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Integrating Video-Based Multimedia in Teaching Physics in Context of Covid-19 in Rwandan Secondary Schools

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Abstract. The Covid-19 pandemic has paralyzed the education system and lead to temporary school closure. After school re-opening, long-term responses to a resilient education system were needed. A descriptive survey research design was used to diagnose the barriers to video-based multimedia integration in teaching and learning physics in certain secondary schools. 47 physics teachers (35 males and 12 females) were purposely selected from 24 schools located in the Rutsiro and Rubavu districts. A questionnaire was given to all 47 teachers. One-on-one interview with great attention to the measures of reducing the transmission of Covid-19 was conducted to all senior five physics teachers. Research findings revealed that video-based multimedia is less used in teaching and learning physics. Teachers indicated that poor infrastructure, poor teachers' training aimed at effective integration of multimedia in education, pressure to prepare students for exams, and teachers' lack of time for preparation are major factors that impede the use of video-based multimedia in teaching and learning physics. Results also provided proof of the necessity to provide digital devices to teachers and learners, teachers' training, and learners' preparation for virtual classes so that video-based multimedia could be a better instructional strategy to long-term responses for Covid-19 and future shocks. The findings of this study revealed that VBM could be a consensus on education and technology competency required to support teaching and learning especially during Covid-19 and future shocks.

Keywords: Video-Based multimedia; Covid-19; physics education; e-learning

1. Introduction

The first case of Covid-19 was signaled in Wuhan, China in December 2019. Later, the disease has escalated briskly worldwide, leading to a world pandemic (World Health Organization [WHO], 2020). In the 21st century, Covid-19 has been considered as one of the dangerous health crises for people in the world. Consequently, many countries put in place measures to fight against Covid-19 and to reduce the citizens' transmission. As a result of those measures, many countries worldwide decided to close schools. The school closure paralyzed the education system in more than 186 countries and 80% of the learners in the world were affected (UNICEF, 2020).

In sub-Saharan Africa, Covid-19 has had an enormous impact on education (UNESC0, 2021). The experience of the pandemic has been traumatic, and there has been widespread school closure across sub-Saharan Africa in response to the pandemic (Mukuka et al., 2021). The government of Rwanda reported the first case of Covid-19 on 14 March 2020 and the total number of Covid-19 positive cases has increased to 96,570 with 1,242 deaths as of September 25, 2021(Worldmeter, 2021). The Covid-19 has caused the worst education crisis in Rwanda leading to school closures in March 2020 (Mineduc, 2020; UNICEF, 2020). During the time of school closure, the government of Rwanda proposed responses to assist learners to continue learning remotely. Low-tech multimedia such as radio and television-assisted learning were used to ensure continuity of learning for all students including vulnerable students, students with disabilities, and students from disadvantaged communities (Mineduc, 2020).

After school reopening in November 2020, long-term projections to build resilient education systems were needed. Since then, according to Rwanda's education sector Covid-19 response plan, Rwanda ministry of education and Rwanda basic education board launched several initiatives that aimed to education system the resilient (Mineduc, 2020; Mugiraneza, 2021). Adopting an appropriate integration of technology and moving a step forward on the way multimedia is used in teaching and learning were parts of the selected initiatives (Mineduc, 2020; Mugiraneza, 2021). In addition, expanding online learning, combining the use of digital and multimedia tools, teacher' professional development, and establishing remote assessment strategies were among priorities (Mugiraneza, 2021). However, those initiatives face many challenges even before Covid-19. Therefore, this study seeks to diagnose the barriers associated with the integration of video-based multimedia (VBM) as a long-term response to Covid-19 and future shocks. Even if the Covid-19 turns all education upside down, it exacerbates the crisis that was already raging in physics education (Uwizeyimana et al., 2018). That is why special attention has been given to physics education in this study.

2. Literature Review

2.1. Theoretical Framework

This study is based on the cognitive theory of multimedia learning which suggested the use of multimedia as remedies to run-down learning (Castro-Alonso et al., 2021). The cognitive theory of multimedia learning goes hand in hand with the constructivist theory that requires learners to interact with knowledge construction (Yuejue et al., 2021). The cognitive theory of multimedia learning asserts that learning can be enhanced by the use of multimedia (Chelliah & Masran, 2020; Kiat et al., 2020). This requires teachers and/or learners to choose appropriate words and appropriate pictures, arrange these words and pictures independently into clear mental models, form connections between verbal and mental models, and incorporate those models with prior knowledge (Castro-Alonso et al., 2021).

