, Experiences, Perceptions, Students, Virtual lab

1. **Introduction**

On 31st December 2019, the World Health Organization (WHO) was informed of cases of pneumonia of obscure cause in Wuhan City, China. A novel corona virus was distinguished as the cause by Chinese specialists on 7 January 2020 and was named COVID-19. On 11 March 2020, the fast increment within the number of cases in China forced the World Health Organization (WHO) Director-General to announce that the flare-up could be widespread and driven to enormous lockdown in Europe, Asia, America and Africa (World Health Organization, 2020). Therefore, to decrease the mortality, several governments forced physical isolation to school closure in an effort to decrease the COVID19 contamination rates. According to the World Health Organization (2021), ‘‘the instruction portion was altogether crushed by the Pandemic causing all-inclusive closure of universities as well as schools and colleges to halt gigantic student community gatherings which contributed to the spread of the corona-virus.’’

Numerous nations within the world including Zambia, experienced unimaginable tremors coming about from the COVID-19 actuated catastrophe. Since its advancement in Zambia, the COVID19 pandemic was anticipated to compound the issue of learners’ low achievements in practical subjects like practical physics. The primary two positive cases of COVID-19 in Zambia were broadcast on 18th March, 2020 by the Minister of Health during the standard reports on the COVID-19 condition within the country (Mukuka *et al.*, 2021). This declaration was headed by a media announcement a day prior in which the government through the Minister of Health ordered the closing of all schools, colleges and universities in Zambia in an endeavour to battle and reduce the corona virus in Zambia (Mukuka et al., 2021).

In Zambia the corona virus constrained a momentary move to a digital learning platform (Mulenga, 2020). The Ministry of Education, working in conjunction with the Zambia telecommunication Company in consolidation with the Examination Council of Zambia, propelled a collaborative e-learning stage (Mulenga, 2020). The stage facilitated different educating and learning materials for all primary and secondary school learners. The keen modification stage, on the supplementary hand, facilitated Examination Council of Zambia past papers beside test

answers and questions for grade 7, 9 and 12 in all the subjects offered in Zambia. Besides that, the ministry of education working with the Zambia National Broadcasting Corporation (ZNBC) came up with an instructive channel called ZNBC TV 4 which was committed to broadcasting instructive programs in all subjects (Mukuka et al., 2021). Unfortunately, the Ministry of Education did not launch national virtual lab platforms to offer virtual experiments to physics students. However, virtual lab simulations were used by the physics teachers who taught practical physics (Physics 5054) on national television and other TV channels like DSTV educational channels. It was anticipated that students used virtual lab simulation during self-study. Hence, there was a need to explore grade 12 learners' perceptions and experiences with virtual labs in Zambia.

According to Gunasekara *et al.* (2021), virtual laboratories provided an occasion for learners and teachers to conduct physics experiments online while functioning from their households. In the setting of this study, all practices of physics experiments conducted online either by the physics teachers or physics students throughout the closure of secondary schools due to the corona-virus are referred to as virtual experiments since they were conducted virtually and no physical contact was allowed. From the Zambian practice, virtual labs included learners' self-study using online based simulations, animation, online videos and digital experiments conducted through television. However, it was anticipated that virtual experiments contributed to the difficulty of learning practical physics, the subject matter which has been considered to be challenging at secondary level of education. It was projected that virtual platforms used in the teaching of practical physics had its own benefits and challenges as a result learners showed varying perceptions and experiences with virtual experiments (Ahmad *et al.*, 2020).

In Zambia, it was observed through examination results analysis that Practical Subjects, Mathematics and Natural Sciences continue to record unsatisfactory results in government schools (Curriculum Development Centre, 2013). The continued low pass rate in natural sciences is evidenced by the (ECZ) annual performance reports in Physics 5054 which stood at 33.28% in 2017 and 33.25% in 2018. This failure can be attributed to the current situation in Secondary Schools where hands-on science labs are not combined with virtual labs for effective teaching and learning of practical subjects. Most of the teaching and learning is done theoretically using conventional methods, even for practical physics (Curriculum Development Centre, 2013). The coming of COVID-19 worsened the situation in practical sciences due to the sudden school closure which prevented secondary school learners from having hands-on physics labs.

