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# Exploring the Impact of Enquiry-Based Instructional Strategies on Students' Attitudes towards Biology

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**Abstract.** Teaching methods dominated by teacher demonstration, chalk and talk, have been attributed as the main source of negative attitudes towards biology. This study aimed to explore the impact of enquiry-based learning on students' attitudes towards biology. The study comprised 228 students purposely selected from six secondary schools. Focus-roup discussions were used to collect qualitative data with a phenomenological design. Six groups were probed with interview questions, three on the side of the experimental group and three on the side of the group subjected to conventional teaching methods. The data were analysed by using NVIVO software, and later, content analysis was employed descriptively. The study's findings revealed an extensive impact of enquiry-based learning on enhancing students' attitudes towards biology. Moreover, a remarkable commitment was identified on the side of the experimental group, while exploring biological concepts in their groups. Difficulties, such as insufficient laboratory activities, lack of planning for practical laboratory skills, and the inability to grasp the scientific names of micro-organisms were identified. Learners proposed ways of improving teaching and learning biology, such as providing learning resources, extra time to explore the biological content, more laboratory practical work, access to ICT tools, field studies, and the need for active learning methods. More support in active learning was requested on the side of the control group. The students subjected to

enquiry instructions improved their attitude towards biology. Further studies can adopt in-depth interviews, in order to gain more information.

**Keywords:** Enquiry-based instructions; biology course; phenomenological method; students' attitude

## 1. Introduction

Teaching methods play an important role in science to promote learning outcomes, where the attitude of learners helps students to manifest behaviours and interests in a particular subject (Adejimi et al., 2022). Nevertheless, teaching methods dominated by a teacher with teacher's demonstration and chalk and talk have been attributed to the main source of problems that affect students' learning outcomes, including negative attitudes towards science, including biology (Bizimana et al., 2022).

To date, active learning methods are being recommended for teaching and learning biology. Active learning methods are considered to be instructional approaches that allow learners to play a part in their learning, while using resources for knowledge construction (Lombardi et al., 2021; Harris et al., 2020). It helps to attain the most learning outcomes; and it facilitates students' interactions. In this regard, science education and trends that advocate the integration of innovative teaching techniques, such as co-operative learning methods, concept mapping, and enquiry-based learning that engages learners in the learning process and are learner-centered (Dotimineli & Mawardi, 2021). The benefits of implementing active teaching strategies were reported in a number of studies. In this vein, optimal performance, high motivation, and interest in learning biology were pointed out, among others (Chidubem & Adewunmi, 2020; Rabgay, 2018; Erbas & Demirer, 2019; Dorfner et al., 2018). Consequently, the attitude towards learning biology was improved.

Enquiry-based learning methods were identified as one of the instructional strategies that reflect the active learning method (Khalaf & Zin, 2018). In this regard, occasions are furnished for students to explore their concepts and resources bestowed. With enquiry-based instruction, questions are posed to the students, and time is given to find solutions with their peers by using the available resources. Given this opportunity to grasp concepts themselves, their thinking skills are upgraded (Kang & Keinonen, 2018). Collaboration between students is more motivated, which produces more skills and knowledge of a particular concept. Thus, their attitude towards learning science subjects is improved (Manishimwe et al., 2022).

In relation to biology, the teaching and learning of biology have been characterised by poor teaching methods dominated by the teacher (Chidubem & Adewunmi, 2020; Kareem, 2018). Moreover, it has been marked by a lack of resources, insufficient laboratory activities, biological terminologies, and insufficient time cited, among others (Byukusenge et al., 2022; Island et al., 2022; Chidubem & Adewunmi, 2020). Therefore, instructional strategies that provide an engaging learning environment were scarce, and consequently the attitude of students towards biology was not satisfactory. With this background, the present

study was conceived, in order to explore the effect of active learning methods, such as enquiry-based learning, in order to improve students' attitudes towards biology.

Biology is an enormous subject with different subjects, from secondary level to university. Amidst biology lessons, microbiology is a fundamental subject that gives basic knowledge about micro-organisms,the diseases they cause, and the ways of prevention (Mukagihana et al., 2021). On top of that, it brings forth some useful aspects of micro-organisms with respect to economic importance. A number of studies have been done on microbiology teaching and learning (Cheng et al., 2022; Mukagihana et al., 2021; Cox & Simpson, 2018). Most of them were conducted at the university level. However, there was a deficit in the literature about microbiology at the secondary school level. This study investigates the effect of enquiry-based learning on improving students' attitudes towards biology, particularly in microbiological subjects.

Studies reported the influence of conventional teaching methods on students' learning of biology. It was observed that poor teaching methods make biology courses abstract; and they do not promote students' commitment to playing any role in the learning process (Akinbadewa & Sofowora, 2020; Harris et al., 2020). Students became less involved in the lesson, relying on teachers' information; and they consider biology boring (Chidubem & Adewunmi, 2020). Consequently, their interest in learning biology decreases, and they develop a negative attitude towards biology. There is a need to evaluate how active learning methods, such as enquiry methods, raise students' commitment to exploring biological concepts and improve students' attitudes towards biology.

In the light of the effect of enquiry-based learning on students' attitudes towards science, specifically in biology, studies with mixed research methods were rare. This research will contribute to the existing literature by evaluating the effect of enquiry-based learning on students' attitudes towards biology, with a focus-group discussion to enrich the research with deep qualitative data ,which provide detailed and accurate information. Specifically, students' attitudes towards biology at a higher level were less highlighted in Rwanda. The findings of this study may be useful in disclosing the difficulties that students encountered in learning biology and suggesting ways of improving. The study answered the following research questions:

1) What are the effects of enquiry-based instructional strategies on students' attitudes towards biology?
2) How was the commitment of students to exploring biological concepts?
3) What are the difficulties in learning biological concepts?
4) What are the factors that could improve the teaching and learning of biology?

