Rwandan Secondary School Biology Teachers' Knowledge and Skills of Practical Work

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Abstract

This research is aimed at investigating Rwandan secondary school biology teachers' knowledge and skills of practical work. It also examined the contributions of such knowledge and skills on how the teachers taught practical work in biology classes. The study employed qualitative method under pragmatic research design. The study was conducted in 26 schools located in three districts of the Western Province in Rwanda. The districts, schools and teachers were selected randomly while the Province and advanced level were selected purposively. The data were collected using depth interview and observation of classroom science practical activities. The collected data were thematically analyzed and the results revealed moderate biology teachers' knowledge and skills of practical works as gaps and limitation had been noticed. The lack of procedural understanding of practical work and lack of content knowledge of the subject matter as well as skills to conduct some practical work on the program had been also reported. In addition, teacher-centered approach to practical work is common in biology classrooms even though a few teachers practice the student-centered approach. The positive contribution of teachers' knowledge and skills on the practical work conducted in class had been reported. In conclusion, the study suggests an imperative professional development of biology teachers concerning the practical work as well as the provision biology practical work equipment and reagents. It also recommends to REB the alternation of examined practical work topics in order to avoid teachers' predictions of practical work topics to be assessed. That can trigger their own knowledge and skills improvement through research.

Keywords: biology teachers, biology practical work, teaching science, teaching biology

Introduction

Countries like the United Kingdom, United States of America and Japan that have promoted Science, Technology, Engineering, and Mathematics (STEM) programme changed their peoples' ways of living through skilled manpower (Tufuor et al., 2004; Isozaki, 2017; Stimmer & M. Froschl, 2019). In Rwanda, STEM is acknowledged by the government as engine to socio-economic development as the country is striving to build a knowledge-based economy (MINEDUC, 2015). Achieving this goal requires the country to ensure the improved quality of education through updated STEM curriculum,

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improved teaching and learning techniques and availability of teaching materials. This is why, in 2015, the country shifted from a knowledge-based curriculum to Competence-Based Curriculum (CBC) nurturing a citizen capable to fit into 21st century (MINEDUC, 2015). The shift in curriculum followed the change from teacher to learner-centered pedagogy implemented from 2006. There was also change in teaching language from French to English since 2009, when Rwanda joined the East African Community education system.

In the new CBC, different generic competences including the learner-centred which stresses participatory active methods were prioritized (MINEDUC, 2015; Ngendahayo & Askell-williams, 2016). According to the same authors, this is where practical works are rooted and have replaced the traditional pedagogy. Practical works refer to all activities related to learning and teaching science subjects that may be done individually or in a group (Omiko & Akani, 2015).Those activities include conventional activities or virtual activities assisted by computer technologies, laboratory work and field work. They involve learners in observation, experimentation, investigation and manipulation (Isozaki, 2017). Science practical works are also explained as hands-on investigation activities and minds-on activities which require use of active teaching and learning approaches (Hofstein, 2014; Nwagbo & Uzoamaka, 2011). In addition Nwagbo & Uzoamaka (2011), asserted that science practical works involve manipulation, measuring, classification, questioning, communicating, designing experiments, analyzing the results and drawing sounding conclusions.

Different studies conducted in science education, acknowledged the roles of practical activities. Various authors argued that science practical activities are essential and fundamental in science teaching and learning owing to helping learners deepen their learning, construct knowledge and develop skills (Nwagbo & Uzoamaka, 2011; Omiko & Akani, 2015; Odutuyi, 2016; Chibabi et al., 2018). This is due to the fact that science practical works concretise the teaching and learning rather than being limited to presentation of the theories concepts, principles and facts (Omiko & Akani, 2015; Ottander & Grelsson, 2006). Further, with practical works, secondary school science students with little interest in science subjects are attracted and motivated as they are engaged and less boring than listening to theories and concepts (Abrahams & Abrahams, 2009). With science practical works, interest and motivation of science students are improved (UR-CE, 2019) and positive effects of science students learning outcomes and school achievements were noticed (Chibabi et al., 2018; Omiko & Akani, 2015).

Considering the importance of practical works in science learning and Rwanda education philosophy of producing competent citizens, science practical work which is unique characteristic to science as one of the dimensions in the profile of science curriculum implementation (Rogan & Grayson, 2003) remains a matter of concern specifically to biology as until now no particular study interested in that domain had been carried out in Rwanda.