Sulaiman *et al.* (2020) conducted a study on Malaysian primary and secondary school students to examine teachers' and students' perceptions on planned utilization of virtual lab facilities in learning Physics in primary and secondary schools. The results of the study

uncovered that there were positive recognitions towards the choice of utilizing virtual labs in learning physics in the close future. The study uncovered that virtual lab diminishes the level of abstraction that goes with ordinary or conventional science labs and helps the students associated with both hypothetical and viable information. Sulaiman recommended that another experimental research study should be conducted on a bigger group of physics learners using other options available in virtual labs and find out if students will still develop positive perceptions towards learning by virtual labs. Hence, there was a need to conduct this study in Zambia.

2. **Need of the study.**

The pass rate in practical physics: school-based assessments decreased by ten percent in 2020 compared to 2019 (Mufulira Secondary School Result Analysis Report, 2020). The 2013, 2014, 2015, 2017 and 2018 Examination Council of Zambia (ECZ) Annual Performance Reports disclose the low achievements in physics and science. The performance rate in physics (science) was at 33.94%, 17.76%, 17.65%, 35.28%, and 33.25% respectively. The pass rate in physics was 48.33% in 2016 and 48.83% in 2017(Examination Council of Zambia Annual Report; 2013, 2014, 2015, 2017 and 2018). The low pass rate could be attributed to lack of good practical skills and experiences required in practical subjects. Most of the teaching and learning was done theoretically using conventional methods, even for practical subjects like physics (Curriculum Development Centre, 2013).

The coming of pandemics such as COVID-19 had the potential to slow down school-based assessments due to unplanned school closure which do not allow physical contacts (UNESCO, 2021). School based assessments in experimental physics in most Zambian schools were done using traditional hands-on labs which encouraged physical contact. In order to prevent the stoppage of school-based assessments in practical physics during pandemics and also to address the problem of lack of specialized physics labs, resources and practical equipment there is need to introduce virtual experiments in the school curriculum. Free virtual labs for secondary schools are available on http://www.olabs.edu.in/ and (http://amrita.vlab.co.in/).

Even though the Zambian government did not officially launch virtual lab platforms like it did with other platforms; various physics teachers who taught digitally on national television and other digital satellite television stations used virtual lab simulations to teach practical physics (Physics 5054). It was also anticipated that students used virtual lab simulations online. Various research studies (Ngoyi 2013; Sulaiman et al. 2020; Chan and Fok 2015) revealed that if students are effectively exposed to virtual labs and gain technological experience with virtual

labs, they develop positive perceptions towards virtual labs. Therefore, there was a knowledge gap that needed to be addressed in the Zambian context through a descriptive survey since learners were abruptly introduced to virtual labs without equipping them with technological experiences.

It was beneficial to do this research because virtual labs are vital components in secondary schools' effort to expand lab-based science courses to distinctive groups of secondary school learners. Virtual labs can be utilized as an optional learning mode during calamities.

2.1 Purpose of the study

The drive of this study was to examine grade 12 learners' experiences with virtual labs in learning practical Physics (Physics, 5054) amid COVID-19 school closure. It also investigated the perceptions of grade 12 learners towards the virtual labs utilized amid COVID19 school closure.

2.2 **Research questions**

This research was guided by two investigate questions:

i. What are grade 12 learners' experiences with virtual labs used amid COVID-19 school closure in learning practical Physics in chosen secondary schools of Mufulira District, Zambia?
ii. What are grade 12 learners' perceptions about virtual labs utilized amid COVID-19 secondary school closure?

2.3 Significance of the study

This study sought to respond to the on-going exploration for pedagogies that makes secondary school learners to be collaborative problem solvers, self-directed and creative learners.

The study helped physics educators to see the importance of combining hands-on physics labs with virtual labs when teaching practical physics. The effective use of hands-on and virtual labs equips both teachers and secondary school students with technology skills and experience needed in the use of virtual labs.

By doing this study, the information has been included in the on-going inquiry with respect to virtual labs, and provides a better

understanding on how virtual labs can be used effectively in secondary schools with or without pandemics.

The research results have contributed to the current debate on the utilization of virtual labs in teaching practical physics in secondary schools. It has also shown that virtual labs are alternative arrangements that can be used in times of pandemics that do not permit physical contacts or other intrusions of school exercises.