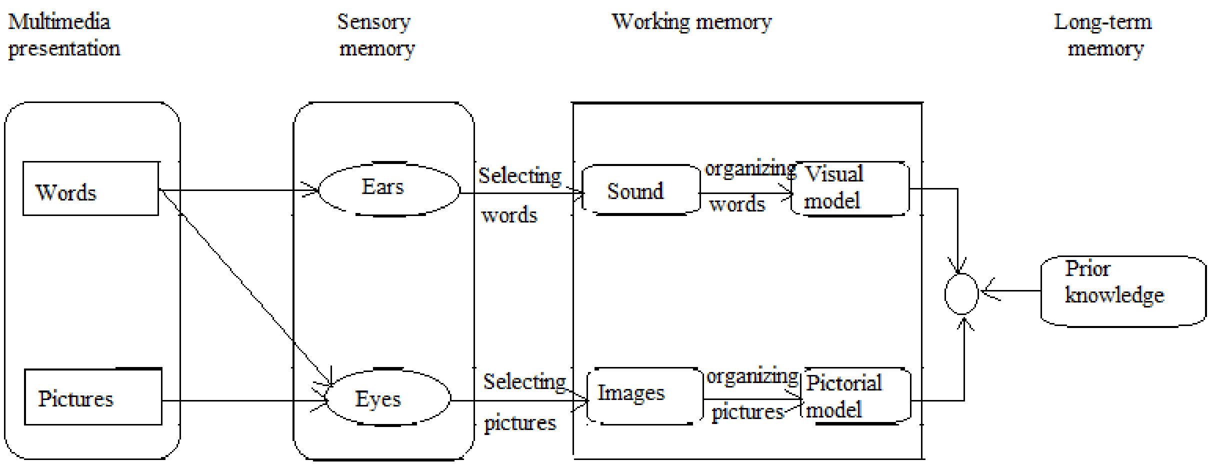

Figure 1: Schematic of the cognitive theory of multimedia learning adapted from Mayer (2001)

2.2 Multimedia in Education

The improvement of technology has changed the way we view the world and paved the way to new opportunities. The education system also benefits from this development of technology (Oliveira et al., 2018). The progress in the digital era has stimulated the production of new interesting and effective approaches in teaching and learning contexts such as multimedia (Ndihokubwayo et al., 2020). Multimedia in education stems from the theory of constructivism and supports self-paced learning (Bull, 2013). Multimedia based instruction support learner-centered methodology which puts learners at the center of the learning process by focusing on their needs (Yap, 2016). Within multimedia based instruction, learners are likely to work cooperatively, increase development in the economic and technological world, and equip learners with dynamic skills, value, and knowledge required for the development of the person (Kabigting, 2021; Ndihokubwayo et al., 2020). However, integrating multimedia in teaching and learning is handicapped by infrastructure and ICT tools readiness (UNESCO, 2021), teachers' ICT literacy (Hafifah & Sulistyo, 2020), teachers' beliefs and confidence to use technology in teaching and learning (Martin et al., 2020; Creely et al., 2021), and national policies managing and supporting the use of technology in education (Valente & Almeida, 2020).

Video-based multimedia (VBM) is mostly used when integrating multimedia based instruction in science education (Adekoke, 2011; Gambari et al., 2014). Researchers revealed that VBM provides and promotes a learning climate in which learners take responsibility for their own learning by solving problems, teaching one another, debating and group discussion about activity at hand (Castro-Alonso et al., 2021). Moreover, VBM increases competency to the application of levels of blooms taxonomy and enhances professional and technological skills that are crucial for a successful career in today's global context (Akinoso, 2020). The rationale behind VBM is the use of videos in class or outclass activities where learners interact and get engaged with knowledge construction, discuss/debate and clarify doubts without embarrassments, and teachers act as a guide by the side to facilitate learning (Adi et al., 2021; Gambari et al., 2014). Thus, VBM stems from the theory of constructivism (Yuejue et al., 2021).