**The Theoretical Framework**

Basically, the teaching method is established in the constructivism theory of learning. In the constructivist learning environment; students are engaged in the lesson; and they play a considerable role in knowledge construction (Anagün, 2018; Fuchsova & Korenova, 2019). Teachers' support is subsidiary to learners' effortts during the lesson (Rogayan, 2019). In the learning process, students use

their previous knowledge and their past experience, in order to understand any new notions (Musengimana et al., 2022). Social constructivism underpins the study concerning students' learning in the social domain, as well as integrating knowledge at the individual level (Xu & Shi, 2018).

## 2. The Methodology

### 2.1.The Research design

A qualitative phenomenological method was employed to collect the qualitative data with focus groups. This method was chosen because it provides people's understanding and experience (Dahlin et al., 2012). A qualitative research approach was employed in the study, due to the quality of the data that it displays (Moretti et al., 2011).In this perspective, focus-group discussion was chosen because it creates an opportunity for sharing experiences; and it suits phenomenological research design.

### 2.2.The Sampling design

The population of this study comprises 1216 students studying biology at the upper secondary-school level in senior four. The schools concerned in the study are in Kigali City (Kicukiro district) and the southern province (Kamonyi and Muhanga districts) of Rwanda. The selection was based on the availability of teaching resources to compare schools with the same standards, so that the effect of the intervention could be traced. Having mathematics, chemistry, and biology (MCB) as subject combinations at the senior four secondary levels was also another considered criterion for selection. Moreover, the schools to be selected should have both male and female students. Thus, the sample size for this study conaisted of six schools.

Since the average classroom size in one class in the selected districts in the Rwandan context is 38, for six schools, 228 students participated in the study (Ministry of Education, 2018). One of two schools in each district served as the control group, while another from two schools in each district served as the experimental group. Students to participate in the focus-group discussions were chosen deliberately, based on students who were able to respond to the questions, and on gender balance. Using four to eight people in a focus-group interview is recommended. Thus, six students per class participated in this research. After one round of interviews,the data were saturated; and we could not take any other groups.

### 2.3 The Research Instrument

The instrument was made up of six open-ended questions (See Box 2.1) reflecting students' attitudes towards learning biology, from broad to specific questions. The questionnaire was reviewed by experts in science education at the University of Rwanda College of Education (URCE), in order to ensure the trustworthiness of the instruments. Interviews scheduled were subjected to consultations with other researchers, in order to contribute in making themes to ensure credibility. Dependability was considered to maintain the consistency of the instrument, the transferability for the generalisability of the findings was employed, and conformability was thereby ensured. Questions were put to the entire group, giving equal opportunities to all the participants to share their experiences freely.

The first author played the role of moderator, guiding the conversation and preventing divergence from the main objective of the conversation, and avoiding influencing the participants' responses, in order to ensure the confirmability of the data collected. The research assistant took notes of the major points during the discussions and examined the consistency of the process.

**Box 1. Key Questions Used in Interviewing Students via Focus-Group Discussions**

**FOCUS-GROUP DISCUSSIONS**

1. What did you learn in the lesson we had last time?
2. What specifically did you like in the lesson we had last time?
3. How did the teaching methodology used in the lesson help you to learn new things?
4. How committed were you while exploring biological concepts in groups?
5. In what ways do you think biology would help you to understand other science subjects?
6. (a) Did you find any difficulties in learning some of the concepts in the lesson we had?
   (b) Can you tell me anything you think could help to improve the teaching and learning of biology?

### 2.4. Data-collection procedures

Before the data collection, an ethical clearance certificate was given by the research and innovation unit of the University of Rwanda - College of Education. The purpose and procedures of the research were explained to the participants, and they willingly agreed to participate in the study; and they signed a consent form. The research was conducted from April to June of the 2021 school year; and the intervention took four weeks. The purpose of the intervention was to compare the achievements and attitudes of the students subjected to enquiry-based instructions and the achievement and attitude of students taught by the conventional teaching methods group. Since the achievement tests indicated poor performance on the side of control, achievement correlates with attitude. The idea was to determine the impact of enquiry-based instructional strategies to improve the attitude towards biology.

For three days the workshop was conducted with the teachers of the experimental group on the enquiry-based learning method early in April of the 2021 school year, before embarking on microbiology teaching. On the other hand, teachers explained the purpose of the research and delivered their biology lessons as usual. Permission to record the discussions was requested prior to starting the discussions. Six students per class were selected to participate in the focus-group discussion after the teaching intervention, and gender balance was considered. A treatment of enquiry-based learning, designed by the 5Es instructional model, was given to the experimental group, and a conventional teaching method was on the side of the control group. The microbiology lesson was taught to all the groups.

On the side of the experimental group, the students were taught with enquiry-based learning methods. The learning takes place in a social context by interacting with their peers in their respective groups in the company of teaching and learning materials. Gender balance was maintained, as male and female students

participated equally in the learning process. Assessments occurred at the end of the lesson. Consequently, students' attitudes are polished, due to their active participation and social interactions while acquiring knowledge. Inversely, the control group underwent their accustomed teaching methods dominated by teachers' knowledge derived and summative assessment prevailed. After intervention and achievement tests, the students from all the groups were subjected to focus-group discussions on examining their attitudes towards biology. These focus-group discussions were administered in the last two weeks of June. Since it was impossible to conduct interviews with all the students of the entire class, six students were selected from each class: three males and three females.

### 2.5. Analysis and Data Presentation

The interviews were recorded and transcribed in Microsoft Word. The data were transferred to NVIVO software for analysis. Deductive data analysis (Orodho et al., 2016) was employed from specific observation of the students' views to general conclusions. The major themes were predetermined. These were remembering what was learnt, what students liked in the lesson, the characteristics of the method used, group-work activities, the relationship between biology and other subjects, difficulties faced during learning, and ways of improving. Transcripts were first imported into NVIVO files, followed by the set-up of a coding table, based on the emerged themes and categories. The software coded the transcripts and analysed them. Finally, content analysis was made with major themes and their frequencies. Figure 1 shows the data entry and outlook of NVIVO.