2.4 Theoretical framework

The study is grounded in Mayer's (2005) cognitive hypothesis of interactive media learning and Jerome Bruner's (1966) hypothesis of constructivism. These hypotheses establish the hypothetical foundation of this research since they support incorporation of students' day-to-day experience, their previous data and learning by doing. These theories support conceptual changes in students as they integrate new information of their current cognitive structure or in fact by adjusting their existing information into deductively acknowledged conceptions as person or with the assistance of others.

Mayer's (2005) cognitive hypothesis of mixed media learning

According to Mayer (2005), the Cognitive hypothesis of interactive media learning states that "people learn more profoundly from words and pictures than from words alone" (p. 47). However, essentially including words to pictures is not an effective way to attain multimedia learning. The objective is to plan enlightening in light of how the human intellect works. This hypothesis proposes three primary thoughts when it comes to learning with multimedia:

There are two isolated channels (sound-related and visual) for handling data (some of the time alluded to as Dual-Coding hypothesis). Instructional schemes in virtual labs advance the representation of data. Physics students are able to utilize two partitioned channels for preparing data, sound-related and visual in this way permits them to construct their own mental representations and schemes:

- Each channel features a constrained (limited) capacity. People can only process a limited sum of data in a channel at a time, and they make sense of approaching data by effectively making mental representations. Virtual labs make a difference student's handle a limited sum of data in a channel at a time subsequently students make dynamic mental representation; and

- Learning is a dynamic process of selecting, organizing, and joining data based upon earlier information. Instructional plans in virtual labs advance dynamic learning. Students learn by doing hence, students are able to select, organise and integrate information to solve a new practical problem.

  Students can only develop a limited sum of data in a channel at a time, and they make sense of approaching data by effectively making mental representations. Mayer examines the part of three memory stores: tangible (which gets stimulus and stores it for a really brief time), working (where we effectively prepare data to make mental developments (or 'schema'), and long-term (the store of all things learned). Mayer's cognitive hypothesis of mixed media learning presents the thought that the brain does not decipher interactive media introduction of words, pictures, and sound-related data in a commonly selected design; or maybe, these components are chosen and organized dynamically to deliver coherent mental developments. Besides, Mayer underscores the significance of learning (based upon the testing of substance and illustrating the fruitful exchange of information) when unused data is coordinated with earlier information.

  Design standards in virtual labs incorporate the utilization of animation and simulation devices, and guidelines recordings as well as interactive outlines. The hypothetical viewpoint behind this guidelines plan is to assist students visualize information and phenomena which helps students to understand abstract physical concepts and concepts in physics instruction. Concurring with the cognitive hypothesis of interactive media learning, CTML (Mayer, 2005), the utilization of interactive media representation of concepts in both visual and verbal organize permits learners to utilize both data preparing channels at the same time in this way permitting them to construct their claim mental representations and plans. This will in turn help learners create positive perceptions towards a given subject or topic.

Jerome Bruner's (1966) hypothesis of constructivism

Bruner's constructivist hypothesis proposes that learning is an active process in which learners develop meaning or unused thoughts or concepts based on their current or past encounters (Bruner, 1966). Bruner contended that learners build their possessed information by organizing and categorizing data employing a coding system. He accepted that the foremost compelling way to develop a coding framework is to find it instead of being told it by the instructor. This can be what he named as the concept of discovery learning. Discovery learning takes place

in problem solving circumstances where the learner develops modern information from his possessive encounter and his earlier information and could be a strategy of instruction through which students are connected with their real or virtual environment by investigating and controlling objects, engaging in debates and discussions, or performing experiments.

Constructivism is a philosophy of learning on the foundation that, by reflecting on our past and displaying encounters, we develop our claim of understanding of the genuine world in which we live. Each of us builds our own understanding and mental models which we utilize to form a sense of our learning encounters. Learning, subsequently, is essentially the method of altering our mental models to absorb and suit modern encounters. The reason for learning is for a person to develop his or her meaning and understanding (Bruner, 1966).