Multimedia based instructions have been identified to attract students' attention, motivation, and enhance students' achievement, and retention (Adekoke, 2011). The use of multimedia in physics classroom revealed several opportunities such as access to knowledge that is stored beyond textbooks, solutions to manual paper based processes and procedures, better teaching and learning methods, save time, student management, motivation, and raise academic achievement and retention(Adekoke, 2011; Rusanganwa, 2013; Yap, 2016).The VBM allows students to explore and visualize physics content that is closely related to a specific form of constructivist learning theory (Adi et al., 2021). VBM is valuable in physics as it promotes students' problem solving, builds a bridge between verbal and scientific representations, and helps students to develop images that give meaning to scientific and mathematical symbols (Rusanganwa, 2013). VBM enables physics learners to access knowledge and develop their multiple intelligence skills (Blomberg et al., 2014). VBM learning strategies help to make sense of what is happening in class and support learners' sense of being actors, researchers, and creators (Holmes et al., 2019; Ziegelbauer & D'Errico, 2021).

2.3 Video Based Multimedia in the Context of Covid-19

Covid-19 shows that educationists are required to change their mindset on how they view the education system (Mukuka et al., 2021). When schools were closed due to Covid-19, educationalists had no other option than to shift to online classes (UNESCO, 2021). Covid-19 pushed teachers to assume virtual teaching where they had to use digital technologies, sometimes for the 1st time to facilitate their students' learning (Code et al., 2020). Video based multimedia in multiform was used during school closure (Mugiraneza, 2021). For instance, recorded videos were shared among learners using their cellular mobile phones (Rodríguez et al., 2020), YouTube videos (Malea et al., 2020), and videos broadcasted on TV (Mugiraneza, 2021), etc. After schools reopening, it has been necessary to rethink the teaching strategies to resilient the Covid-19 and future shock (Mineduc, 2020). Educationists recall the mixture of face-to-face and virtual classrooms (Neuwirth et al., 2020). Researchers revealed that the use of VBM in these jointly learning strategies makes sense (Babelyuk et al., 2020). However, the effectiveness of the said learning strategies requires various types of preparedness such as technological readiness (Nimavat et al., 2021), preparing in-service teachers (Mukuka et al., 2021), pedagogical and home-based learning (Gonzales, 2020), readiness for monitoring and assessment (Egede, 2021), and adjust learning management (Moore et al., 2021).

2.4 Research Problem and Focus

In the light of the Covid-19 pandemic and its effect, the education sector is experiencing transformation (Mhlanga & Moloi, 2020). In other terms, the pandemic has changed the education system dramatically and ushered in a pressing need for the enhancement of information and communication technology (ICT) tools, digital platforms, and multimedia utilization in education (Adi et al., 2021; Mugiraneza, 2021). To ensure continuity of learning and prepare the resilience of the education system against Covid-19 and future shocks, the government of Rwanda prepared short, medium, and long-term responses to support the continuation of quality learning (Mineduc, 2020). However, those responses would have a substantial effect on integrating technology in the education system. Therefore, this study seeks to diagnose the challenges associated with integrating video-based multimedia in physics classrooms in Rwandan secondary schools. Built on the research problem underlined above, the following research questions were sought:

i) To what extent video-based multimedia is used in teaching physics?
ii) What are teachers' views about barriers that impended video-based multimedia implementation in the physics classroom?
iii) How could the recognized barriers be addressed to make sure that video-based multimedia is integrated effectively in those classrooms?

3. Research Methodology

3.1. Research Design

This study used a descriptive survey research design. The employed design was considered suitable for this study because statistical data can be secured, and analysis of that information can be done to infer anticipated results (Ary et al., 2020). Both qualitative and quantitative data were collected respecting measures to fight against Covid-19.

3.2. Research Participants

Respondents were selected from public secondary schools within Rutsiro and Rubavu districts in western province, Rwanda. The purposive sampling method was used in this study. A purposeful sampling of schools is based on the availability of ICT equipment and physics as one of the core subjects taught in those schools. In each selected school, all physics teachers were requested to participate in this study. 47 (35 males and 12 females) physics teachers took part in this research. Participants' experience as physics teachers ranges between 2 to 19 years.

3.3. Research Instruments and Validation

The data reported in this study were collected using a questionnaire and an interview. The questionnaire items were prepared based on previous research on the seeming barriers to integrating multimedia in education. However, since the purpose and scope are not the same as the original ones, we checked the reliability before distributing the questionnaire. SPSS Version 21 was used. Exploratory factor analysis has shown that all the 27 items' factor loading was greater than .40 and were all retained and presented in this study. The internal consistency showed a Cronbach alpha of .85 which exceeded .7 (Taber, 2017). There is no multicollinearity among the items since there are no pair's inter-item correlations of more than .80, hence all items were independent. An interview structured questions but allowed room for discussion to provide respondents time to explain their personal experiences concerning multimedia use in education. It was also used to collect qualitative data until data saturation was reached. The reason to conduct the one-on-one interview was to understand the details behind participants' answers, make an investigation on apparent factors that impede video-based multimedia integration in teaching and learning physics, and the possible solutions to ensure effective integration of video-based multimedia. Classroom observation protocol was used to know the principals of VBM practices in selected schools. To validate the instruments, an expert in ICT education from University of Rwanda together with experienced physics teachers checked the questionnaire, interview protocol and classroom observation protocol. Their comments and suggestions were used to build the final instruments used in this study.

