Factors Affecting Use of Practical Work in Teaching and Learning Physics: Assessment of Six Secondary Schools in Kigali City, Rwanda

Theoneste Niyitanga[1], Pheneas Nkundabakura[2] & Theogene Bihoyiki[3]

Abstract

Nowadays there is a global change in teaching and learning methods. Methods that support learners' participation and construction of their own knowledge have been emphasized in all academic activities. Science theories are mastered in practices in teaching and learning activities. Teaching and learning through practical work is among methods that undoubtedly facilitate knowledge transfer and skills acquisition in teaching and learning events. The present study examined the real factors affecting the use of practical work in teaching and learning sciences, particularly physics in secondary schools located in Kigali city/Rwanda. The participants in this study were physics teachers, learners, directors of studies and headmasters from public and government-assisted schools. Qualitative and quantitative data were collected using questionnaires, interviews and observations. The findings indicated that lack of training and policy governing the use of practical work coupled with inadequate resources and facilities hindered the use of practical work in the teaching and learning of physics in secondary schools. The study recommended that in-service teacher training prioritizing the use of practical work in teaching and learning should be initiated and sustained, assessment of practical skills should be required for qualification and used formatively in all levels, Government Funds for education should be allocated to build, equip, and sustain laboratories in schools, also practical physics should be allocated on the school timetable and regular supervision should be carried out in the classroom to ensure effective implementation of practical work. Conversely, putting into practice practical work in teaching and learning actively engages learners in the creation of their understanding and be familiar with the everyday phenomenon that learners observe and experience around them.

Keywords: practical work; practical physics; minds-on and hands-on method; sciences learning; self-learning; life-long learning.

Introduction

Education is of paramount meaning in the development of the country and worldwide, Sub-Saharan African countries are tremendously targeting to shift from traditional methods where the teacher acts as the sage of stage in teaching and learning processes. Therefore, learning methodologies that strongly engage learners' active participation in learning activities are of utmost importance nowadays in secondary schools.(Mısır et al., 2018). Many learners have a misconception of taking sciences as difficult topics. To eradicate this misunderstanding, methods that help learners to construct their learning are recommended in teaching and learning endeavours (Türkmen et

[1]Theoneste NIYITANGA, University of Rwanda - College of Education (UR-CE), African Center of Excellence for Innovative Teaching and Learning of Mathematics and Science (ACEITLMS), P. O. Box 55 Rwamagana, Rwanda. Email: theoniyitanga@gmail.com

[2]Pheneas NKUNDABAKURA, the University of Rwanda - College of Education (UR-CE), African Center of Excellence for Innovative Teaching and Learning of Mathematics and Science (ACEITLMS), P. O. Box 55 Rwamagana, Rwanda. Email: p.nkundabakura@ur.ac.rw

[3]Theogene BIHOYIKI, Ecole Secondaire Kanombe (EFOTEC), Kicukiro/Kigali-Rwanda, P. O. Box 6092 Kigali, Rwanda. Email: theobihiyiki@gmail.com

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al., 2007; Uwizeyimana et al., 2018). Prior researchers have argued that teaching through practical work can motivate learners' self-learning and powerfully grasp sciences, especially physics (Abrahams & Reiss, 2012). Learners may act in diverse ways in a similar educational system based on the practical work done in their learning. Learners master the scientific subjects and have deeper thinking into practices (Motlhabane, 2013). Practical work embraces different activities like a laboratory experiment, project work, library research, fieldwork, place visits, environmental monitoring, and investigating technologies (Vilaythong, 2011). Consequently, practical work should be conducted in different areas without restricting it to the classroom or laboratory. Since practical work is one of the teaching and learning methods that obliges learners' participation rather than passive with the confidence of doing practices (Babalola, 2017). Therefore learners may autonomously be engaged in teaching and learning activities through observation and the problems they have asked and responses provided. Moreover, practical work or hands-on learning in sciences is largely striving to produce learner who has ability and capability of hearing, manipulating and observing the expected outcomes (Kibirige & Maponya, 2021). Unfortunately, students in some secondary schools are not given the opportunities to manipulate the materials and participate actively in doing practical work to prevent them from damaging the limited equipment available. Consequently, learners have to follow teacher demonstrations in the actual classroom setting in what Motlhabane (2013) called "theoretical-practical", which is the teaching of the supposed practical activities theoretically in the classroom instructions. The digital technology that is predominating the current economy requires that the learners are well-trained in practical-related skills. However, teaching practical work theoretically is a hopeless and poor teaching and learning approach in the current world that does not foster creativity and innovation of useful academic technological tools such as ICT to enhance and develop today's academic endeavours and the world (Serdyukov, 2017).