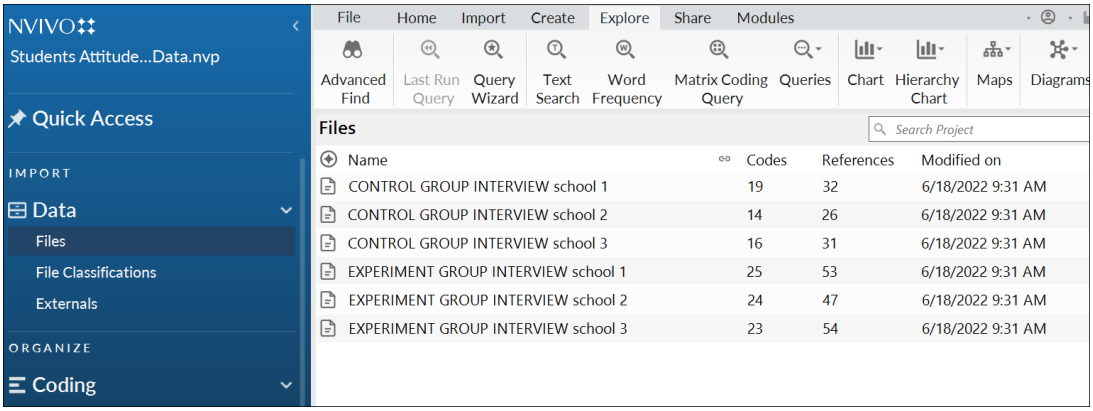


**Figure 1. Our data in NVIVO**

While Figure 1 shows our files entered in NVIVO software, Figure 2 shows an example of the relationship of the codes extracted from the files in both the control and the experimental groups of the students.

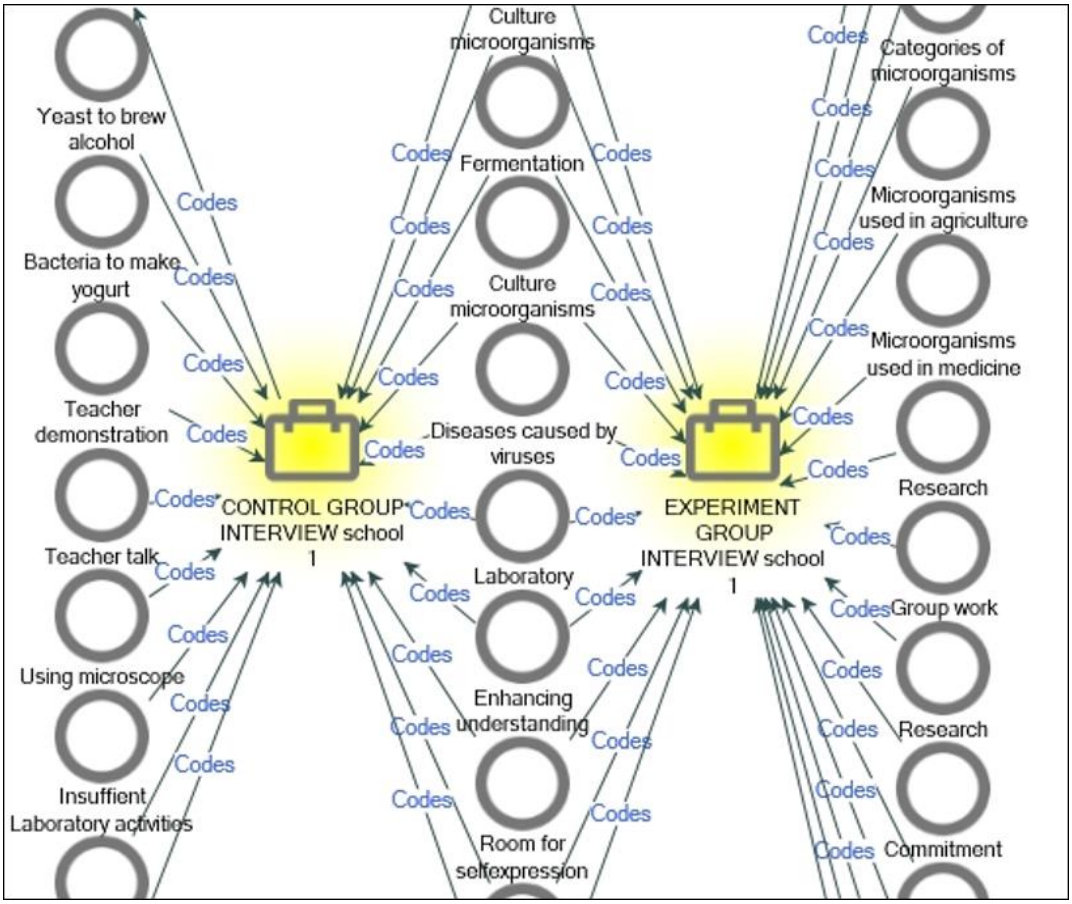


**Figure 2. Comparison group between control and experimental groups at school-1**

Under each theme, we selected all the codes; and via the "visualised" option, we selected chart coding by the attributed value. Under the chart-item box, we selected the relevant codes, as well as our teaching-intervention groups under the x-axis attribute. We obtained an unclear chart that did not clearly show the visibility of the percentage coverage of each of the control and experimental groups. We opened "summary" and exported the results into MS Excel 2016. From there, we appropriately designed the relevant figures.