However, even though fewer studies investigated the knowledge and skills of biology teachers towards practical work development and implementation in some countries of East Africa, no particular study investigated deeply the relationship between the knowledge and skills of teacher in that domain (Tibyehabwa et al., 2017). Considering the role of teachers' vis-à-vis teaching and learning, however, it is not possible for learners to demonstrate

knowledge and attitudes and thereby develop skills of practical works, unless they are supported by their competent teachers (Wei & Li, 2017). It is in this regard that this study seeks to investigate the knowledge and skills of Rwandan secondary school biology teachers toward the practical works. The following research questions guided this study: 1. what knowledge and skills of science practical works do secondary school biology teachers have and demonstrate while teaching their lessons? 2. What is the contribution of biology teachers' knowledge and skills on practical work conducted in class?

Review of literature

Types of science practical work and their application in teaching

The goal and objectives are the key factors to determine the types of practical work to be carried out (Kandjeo-marenga, 2014). They are three types of practical work featuring as equipment- based practical work, concept-based practical work and inquiry-based practical work. In this regard, the equipment-based practical work involves the learners to handle scientific equipment and laboratory materials. It is carried out through different instructions to follow and a lot of exercises aiming to learn practical skills (Kandjeo-marenga, 2014). Teachers ask different reflection questions involving students to think about why they are doing such activities. They are many examples of this type of practical work such as the use of microscope, titration of organic substances from plants mentioned among others.

Besides equipment-based practical work, a concept based practical work requires the teacher to help students learning new scientific concepts. It can take a series of exercises or activities to teach the new concept, and in most of the time it is started with practical activities, and the theory is explained after. Teachers can use simple equipment with a series of activities and bear in mind to focus on teaching new scientific concept (UR-CE, 2019). The experiment should be organised in the ways it is related to learner's daily life to let them make a connection between the concept and their life and enhance their understanding.

The other type is an inquiry- based practical work that involves teachers to help students learning the process skills like investigation method, installing equipment in experiment design, measuring, observing among others. It lets the learners independency of setting up the experiment and then discuss about it (UR-CE, 2019). Teachers work in small steps or phases to reach the targeted goal and try to formulate investigation questions that are workable in the context of the school setting.

Teachers' knowledge and their application in teaching science through practical work

Shulman was the first researcher to classify the clusters of knowledge domains for any teacher and later Windschitl adapted his work on science practical work distinguishing general pedagogical knowledge, the content knowledge, the pedagogical content knowledge, the curriculum knowledge and disciplinary knowledge (Shulman, 1986; Shulman, 1987; Windschitl, 2004). In this regard, the general pedagogical knowledge encompasses the major principles of classroom management and the organization of the subject matter to teach (Shulman, 1986; Shulman, 1987). For practical work, it requires teacher's capacity to conduct and moderate practical work class discussions, designing group activities, prepare and organize different appropriate material of science practical works including adequate text books and medias (Lewis, 2016).

The content knowledge are the structured deep understandings of the subject matter to teach (Shulman, 1986; Shulman, 1987). It involves the teacher capacity to master the concepts, theories and laws or principle indicated in the syllabus of a given science subject

(Windschitl, 2004; UR-CE, 2019). In science practical work, it involves the teacher capacity to prepare and conduct all practical works prescribed in the syllabus intended to be taught and make the connection with the related theories(Tibyehabwa et al., 2017). Besides the content knowledge, the pedagogical content knowledge is the integration of content and pedagogy that enlarge the knowledge of the subject and teaching(Shulman, 1986; Shulman, 1987; Lewis, 2016). In the context of the practical work, it reflects the capacity of the teacher to involve leaners in scientific practical activities, ideas and concepts at appropriate age, in appropriate time and in appropriate ways (Lewis, 2016).

Disciplinary knowledge on the other hand can be explained as the knowledge of the subject or discipline. Discipline here, is seen as systematic group of knowledge presented in smooth organizational structures. According to Hu, disciplinary knowledge is made up of two broader groups including hierarchical and horizontal structures (Hu, 2018). The author describes the natural sciences practical works as the disciplines of the hierarchical knowledge, characterized by theory development, where humanities and social studies are horizontal knowledge structures. For the author, science practical work disciplinary knowledge reflects teachers' understanding of purpose of practical work, method of conducting practical work and recognition of the updated source related to the subject (Windschitl, 2004).