As usual, science schools aim to assist slow and fast learners in developing knowledge and skills, manipulating and participating confidently and effectively in the current world. These are attained through practical work (Gyllenpalm et al., 1970; Haslam & Hamilton, 2010). The attitudes of learners and teachers toward sciences are significantly affected by usual practices. This means that well-proposed and applied "minds-on" and "hands-on" or practical activities in science schools can generate critical thinkers learners who are competent in the labour market and have the ability to handle problems encountered by society (Lunetta et al., 2007; Miyoba & Banja, 2019). Science and technology have led to the transformation of the world (Steenhuis & De Bruijn, 2012). The uniqueness of science education is that it involves practical work (Abrahams & Millar, 2008). The effectiveness of teaching and learning physics in secondary schools depends on the extent to which practical works are inserted and implemented in the desired content and skills acquisition. Generally, physics is considered as the heart of all technology. This explains the fact that physics controls all forms of technology (Harcourt, 2018).

The education system in sub-Saharan Africa (Rwanda included) has been influenced by two major education policies such as education for all (EFA) and the knowledge-based economy. These two policies have been emphasizing the development of life skills and 21st-century skills among the learners in secondary education, which provide them with competencies to make connections between formal knowledge and the informal, common-sense knowledge of home and community. These imply that the main purposes of science in general and physics in particular in secondary education should be development(Barret, Gardner, Joubert & Tikly, 2019, p. 6).

Physics knowledge, skills and attitudes are developed effectively through effective teaching and learning using practical work because science is taught excellently through practices (Millar, & Abrahams, 2009**).** Practical work has been regarded as a learning activity in which the students are actively engaged in manipulation and observation of real objects and materials (Millar, (2004). According to Lunetta, Hofstein, and Clough, (2007, p. 394), Practical work is among teaching and learning approaches that advance interaction between learners and materials. This support learners to highly visualize and familiarize themselves with the natural world. The use of practical work is an important approach in teaching and learning physics due to its potential to promote the acquisition of practical skills, engage, arouse interest and attitudes of learners towards sciences learning (Score, 2008).

Practical work lead to the development of conceptual understanding and procedural skills acquisition (Welford, 2000, Score, 2008). Practical work plays a key role in the development of scientific knowledge through thinking linked to the actions done during experimental activities (Millar, 2004**).** Practical work also helps the learners to develop relationships between observations and ideas (Abrahams & Millar, 2008).

According to Omeodu (2018) practical work increases knowledge acquisition of the learners, develops skills and competencies required to meet scientific and technological demands of the nation, makes scientific phenomena more real and during practices, social interaction is enhanced. Thus, practical work is an essential aspect to improve teaching and learning physics. Its effective implementation is affected by different constraints such as the lack of enough funds for purchasing and maintaining practical equipment and lack of motivation to arouse teachers' interest and commitment to organize practical activities (Vilaythong, 2011). Furthermore, the effectiveness of practical work requires the availability of qualified and dedicated teachers and laboratory assistants (Anza et al., 2016).

