JRIIE Journal of Research Innovation and Implications in Education
Center for Research Implications & Practice

Website:www.jriiejournal.com ISSN 2520-7504 (Online) Vol.6, Iss.1, 2022 (pp. 244 - 252)

Effects of Laboratory Practical Activities on Learners' Academic Achievement and Attitude towards Biology in Selected Secondary Schools in Rwanda

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Abstract: The main objective of the present study was to investigate the effect of practical activities on students' academic achievement and attitude towards biology. Quasi-experimental design under quantitative method was adopted, pre-posttest biology achievement test (BAT) and biology attitude questions test (BAQT) were used for data collection. Two public secondary schools from Nyamagabe district with 272 students were purposively selected based on the availability of biology laboratories and equipment. The intact classes were randomly selected for experimental and control groups with 142 and 131 students respectively. Results were analyzed through descriptive statistics and independent sample t-test using statistical package for social science (SPSS). The findings revealed that, experimental group taught under laboratory practical activities achieved higher mean-scores than control group taught using teacher centered activities, the" chalk and talk method". However, laboratory practical activities did not exert a significant effect on students' attitude towards biology. The study recommends the use of laboratory practical activities to improve students' biology performance in secondary schools and a further investigation on the effect of practical activities on students' attitude towards biology.

***Keywords**: Laboratory, Practical activities, Biology learning, Secondary school, Academic achievement, Attitude towards biology.*

How to cite this work (APA):

Ntawuhiganayo, F. & Nsanganwimana, F. (2022). Effects of Laboratory Practical Activities on Learners' Academic Achievement and Attitude towards Biology in Selected Secondary Schools in Rwanda. *Journal of Innovation and Implications in Education, 6*(1), 244 – 252.

1. Introduction

Science cannot be meaningful to students if they are deprived of practical experiences in the schools laboratories (Hofstein & Mamlok-naaman, 2007). Laboratory practical activities also known as laboratory work are used in the context that the experiments are done in the school laboratories (Motlhabane, 2013).

European countries like France, Italy, Ireland, Portugal, Roma, Spain and United kingdom emphasise on inspiring teaching of science using practical activities with the purpose of raising students skills (Dumbraveanu, 2007). In the United Kingdom, the science classes do practical activities more than in other countries elsewhere (SCORE, 2008). In America, the American association for the achievement of science (AAAS) established a science process approach that was intended to enhance students' skills in scientific methods (Ibe, 2004). In south Africa, the science curriculum emphasises the practical activities in addition to the delivery of resources and heartening learning by doing (Motlhabane, 2013, Hattingh et al. 2007).

In Rwanda, the new curriculum referred to as Competence Based Curriculum (CBC) encourages learning by doing rather than memorization of the subject matter (MINEDUC, 2015). Since the inception of CBC, Rwanda Basic Education Board (REB) advocated that,

teachers need to shift from traditional instructional methods and adopt the learner centred instructions which are participatory and interactive teaching methods. Some examples of the encouraged learner centred instructional methods include, practical work or activities, discussion, field visit and problem solving (REB, 2015). Likewise, Ndihokubwayo et al. (2018) noted that, science should start with hands-on experiment that pupils are familiar with and not with definition of scientific concept.

In the same line, Niyitanga et al. (2021) revealed that, teaching and learning through practical is among the methods that undoubtedly facilitate knowledge transfer and skills acquisition, putting into practice the practical work in teaching and learning activities will engage students in the real learning, be familiar with the observed phenomena and experiences around them. In the same context, Ndihokubwayo (2017) maintained that, laboratory activities make learners active in science learning and establish the accuracy of their beliefs.

In this regard, it is important to acknowledge and adopt the use of practical activities in science and biology particularly and design them in such a way that demonstrates a specific concept appropriate to curriculum (Almroth, 2015). The present study focused on the concept of " *enzymes*" It is a unit adopted from Rwandan Senior Four secondary schools' biology curriculum. It was selected for this study due to its abstract nature and with a hope that, practical activities should concretise learning such a concept.