Amid COVID-19 school closure, advanced learning situations offered openings to extend learners' engagement, inspiration, and positive perceptions toward practical physics. Virtual labs empower students to carry out experiments in an online environment. Instructional plans of virtual labs may include the utilization of animation and simulations instruments and instructional recordings as well as interactive presentations. The hypothetical viewpoint behind this guidelines plan is to supply a helpful learning environment, in which students can connected with online learning substance in any time and place where the web is accessible and agreeing to their pace of learning

3.0 Methodologies

3.1 Research design

According to Tichapondwa (2013), a research design "is a plan or strategy which moves from the underlying philosophical assumptions to specifying the selection of respondents, the data gathering techniques to be used and the data analysis to be done" (p.114). In this research study a descriptive research design was utilized. This research design was appropriate since it permitted the researcher to accumulate both subjective and quantitative information at once without proceeded interaction with the students in compliance to corona virus social separating measures within the middle of the third wave. This design empowered the researcher to obtain comprehensive suppositions from the respondents concerning their discernment and encounters with virtual labs in learning practical physics amid COVID-19 pandemic.

3.2 Research site

The research was conducted in Mufulira District in the Copperbelt Province of Zambia. The study was conducted from six government secondary schools offering Physics 5054 in Mufulira District. The following were the participating schools: Mufulira high school, Pamodzi girls' secondary school, Kantashi secondary school, Chakwa secondary school, Ipusukilo secondary school and Butondo secondary school.

3.2 Population and sample

The target population of this study was 902 grade 12 learners studying in six government secondary schools offering Physics 5054 in Mufulira district, Zambia. Six schools were selected from the total of 17 secondary schools, because these were the only secondary schools offering Physics 5054 in agreement with the purpose of the study. Sample size for the study was 202 grade 12 learners.

Homogeneous purposive sampling technique was employed to select the research participants. From each secondary school, the researcher purposefully picked the grade 12 class studying Physics 5054. Each secondary school had only one grade 12 class taking Physics 5054 ranging in six from 26, 26,27,35,39, to 49 learners (Class Registers,2022).

3.4 Instrumentation

The instrument used in this study was a questionnaire which had both closed-ended and open-ended questions. This instrument is in Appendix A. This instrument had two areas. The primary segment consisted of six closed-ended questions and three open-ended questions to investigate Learning Experiences amid COVID-19 School Closure. The lead question was: How were you learning practical physics amid the covid-19 school closure? Learners responded by ticking yes or no to the six practical learning modes used during COVID-19 school closure. The items were based on the teaching approaches physics teachers used to teach Physics 5054 digitally such as; online videos shared on ZNBC TV 4, digital simulated experiments on ZNBC TV 4 and digital animated experiments on ZNBC TV 4. The other three practical learning modes namely self-study using online video labs, self-study using online simulation and self-study using online animation were adapted from the study by Sulaiman et al. (2020). Three open-ended questions were used to collect in-depth responses on grade 12 learners' experiences with virtual labs.

The second section consisted of ten Likert type items and three open-ended questions. This section explores grade 12 learners' perceptions about virtual labs. The lead question was: What is your opinion about virtual labs? The first five sample items such as virtual labs are safe; virtual labs help learners develop life skills, helps learners visualise concepts and cheaper were developed based on the merits of virtual labs. The researcher also borrowed items such as virtual labs that are boring; challenging and time consuming from the study done by Radhamani et al. (2021).

3.5 Validity and reliability of data collection instruments

The thesis supervisor, an expert in education research and secondary school science curriculum authorized the use of the draft questionnaire for administration. Upon the authorization, the questionnaire together with the content tabulation form were sent to a college of education lecturer, an expert in physics teaching methods and education research for validation. The instrument and the content tabulation form were also sent to a secondary school teacher; an expert in Physics 5054 for validation. The two validators were asked to complete the content validation form by scoring each item on the questionnaire accordingly, based on its quality, relevance and clarity. The rating scale for each questionnaire item ranges from 4 to 1, and it is in appendix C.

Content validity was used to determine the validity of the instrument and it was found to be 0.9 valid. The validity of the questionnaire was determined using a statistical approach. The validity of the instrument was obtained by dividing the total number of agreements per questionnaire item by the total number of questionnaire items. Formulations are in the Table in appendix B.

The reliability of the instrument was determined using an inter-rater reliability test and the instrument was found to be 0.8 reliable. Reliability of the questionnaire was statistically determined by counting the number of ratings in agreements for the two experts (**Table in appendix B**) and dividing it by the total number of ratings. Refer to the Table in appendix B for complete tabulations. According to Davis (1992), when the content validity index ranges from 0.8 to 1, the questionnaire is valid and reliable.