**Table 1. Themes, extracted codes, and their references within source files**

| Themes | Codes | Files | References |
|---|---|---|---|
| Remembering what was learned | Categories of micro-organisms | 3 | 4 |
| | Characteristics of micro-organisms | 4 | 8 |
| | Culturing micro-organisms | 3 | 11 |
| | Fermentation | 3 | 6 |
| | Genetic engineering | 1 | 1 |
| | The negative effect of bacteria | 3 | 6 |
| What students liked in the lesson | Bacteria to make yogurt | 1 | 1 |
| | Culturing micro-organisms | 6 | 10 |
| | Diseases caused by viruses | 6 | 18 |
| | Group discussion | 1 | 1 |

| | | | |
|---|---|---|---|
| | Micro-organisms used in agriculture | 1 | 1 |
| | Micro-organisms used in medicine | 1 | 1 |
| | Using microscope | 1 | 2 |
| | Yeast to brew alcohol | 3 | 4 |
| | Yeast to produce pieces of bread | 1 | 1 |
| Characteristics of the method used | Group work | 3 | 16 |
| | Laboratory | 5 | 7 |
| | Research | 3 | 6 |
| | Teacher demonstration | 2 | 3 |
| | Teacher talk | 2 | 3 |
| | Watching videos | 2 | 3 |
| Group-work activities | Commitment | 3 | 14 |
| | Enhancing understanding | 6 | 13 |
| | Mutual work | 3 | 3 |
| | Research | 3 | 5 |
| | Room for self-expression | 3 | 7 |
| | Self-preparedness | 2 | 6 |
| | Self-study | 3 | 3 |
| Relationship between biology and other subjects | Keep environment | 1 | 1 |
| | No linkage | 1 | 2 |
| | Others | 4 | 10 |
| | Understanding the Chemistry | 5 | 14 |
| Difficulties faced during learning | Drawing | 1 | 1 |
| | Insufficient Laboratory activities | 4 | 5 |
| | Scientific names | 5 | 9 |
| | Time scarcity | 2 | 3 |
| | Using a microscope | 1 | 1 |
| Ways of improvement | Active learning methods | 1 | 1 |
| | Need for field trips | 1 | 2 |
| | Need of resources | 5 | 13 |
| | Need for enough time | 2 | 3 |
| | Practical work | 3 | 7 |
| | Teacher support | 1 | 1 |

## 3. The Results

- ❖ Remembering what was learnt

When students were asked what they remembered after learning microbiology, the average percentage coverage for students in the experimental group was higher (68%) than in the control group (32%). Students that learned with the traditional method still remember the characteristics of micro-organisms and the

negative effects of bacteria, while those taught with enquiry-based techniques still remembered the categories of micro-organisms, culturing micro-organisms, fermentation, and genetic engineering (Figure 3).

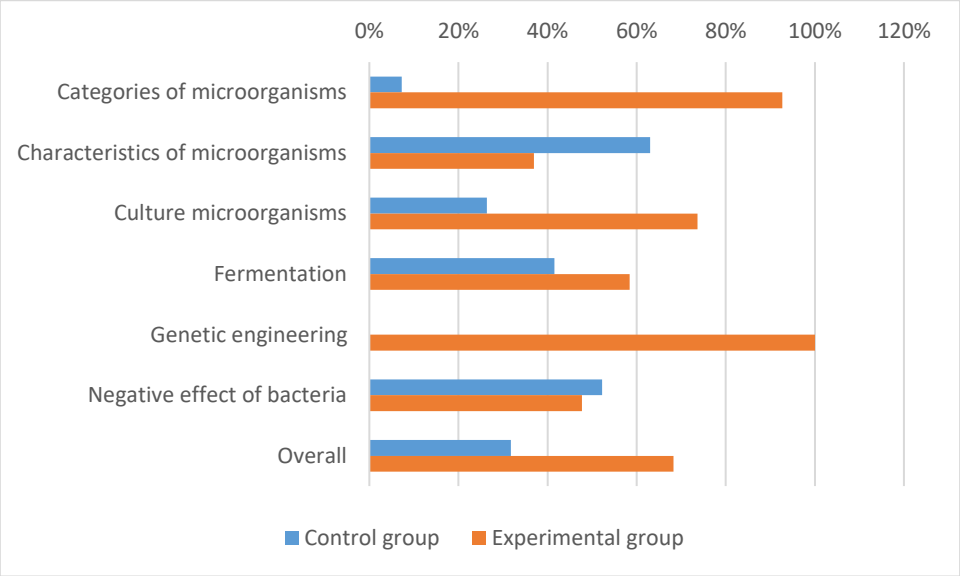


**Figure 3. Average of percentage coverage by "Remembering of what was learned"**

The learning was better in the experimental group than in the control group. For instance, students taught with the traditional method testified that they learned how micro-organisms are developed in agar-agar medium, which contains all the nutrients responsible for the growth of bacteria. They have also seen how yeast is grown and fermentation is made. One student said, *"I also learned about viruses and how they can live in living organisms, I have learned the characteristics that make them living things. For example, they reproduce inside the host cells, and they cause diseases and characteristics that make them to be non-living thing;s since they do not reproduce outside the host cell, do not respond to stimuli, and do not feed."*

Students that learned with enquiry-based learning (EBL) said that they have seen how bacteria can cause diseases, how bacteria can cause food spoilage, and how gram-staining techniques can differentiate bacteria. One student ascertained, *"In microbiology study, we have seen how we can culture micro-organisms in medical research. For example, culturing bacteria staphylococcus for searching the role of penicillin as an antibiotic."* Another student was able to explain how micro-organisms can be cultured. She said, *"This means that they can grow by using different methods. For example, suppose you want to grow the bacteria Tuberculosis. In that case, you can take a sample from the sinus of the patient affected by it and culture it in a Petri dish on a medium containing the necessary nutrients."*

Students taught with EBL were certain to describe what they had learnt One student said, *"We have learnt about bacteria in microbiology; there are Archaebacteria and Eubacteria; the first one has special characteristics, which are different from those of other bacteria; for example, they live in an extreme environment like living in a hot area (the bacteria), and the second ones are normal bacteria that can be categorised by gram-staining."* Another student said, *"We learnt that some diseases are caused by micro-organisms. For example, Entamoeba Histolytica causes Amoebiasis as its symptoms, and*

*preventive measures are required."* Students were aware that micro-organisms could not be seen with our eyes and that they are harmful and important to other living things. One student said, *"The chemicals which harm them limit their usefulness to people. We have seen the application of microbiology in bread-making, and genetic engineering; and we have seen different categories of micro-organisms, such as algae, viruses, protozoa, and so forth."*

- ❖ What students liked in the lesson

Four of the nine codes revealed under the "what students liked in the lesson" theme were depicted from experimental group-focus discussions. Two codes were found in the control group alone (how bacteria are used to produce yoghurt and how yeasts are used to produce bread). Both the control and the experimental groups (cultured micro-organisms, diseases caused by viruses, and how yeast is used to brew alcohol) shared three codes. These students liked the use of group discussion, and the way in which micro-organisms are used in agriculture and in medicine; and they enjoyed using the microscope. As shown in Figure 4, the overall liking of the lesson was in favour of those learnt with the EBL technique (experimental group students), with 58% alongside 42%.