Finally, curricular knowledge is the knowledge of the arrangement of the instructional material that are available in order to teach a given topic (Shulman, 1986; Shulman, 1987). It also reflects the ability of a teacher to connect the current lesson to the lesson learnt previously (Lewis, 2016). It is also related to the capacity of teachers to help the learners strengthening their understanding of the interdependence between different scientific subject matter during practical works.

Teachers' skills of science practical work and their application in teaching

The term skills denotes the expertise of an individual to do things or the expertise of an individual in accomplishing a given task (Lewis, 2016). Windschitl discribed five general activity structures that demonstrate the skills of teacher to prepare and conduct a science practical work, featuring as demonstration, problem solving, learning discovery and school science inquiry (Windschitl, 2004).

Practical work demonstration requires the involvement of the teachers into action. Before the students become engaged in conducting science practical work, teachers give them an example using the same material required and the students follow the procedure and record the protocol. Then after, they are asked to produce the same work themselves either individually or in group. With this technique different procedures of scientific concepts, principle and law are gained (Windschitl, 2004; Kennedy, 1998). In Africa, some school experiencing a shortage of the material added to big class size, demonstration is done by teachers who show all protocol and procedure to students who never get the chance to do the same work (Mwangu, 2017). In some conditions like scarcity of material, hazardous materials or potential health risk the demonstration is preferable (UR-CE, 2019). However this approach limits the independence and creativity of the learners as they are required to produce what the teachers had shown to them (skills transmission from experts) instead of creating they own views (Woodley, 2009).

The discovery of learning in classroom involves the teacher's ability to help the learners discover and confirm idea or set a

relation through different practical works in structured or semi structured ways, with the material and scientific procedures. Teachers use different approaches such as inductive reasoning and they organize different activities that relate to each other in constructing the needed scientific concept, law or principle to learn. Students work in structured or semi structured ways with the activity or the material to discover. They measure, compare and contrast different material in order to set and confirm an idea or concept (Windschitl, 2004). However, learning discovery had been criticised. Scholar had pointed out that it is impossible for student to discover the theories underpinning various phenomena with simple data observation only"(Driver et al., 1996). The learning discovery requires the teachers to go beyond and use the inductive procedure of the scientific, empirical views of science and even the hypothetic-deductive procedure of science (Driver et al., 1996).

Problem solving requires teacher capability to help the learners, using their understanding of scientific concepts and procedures of practical works, to solve the problem that they can set themselves or designed by their facilitators (Windschitl, 2004). This technique involves the student's creativity, they combine ideas, procedures and methods or approaches in new ways. Science practical work problem may be given to students and they seek for the solution themselves. Teachers may create a problem that the students have not learned the approach of resolution and seek themselves the solution or they may create a situation in which problem exist but not identified and is for the students to identify it (Hofstein & Lunetta, 1982).

Research methodology

This article reported a research that employed qualitative method under pragmatic research paradigm. The researcher collected qualitative data in order to investigate a more complete understanding of the knowledge that biology teachers have and the skills they use while teaching (Creswell, 2014).

Population

This research had been carried out in Western Province of Rwanda and the targeted population were all secondary school biology teachers in advanced level in Western Province of Rwanda. The total population of this study is 132 teachers including females and males.

Sampling and sample size.

Western Province was selected purposively for only one reason; the researcher lives there. Three districts from this Province were randomly selected from the pool of seven eligible districts across the Province and this number was selected due to time constraints and financial limitation. Secondary biology teachers of advanced level with compulsory biology education degree; a diploma or Bachelors with at least one year of experience participate in this study. Upper levels biology teachers had been purposively targeted for only one reason, biology students in upper level in Rwanda sit for practical work national examination for getting their secondary school Certificates. 62 teachers had been randomly sampled from 26 advanced level secondary school including boarding and day school having PCB, MCB and BCG combinations. All responded to the questionnaire. From them, 24 have been interviewed and 20 practical lessons had been observed and video-recorded.

Instruments

Instruments to collect data were structured interviews, protocol or guide observation of classroom science practical activities and teachers' teaching documents. Interviews were held with 24 teachers, eight per each district while 20 lessons were observed and video recorded. Teachers and class activities were carefully video- recorded. The checklist

tools were used to identify the applied skills as well as knowledge of teaching practical work in class. Teachers' documents were also observed.