Rwanda is emphasizing experimentation with sustainable and affordable alternatives to science laboratories such as low-cost science kits or the concentration of resources in centres of excellence. Science kits allow teachers to perform demonstrations and improve their scientific skills and understanding and may also boost learners' opportunities to do experiments themselves (A.M. Barret, V. Gardner, M. Joubert, 2019). One of the pillars of Vision 2020 in Rwanda is focused on the development of human resources and the creation of a knowledge-based economy. Therefore, the learners should develop knowledge, skills and attitudes to compete in the labour market and contribute to the social and political life of their country (MINEDUC, 2013).This means that strong alignment between courses, industries and commerce should be ensured in Rwandan schools (Mineduc, 2018). Mcneil & Heron (2018) have argued that physics courses need to be related to career-relevant applications such as innovation of various commercial devices in the industry. Therefore, these cannot be possible without using practical work and be willing to incorporate commercial products into practical courses in the classrooms.

In Rwanda, science equipment in schools is still scarce (Ndihokubwayo, 2017). However, there has been an effort in the last 5 years in building science laboratories and providing practical science equipment in some schools (schools having science laboratories represent 27 percent whereas science kits in the lower secondary have been distributed at the level of 62 percent (MINEDUC, 2018b).

An effort is also being made to provide ICT-related facilities (SMART classrooms) to promote science. However, the availability of materials and practical equipment does not imply the achievement of employing practical work in academic actions and where practical work is used in the teaching and learning process does not mean that effective implementation is being attained. Many teachers keep complaining that there is a lack of laboratory and practical equipment in their schools. However, in some schools that are well-equipped with those resources, teachers do not make use of them. They keep claiming that they face the following challenges: lack of equipment, overcrowded syllabi and large class sizes (Motlhabane, 2013). Practical work carried out by the students themselves is essential for science teaching (Millar, 2012).

Learning physics without practical work is like learning how to drive a car by reading its operating manual. Developed countries have adopted alternatives and complementary resources to improve the use of practical work in physics teaching and learning, those resources include: the use of virtual laboratories, video demonstrations, online simulations and animations (George, 2017). These resources allow experimentation and application of skills in ways that could not be possible in the classroom setting, this opens interesting opportunities for learners to effectively perform different experiments for educational purposes (Mirçik & Saka, 2018).

They allow teachers and learners to do experiments and observe things that can take a long period in real life and provides tools that can speed up and slow down the process of experiment, give learners the flexibility to satisfy their curiosity by repeating the situation several times observing the relationship between the concepts and phenomena (Li, 2015).

In the case of insufficient materials, teachers should perform experiments for the students through demonstrations and improvisations using local materials (Ndihokubwayo, 2017). Education policies are often coherent with national development visions in sub-Saharan Africa (Barret, Gardner, Joubert & Tikly, 2019). Syllabuses specify that practical and exploratory activities should be conducted by learners themselves. However, "there is frequently a gap between policies and practice, between what is written in curriculum documents, what teachers say they do, and what learners experience in many countries including *Rwanda* (Motlhabane, 2013, p. 167)".

It is this claim that motivated the researchers to investigate the real factors that affect the use of practical work in teaching and learning physics in Rwandan secondary schools intending to provide possible strategies for improving the current situation. The findings from this study will be generalized to all Rwandan secondary schools.

Impact of using practical works in teaching and learning sciences

Always starting is not easy but shifting from traditional to modern teaching approaches has been privileged to teachers and learners. The implementation of practical work in teaching and learning has been taken as a method that motivates, bring learners' interest in their learning and 3D-Science content visualization (Park et al., 2016). Programs involving practices had been taken as the method that permits the teacher to open the world to their learners because it offers them skills of understanding different issues in the world (Perry & Richardson, 2001).

Teachers are confidently made the content simple and take it like his/her founder. Besides, teachers taught quality rather than quantity of the content and learners develop their understanding and life-long learning (Knut Neumann, 2019). Those previous researchers' scenarios specify the paramount reflective importance of practical work in science teaching and learning to teachers, learners and its implication to the world.

Objectives of the study

1. To scientifically discover the extent to which secondary school science teachers and leaders comprehend the advantages of employing practical work in teaching and learning actions.
2. To find out obstructions to teachers' effective use of practical work in science teaching and learning.
3. To propose feasible keys that can address the barriers encountered by teachers when trying to implement appropriate use of practical work in teaching.