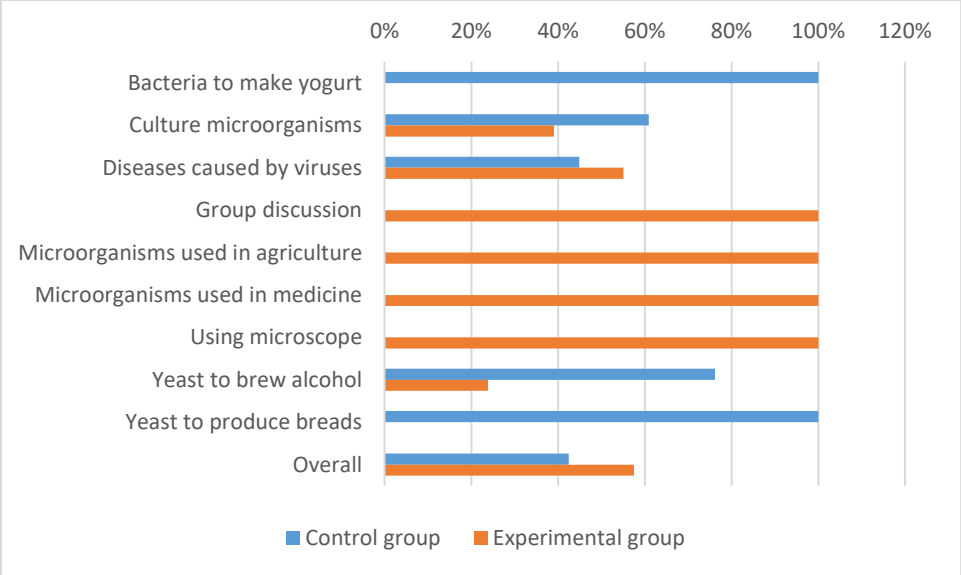


**Figure 4. Average percentage coverage by "What students liked in the lesson."**

Students are taught by traditional methods, like how yeast changes glucose into alcohol, how they culture micro-organisms, and the lesson about diseases caused by viruses. One student testified that he didn't know that microbes could grow and how they cause diseases. The following are extracts from the students:

> *"What I liked is the importance of bacteria and how they are used in making yoghurt, for I like it. I knew that they decompose glucose into lactic acid."*
>
> *"As we were studying micro-organisms, after seeing how Alexander Fleming cultured micro-organisms and found penicillin from Penicillium Notatum; it made me curious because I had a dream to be like him, and I*

*want to invent something which is not known; that is what I liked in that lesson that made me interested in biology."*

Students were surprised to see micro-organisms on the door they touched. So, they came to know that micro-organisms are everywhere. The lesson has inspired students to know and emphasise Coronavirus; as they testified that this pandemic is mainly found in microbiology; they have known the composition and shape of the Coronavirus, and how it causes Covid -19, and how to prevent this infection.

Likewise, the students taught by EBL liked how micro-organisms are applied in our daily life. For example, how they are involved in making useful products like human insulin used to protect against diabetes. They also liked to see bacteria and other micro-organisms that help in agriculture; since they decompose organic matter in the soil to produce fertilisers, so that the soil can sustain growth. They liked the sterilisation techniques used before culturing micro-organisms, such as washing hands, cleaning working areas, and cleaning Petri dishes. Students testified that they learned the lesson about protozoa and how they could cause diseases; for example, they can cause malaria, which is dangerous to humans. The following are extracts from the students:

*"I liked how we can prevent diseases. I liked the topic of protozoa[ because it teaches me about different diseases and how we can prevent them, and how those diseases are spread. For example, we learned how Entamoeba Histolytica and plasmodium cause diseases, and the knowledge I got from this lesson helped me to -protect myself."*

*"We did the culture of micro-organisms as in industries and other laboratories. For me, I liked culturing micro-organisms, and we saw how they reach the stage to grow and reach the stage where they can reproduce and infect other organisms."*

❖ Characteristics of the methosds used

Group work and watching videos were two teaching methods that the students in the experimental group described that were used in their class. Likewise, teacher demonstration and talk were mentioned by the students in the control group. Research and laboratory were used in both groups, but they were extensively used in the experimental group. The overall findings showed that the teaching methods used were more characterised by students that learned with EBL (56%) than those who learned by the traditional method (44%). Figure 5 visualises these results.