Data analysis

The qualitative data collected were thematically analyzed using an analytical framework developed by Rogan & Grayson (2003), adapted by Hattingh et al. (2007) and Nsengimana et al. (2014). Data from interview were carefully analyzed in comparison with qualitative data from the lesson observations in order to track their trustworthiness. Those that were also displayed in themes on the scale 1 - 4 in analysis tools, in their respective sub constructs (Tables 1 & 2).

Table1 An Analytical Framework

	Sub constructs	Levels & their descriptors
Teachers knowledge of practical work	Equipment based practical work	1. Teacher centered activities: Only teacher does practical work demonstration and students passively observe.
		2. Teacher centered practical work demonstration first and then involvement of few students
		3. Teacher does demonstration activities and involvement of many students with many exercises
		4. Teacher gives instructions and protocol to follow and all students are involved independently in doing practical demonstration.
	Concept based practical work	1. Only teacher-centered activities: s/he does practical work at the beginning of the lesson and s/he explains the theory after
		2. Teacher and few students do practical work at the beginning of the lesson and s/he explains the theory after.
		3. Teacher and many students are involved in doing practical work and finally s/he helps them to understand the theory
		4. All students are involved in doing practical work at the beginning of the lesson and then through they their reflection and discussions they discover the meaning of the theory.
	Inquiry based practical work.	1. Cook book lab activities: teacher-centered practical work investigation process.
		2. Teacher determines then, suggests hypothesis, the methodology and collect the data but s/he involves some students in interpreting and presenting the results.
		3. Structured inquiry: teacher determines the problem and the students organized in small group do all remaining investigation phases.
		4. All students are independently involved in investigation practical work.

Table 2 An analytical framework

	Sub constructs	Levels & their descriptors
Teachers skills of practical work	Building skills	1. Only the teacher carries out the manipulative activities while students are following passively 2. Teacher and few students do the manipulative activities while the remaining are following passively 3. Teacher and many students do the manipulative activities 4. All students are involved in manipulative activities following the instruction and protocol given by the teacher
	Problem solving	1.Teacher gives the problem in practical work and seek himself the solution 2. Teacher gives the problem to students who in turn seek for the solution 3. Teacher creates a situation in which no identified problem exists, then learners identify it and seek for the solution. 4. Students themselves set the problem and seek for the resolution independently.
	Discovery of learning	1 Only teacher centered discovering practical work activities 2. Only teacher and few selected students discovering practical activities 3. Teacher and many students organized in small groups discovering practical activities 4. All students are independently involved in discovering practical activities.
	School science inquiry: investigation	1. Cook book lab activities: teacher-centered practical work investigation process. 2. Teacher determines then, suggests hypothesis, the methodology and collect the data but s/he involves some students in interpreting and presenting the results. 3. Structured inquiry: teacher determines the problem and the students organized in small group do all remaining investigation phases. 4. All students are independently involved in investigation practical work.

Results

Biology Teachers' knowledge of practical works

Biology teachers' knowledge of practical works were obtained from interviews in Western Province in Rwanda. The interview questions focus on the knowledge of the types of practical works, their characteristics and practices, the easier to perform and complicated ones due to lack of skills.

The results of the study revealed that all participants have moderate knowledge of practical works. They are limited at certain level regarding individuals in particular, some teachers' lack procedural understanding of the

types of practical work and they don't master the subject content matter of practical work. Regarding the names and practices of types of practical work, all respondents reported that they don't know the exact names of different types of practical work but asked about their practices in class room they revealed that they perform different types of practical work without knowing exactly their names, their difference and their framework.