3.4. Data Collection Procedure

Data were collected in May and June 2021. This was almost seven months after schools re-opening following the joint ministry of education and ministry of health directive measures to re-open schools. Measures emphasized the Covid-19 preventive guidelines and the medium and long-term response to support the continuation of quality learning. Once the participants were selected and agreed to participate in this study, questionnaires were distributed to participants to complete. The completed questionnaires were collected back after one week. All the questionnaires were collected back at the end of the agreed time at a rate of 100%. After handing back the completed questionnaire, interviews with all senior five (grade 11) physics to each school were planned. One-on-one interviews were scheduled and conducted during working hours at the working schools and lasted approximately 50 minutes per teacher. Interviews started with structured questions associated with discussion to provide respondents time to explain their statements. Interviews were audio-recorded and then transcribed. After the face-to-face interview, teachers were then observed in an ICT classroom setting. Notes taken were analyzed to develop a common understanding of the effective incorporation of video-based multimedia in the physics classroom.

3.5. Data Analysis

Data analysis involved the use of different methods to examine and interpret all the data collected, and analysis involved both qualitative and quantitative aspects. Statistical analysis such as standard error, standard deviation, mean, percentage, and sample t-test was used to summarize data from the questionnaire. Moreover, the formula $d_s = \frac{M_{dif}}{SD_{dif}}$ was used to calculate Cohen's d to communicate the magnitude of the treatment (Lakens, 2013). To analyze qualitative data, a constant comparison method of content analysis was used to classify semantic categories into sub-themes and themes. Thereafter, the developed sub-themes and themes were pooled and synthesized through the semantic category to which it refers (Akinyode & Khan, 2018).

4. Results

4.1. Extent to Which Video Based Multimedia is Used

Table 1: Descriptive statistics on instructional strategies

Instructional strategies	M	N	SD	SE
Teacher's Usual Teaching Strategies	4.11	47	0.512	0.071
Technology-Based Strategies (VBM included)	3.20	47	0.512	0.071

Teachers' responses under each instructional strategy were combined. Mean, standard deviation, and standard error were calculated and presented in Table 1. Results displayed in Table 1 indicated that, on average, teacher's usual teaching strategies were more dominant (M=4.11; SD=0.512) than technology-based strategies (M=3.20; SD=0.512).

Table 2: Paired samples t-test for Teacher's Usual Teaching Strategies (TUT Stra) and Technology-Based Strategies (TB stra)

	Paired difference							
				95% C.I. of the difference				
	M	SD	SE	Lower	Upper	t	df	p
TUT stra-TB stra	0.91	0.51	0.07	0.81	1.09	13.15	46	0.001

For Cohen's d $d_s = \frac{M_{dif}}{SD_{dif}}$, hence $d = \frac{0.91}{0.51}, then\ d = 1.78$

Table 2 displayed the paired t-test for teachers' usual teaching strategies and technology-based strategies (video-based multimedia included). The difference of 0.91, (95% CI {0.81, 1.09}) was significant, (t=13.15, p<0.05) to conclude that usual teaching strategies were statistically more dominant than technology-based strategies. Moreover, the size effect calculated of 1.78 represented a large effect size as it exceeded the threshold of 0.8. Hence, built on the findings shown above, it was revealed that usual teaching strategies were significantly more prevalent than technology-based strategies.

4.2. Seeming Barriers Impending Video-Based Multimedia Implementation in Physics Classroom

Table 3 displayed the seeming barriers to effective implementation of multimedia in education. Referring to Table 3 and taking into consideration the standards that 1= strongly disagree (sd), 2= disagree (d), 3= neutral (n), 4= agree (a), and 5= strongly agree (sa), a considerable number of respondents were likely to consent that the resulting seemed fences influenced video-based multimedia instruction implementation in their physics classroom: infrastructure (72.3%), Lack/poor adequate teacher's training (72.3%), the pressure to prepare students for exam and tests (70.2%), Time vs high teaching load (68.3%), and difficulties in assessing and monitoring learners' progress (68%).