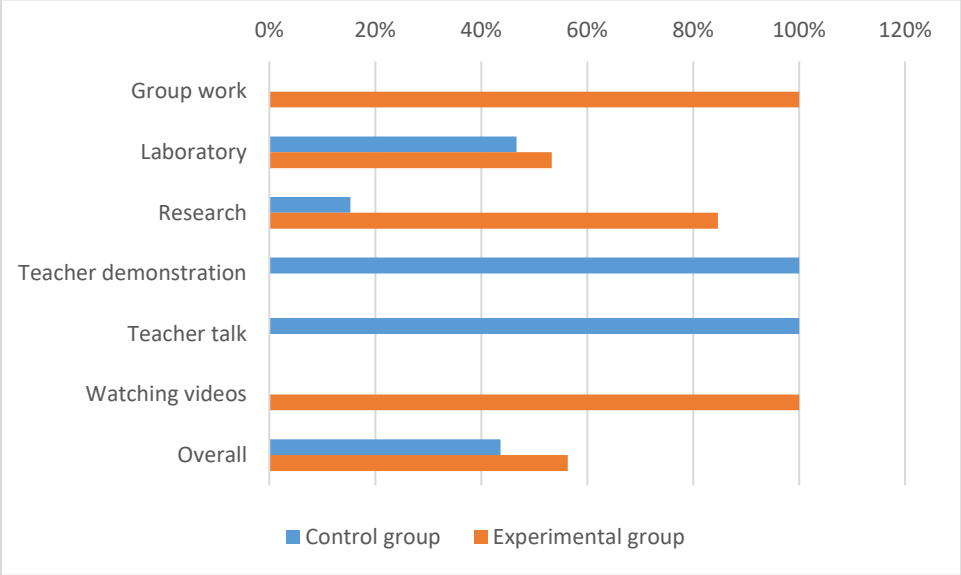


**Figure 5. Average percentage coverage by the "Characteristics of the method used"**

Ideas from students taught by traditional methods clearly show the use of teachers' demonstration and talk. For instance, they testified that they didn't know how to grow bacteria, but the teacher showed them how to grow them by using agar-agar. Their teacher told them how to prevent Escherichia Coli from being transmitted through faeces.

Expression of the use of the laboratory was mentioned. One student said: "*For me, a new thing I have learnt is laboratory equipment called an incubator; I didn't know you can put microbes in it and grow them. It is like in a refrigerator. We tested micro-organisms in the laboratory by using a microscope; because they were too small; and without a microscope, we could not see them.*"

Students taught in the EBL method testified that group work encouraged them to do research and present their findings. This presentation then improved their communication skills. They said that when they were in groups, they acquired many skills because when they join in the group, they share some skills about the topic they are learning. Students appreciated the way they have acquired a leadership style. One student who was representative of his group concurred that he had to do everything to make a good presentation in front of the teacher. The following are extracts from students:

> "*The method used in this unit is different from the other methods we are used to; as just the teacher went on the blackboard giving summaries; and the rest of the work is supposed to be done by the students. But this lesson on microbiology was different; everybody was to put together everything we had got. This unit involves much effort between the teacher and the students. The teacher brings his ownis ideas, and the students bring their own ideas, and they compare these; and perfect ideas were consequently formed.*"
>
> "*When you are not in groups, sometimes you get scared, 'saying may I ask this question'; but when you are in a group with your group members,*

*you are free to talk to them; you won't fear, we would ask a question; he or she would answer, or ask the teacher; so, ithis builds confidence in us."*

Many students appreciated the research. They said they learned how to use the internet in a study because they accessed the internet, in order to study the lifecycles of some bacteria. They realised that the internet is not for entertainment only; but it can also be used in class. One student concurred: *"I didn't know some life ycles of some organisms; they helped me to get more about them, and I went to a computer lab and we did something practical, like the lifecycle of Amoebiasis and how it's going through it.' This was quite awesome; but it was enjoyable."*

- ❖ Group-work activities

Related to activities used in group-work, students in the experimental group said that group work increased their commitment to engage in different activities; they developed mutual work; as it allowed them to work together, where each one could contribute to the task given; it allowed them to do research before presenting their findings, they became self-prepared. They were then able to learn by themselves (self-study). The overall group work activity (see Figure 6) was found to be on the side of students that had learnt with EBL (81%).

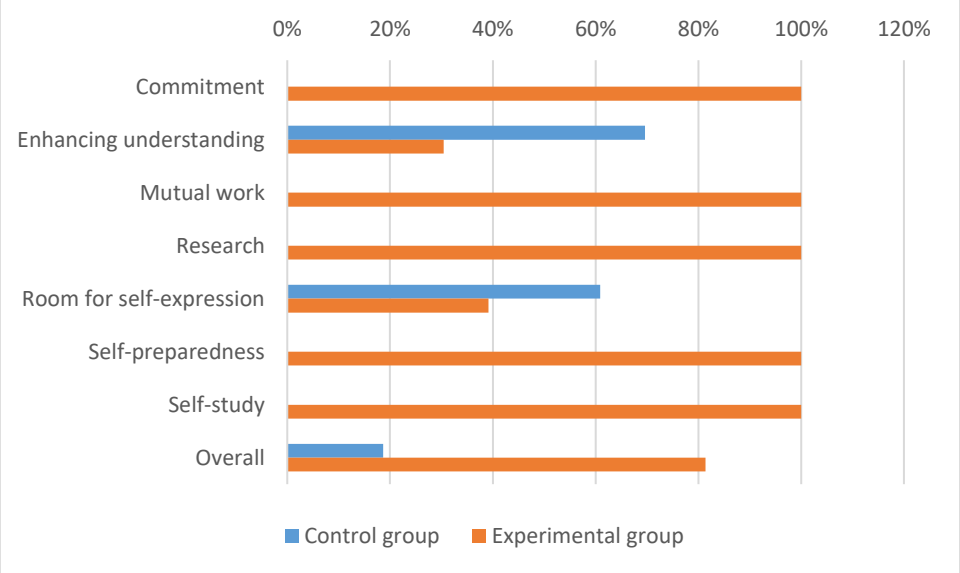


**Figure 6. Average of percentage coverage by "Group work activities."**

Although group-work was not extensively used in the control group; the little that it was used, students taught by the traditional method applied to it. For instance, one student said that her role in the group was to give an idea as a group member, knowing that this would help all the members. Another student agreed that when they are grouped together with others, it is better than when one is studying alone, for we can then understand more. The following is an extract from one of the students:

*"In our group, we used groups at the beginning of the topic; then the teacher gives us a topic, and we discussed it in our group, and everyone in the group participates and gives his idea rs her idea about it a it, and how he/she thinks; and thereafter the teacher comes and supplements this as a group, in order to reach a common understanding in the whole class."*