Concerning the characteristics of different types of practical works, 40% reported that equipment-based practical work is dominated by teachers centered activities and limited involvement of learners and it is rated in level 1. Here are some of their statements:

> *"we start by theory of microscope; we describe its parts and function in class room and then we go in lab for practices to show them how it really works. Most of the time I give the demonstration and explain how I am doing it and few students do the same in front of their fellow". Teacher 1.*
>
> *"For the use of the magnifying instruments like the microscope and hand lens, we start by explaining their function in the class room and we go in lab for the practices, where I demonstrate to all students how they work and then some students do the same in front of their fellows". Teacher 2.*

60% reported that equipment based practical like the manipulation of the microscope is dominated by students' activities and is rated in level 3

> *"First of all, I explain the theory in class room and then students are organized in different manageable groups for the practical lab. After their attentive follow up of my demonstration, each group perform the same but due to lack of sufficient apparatus only the group representatives perform the practice while their group members are helping them and following" Teacher 3.*

In addition, for the concept based practical work, most of respondents reported that it is carried out by starting with explanation of the theory of the concept and then the practices are done to verify the theory. Here are some respondents' statements:

> *"we explained the theory of transport across the cell membrane and then we prepared osmosis practical work with Irish potatoes to verify the process. With slides of Irish potatoes that I prepare very well with students, we put them in different solutions of salt and water and after a certain period of time, one day for example, students come to check the changes and report their observation". Teacher 1.*
>
> *"After explaining the concept of osmoregulation in mammals, I prepare the lab practices on osmosis. I prepare them using onion, water and different solutions of salt or sugar. After setting up my experiment, I asked students to do the same in their respective groups and let the experiment for a while and in one day we come back to see the changes that they report accordingly". Teacher 2.*
>
> *"After explaining the theory of photosynthesis, I improvise the practical work related with beaker, leaves, water funnel and test tubes. I set up the experiment myself and the students observe the process. We let it for a certain period of time and we come back to observe the reaction that the students report". Teacher 3*

Concerning the inquiry based practical it has been revealed that all respondent doesn't know all phases of investigation. Only they

carried it out without knowing the phases and don't respect them. Here are their statements

> *"I don't know the investigation phases that you mean but for example when we want to study the characteristics of insects, I bring the collected insects in the classroom and give them to students who in their respective group discuss their characteristics and give their findings." Teacher 4*

> *"In studying the characteristics of insects, most of the time I asked students to collect insects in the school surrounding and bring them in lab. In their respective groups they discuss and report their findings" Teacher 5.*

> *"I use the investigation in studying arthropods, insect, dichotomous key when classifying plants and most of the time I collect the specimens and let the chance to students to give their observation after their investigation". Teacher 6.*

Biology teachers' skills

Furthermore, the results from the interviews of twenty-four biology teachers reported their practices on building skills, problem solving skills, discovery of learning skills and science inquiry skills. 37.50% of the respondents reported their practices of building skills to be in level 1 in Rogan frame work, 20.8% in level 2, 25% in level 3 and 16.6% in level4. For the problem-solving skills, 12.50% of the respondent reported their practices in level1, 8.3% reported their practices to be in level 2 and 4.10% to be in lev3 and no one reported his or her practices to be in levl4. For the discovery of learning, 37% reported their practices to be rated in level 1, 33.3% to be rated in level 2 20.80% to be rated in level 3 and 8.30% to be rated in level 4. For the science inquiry 41% of the respondents rate their practices to be rated in level 1 and 30% of the respondents rate their practical work to be rated in level 2, 8.30% to be in level 3 and 16.60% to be rated in level 4.

Some interviews questions were concerning the practical works on the program which may be complicated to teachers to perform due to lack of skills. The results of the interview revealed that some practical works on the program are complicated to teachers to conduct due to lack of the required skills. All respondents reported that DNA extraction, DNA replication, using Isotope of Nitrogen to explain the semi conservative model of DNA replication, genetic engineering, chlorophyll extraction, photosynthesis using aquatic plants, Chloroplasts extraction, respiration in insects, diffusion in root cells, culturing of microorganisms are the complicated ones and they have never perform them due to lack of required skills. Here are some of their statements

> *"I have never performed those practical works even when I was a student in University and I don't have skills now to perform them." Teacher 1.*

> *"Those practical works are complicated and here we are not able to perform them we perform simple practical works because they are easy to carry out and also, they are most assessed in National examination and we can't go beyond of what REB evaluate." Teacher 2.*

> *"Even REB doesn't assess such practical works during national examination because they are aware that there are complicated." Teacher 3*

20 biology practical lessons have been observed and video recorded. All observed lessons were food tests which are in inquiry based practical work form (test of starch, test of proteins, test of ascorbic acid, test of

glucose in urine, test of lipids). The results of the lesson observations revealed the variation in skills of practical work among biology teachers rated in four levels as indicated by Rogan frame work featuring as Level1, level2, level3 and level 4. 20% of the observed lessons were only teacher-centered practical activities and rated in level 1. No protocol, all required experiment activities were conducted by the teacher and the students were there to observe, answer to teachers' questions and note the process and finally do a report. Asked about that method of teaching, most of them reported that