Indeed, teachers who have taught the topic of enzyme found that learners have misunderstanding of the enzymes reaction; this has been discriminated by the fact that, the ways of determining enzymes activities are complex (Laloknam & Phornphisutthimas, 2010). Likewise, Leksmono et al.(2018) reported that the properties of enzyme reactions are best understood through the use of hands-on practical experiences.

Lack of practical activities could be one of the reasons that learners do not perform well and develop less interest when they are taught with traditional method (Motlhabane, 2013). The poor science teaching methods have negative effects on students' performance and attitude towards science (Juweto, 2015). Moreover, the current researches show that teachers still use traditional teacher centred instructions which lead to students' poor performance.

In Rwanda for example, Uwizeyimana et al.(2018) revealed that teacher centered methods is the most used to teach science. Nsengimana et al.(2017 added that in science, questions- answers method is dominated at the rate 75% , group discussion and experiment are used at 25% for each. Likewise Mukamwambali (2012) found that teaching biology in Rwanda is dominated by teacher centred methods. The emphasis of traditional teaching method is in contradiction with new curriculum (CBC) that emphasises learning by doing to improve student learning (REB, 2015).

The current examination results from Rwanda Basic Education Board (REB) in 2018 and 2019 years in biology in Senior six national exams in Rwanda, particularly in Nyamagabe district, indicated poor performance of biology where by most students obtained the last grades. Teacher pedagogical instruction and poor performance is not a problem of Rwandan only. In Kenya, Albert et al. (2014) revealed that poor performance in Nyakach district is due to teachers' characteristics, irregular provision of practical activities, insufficient teaching resources and lack of student's feedback.

Once students learn theories deprived of practical activities, they ultimately lack practical skills and as result the nation would end up with inadequate students with science capacities from secondary (Nyanda 2017).

The present study contributes in improving students' performance and biology teaching- learning via laboratory practical activities also known as "*explore and explain*". Some studies have been carried out but in the context of this study, there is no enough founds on the effect of laboratory practical activities on students' academic achievement and attitude towards biology in secondary schools. Particularly, in Rwanda there is no evidence of published data found. Hence, the study came to fill this research gap. The findings offer a detailed account on the effect of laboratory practical activities on learners' academic achievement and attitude towards biology. It informs the policymakers and teachers to take informed decision in selecting effective teaching methods. It also provides opportunities for future research.

Objective of the study

This study was set out to investigate the effects of laboratory practical activities on students' academic achievement and attitudes towards biology. In this study data from pre-post-test biology achievement test and biology attitude questions test were collected and analysed to answer the following research questions:

1. What is the students' achievement mean- scores differences before and after the use of laboratory practical activities in learning enzymes?

2. What are the impacts of laboratory practical activities on students' attitude towards biology subject?

2. Literature Review

Practical work refers to any teaching and learning activity which encompasses the students in observing, manipulating objects and materials they are learning (Millar, 2004). Grounded on the goals of practical activities or work and how it is organized, there are three types of practical work. First one is, equipment based practical work, the goals of this practical activities is to

help learners to be aware on how to use various scientific equipment. Second types are concept based practical, it is concerned with helping students to learn and appreciate new concepts.

The third one is the inquiry based practical activities that is concerned with learning processing skills like experimentation, defining problem, observing, measuring, processing data, tabularizing, graphing, categorizing and taking deduction (UR-CE, 2019). Morais and Ferreira (2014) reflect practical work as any teaching activities that range from paper and pen activities to the activities that need the use of laboratory activities and field trip. Their studies consider various practical works including laboratory activities, field trip, and application of knowledge to new situation and guided discussion.