3.6 Data analysis

The researcher used Statistical Package for Social Sciences (SPSS) Version 26 to run descriptive statistics, and the category of descriptive statistics used was the measure of frequency distributions. The researcher employed percentage counts and frequency distribution tables to analyse quantitative data. The analysis of information from open-ended survey questions was not extremely complying with all

procedures of qualitative data analysis but responses that were judged to be consistent and expressive of closed-ended reactions were categorised and thematized.

4.0 Results

4.1. Practical Physics learning alternatives amid the COVID-19 school closure.

The questionnaires were completed by 202 students. For the research question 1, students were inquired to select the learning modes that were accessible to them amid the COVID-19 school closure. **Table 1** shows their choices.

Table1. Accessible Practical Physics learning options during the COVID-19 school closure (n=202)

	How were you learning practical physics amid the COVID-19 school closure?	Responses	
		Yes N (%)	No N (%)
1	We did self-study using online simulations	123**(60.9)**	79(**39.1)**
2	We did self-study using online animation	88**(43.6)**	114(**56.4)**
3	We did digital simulated experiments on ZNBC TV4	86**(42.6)**	116**(57.4)**
4	We did digital animated experiments on ZNBC TV4	73**(36.1)**	129**(63.9)**
5	We did online video labs shared on ZNBC TV4	73(**36.1)**	129**(63.9)**

6	We did self-study using online video labs	66**(32.7)**	136(**68.0)**

The results in **Table 1** showed that a large number of students did not use virtual labs to learn practical physics during COVID-19 school closure. Data revealed that most of the students did not learn practical physics during COVID-19 school closure using practical learning options available on ZNBC TV4. The result showed that 61.7% of the learners did not learn practical physics using ZNBC TV4, only 38.3% of the learners did. The result further revealed that students who did virtual labs using online platforms were fewer than those learners who did not. The number of students who did virtual labs using online learning options were at 45.6% while for those who did not was at 54.7%.

Students who had experiences of virtual labs amid COVID-19 school closure were fewer than those who did not. On average **42.8 %** of the students did practical physics using virtual labs while **57.2%** of students did not learn practical physics using virtual labs.

For the research question 2, students were inquired to clarify other learning alternatives that they utilized amid the COVID-19 school closure. Findings showed that 7 % of the students proceeded learning viable practical physics using WhatsApp and Zoom stages amid the COVID -19 school closure.

4.2 The most beneficial practical learning modes used amid the COVID-19 school closure.

For the research question 3, students were asked to explain which practical learning mode was the most beneficial to them. The students who had experience of virtual labs mentioned that self-study using online simulation and digital simulated experiments on ZNBC TV4 were the most beneficial modes of learning practical physics amid COVID-19 school closure. The reasons given by these students for choosing the said learning options indicated benefits associated with virtual labs. The advantages of virtual labs as seen by the students (42.8%) were: Flexibility, Convenience and Safe.

Flexibility: The foremost common advantage of virtual learning is that it permits adaptability, which in turn helped to move from teacher-centred learning to student-centred learning. The virtual labs were said to be adaptable since they permitted understudies to pace themselves (Research Participant # 1). According to (Research Participant # 10), online virtual lab simulations were flexible because they allowed students to move at their own pace. Some research participants gave the following reasons:

- **Research Participant # 109**: *Online simulations were beneficial to me because they were available at anytime and anywhere, even when I was sick at home, I was still able to learn at my own pace.*
- **Research Participant # 30:** *I learned practical physics using online simulations because if I do not understand the concept, I would do it myself at my own pace as many times as I would prefer for me to understand*.

Convenience: Another benefit associated with online simulations and digital simulated experiments on ZNBC TV4 is that, provides learners time to do their labs at their own suitability, permitting them to formulate class at home (Participant 2). Online virtual labs simulations were convenient because they allowed students to do experiments at their own suitability. According to (Respondent #4) virtual labs were convenient because even when a student was sick, he or she was able to learn practical physics on ZNBC TV4 without spreading COVID-19. Participants' responses were:

- **Research Participant # 97**: *I used online simulation because it was very convenient. I had more time to focus on the practicals because I used to learn day and night at home.*
- **Research Participant # 35:** *I learned practical physics using online simulations because if I do not understand the concept, I would do it myself at home as many times as I would prefer for me to understand.*