Conversely, students taught by EBL extensively explored the concepts of microbiology in groups. Students testified that they were very committed; because they had to find information in the library, in ICT, and any available information source to present in front of the class. One student said: *"In my group, the commitment was very good; someone could go into the library to search for information and come and share the it in the group. Others go to the ICT room; others read books we have in our classroom and come to share the information they hadgot."*

Students were ready because although the group consisted of six or seven students, the teacher would call someone to present; this helped everyone to go in deep and think about what they were discussing. One student testified that *"Sincerely speaking, this lesson was interesting. Whenever we study a new topic, I will always have that feeling to read what we are about to study, in order to motivate me to know much better."*

In each group, everyone had a responsibility to know all things related to the topic they were studying, so that he or she might represent the group on the stage if he/she were selected. Students were helping each other. The following is an extract from one of the students:

> *"According to me, during learning microbiology in my group, the purpose was to benefit from each other if one had an opinion on a certain term; and another one did not know it. Then, I should explain it to him or her, so that we could share ideas, in order to benefit from each other; in that way everyone had a task; for example if the teacher gives us a topic, we would share thee task,s so that each member could participate in our presentation, saying this one will present on this, or like that; so everyone should participate in front of the whole class."*

- The relationship between biology and other subjects

This theme revealed four codes. Some students in control said there is no link between biology and other subjects, while those in the experimental group said it is related to keeping our environment. Both students in the group attributed chemistry and other subjects (such as physics during learning microscope) with strong links to biology as a subject. Thus, the EBL method contributed to the attitude of the experimental group (59%) to thinking of the connection between biology and other subjects (see Figure 7).

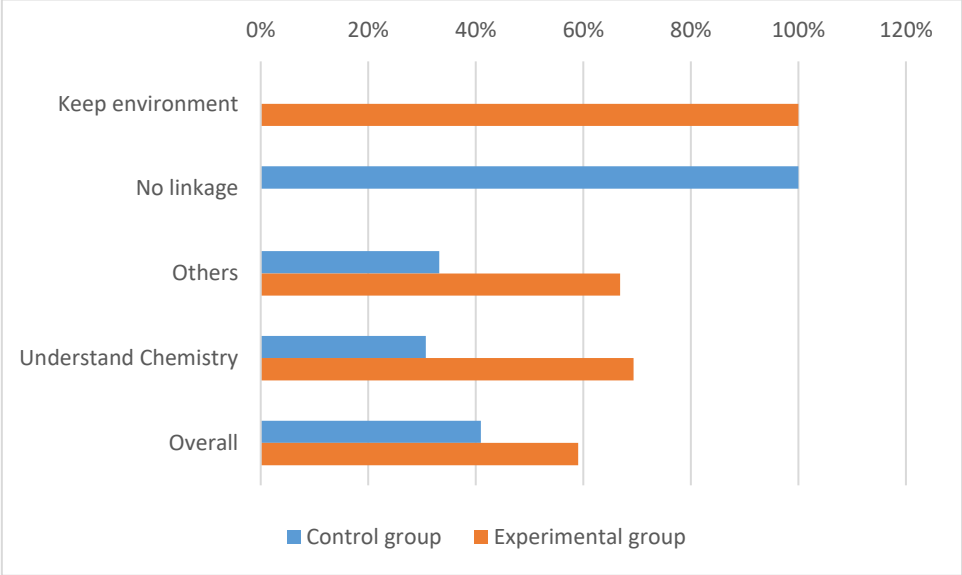


**Figure 7. Average of percentage coverage by "the relationship between biology and other subjects"**

Students taugtht by using traditional methods that conceive biology as a subject that can help in learning chemistry. They gave an example that learning organic chemistry, like things that make glucose, polysaccharides, and other things like that, help one to understand organic chemistry better. Students agreed that biology could help to understand chemical reactions, which is why it can help to understand other science subjects. Other students didn't realise the link between biology and other science subjects. One student said he couldn't see how biology could be useful to other science subjects; because it is teaching him something very different from chemistry, mathematics, and other subjects that he studies.

Students taught by EBL realised the things they study in biology, and found them in chemistry; for instance, in food testing, and also laboratory rules they study in biology help them in a chemistry laboratory. Biological knowledge helps them to understand chemistry; for example, it helps them to understand glucose molecules. They agreed that biology gives us some knowledge to understand organic chemistry. The students were open-minded and linked biology to other real-life t subjects. The following are extracts from some of the students:

> *"As you know, biology is too much; and it requires us to sit and read; this gives us skills in taking time to study, and this it reduces laziness and gives us the courage to study other subjects hard and work on time. With biology, you can make good quality products in entrepreneurship. The laboratory skills we have got in biology help us in other subjects' practices. The knowledge and skills in biology can help us in entrepreneurship, like bread-making."*
>
> *"Biology gives us life skills that help us to adapt to our environment and help us to know how we can keep our things well."*
>
> *"For biology in most cases, we use a microscope; and in physics, we learn more about microscopes and their parts; but in biology, they teach us their parts, their uses; if we in the laboratory use a microscope, we see how*

*it is used when we go back in physics we learn how to use it, so laboratory practices in biology help us to understand other science subjects."*

❖ Difficulties faced during learning

Five difficulties faced during learning were revealed. Students in the control group struggled to use the microscope, while those in the experimental group believed that drawing challenged them, and time was scarce to fully learn the prepared content. However, insufficient laboratory activities and scientific Latin names challenged their control and that of experimental students (see Figure 8).