Questions under investigation

1. At what extent does secondary school teachers and leaders perceive the advantages of employing practical in teaching activities?
2. What are the real factors affecting the use of practical work in the teaching and learning of physics?
3. What are the strategies that could improve the implementation of practical work in science teaching and science learning in secondary schools?

Methodology

The data used in this article were collected as a part of a wider investigation carried out in Rwanda on the use and impact of practical work in the teaching and learning of physics in secondary schools. The major concern was on the present situation with the use of practical work, the extent to which physics practical work enhance the teaching and learning of physics, the barriers that may hinder physics teachers from using practical work and the strategies to improve physics practical work in secondary schools.

This study adopted a descriptive survey design employing both qualitative and quantitative methods to assess the real factors affecting the use of practical work in teaching and learning physics in Rwandan secondary schools.

The purposive sampling technique was used to select 9 physics teachers involved in the study while other participants were selected by using a simple random sampling technique. Purposive sampling strategies are used to ensure that a particular category of cases within the total population is represented in the final sample of the study while Random sampling is defined as the process of selecting cases from a list of all (or most) cases within the sample universe population using a random selection procedure (Robinson, 2014).

A sample of 117 students was taken randomly from students that learn physics as a core subject in the final year of their schools either in senior three or senior six. This is because some schools have ordinary level only while others have both ordinary and advanced levels. Senior three and six students were selected for the simple reason that they have spent several years learning physics.

Questionnaires and interviews were used for data collection in this study and classroom observation was also used for supporting data collected. Validation of the instruments used for the study was confirmed by one expert physics educator at the University of Rwanda - College of education. To ensure validity, an instrument must measure what it was intended to measure (Gray, 2011). The teacher and learner's questionnaire were administered to physics teachers and students with the assistance of one of the physics teachers in the schools involved in the study. However, before the collection of main findings, a pilot study was carried out within one school located in the Gasabo district to ensure the reliability and validity of the items for the purpose of checking whether the instruments are measuring what they are supposed to measure. After the pilot study, the student's questionnaire was modified by reducing the number of questions because it was too long, the questions that seemed to be irrelevant to the research questions were removed. Thereafter, the questionnaires were hand-delivered to the selected students and teachers in 6 secondary schools in Kigali city by the researcher himself and collected as soon as they have been completed. Nine physics teachers in the schools involved in the study completed the questionnaires.

The researcher did everything possible to ensure that schools selected were representative of the types of schools in Kigali, commonly in Rwanda in terms of distinctions such as urban/rural and how well the schools are equipped with practical resources.

Interview protocols were formulated through collaboration with other researchers. Thereafter, their pilot tests were conducted to assess the abilities of questions to stimulate required responses, how the data provided by the interviewees are relevant to the research questions and whether some modifications in questioning are needed to ensure validity and reliability of research instruments.

Data that were collected from learners and teachers survey questionnaires were organized onto an MS Excel spreadsheet and statistical packages for social sciences (SPSS 16.0). The data have been analyzed using descriptive statistics, using frequency distribution and percentages where applicable after allocating identification number to data in the process of coding. One of the major aims of descriptive statistics is to describe the main structures of study, often through the use of graphical analysis. Frequency distribution is known as one of the most common methods of data analysis, particularly for analyzing survey (Gray, 2014). Data from interviews were recorded by using the recorder. Then, the researcher listened to audio recorded several times to identify and categorize the main themes. During qualitative data analysis, a theme should be taken as important and relevant when it captures something important concerning the overall research question (Gray, 2014).

Relevant information was organized and transcribed, thereafter, similar information was analyzed and gathered into their relevant themes. Structured classroom observations were conducted and analyzed. These observations provided deep insight that helped in the validation of data analysis.

Ethical approval for the research was provided by the directorate of research and innovation of the college of education, University of Rwanda and permission to carry out the research was sought and obtained from the City of Kigali. In addition, written informed consents were sought from headteachers and physics teachers in all schools involved in the study. All participants were reassured that there are no risks that are associated with this study and that, they have the right to participate or not participate or they can withdraw from the research whenever they want to without punishment.