According to UR-CE (2019) the goals of practical work suggest the types of practical work to use. The goal of laboratory practical activities in this study is to help the learners to learn and understand biology concepts in order to improve biology achievement and attitude. For the purpose of this study, the focus is on concept based practical work also known as‟ *explore and explain".* In concept based practical, the lesson is initiated by practical activities and theory can be clarified by teacher after words. This is because teaching theories first and doing practical activities to evidence the theoretical lesson is discouraging and offer slight added value on students learning (UR-CE, 2019).

2.1. Role of practical activities

The practical activities enhance students' proprietorship in science learning. It helps students to boost manipulation skills, logical skills and thought scientific concept (Dikmenli, 2009). It figures learner capacity and kindness towards science, equip learners with suitable competences and empower them to attest scientific phenomena , boost collaborative learning and problem solving skills (Etiubon & Udoh, 2017). In the same line, Kulshretta (2013) revealed that, practical activities enhance students manipulating skills, observation, investigation, evaluation and experiential learning.

2.2. Practical activities and students' achievement

Different literatures appreciate the frontline and crucial intervention of practical activities in improving students' academic achievement. In Nigeria, the students exposed to practical activities gain higher average scores than the students exposed on alternative to practical and gender has no significance effect on students' performance (Olutola, 2016).

In Turkey, Çimer (2012) revealed the teaching style, lack of materials, students feeling, and negative attitude as the causes of biology difficulty and recommended practical work for effective biology learning. The above Çimer's recommendation was also one of the motives to undertake this study in order to boost students performance in biology. Kambaila et al.(2019) reported that, practical activities positively enhance students' performance in biology than traditional teaching method.

In Tanzania, Nyanda (2017) states that, learning and teaching science without laboratory practical work hinders teachers from empowering inquiry learning and accessing specific objectives; learners claim that without practical activities they cannot master science concepts. Even though some researches have been carried out; there is no enough that can be found. Specifically in the context of Rwanda there was no evidence of published research found on the effect of laboratory practical activities on students' academic achievement and attitude towards biology in secondary schools. Hence, needs of this study to fill the gap.

2.3. The practical activities and students' attitude towards biology

The main emphasis of science and biology teaching in particular is to aid learners to be active, feel confident, committed, develop scientific literacy and positive attitude towards science. Negative attitude lead to dislike, positive attitude lead to interest and interest lead to assurance that result to well academic achievement (Jolif, 2016). The students' exposed to a well-equipped laboratory gain high mean- scores and have positive attitude towards biology than those exposed to inadequate laboratory activities (Katcha & Wushishi, 2015).

In England, Sharpe (2012) revealed that students favor practical lesson than non-practical lesson as the latter is enjoyable than writing and afford the senses of self-autonomy for learning. Students' attitude stimulate their self-assurance in biology, mostly in terms of feeling about getting good grades, undertaking tasks and wish to pursues biology related courses (Fareo, 2019). Therefore, it is significant to take students' attitude towards biology into consideration if we need to invest in learners equipped with scientific capacities.

3. Methodology

3.1. Design, method and ethical consideration

The main objective of the present study was to investigate the effect of practical activities on students' academic achievement and attitude towards biology. Quasi-experimental in pre-posttest design under quantitative method was adopted. Fernando et al. (2017) and Creswell (2014) revealed that, quantitative method seeks to obtain accurate data and reliable measurement that allows statistical analysis, use of statistical software and hypothesis testing. Two boarding public secondary schools with 272 Senior Four students from Nyamagabe

district were purposively selected based on the availability of biology laboratories, chemicals, equipment and combination including biology as core subject.

The intact classes from the selected schools were randomly taken for experimental and control groups with 141 and 131 students respectively. This is because it is not possible to carry out pure experimentation on students as it is unethical in the usual school system. The selected schools and classes also followed different time tables and it was not possible to disrupt the school setting system. Prior to data collection the researcher followed all the research ethical procedures. This study was cleared by the ethical clearance committee in research and innovation unit at University of Rwanda College of Education. The mayor of the selected district and head masters of the selected schools granted permission to carry out the study. All participants were above 16 years old and they signed the consent form and participated in the study voluntarily. The names of the schools as well as the students were not mentioned.