Safety: The use of virtual labs helped students to adhere to covid-19 social distancing rule and this prevented students from being exposed to COVID-19. Online virtual labs and digital simulated experiment were mentioned by the respondents to be the safest method of learning practical physics during COVID-19 school closure because they help to reduce the spread of the disease (Respondent # 30). According to the

research (Participant # 70), virtual labs are safe because they reduce the spread of COVID-19, even when a student had COVID-19 he or she was able to learn practical physics without infecting others. Below we quote one research participate:

- **Research Participant # 21:** *Well, I used self-study using online animations and simulated experiments on ZNBC TV4 because it was the safest way of learning practical physics and helped to reduce the spread of COVID-19.*

4.3 Results for grade 12 learners' perceptions about virtual labs.

For research question 4, students were asked to express their opinion about the virtual labs used during school closure caused by the corona virus pandemic. For this question only opinions of 85 learners who had experienced virtual labs amid the COVID-19 school closure were analyzed. Those who did not have experience of virtual labs were isolated because they did not use virtual labs. **Table 2** displays their opinions.

Table 2: Grade 12 Learners perception on virtual labs used during COVID-19 school closure (n=85)

Survey items	**%**				
What is your opinion about virtual labs?	**Agree**	**Strongly Agree**	**Undecided**	**Disagree**	**Strongly disagree**
Virtual labs are safe	47**(55.3)**	19(22.4)	6 (7.1)	5(5.9)	8(9.3)
Virtual labs are beneficial	43**(51.0)**	26(30.6)	6(7.1)	7(8.2)	3(3.1)
Virtual labs are cheaper	17**(20.0)**	7(8.2)	9(10.6)	35(41.2)	17(20)
Virtual labs are time Consuming	15**(17.6)**	8(9.4)	11(12.9)	37(43.5)	15(17.3)
Virtual labs help learners develop skills	34**(40)**	10(11.8)	10(11.8)	23(27.1)	8(9.4)

helps learners visualise concepts	33**(38.8)**	7(8.2)	34(40)	6(7.1)	5(5.8)
Virtual labs are challenging	28**(32.9)**	8(9.4)	11(12.9)	23(27.1)	15(17.6)
Virtual labs are boring	18**(21.2)**	9(10.6)	4(4.7)	25(29.4)	29(34.1)
Virtual labs are for private schools	9**(10.6)**	4(4.7)	7(8.2)	23(27.1)	43(51.0)

Results displayed in Table 2 reflect that 15.2% of the students indicated that virtual labs are not safe while 77.7% of the students agreed that virtual labs are safe. Results showed that 11% of the students said that virtual labs are not beneficial compared to 81.6% of the respondents who indicated that virtual labs are beneficial. Table 2 showed that 28% of students mentioned that virtual labs are cheaper while 61.2% of learners indicated that virtual labs are not cheaper. It was also revealed that 27 % of learners mentioned that virtual labs are time consuming compared to 60.8% of students who indicated that virtual labs are not time consuming. 21.3% of students agreed that virtual labs do not help students visualize concepts while 67.3 % of learners disagreed with this survey item indicating a positive perception.

The outcomes showed that 40 % of students concurred that virtual labs are challenging while 43.6% of students disagreed. The results also showed that 26.9% of the respondents agreed that virtual labs are complicated compared to 61.9% of respondents who disagreed with this statement indicating a positive perception.

Research Findings in **Table two** showed that learners who had experience of virtual labs when schools were closed amid the COVID-19 pandemic showed **positive perceptions** about virtual labs used.

For research question 5, students were asked to explain if they enjoyed virtual labs used amid the COVID-19 school closure. Majority

(**57.2%**) said that they did not use and gave justifications to why they did not use virtual labs. The responses given by students' highlighted challenges associated with virtual labs. The following were challenges: lack of ICT gadgets (televise-ion, smartphone and computer), lack of electricity, and not blending virtual labs with physical labs.