Results and discussions

This research was directed to discover the impact of using practical works to make theoretical science simple and concrete for both learners and academic instructors. Based on researchers' observation and views from other educational experts in Rwanda mainly those from six selected secondary schools and worldwide, the qualitative and quantitative data collected, could be analyzed to deeply observe the influence of inserting practical work in science teaching and learning events. Data were analyzed using percentage to observe challenges faced by teachers to implement practical work in teaching and learning activities. The study involved four groups of respondents as illustrated in Tables 1 and 2. Excluding ideas and proposals from learners, teachers, director of studies and headteachers in otherwise other thoughts are the purely personal viewpoint of involved investigators. The sample was randomly chosen amongst the specialists connected to teaching and learning in secondary schools.

Table 1 shows that a total of 117 learners whose combination involved science particularly physics and 9 physics teachers nominated in different six secondary schools located in Kigali city-Rwanda were involved in data gathering paper question exercise answer, the number of both teachers and learners at each school and their participation percentage was shown. Table 2 shows, 31 learners among learners who completed questionnaires, 4 Director of studies and 2 headteachers have interviewed to authenticate the impact of practical work in science academic endeavours.

Table1 Distribution of Learners and teachers by Schools in a sample

School code	A	B	C	D	E	F	Total
Learners	19(16)[1]	15(13)	19(16)	16(14)	23(20)	25(21)	117(100)
Teachers	2(22)	1(1)	2(22)	1(1)	2(22)	1(1)	9(100)

[1]Percentages in parenthesis, Source: primary data from survey, 2021

Table 2 Sample of participants interviewed

Stakeholders	Number of participants
Physics teachers	9
Director of Studies	4
Learners	31
Head teachers	2
Total	46

Source: Primary data from survey, 2021

Generally, outlooks were about hindrances of effective implementation of practical work in science teaching and learning in Rwandan secondary school, Lack of laboratory and insufficient science kits were of core factors that prevent the effective implementation of practical work in teaching and learning activities. However, they suggest that in absence of those obstructions a productive practical work for both teachers and learners can be carried out to make teaching and learning excessively significant.

Teachers were asked to indicate the extent to which they agree with the statements about schools' facilities and resources available for teaching physics. Approximately 100 percent disagreed with the statement that they "have sufficient facilities for practical work". Most also disagreed that they have separate physics laboratory and laboratory assistant support. When asked about practical competencies they have acquired during pre-service teacher preparation programs, three skills dominated such as reporting skills, setting up of physics apparatus for practical activities and verification of a theory using experiment.

Teachers were also provided with twelve assertions about the present status on the use of practical work in teaching and learning, most teachers strongly agreed with the claims that most of them have limited knowledge and skills in teaching practical physics and that they use demonstrations during practical sessions. However, a large majority disagreed with the assertion that "teacher get opportunities to attend seminars and workshops for improving their practical skills". When asked about their views on the impacts of practical work in teaching and learning, most were in agreement with the statements that practical work arouses interest and attitudes towards learning physics, make scientific phenomena more real, develop conceptual understanding and skills acquisition.

Finally, teachers were provided with seventeen statements about the barriers to effective use of practical work in teaching and learning (Table 3) and requested to identify the 10 most dominating obstacles in their schools. The most dominant barriers were lack of laboratories facilities, lack of motivation, large class size and lack of regular pieces of training for in-service teachers.

The challenges that avert teachers to implement practical work in teaching and learning were illustrated in Table 3. Researcher found that only 242 out of 1502 secondary schools in Rwanda have a laboratory (Ndihokubwayo, 2017). In the present study, all teachers who had participated in data collection testify that the lack of laboratory is among obstacles that hinder the implementation of practical work in science teaching and learning. 67 percent of teachers also suggested that this insufficient of equipped laboratories are caused by a lack of funds. However teaching through practices help learners to identify object and phenomenon, learn facts, learn concepts, learn relationship and learn theory and to link domain of ideas, real object and observable thing (Millar, 2004). Moreover, teachers in science schools with laboratories are still challenged by large class size, lack of training and outsized curriculum.