Prior to the intervention both control and experimental groups were pretested to determine students' prior knowledge on the concept of *"Enzyme"*. Pretest also helped researcher to know whether the control and experimental groups were academically comparable before the intervention. During the intervention, the experimental group was taught under laboratory practical activities while the control group was taught with traditional teacher centered activities "*chalk and talk method*" and biology text books. After intervention the researcher administered a post-test to both experimental and control groups to check if the intervention or treatment had an effect on students' biology academic performance and attitude.

Table 1: Details on used lessons and teaching and learning materials used in experimental group taught through laboratory practical activities

Lessons	Content	Teaching, learning materials and chemicals
1.	Effect of amylase enzyme on starch at different temperature, PH and substrate concentration.	Amylase enzyme, starch solution, iodine solution, test tubes, droppers, hydrochloric acid (HCl), cold water (ice) and water bath.
2.	Effect of digestive enzymes (pepsin and lipase) on food substrate.	Pepsin, lipase, white of the eggs, water, water bath, HCl and test tubes, bile salt and lipids.
3.	Action of catalase enzymes on hydrogen peroxide Test for the presence of oxygen.	Test tubes, fresh liver, catalase enzymes and lighted wooden splint.
4.	Description of the mode of action of enzymes in terms of lock and key hypothesis	Pad lock and key 

Table 1 above show the lessons, materials, chemicals and equipment used in this study, where the enzyme amylase was used to hydrolyze the starch to maltose, lipase which is responsible for digesting lipids to glycerol and fatty acid, protease (pepsin) to digest protein to amino acid and catalase enzymes to breakdown harmful hydrogen peroxide to harm less substances which are water and oxygen.

The padlock and key were used to help students understand the lock and key hypothesis. In lock and key hypothesis, the key fits into their respective pad lock as the substrate fits into the enzyme active site (REB, 2019). The lock stands for the enzymes and key represents substrate.

3.2. Instrument used for data collection

Biology achievement test was designed by the researcher based on the learning objectives highlighted in the Senior Four Rwandan biology curriculum. It was constructed with open and multiple-choice questions for triangulation purpose. Prior to data collection the instruments were validated and piloted for reliability purpose. Biology achievement test was validated by four Senior Four biology secondary schools' teachers whose teaching experiences are above five years and the biology expert

and senior lecturer at University of Rwanda College of Education.

Biology Likert scale attitude questions test was adopted from the work of Prokop et al. (2007) from Slovakia with some modification to meet the standard of learners in Rwandan context. It was made of three dimensions that are, students' interest towards biology, students' attitude towards importance of biology and students' attitude towards biology difficulty. The instruments of this study were piloted in the other school not included in the sampled school for reliability purpose. Biology achievement test Pearson correlation Coefficient was found to be 0.78 and Likert scales attitude questions test Cronbach Alpha Coefficient was found to be 0.82. Therefore, this study data collection instruments satisfied the validity and reliability to be used in this study.

3.3. Data analysis

The main objective of the present study was to investigate the effect of laboratory practical activities on students' academic achievement and attitude towards biology. Quantitative data collected through pre-posttest in quasi experimental design was analyzed via descriptive statistics and independent sample t-test with Statistical Package for Social Sciences (SPSS) at 0.05 significant level. Likert scales attitude questions test was ranked from strongly agree to strongly disagree. The negative statement was scored in revised order to positive statement. Strong agree (five marks) agree (four marks), neutral (three marks), disagree (two marks) and strongly disagree (one mark).

After scoring each item, the average mean-scores, standard deviation and t- test among experimental and control groups were computed before and after intervention. Biology achievement test was also scored and average mean-score, standard deviation and t-test among groups was computed and compared, the results are presented in tables.