> *"I cannot let students do practical because some reagents are very dangerous and students can make disasters. Here we are careful". Teacher 1.*
>
> *"We have few material and reagents and we only do demonstration to show them how it works but it is difficult to allow students to perform their own experiments in that condition". Teacher 2.*

40% were conducted in level 2 where teachers give example of experiment and few selected students do the same in front of their fellows and in most of the case were group representatives. 30% were conducted in level 3, the protocol explained on the black board, teacher give an example in front of all students and then after students in group were allowed to set up their experiments and the group representative was designed to reproduce the same as the teacher did in front of his or her fellow. 10 % were conducted in level 4, characterized by a teacher who prepare a well-designed protocol, containing even questions about the practical work, students were well organized in workable groups, each group was given a protocol and through their discussions students performed practical work, they presented the results and made a report. The teacher didn't do any practical demonstration but he was a facilitator distributing the material and reagents as needed and moderating the ongoing process. Asked some questions on the ways of teaching other types as the observed were in inquiry form, he replied "my students are accustomed to this approach of doing, even in manipulating the microscope for the first time we don't demonstrate, we only explain its function in class and prepare protocol for practice and students conduct the experiment. But is time consuming regarding the work load".

The contribution of biology teachers' knowledge and skills on practical work conducted in class

Results from interviews and practical lessons observed revealed that teachers' knowledge and skills affect positively practical works. Biology teachers are likely to implement practical works that they are able to perform and conduct and so that most of the practical works performed in class are the ones that teachers know very well and have skills to conduct. Here are some statements from the interviewed teachers. "Before we conduct practical work with students, we first try it ourselves. How can you conduct a practical work that you don't know and you don't have skills?" Teacher1. "Most of the time we carry out food test, osmosis, diffusion, flowers and fruits dissection because they are easy to perform as we master them and easy to improvise with local material". Teaccher2

During this study, it has been revealed that a same type of practical work may be conducted in different ways and rated in different levels due to teachers' individual difference in knowledge and skills. Data from lesson observation revealed variation in level of practices in the inquiry based practical work of different food as presented in the above paragraph describing the lesson observations results. That revealed how teachers' knowledge and skills have positive impact on

the practical works conduct in practical classes.

This study has also revealed that the lack knowledge and skills of some practical works of biology teachers' lead to unpracticed of those practical works as it had also been presented in the above paragraph of complicated practical works and that indicate clearly how the lack of knowledge and skills of biology teacher for certain practical works affects or hinds the practices of those practical work during practical classes.

In addition to the lack of biology teachers' knowledge and skills of practical work as factor that affect negatively the practices of practical works in school, this study also revealed the unavailability of practical work materials equipment and reagents as a factor that affect negatively the practical work. During the interviews many teachers of day schools revealed that they don't perform practical work due to unavailability of different lab equipment and reagents. Here are some of their responses:

> *"Here we don't perform practical works because of lacking required apparatus and reagents". Teacher1.*
>
> *"I have never carried out any practical work here in this school because no material and reagents available for the practical work". Teacher 2.*
>
> *"Conducting biology practical activities seem to be impossible here in this school as no material and reagents are available". Teacher 3.*
>
> *"Most of the practical work are even taught theoretically here may be the learners will adapt when they arrive in exam, as we don't have material to perform them"! Teacher 4.*
>
> *"In day schools like ours here, practical works are very difficult to perform as they are no required material and reagents" Teacher 5.*

Furthermore, the lacking of required material for practical work in certain schools had been seen to be addressed by the knowledge and skills of some biology teachers able to use improvisation in this study. Here are some of their statements:

> *"Here in our school we cannot perform the practical work of photosynthesis in that way due to unavailability of the required material. What we do is to improvise with beaker, leaves, water, funnels and test tubes so students may arrive at realizing that the reaction of photosynthesis is happening''. Teacher 1.*
>
> *"Most of the time in this school we arrange ourselves using simple available materials to conduct practical work as the conventional material are not available here. We use for example Irish potatoes, salt and water to improvise osmosis and diffusion and then we can explain the process of transport across the cell membrane" Teacher 2.*