In the learners' survey, they were provided with a list of thirteen assertions and asked to provide their views on how time is allocated on different teaching style and learning activities. The findings indicated that learners spent most of their time making a copy of teachers' notes, doing exercises, listening to teachers' explanation from the textbook, class discussion and learning practical theoretically. The majority agreed that physics learning was challenged by a lack of physics equipment, laboratory, and lack of practical physics textbook (Table 4)

Table 3 Number (and proportion) of teachers agreeing on statements that are barriers to the implementation of practical work in teaching and learning physics

Statements	Respondents (%)[1]
1. Lack of enough funds for purchasing and maintaining practical equipment.	6(67)
2. Lack of motivation for arousing teachers' interest and commitment to organize practical activities.	7(78)
3. Lack of confidence and skills among physics teachers in organizing practical work.	2(22)
4. Overloaded curriculum.	7(78)
5. Lack of current standardized assessment information available to measure the implementation effectiveness of the practical physics teaching and learning strategy.	1(11)
6. Insufficient availability of physics teachers in the schools	1(11)
7. Lack of laboratory assistant support.	6(67)
8. Lack of teachers 'guide book about practical physics	7(78)
9. Lack of time assigned to practical activities on the school timetables	6(67)
10. Poor teacher compensation and lack of support from school administrators	4(44)
11. Poor pre-service teacher preparation program on the implementation of practical wok in schools.	6(67)
12. Lack of laboratory facilities.	9(100)
13. Lack of continuous professional development for teachers.	5(56)
14. Poor background and lack of experience in practical work	5(56)
15. Lack of regular trainings for in-service physics teachers on the use of practical work	8(89)
16. Large class size and insufficient time for teaching	7(78)
17. Students are not achieving expected learning outcomes at the completion of their primary, lower and upper secondary education	4(44)

[1]Percentages in parenthesis, Source: primary data from survey, 2021

Table 4: Learners' insight on barriers that hinder the implementation of practical work in teaching and learning doings.

Statements	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1. Insufficient knowledge of Mathematics.	31(27)[1]	49(42)	14(12)	18(15)	5(4)
2. Challenges in using English as the language of instruction.	25(21)	50(43)	6(5)	22(19)	14(12)
3. Large class size.	20(17)	38(33)	20(17)	17(15)	22(19)
4. Shortage of infrastructure.	24(21)	38(33)	20(17)	24(21)	11(9)
5. Ineffective maintenance of laboratory.	36(31)	20(17)	25(21)	20(17)	16(14)
6. Too short period for physics course.	25(21)	24(21)	13(11)	34(29)	21(18)
7. Lack of laboratory.	58(50)	15(13)	9(8)	16(14)	19(16)
8. Insufficient physics books.	25(21)	47(40)	13(11)	19(16)	13(11)
9. Lack of practical physics textbook (manual).	44(38)	34(29)	19(16)	12(10)	8(7)
10. Shortage of qualified physics teachers.	26(22)	17(15)	21(18)	33(28)	20(17)
11. Lack of equipment in the laboratory.	48(41)	30(26)	10(9)	16(14)	13(11)
12. Insufficient use of audio-visual materials.	41(35)	33(28)	16(14)	19(16)	8(7)
13. Insufficient learning resources and facilities.	25(21)	44(38)	22(19)	18(15)	8(7)
14. Insufficient promotional interventions to motivate children.	31(27)	31(27)	14(12)	30(26)	11(9)
15. Lack of laboratory attendant.	38(33)	35(30)	10(9)	17(15)	17(15)
16. Lack of separate physics laboratory.	52(44)	20(17)	12(10)	19(16)	14(12)