Lack of ICT gadgets: data showed that students did not enjoy virtual labs used during COVID-19 school closure because they did not have smartphones, computers and television sets. According to (Research Participant # 181) virtual labs were not good to him because he did not have a television set and a smartphone. "Those who had smart phones and bundles learned practical physics but for me I did not learn practical physics because I did not have a smartphone which had internet" (Research Participant # 30). Lack of ICT gadgets such as televisions sets, smartphones and computers were a few of the challenges related with virtual labs utilized amid the COVID-19 school closure. Below we quote two respondents:

- **Research Participant # 181:** *It was not good; some of us did not have televisions and smartphones.*
- **Research Participant # 131:** *Virtual labs were not good because pupils did not have smart phones and cannot afford daily bundles in order to do online virtual labs.*

Lack of electricity: During the COVID-19 pandemic Zambia experienced massive load shedding. According to (Research participant# 139**)** lack of electricity was the major obstacle faced in learning practical physics during COVID-19 school closure using virtual labs**.** ''I did not enjoy virtual labs used during COVID-19 school closure because electricity was going a lot. There was massive load shedding in my area'' (Research Participant # 181). Lack of electricity hindered virtual and digital learning during the COVID-19 school closure. Below we quote two respondents:

- **Research participant # 138:** *Where I live there is no electricity and we do not even have a television set and a phone. I did not enjoy virtual labs during COVID-19 school closure because electricity was going out a lot.*

Not blending virtual labs with physical labs: During the Lockdown virtual labs were not combined with physical labs because no physical contacts were allowed. Students explained that they were used to labs conducted in schools rather than the virtual labs conducted on television

and the internet. ‘‘The labs were not clear because they were not combined with real labs” (Research participant# 139). Below we quote one respondent:

- **Research participant# 41**: *I needed guidance from the teacher when doing labs, if I learn on my own, I will not understand unless they combine the two labs.*

4.4 Use of virtual labs in learning practical physics

For question 6, students were inquired to reply on whether virtual labs must proceed to be utilized in learning practical physics in secondary schools or not.42.8% of students who had experience of virtual labs during COVID-19 school closure agreed while 57.2% of students who had not experienced virtual labs during the COVID-19 school closure disagreed.

4.5 Conclusion

Chapter four presented results collected from the descriptive survey. The following was the conclusion:

The majority **(57.2%)** of the students did not have experience of virtual labs used in learning practical physics when secondary schools were closed due to corona virus. Lack of electricity, ICT gadgets and lack of blending were found to be the challenges associated with the virtual labs available when schools were closed due to COVID-19 pandemic.

Learners who had experience of virtual labs had positive perceptions about virtual labs and mentioned safety, convenience, flexibility as benefits of virtual labs. Online simulation and digital simulated experiments on ZNBC TV4 were mentioned by the students who had experience of virtual labs during COVID-19 school closure as the most beneficial modes of learning practical physics.

5.0 Discussion of results.

The main finding of this study was that; a large number of students (57.2%) did not have experiences of virtual labs used during lockdown caused by corona virus. This is contrary to the assumptions that students learned practical physics when schools were closed during the corona virus pandemic using virtual labs or any other practical learning options.

It is a well-known fact that the Zambian government in collaboration with other stakeholders introduced ZNBC TV4 to offer practical

and theoretical science lessons to secondary school students. Based on the data evidence, practical learning in physics 5054 did not fully take place among secondary school students. It is also disappointing to note that, even the learning option (ZNBC TV4) which the government had put in place to teach physics and other practical subjects, did not produce its intended purpose of providing practical learning to the secondary school physics 5054 students in Zambia. The findings of this study have disclosed that a large number of the students did not learn practical physics amid the COVID-19 school closure using online and digital platforms available due to the lack of electricity and ICT gadgets such as televisions, smartphone and computers (Research Participant # 30).This comes to an agreement with what other researchers have found in other research studies. For example, a study which was done in Jordan by Abuhammad (2020) also cited individual, logistical, and technical obstacles as hindrances to the virtual learning mode amid the COVID-19 lockdown. Another study conducted in Bangladesh by Al-Amin et al. (2021) reported that restricted access to electricity were among the major obstacles to virtual learning in most developing nations.