4. Results and Discussion

The main objective of the present study was to investigate the effect of laboratory practical activities on students' academic achievement and attitude towards biology. This section addresses the study results and their discussions. Pre and posttest results are presented in tables and offer answers to the research questions and test hypothesis.

4.1. Academic achievement among students taught the concept of enzymes with laboratory practical activities and those taught under teacher centred activities (*chalk and talk method*)

The first research question sought to students' achievement mean-scores differences before and after the use of laboratory practical activities in learning enzymes. To provide answer to this research question, pre and post-test biology achievement test was administered to the experimental and control groups. Table2 below shows the summarized descriptive statistic result. Where N: stand for a number of participants, M: mean score and Sd for standard deviation.

It was observed that the average mean-scores of the experimental and control groups in pre-test was approximately equal. This means that, experimental and control groups are academically comparable before intervention, any difference after intervention would be attributed to the intervention. The standard deviation of control group in pretest is greater than the standard deviation of the experimental group that means there was variability in scores among students in control group.

The post-test results indicated that, experimental group doing practical activities on enzymes or received treatment gained higher mean scores than the control group that did not received any practical activities. The independent sample t-test was computed to check if the mean scores difference is statistical significant and the inferential statistical results are summarized in table3.

Table 2: Mean score and standard deviation results in pre-post-test in biology achievement test before and after intervention

Groups	N	M	Sd
Pre-test control group	131	20.916	7.680
Pre-test experimental group	141	21.411	5.389
Post-test control group	131	35.626	8.292
Post-tests experimental group	141	51.021	6.714

In the Table 3 below, the independent sample t-test results revealed no significant difference in pretest and confirmed a significant difference in post-test results (df = (270) t =-16.881, p =0.00<0.05), hence providing answer to the first research question and rejecting the null hypothesis. Based on the finding, laboratory practical activities improve students' academic achievement than teacher centred activities commonly referred to as "*chalk and talk method"*. The experimental group taught the concepts of enzymes via laboratory practical activities outperformed the control group taught the same concepts under teacher centred activities. The finding was not particular because it similar to that of Kambaila et al.(2019) from Zambia who found out that practical activities positively improve students' performance in biology more than the traditional teaching method.

Table 3: Independent sample t-test result in pre-posttest from biology achievement test

Groups	df	t	Sig (two tailed)
Pre-test control group	231		
Pre-test experimental group	231	-.611	.542
Post-test experimental group	270	-16.881	0.000
Post-test control group	270		

The findings of this study are also in the same line with that of Olutola (2016) in Nigeria who investigated the effect of practical and alternative to practical method on students' academic achievement in biology and revealed that practical method has significant effect on secondary students' performance in biology. Similarly, Elias (2017) reported that, pupils who were taught the genetic via hands-on approach out performed those taught the same concept under the conventional teaching method. The positive effect of practical activities has been observed in other science subject taught in schools. For instance, a study on the effect of practical work on academic performance in physics among learners at the selected secondary schools in Rwanda, revealed that practical work is more effective in improving students' performance (Twahirwa & Twizeyimana, 2020). Therefore, based on the finding of this study and supported by the literatures above, laboratory practical activities improve students' biology performance in comparison to the teacher centred activities, the" *chalk and talk method"*

4.2. The impact of laboratory practical activities on students' attitude towards biology

The second research question looked on the impacts of laboratory practical activities on students' attitude towards biology subject. To provide answer to this question the pre and post biology attitude questions test was administered to both experimental and control groups. The summarized descriptive statistical results are presented in table 4 below. Where N: stands for a number of participants, M: mean-score and Sd: for standard deviation.

Table 4: Mean, standard deviation results in pre and posttest in biology attitude test before and after intervention

Groups	N	M	Sd
Pre-test control group	131	45.908	5.006
Pre-test experimental group	141	45.496	4.982
Post-test control group	131	45.038	4.133
Post-test experimental group	141	45.120	4.219

In Table 4 above, the pre-test results indicate that, experimental and control groups average mean -scores are approximately equal. The similar standard deviation among control and experimental groups implies the similar biology attitude among groups (experimental and control groups) before doing practical activities on experimental group.