[1]Percentages in parenthesis, Source: primary data from survey, 2021

Learners are in the same line with their teachers that the lack of equipped laboratory resources is among the core factors that preclude the implementation of practical work in secondary schools. 48 (41) strongly agreed and 44 (38) agreed about the poor implementation of practical work in teaching and learning. 44 (38) and 34 (29) strongly agrees and agree respectively that the lack of a book of practices can hinder the implementation of our strategy. Thus, the implementation of practices can be achieved if the equipped laboratories are available at different secondary schools. Moreover, 25 (21) and 24 (21) strongly agreed and agreed correspondingly that too short a period for a physics course can impede putting into practice practical works in teaching and learning. 41 (35) and 33 (28) strongly agreed and agreed that insufficient use of audio-visual materials impedes learners to relate the learned theory with real-life practices. 44 (38) and 25 (21) agreed and strongly disagreed that Insufficient learning resources and facilities are also consequences that promote learning without practices. English as a medium of instructions is also among difficulties that hamper also the implementation of practical work in teaching and learning academic endeavors. However, in the absence of those

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challenges encountered by both teachers and learners, the hands-on teaching method will be successfully conducted and implemented in teaching and learning. This method develops learners own learning, relate the content learnt with real-life experiences.

That is in line with (Ng & Nguyen, 2006) who saw that through practical work learners construct their own understanding of scientific difficulty concept and make abstract science theories to tangible. Practical work is unique to judge scientific truth, it makes Science theory more explicable for learners and uses them to solve the problem encountered in society (Koponen & Mäntylä, 2006).

Interview responses were analyzed on the barriers and challenges to integration of practical work into teaching and learning physics in secondary schools, three broad themes were preferred that gathered together the main views from the participants' responses. These themes are as follows:

1. Resources and facilities (Physics equipment, physics laboratory, class size and laboratory assistance support)
2. Time shortage and allocation (shortage of available teaching time and lack of practical physics on timetable)
3. Competence development (barriers linking to practical skills of teachers and lack of regular trainings).

Resources and facilities.

A large majority of interviewees commented on the lack of laboratory, inadequate physics equipment, large class size and lack of enough teachers in schools as the major barriers to the use of practical work in teaching and learning physics. Some participants also mentioned that practical physics is hindered by the lack of practical physics manual. Some of the participants' comments are as follows:

> *"The major barrier is insufficient of laboratory equipment, lack of laboratory and large class size*" (Headmaster 1).

Several teachers commented that lack of laboratories and practical physics guidebooks hindered them from integrating practical work in their teaching.

> *"Another obstacle is the lack of laboratories and lack of specific curriculum of practical work that can guide teachers so that practical activities be organized to make it easy for teachers to know what they have covered and the remaining experiments that need to be covered"* (Physics teacher E).

> *"Lastly, they don't exist books of practical physics, you cannot find any books that can guide you in practical activities"* (Physics teacher C).

One director of studies offered similar comment.

> *"Large class size is a barrier but I hope that it is going to be solved because the government has planned the way the learners should not exceeds 46 in one classroom"* (Director of studies D).

All the students interviewed reported that the lack of laboratory and adequate physics equipment are the major challenge the prevented them from using practical work in their learning. Some of their comments are presented here as follows:

> *"The first barrier here is the lack of laboratory and adequate physics equipment"* (Student, Gasabo).

> *"The major barrier is lack of physics equipment that can help us to do those practical and there is no laboratory where those experiments can be conducted"* (Student, Nyarugenge).

Another student offered this comment.

> *"The first barrier is the lack of laboratory; the second barrier is large number of students per one teacher where one teacher struggles to attend to each student while explaining and demonstrating how an apparatus is used"* (Student, Gasabo).

Time shortage and allocation

Shortage of time and Lack of specific time assigned to do practical work on the school time table were mentioned by most physics' teachers and students in the survey and those issues were also confirmed during interviews as follows:

> *"There is no practical physics curriculum exist and there is no specific time allocated for doing practical work. Practical work does not exist on the school timetable. Teachers themselves have to make time for practical activities"* (Physics teacher D).

Other physics teacher offered similar comment.

> *"There is no practical work planned on the school timetable, I think it is because there are no materials, even if it can be allocated on the timetable, the theory will continue to dominate due to lack of materials and laboratory"* (Physics teacher B).

Students' comments on these issues include the following:

> *"Another barrier is that there is no specific time allocated for doing practical work on the school timetable and also some physics teachers who are responsible for teaching practical physics have many responsibilities in school such as being physics teacher, class teacher, laboratory attendant and dean of teachers"* (Student, Kicukiro).