Table 3: Seeming Barriers to Effectively Implementation of Multimedia in Education

Seeming barriers	**Frequency (%) n=47**				
	sd	**D**	**n**	**a**	**sa**
Infrastructure	0	14.9	12.8	38.3	34
Lack/poor adequate teacher's training	2.1	10.6	14.9	40.4	31.9
Pressure to prepare students for exam and/or tests	14.9	4.3	10.6	34	36.2
Time vs high teaching load	6.4	8.5	17	42.8	25.5
Problems in evaluating and checking learners' progress	0	19.1	12.8	34	34
Poor communication skills	10.6	12.8	17	34	25.5
Poor technology literacy	8.5	12.8	19.1	27.7	31.9
Big number of learners' in classroom	8.5	19.1	17	36.2	19.1
Lack/poor technology supporting materials	0	23.4	21.3	29.8	25.5

Related barriers to those reported in Table 3 were also highlighted during a one-on-one interview. Here are some of the noteworthy responses from respondents on how time for preparation, class size, and pressure to prepare students for examinations hinder the effectiveness of video-based multimedia:

Respondent number 4: video-based multimedia (and other technology-related instructional strategies) is too demanding in terms of time, together with a heavy teaching load that appears difficult to use technology.

Respondent 3: it is difficult to use video-based multimedia in a big class like this one, sometimes learners' pretend to be doing classroom activities while they are busy with social media and other computer games.

Respondent 2: our school is judged based on national examination results, so the use of video-based multimedia will not help me to prepare the students well as I am not experienced in using such kinds of instructional strategies.

Respondents 1: it is not easy to monitor the learners’ progress under a video-based multimedia class setting.

Classroom observation revealed difficulties in preparing VBM classrooms of learners with different levels of ICT literacy. Some teachers still have difficulties setting clear objectives during the VBM class. Learners’ ICT literacy and poor communication skills were also identified as a barrier since learners struggle to use the right keywords in research.

4.3. Suggested Solution to Effectively Integrate VBM in Physics Classroom

During one-on-one interviews, respondents suggested solutions to the raised barriers. Table 4 revealed the respondents’ proposed solution to ensure that VBM is effectively incorporated in classroom, and to guarantee its effectiveness in teaching and learning physics.

Table 4: Proposed solution

	Theme	Proposed solution	Frequency (%) n=47
1	ICT Skills	Teachers' training on ICT integration in education, raise the level of learners' ICT literacy	95.8
2	Time	Avail time for preparation, increase learners' access to ICT tools such as computer	87.3
3	Belief	Focus discussion about the effectiveness of VBM in teaching and learning physics	85.1
4	Experience	Share best practices with others	74.5
5	Infrastructure	Increasing ICT tools such as computer and internet connectivity	68

To effectively incorporate VBM in teaching and learning physics and to ensure that VBM is integrated to resilient Covid-19 (and future shock) effects, respondents stressed the need for ICT professional development training. Respondents have shown a relationship between teachers’ skills level, confidence, and competence. Classroom observation also revealed that there is a need to develop strong classroom management during VBM classes with different ICT levels of literacy.

5. Discussion

This study diagnosed the barriers to integrating VBM in Rwandan secondary schools as a long-term response to Covid-19 and future shock in education. Results of this study revealed that switching to technology integration in teaching and learning as a long-term response to resilience relevant and quality education makes sense (Mugiraneza, 2021). However, this is not unique to the Rwandan context. For instance, Hashimi (2021) reported that technology, VBM included, allows students to access content well beyond textbooks in multiple formats regardless to time and space. The results of this study showed that the incorporation of VBM is still very low (Tables 1 and 2) and has been hindered by some barriers (Table 3). Similarly, the results of this study about the barriers that impede the effective integration of VBM did not seem to be exceptional to Rwandan education. For example, the research conducted in the Philippines by

Wenceslao and Felisa (2021) and in South Africa by Mukuna and Aloka (2020) revealed that online education was impeded by personal barriers, inadequate social interaction, technology-related issues, assessment-related issues, and concerns on learning materials and methods. According to the points raised above, the question that requires a long-term answer is how we can ensure that technology integration in teaching and learning is effectively integrated so that it responds positively to the resilience of the education system against Covid-19 and future shocks. Based on the barriers highlighted in this study (table 3), proposals on the likely solutions to some of the mentioned issues are given:

First, curriculum developers, policymakers, and stakeholders in education should consider the use of specialized materials beyond textbooks. To this, videos in multiple formats can be used. The video contains lessons (regarding the curriculum) that can be stored on secure digital (SD) memory cards and used on telephones, tablets, and computers to remotely study when they are in an online or an offline environment. Moreover, those videos can be shared easily among learners. Here we concur with Holmes et al. (2019) and Blomberg et al. (2014) that VBM technology has been recognized to be a real strategy for bridging the gap in the delivery of unlimited access to quality education and enhanced students' achievement and retention. However, this will need to provide ICT tools such as telephones to students irrespective of their family background otherwise, learners from disadvantaged and rural families will lag (OECD, 2012). Other challenges that come with this strategy are lack/poor infrastructure such as electricity supply, learning aids, etc. Research conducted in Bangladesh by Al-Amin et al. (2021) and in Zambia by Mukuka et al. (2021) reported that poor infrastructure was among the major factors impending e-learning in most developing countries.

Second, the successful integration of VBM as a long-term response to Covid-19 and future shocks requires the effective preparation of teachers through continuing professional development courses and training on effective integration of ICT in teaching and learning physics. Here we agree with Mahdi et al. (2015) that providing teachers with ICT assistance and e-learning supports will lead to the improvement of quality education in teaching and learning physics. Moreover, the brutal suspension of face-to-face classes due to Covid-19 and the spurred use of technology to maintain educational continuity have stressed the need for teachers' relevant skills on digital platforms to ensure a long-term response (Mukuka et al., 2021). Furthermore, it has been recognized that most teachers hold a belief that they cannot assess and/or monitor learners' progress in digital-based strategy (Ziegelbauer & D'Errico, 2021). Therefore, teachers' training on digital transformation in education will boost teachers' confidence and motivation to teach, assess, and monitor their learners even beyond the physical classroom environment. Recent researchers echo similar findings that it becomes crucial to give teachers relevant skills on e-learning platforms (Mukuka et al., 2021; Zhang et al., 2020)

Third, preparing students psychologically about virtual learning should also be considered. Kaplan-Rakowski (2020) reported that students' traditional mindset made them find a virtual class as a challenge. However, teachers and learners need to optimize new learning settings and harness technology to improve their teaching and learning. The psychological preparation of students should be paralleled with time management skills due to their various everyday home-based activities especially for girls and students from rural areas. There is, therefore, a need for parents to be aware of what is going on so that their plan should help these learners. Besides, students' psychological preparation will help to raise learners' self-motivation. A recent study reported that after shifting from face-to-face to virtual learning, many students fall behind and nurture the idea of giving up (Esani, 2010).

6. Conclusion

Technology such as VBM instructions was reported to be a potent force in driving educational reforms especially during this period of Covid-19. However, the findings of this research revealed that VBM is less used compared to the traditional teaching methodologies in selected schools of Rutsiro and Rubavu districts in western province, Rwanda. Respondents reported some barriers related to VBM incorporation in teaching physics. While the results of this study, to a great extent, look like previous studies, this is one of the few pieces of research done in Rwanda about long-term Covid-19 (and future shocks) response plans. Although the Rwanda basic education board enables free access to the education content (elearning.reb.rw), researchers revealed that audiovisual lessons are more beneficial. One noteworthy point that could be of a great value is that videos could be used when learners are online or offline and are easy to share from one device to another. Consequently, VBM instructional strategy could be an effective methodology to use as a long-term response to Covid-19 and future shocks. However, a careful orientation of in-service teachers in integrating VBM in teaching and learning is required. This could be paralleled with providing digital devices to both teachers and learners and to prepare learners psychologically about the virtual learning environment.

7. Implication, Limitation and Further Research

The findings of this study revealed that VBM could be a consensus on education and technology competency is required to support teaching and learning especially during Covid-19 and future shocks. Therefore, educationalists should initiate VBM as a long-term response to Covid-19 and future shocks to resilient and improve the education system. On the limitation side, the methodology used pushed the researchers to use teachers' self-reported information. Teachers provide information according to their understanding. Their status as public secondary school teachers might have influenced their response. Another limitation of this research is that only physics teachers were involved. Although the information of other subject teachers may not vary from that of physics teachers, the selection of respondents may limit the generalization of the research findings. Given these limitations, a follow-up study can be conducted on the same topic for evaluating both public and private teachers together with science and non-science teachers. The effect of geographical location (rural, semi-urban, and urban), socio-economic background of learners, and gender are other variables of interest in this area. Future research could also explore other probable barriers and how those barriers could be alleviated.

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