The post-test results revealed that, the average mean-scores and standard deviation among experimental and control groups stay the same. This implies no attitude variation among experimental and control groups after intervention. The independent sample t -test was computed to check whether there is any significant difference in mean- scores among the experimental group

taught under laboratory practical activities and control group taught through teacher centred activities; the *"chalk talk method"*. The inferential statistic results are summarized in table5 below.

Table 5: Independent sample t-test results in pre and post biology attitude test before and after intervention

Groups	df	t	Sig (two tailed)
Pre-test control group	270		
Pre-test experimental group	270	.680	.497
Post-test control group	270		
Post-test experimental group		-.163	.871
	270		

In Table 5 above the t- test result of pre and post-test confirm that there was no statistical significant difference at 0.05 significance level. This means that, laboratory practical activities have no significant effect on students' attitude towards biology. Hence, providing answer to second research question and not rejecting null hypothesis. Based on the finding from this study, laboratory practical activities improve students' biology academic achievement but did no exert any significant effect on students' attitude towards biology.

The finding is not particular because it was in the same line with Sadi & Cakiroglu (2011) who investigated the effect of hands-on activity enriched instruction on students achievement and attitude towards science and reported that, hands- on activities enriched instruction were more effective than traditional method but statistical result did not revealed a significant difference between experimental and control group concerning attitude towards science.

However, the findings are different from those of Katcha and Wushishi (2015) who reported that, students exposed on equipped laboratory gain high mean- score and have positive attitude towards biology more than the students exposed to inadequate laboratory. The possible reasonable explanation of the present study finding on the students' attitude towards biology should be the factors that, the study focussed on one unit and it should not be enough to measure students' attitude changes on one unit only. Second, the study adopted quantitative method only which is not enough for triangulation purpose.

The third reason is that, intervention was done in four weeks that should be a short period to measure the changes in students' attitude towards biology.

5. Conclusion and Recommendations

The present study's objective was to investigate the effect of laboratory practical activities on secondary school students' academic achievement and attitude towards biology. This was achieved by comparing the achievement mean-scores and biology attitude scores of Senior Four students who were taught the concept of enzymes under laboratory practical activities and those taught the same concept through teacher centred activities, the *"chalk and talk method"*. The pre and post biology achievement and biology attitude question tests were used for data collection via quasi-experimental research design. The findings revealed that laboratory practical activities significantly improve students' biology academic achievement more than traditional teacher centred activities, the *"chalk and talk method"*. However, laboratory activities did no exert significant effect on students' attitude towards biology. Based on the findings, this study recommends the teachers to strive for using laboratory practical activities in biology teaching in order to improve students' biology academic achievement. Laboratory practical activities should also be a frontline and fundamental instructional method for biology teaching, and other science subjects like physics and chemistry should also adopt it. Students should take laboratory activities as a vital method for learning biology in particular. Further investigations on the effect of laboratory practical activities on students' attitude towards biology are needed. Moreover, future studies should extrapolate the studies to the broad sample representing categories of all Rwandan students' population. Furthermore, teacher's attitude towards teaching biology was not investigated due to different measures against covid-19, the future researchers should also take it as ongoing hint.

Acknowledgements

We frankly acknowledged the financial support provided by the University of Rwanda - College of Education, specifically the African Centre of Excellence for Innovative teaching and Learning Mathematics and Science (UR- CE, ACEITLMS). We also acknowledge the academic critics of Joseph Njiku from ACEITLMS.

References

Albert, O. O., Osman, A., & Yungungu, A. (2014). An investigation of factors that influence performance in KCSE biology in selected secondary schools in Nyakach District, Kenya. *Journal of Education and Human Development 3*(2), 957-977.