It is therefore important that before designing virtual labs instructional schemes, physics educators should put into consideration the social and economic standing of their students. It was very shocking to note that a large number of students did not learn practical physics amid COVID-19 school closure despite having practical learning options that were available which did not even require physical contacts for example simulated experiments conducted on ZNBC TV4

5.2 Grade 12 learners' perceptions on virtual labs used amid COVID-19 school closure.

In this section the researcher discusses the study results of students who had experience of virtual labs and isolated those who did not have experience of virtual labs. Students explained that they did not use virtual labs because they did not have electricity and ICT gadgets. When measuring the students' perceptions, the researcher isolated those who did not use virtual labs because if they had used the virtual labs, their perceptions would have fluctuated. Nevertheless, the result analysis indicated that students who had experience of virtual labs amid COVID-19 school closure had positive perceptions about virtual labs used. This concurs with what other researchers have found. For instance, Sulaiman (2020) conducted a study on Malaysian primary and secondary school students to explore teachers' and learners' perceptions on the impending utilization of virtual labs in teaching and learning of physics. The findings of the study showed that students had a positive perception about virtual labs.

It is worthy to note that practical education must continue even in times of pandemic that do not allow physical contact because it helps learners acquire survival skills. The finding of this study indicates that virtual labs can be used to conduct physics practicals in schools and subsequently be used for school-based assessments during pandemics such as COVID-19 because 42.8% of the learners did practical physics during the pandemic. This indicates that practical learning in secondary schools can continue during lock-downs using virtual lab platforms. However, the concerns raised by 57.2 % of students who did not have experience of virtual labs such as; lack of electricity, ICT gadgets and lack of blending of physical labs with virtual labs must be taken seriously whenever physics educators design virtual lab experiments. As evidenced by this study virtual labs used during COVID-19 school closure were not blended with physical labs (Research participant # 41). It is therefore important that physics educators blend physical labs with computer-generated labs when teaching physics 5054 in secondary schools as this will help students change their mindset; appreciate the importance of computer-generated labs and be ready to use virtual labs in times of pandemics that do not allow the use of physical labs. If students are equipped with technological skills and the mindsets of students are changed through exposure, virtual labs can be used to conduct physics practicals in schools and subsequently be used for school-based assessments during pandemics such as COVID-19.

5.3 Study limitations

The major confinement of this study was that the researcher did not carry out a pilot survey to find out if the students from the target population had utilized virtual labs amid the school closure caused by the corona virus. The other limitation of this study was that the researcher's presumption that students were utilizing virtual labs when schools were closed amid the COVID-19 was false since the majority did not utilize virtual labs and had challenges in replying to some research questions.

5.4 Recommendations for practice

Grounded on the results of the study, the following endorsements were made:

i. Before introducing virtual labs to students, physics educators should consider the social and economic status of the students.
ii. Before introducing virtual labs to secondary school students, educators should first orient the students on how to use digital and online virtual labs and the importance associated with such labs.
iii. Virtual labs should be blended with physical labs for teaching practical physics in secondary schools in order to impart the 21st century technological skills into learners.

5.5 Recommendation for future research

Grounded on the limitations of the study, the researcher recommended that:

i. Action research should be conducted in future that will provide insights on how virtual labs can be blended with physical labs for conducting school-based assessments.

5.6 Conclusion

The purpose of this study was to find out grade 12 learners' experiences with virtual labs in learning practical physics (Physics 5054) amid the COVID-19 school closure. It was also seeking to establish the perceptions of grade 12 learners about the virtual labs used amid the COVID-19 school closure. The following were the conclusions:

Majority of students did not learn practical physics using virtual labs during the covid-19 school closure.

Students explained that they did not use virtual labs because they did not have electricity and ICT gadgets.

The students who had experience of virtual labs had positive perceptions about virtual labs and mentioned safety, flexibility and convenience as benefits associated with virtual labs used. They also mentioned that online simulations and digital simulated experiments on ZNBC TV4 were the most beneficial education mode used when schools were closed. The study results contribute to the progressing discourse on the part of virtual labs in learning and teaching of practical sciences (physics) in secondary schools as well as a substitute resolution under the times of pandemics that do not allow physical contact. Virtual labs offer a resolution for physical separation required owing to the predicament imposed by the virus. Therefore, if the recommendations suggested in this study are implemented, virtual labs can be used to conduct physics practicals in secondary schools and subsequently be used for school-based assessments during pandemics such as COVID-19 which do not allow physical labs or contacts.

Declarations

Author contribution statement

Emmanuel Mumba: Conceived and designed the experiments; Performed the experiments; Analysed and Interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Declaration of interests' statement

The authors declare no conflict of interest

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