Discussions

The findings of interview and class observations revealed the variation among biology teachers' knowledge and skills of practical work as rated in Rogan Frame work and all four levels were represented. Concerning the knowledge of the characteristics of different types of practical works, three types of practical works featuring as equipment based, concept based and inquiry based practical works were given their characteristics according to individual understanding and variations in levels among biology teachers knowledge had been noticed. Similar variation had been also noticed among biology teachers' skills. The investigated

skills were among others building skills, problem solving skills, discovery of learning skills and science inquiry skills or investigation skills and rated on scale of 1-4 in Rogan frame work. These findings had been supported by lessons observation. They also revealed the variation among teachers' skills of practical work. The variation of knowledge and skills of science teachers is not new as it had also been found in the study conducted by Nsengimana et al., (2021) who concluded that it was linked to teacher's professional background and motivation. It had been also found in South Africa (Rogan & Grayson, 2003) where there was a diversity among science teachers knowledge and skills. The above researchers recommended taking them into consideration while implementing the curriculum (Rogan & Grayson, 2003).

On one hand the variation created satisfactions to the researcher. He is very satisfied by the practices of teachers rated in level 3 and level 4 as these levels are described as the learner centered practices even the sophisticated ones (Rogan & Grayson, 2003; Hattingh et al., 2007). And learner centered classroom practices are acknowledged of developing students higher order of thinking and helping them to adapt to the global market (Nsengimana et al., 2017). On the other hand the question raises on the teachers' practices rated in level 1 and level 2 .Or level 1 and level2 in Rogan frame work don't represent lower levels of lesson but represent good examples of teacher centered lessons or a transmission of knowledge from expert to students (Rogan & Grayson, 2003; Hattingh et al., 2007). The teaching style plays a capital role in the concept understanding of learners (Lebata, 2014). Lesson in level1 and level 2 are known as teacher-centered teaching styles criticized of not developing higher levels of thinking in science students in general and in biology students in particular (Mudau, 2014; Hattingh et al., 2007). Teacher-centered practices are also criticized of leading learners to academic fail. Wood argued that teachers centered classroom practices remain traditional approaches that failed a big number of students who view biology as a collection of disconnected facts that have little relevance to really life(Wood, 2009). Here, they were concerned about how biology teachers in western Rwanda with knowledge and skills of practical works rated in level 1 and 2 can help young Rwandan citizens in science in general and biology in particular to develop their critical thinking skills and their creativity and hence help their country, Rwanda to reach its objective of transforming its citizens into skilled people to booster its economy(MINEDUC, 2015). Of course, they are bringing Rwanda in falling in the same danger trap of learning science in the developing countries as pointed out by Rogan & Grayson, (2003) and asserted by Mudau, (2014) . They indicated that well designed visionary and sounding educational policies can not take place without considering how their implementation is done in class room. But in most of developing including South Africa that view were not considered and costitute a big concern(Rogan & Grayson, 2003; Mudau, 2014).

Interview in this research revealed the lack of knowledge and skills of practical works for the respondents as well as they lack procedural understanding of types of practical work and their names. The situation does not only remain on the types of practical works but continue even in the content on the program. On one hand, it had been found that biology teachers have a list of practical works on the program that they master very well and perform easily. These have been found to be a cross cutting among all respondents. Some biology teachers in interview even confirm that they perform simples and easy practical works on the program regarding what will be assessed during national examination. This indicate that they are certain topics of practical works on the program that are repeatedly

assessed by REB and biology teachers have learned them and teach them like that as they are aware that there is a strong probability to be assessed. This attracted our attention as it seems that biology teachers in western Rwanda, instead of helping their learners acquiring the needed knowledge and develop skills and attitude of doing science through practical works, they are only helping them to sit for biology practical national examination and get their certificates. This view is the same as that of Tibyehabwa et al., (2017) found in Tanzania where science teachers with low and moderate knowledge of practical works were performing practical works which were repeatedly examined in national examination to help their students standing well in national assessments . That attitude of Tanzanians science teachers, which is becoming the same even for Rwandan Biology teachers, had been criticized in the same study by science students who claimed that poor performance in science in national examination compared to other social subjects was a consequence of poor practical science teaching.