Almroth, B. C. (2015). The importance of laboratory exercises in biology teaching. Institution for biology environmental science, University of Gothenburg. WWW.pil.gu.se/publicerat/texter.

Çimer, A. (2012). What makes biology learning difficult and effective: Students' views. *Educational Research and Reviews*, *7*(3), 61-71. https://doi.org/10.5897/ERR11.205

Creswell, J. (2014). Reseach design: Qualitative, quantitative, and mixed methods approaches (fourth edi). SAGE Publications, Inc. London.

Dikmenli, M. (2009). Biology student teachers' ideas about purpose of laboratory work. *Asia-Pacific Forum on Science Learning and Teaching,10* (2), 1-14.

Dumbraveanu. (2007). From perception of science to the design of teaching materials. *Journal of Science comminication*, *6*(3), 1-5.

Elias, M. (2017). Hands-on genetics and pupils ' academic achievement at selected secondary Schools in the Copperbelt Province of Zambia. *Journal of Education and Ptractice*, *8(29).*

Etiubon, U., & Udoh, N. M. (2017). Effects of practical activities and manual on science students academic performance on solubility in Uruan local education authority of Akwa ibom state. *Journal of Education and Practice*, 8(3), 202-209.

Fareo, D. O. (2019). Study attitude and academic achievement in biology at secondary school level in Mubi metropolis of Adamawa state. *International Journal of Scientific and Reseach Publications*, *9*(8), 333-340.

Fernando, A., Queirós, A., & Faria, D. (2017). Strengths and limitations of qualitative and quantitative research methods. *European Journal of Education Studies,3(9),369-387.* https://doi.org/10.5281/zenodo.887089.

Hattingh, A., Aldous, C., & Rogan, J. (2007). Some factors influencing the quality of practical work in science classrooms. *African Journal of Research in Mathematics, Science and Technology Education*, *11*(1), 75-90. https://doi.org/10.1080/10288457.2007.10740613.

Hofstein, A., & Mamlok-naaman, R. (2007). The laboratory in science education : The state of the art. *Chemistry Education Reseach and Practice,8(2), 105-107.* https://doi.org/10.1039/B7RP90003A

Ibe. (2004). Effect of guided inquiry, demonstration and convertional method of teaching science on acquisition of science process skills among senior secondary school students.(Un published master thesis) departiment of science education, University of Nigeria Nsukka

Jolif, O. J. (2016). Factors contributing to poor performance of science subject: Acase study of secondary school in Busia country. Adessertation submited in partial fulfillement of the requement for the post graduate diploma in education (Unpublished paper), University of Nairobi- college of education and external studies department of educational studies.

Juweto, G. A. (2015). School location on students achievement and attitude towards biology in secondary school in Delta state. *International Journal of Education and Research*, *3*(8), 31-40.

Kambaila, C. M., Kasali, G., & Kayamba, F. (2019). Assessing the effects of biology practical activities on academic performance of senior secondary school students , Zambia . *Journal of Education and Practice* , 10(24), 116-124. https://doi.org/10.7176/JEP

Katcha, M. A., & Wushishi, D. I. (2015). Effects of laboratory equipment on secondary school students' performance and attitude change to biology learning in federal capital territory, Abuja, Nigeria. *Journal of Education Research and Behavioral Science*, *4*(9), 250-256.

Kulshretta, A. K. (2013). Teachers' training and professional competencies. Dayalbagh educational Press, India.

Laloknam, S., & Phornphisutthimas, S. (2010). Learning retention in undergraduate biology using a hands-on practical , enzyme detection from vegetables and fruits. *Journal of Chemistry and Chemical Engineering 4*(5), 1934-7375.

Leksmono, C. S., Manzoni, C., Tomkins, J. E., Lucchesi, W., Cottrell, G., & Lewis, P. A. (2018). Measuring lactase enzymatic activity in the teaching. *Journal of Visualazed Experiment(138), e54377.* https://doi.org/10.3791/54377.