> *"There is shortage time for learning physics because if a teacher is going to teach a new lesson having only one period of 40 minutes, you understand that that time is not enough"* (Student, Gasabo).

Competence development.

Lack of regular training for in-service physics teachers on the use of practical work was confirmed by most teachers, headmasters and directors of studies during interviews. Some of their declarations are presented as follows:

> *"One of the major barriers is the lack of regular training on the use of practical work in teaching and learning to enhance lifelong learning"* (Headmaster 1).

> *"The barrier here is that some teachers do not have those skills to use equipment available and to integrate practical work in teaching and learning"* (Director of studies C).

All of above identified barriers are in line with several study findings (Babalola, 2017; Daba & Anbesaw, 2016; Harcourt, 2018; Mogofe & Kibirige, n.d.; Motlhabane, 2013; Ndihokubwayo, 2017; Olajide et al., 2017; Vilaythong, 2011), their findings also support the findings of this study. They asserted that practical physics is mostly affected by lack of practical textbook, inadequate practical physics equipment, lack of separate well-equipped laboratory for physics, large class size, lack of laboratory at all, less attention of school administrators to practical work, lack of laboratory manual, less motivation of science teachers to use local materials, lack of proper supervision, lack of proper trainings on practical work and time limitation.

The findings of this study are also consistent with obstacles to practical work in science indicated by (Score, 2008), in which most frequent responses from teachers and technicians in rank order were presented respectively from 1 to 10: Curriculum content, Resources and facilities, Time, Exams and assessment, Pupils' behaviour, Teachers' inexperience, Technical support, Health and safety, Class size, and Lesson lengths

Conclusions and Recommendations

Based on the findings, the study concludes that lack of training and policy governing the use of practical work coupled with inadequate resources and facilities hindered the use of practical work in the teaching and learning physics in secondary schools.

The incentives in the present study are to reconsider and reanalyze the benefit of inserting practical work in science teaching and learning endeavours. It has been observed that practical work in teaching and learning generates new knowledge and form the perfect meaning of theoretical science concepts. Although, the use of practical work is limited by many barriers comprising the lack of science resources and infrastructures if it's the perfect implementation in science academic actions is highly significant for learners and teachers. Practical work is an indispensable element of science teaching and learning that is aimed at improving learners' science knowledge and developing learners' knowledge about science.

Learners are willing to be engaged in building their own knowledge through practices. The education method that intrinsically motivates learners brings their interest toward learning, develop learners' critical thinking and develop their own learning is nowadays adopted in different corners of the world. Learning by doing can help learners to create and to solve the problem encountered by society and the world.

Recommendations to educational leaders.

- In-service teacher training prioritizing the use of practical work in teaching and learning should be initiated and sustained.
- Government Funds for education should be allocated to build, equip, and sustain laboratories in schools.
- Develop and implement wide-ranging practical physics frameworks and an essential detailed action plan and their related facilities such as practical teaching manual and teacher's guides.
- Practical physics should be allocated on the school timetable and regular supervision should be carried out in the classroom to ensure effective implementation of practical work.

Recommendation to teachers

To successfully implement practical work in science teaching, sufficient practical necessaries should be available. Consequently, Science teachers have to properly design the adaptive practices for learners that bring learners' interest toward science learning and use the acquired science competencies to satisfy needs for society.

Recommendation for future research

The current study considered the rationale of applying practical work in science teaching and learning to make abstract theoretical science tangible and apply them to solve complications encountered by society. Practices are of paramount importance in many areas unless their implication is hindered by many barriers. Therefore, we suggest for future researchers to progressively on various aspects that hinder the productive implementation of practical work in science teaching and learning.

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Competing interests

The authors affirm that no competing interest within the present work.

Authors' contributions

This study was carried out in collaboration with all authors. Author **TN** designed the study, performed statistical analysis, and wrote the protocol and the first draft of the manuscript. Author **TB** participated in data collection and analysis, searched and managed the literature of the study. Author **PN** analyzed the meaningfulness of the work.