On the other hand, the interview results revealed a list of practical works on the program that biology teachers don't know anything about them and don't have skills to perform them. Some of those complicated practical work had been found to be also a cross cutting issues for all respondents of this study and with these results we can confirm that biology teachers in western Rwanda don't master the practical works on the program. Limitation in in knowledge and skills had also been found in inquiry based practical work. Biology teachers in Western Rwanda don't know all phases of inquiry-based practical work. In class they conduct it as they want without respecting its phases and then they don't empower their learner with the skills of investigation that will help them to found out solutions to challenging scientific problems. The researcher is concerned about how biology teachers with limited content knowledge and skills can help their learners doing biology holistically and develop skills and attitude that are needed for them to become critical thinkers and problem solvers when they are not supported by their competent teachers. Or one of the factors that allow teachers to teach effectively is their mastery of the content knowledge (Shulman, 1987). To address all those concerns is to prepare an imperative professional development for pre and in service biology teachers about the practical work in order to empower them and make them becoming competent so that they can teach effectively (Ndihokubwayo, 2017; Mudau, 2014; Nsengimana, 2021). Rogan & Grayson (2003) pointed out that when teachers lack proper background and strong confidence in the subject matter, in service training must be taken as the solution.

During this study, it had been revealed clearly how the knowledge and skills of practical work of biology teachers contribute more on the practical wok conducted in classroom. As it has been discussed in the above paragraphs, Rwandan teachers don't must all the practical works on program content and they reported that practical works that they muster very well and they have skills to perform are the ones which are likely to be formed in class room. They also added that the practical works which are complicated that they don't must are not performed in class room at all. This finding is not new as is in the same line as what Rogan & Grayson (2003) found in South Africa. They pointed out that the teachers' background, their training level and confident as well as their commitment and perception in teaching contribute more in the implementation of a new idea and in our context the practical work. And the lack of content knowledge and skills hinder the practical work conducted in class (Rogan & Grayson, 2003; Ndihokubwayo, 2017);

In addition, the class observation results emphasized the contribution of biology

teachers' knowledge and skills on the practical work conducted in classroom. The report of lessons observed shows a variation in levels according to different lesson observed. Or all lessons observed were in inquiry-based form practical works. But Even though they were in the same type, some had been found to be carried out in levels 1, 2, 3 and 4 due to different knowledge and skills of the teachers. The type and frame of practical work conducted in classroom depends on the decision of science teacher (Hattingh et al., 2007). The knowledge and skills of biology teachers as well as their perception influence more the teachers' decision of the practical work conducted in class room.

During this study, it has been revealed that teachers' knowledge and skills of the practical work are not the only factors that contribute to practical works conducted I classroom. The availability of biology practical works resources had been found to be a big factor. All teachers in twelve years reported that biology practical works are not conducted in their schools due to unavailability of practical work materials and reagents, the same finding as that of Nsengimana, (2021) . This not new as many researchers concluded that the lack of practical work equipment and reagents affects negatively the practical work conducted in class (Rogan & Grayson, 2003; Ndihokubwayo, 2017; Nsengimana, 2021). To address these issues in twelve years scientific schools, the Minister of education together with Rwanda basic Education should provide the biology practical work resources in those schools.

For instance, in this study in certain schools, some teachers reported how the knowledge and skills of biology teachers may overcome the problem of unavailability of practical work resources. And this had revealed the outstanding of knowledge and skills of biology teachers in playing a capital role in affecting the practical work conducted in class as even in poor schools where lab material are very difficult to find teachers who master the practical woks may use available local material instead of conventional ones to conduct the practical work. This finding is in the same views as that Hattingh et al., (2007) in South Africa who concluded that doing practical in class doesn't largely depend on the availability of practical work resources for teachers. When they have skills and they are motivated to do practical work, they find the way to do so in even poor resourced schools.

Conclusion and recommendations

This research found moderate knowledge and skills of practical works as well as their variation among Rwandan biology teachers. The lack of skills to perform some practical works on the program had been noticed. The positive contribution of biology teachers' knowledge and skills on the practical works conducted in practical classes had been also noticed. All these allow us to recommend an imperative and effective pre-service and in-service teachers' professional development with particular aspect of biology practical work as well as the provisions of science resources in general and biology equipment and reagents in particular. We also recommend to REB the alternation of examined practical work topics in order to avoid teachers' predictions of practical work topics to be assessed. That can trigger their own knowledge and skills improvement through research.

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