Millar, R. (2004). The role of practical work in the teaching and learning of science, University of

York.

MINEDUC. (2015). Summary of curriculum frame-work pre-primary to upper secondary 20*15*.

Morais, A. M., Ferreira, S. (2014). Conceptual demand of practical work in science curricula a methodological approach. *Research in Science Education*, 44(1),53-80.

Motlhabane, A. (2013). The voice of the voiceless: Reflections on science practical work in rural disadvantaged schools. *Mediterranean Journal of Social Science, 4*(14), 165-173.

Mukamwambali, C. (2012). The impact of teaching style on students learning of biology in higher secondary school in Rwanda : Case study of Kigali city. Un pblished thesis submited in partial fulfilimennt of the requirement of degree of master of education, University of the Witwatersrand, Johannesburg.

Niyitanga, T., Bihoyiki, T., Nkundabakura, P. (2021). Factors affecting use of practical work in teaching and learning physics: Assessment of six secondary schools in Kigali city, Rwanda. *African Journal of Educational Studies in Mathematic and Sciences* 17(1), 61-77.

Ndihokubwayo, K. (2017). Investigating the status and barriers of science laboratory activities in Rwandan teacher training colleges towards improvisation practice. *Rwanda Journal of Education*,4(1), 47-54.

Ndihokubwayo, K., Uwamahoro, J., Ndayambaje, I. (2018). Use of improvised experiment materials to improve teacher training college students'achievement in physics, Rwanda. *African Journal of Educational Studies in Mathematics and Science* (14), 63-77.

Nsengimana, T., Habimana, S., & Mutarutinya, V. (2017). Mathematics and science teachers ' understanding and practices of learner - centred education in nine secondary schools from three districts in Rwanda. *Rwanda Journal of Education,* 4(1), 55-68.

Nyanda, F. (2017). Effects of teaching science subjects in absence of science laboratory: Acase study of community secondary school morogoro municipal. Project report in partial fulfillment of the requiremrnt of the bacheror of science with education, Sokoine University of agriculture, faculty of science departiment of education.(Unpublished paper).

Olutola, A. T. (2016). Comparative effects of practical and alternative to practical methods on students' academic performance in biology. *International Journal of Educational Benchmark 3(1), 67-80.*

Prokop, P., Tuncer, G., & Chudá, J. (2007). Slovakian students' attitudes toward biology. *Eurasia Journal of Mathematics, Science and Technology Education 3*(4), 287-295.

REB. (2019). Biology student's book first edition.

REB.(2015). Competence based curriculum, curriculum frame work pre-primary to upper secondary. Ministry of education, Republic of Rwanda.

Sadi, Ö., & Cakiroglu, J. (2011). Effects of hands-on activity enriched instruction on students' achievement and attitudes towards science. *Journal of Baltic Science Education*, *10*(2), 87-97.

SCORE. (2008). Practical work in science: Report and proposal for a strategic frame work. London.

Sharpe, R. M. (2012). Secondary school students attitude towards practical work in school science. University of york.

Thomas, N. O. (2013). Effects of teacher preparation on students academic achievements in SS2 biology practicals. *Journal of Education and Practice* 4(8), 145-151.

Twahirwa, J. N., & Twizeyimana, E. (2020). Effectiveness of practical work in physics on academic performance among learners at the selected secondary school in Rwanda. *African Journal of Educational Studies in Mathemathics and Science,16(2) 79-108.*

UR-CE. (2019). Continuousprofessional development certificate in educational mentoring and coaching for stem teachers, students manual, Volume2: Technological pedagogical content knowledge and gender in stem education.

Uwizeyimana, D., Yadav, L., Musengimana, T., & Uwamahoro, J. (2018). The impact of teaching approaches on effective physics learning : An investigation conducted in five secondary schools in Rusizi district, Rwanda. *Rwanda Journal of Education 4(2), 4-14.*