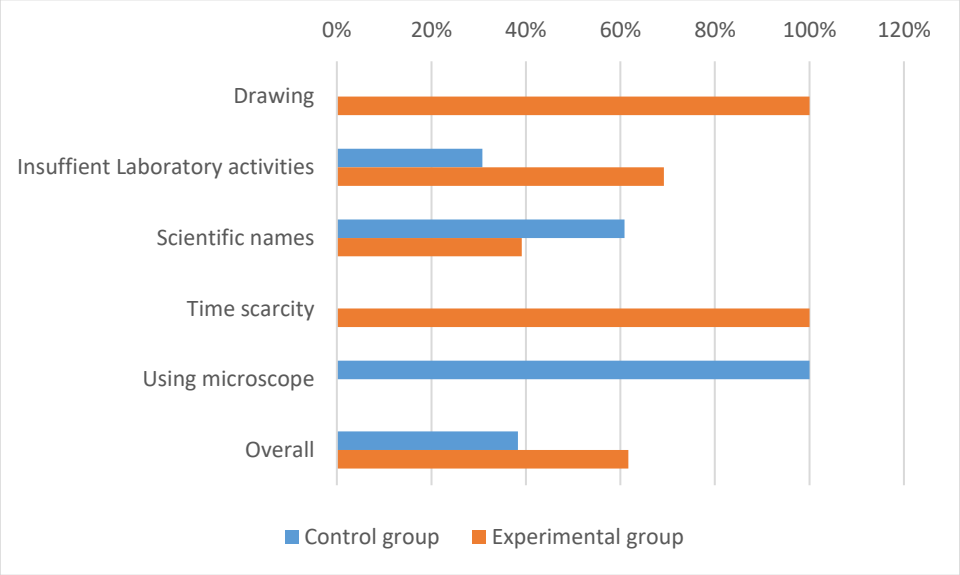


**Figure 8. Average of percentage coverage by "Difficulties faced during learning"**

Difficulties in microbiology were mostly portrayed by students who learned by traditional methods. Students said that while studying that chapter, they used to encounter some difficulties; in our syllabus, it was not well explained where and how they can culture micro-organisms. They found no procedures for practice. Other students testified that it was difficult to differentiate bacteria from other micro-organisms. Students claimed that when studying microbiology, they didn't have enough skills on how to use a microscope; it was difficult for them because this lesson required more practice, in order to understand it properly. Thus, the difficulties they faced were not equipped with the materials that could help them in practice in the laboratory.

Both those students taught by traditional or EBL experienced difficulties with the scientific names of some organisms. They concurred that those names which are from Latin are very difficult to memorise and spell. Apart from scientific names, those students taught by EBL faced difficulty in making drawings of the life cycle of micro-organisms.

❖ Ways of improving

The students suggested various ways of improving. Students in both the control and experimental groups agreed that there is a need for resources (such as a

laboratory, the internet, books, etc.) and enough practical work. On the side of students that learned by the traditional method, the active learning method, the need for field trips, and much more teacher support, were suggested. Likewise, the need for enough time to cover learning content was especially suggested by those students that learned with EBL. Figure 9. visualises how students in the control group need more support (67%); as they suggested more ways of teaching and improving.

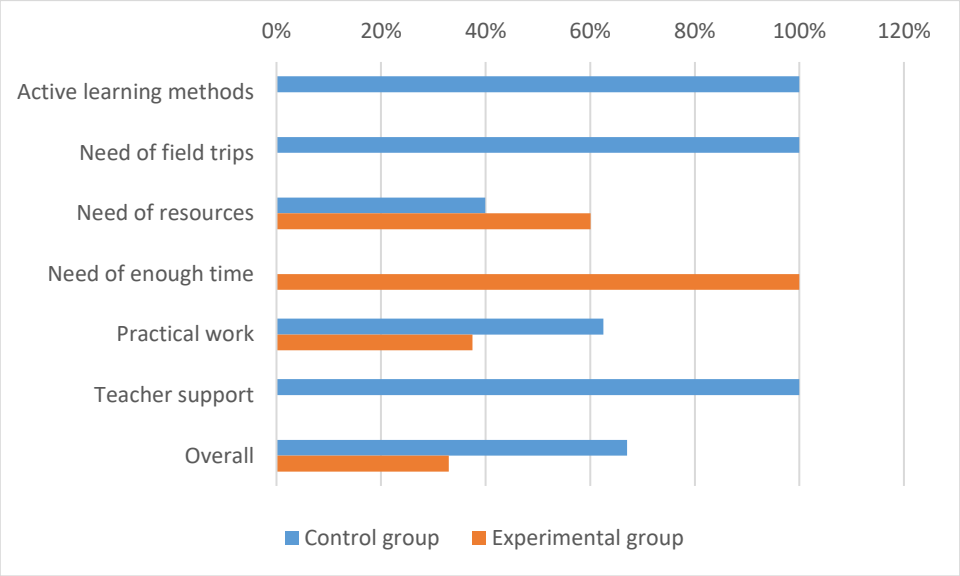


**Figure 9. Average of percentage coverage by "Ways of improving."**

Students taught by traditional methods suggested increasing the number of textbooks, engagement in field trips, frequent visits to the laboratory, provision of the internet, and enough teacher support. The following are some extracts from various students:

> *"We need the provision of books so that every student would be able to use his book on his own. We also need field trips, where we can visit a laboratory that does what we study, in order to get an image of how it should best be done. I wish we could have a place like industrie,.s where we can apply the knowledge we learnt in biology.""Provision of the internet could also help; because we need practice in biology; and we don't have enough laboratory instruments. We need the internet, so that we can see videos of those practices."*

Students wished that teachers could use more active learning techniques, such as group work, debates, and practical work." The following are exracts from some of the students.

> *"Things that I think could help to improve biology are that the teacher could go along the group and discuss the given task; because when students are discussing, all of them are participating and collecting different ideas. This would help us get more clarification and to understand the topic better."*

> *"What I can add is that if there were more debates on biology, it would encourage other students who want to study biology if they see that there is a debate on biology; for example, how human activities affect the*

> *environment. The audience who are seeing would be motivated to study biology.""Practical work helps us to understand better; because we know how they sometimes see we study; but you don't know what it looks like if it is seen in books only. For instance, learning things in theory and someone who has seen them them; they are different because he can never forget their features, but the one who reads can cram for some time and after a period forget, and it will cause you to go back and revise; they can them increase the practices."*

Students taught by EIBL thought that improvement could be achieved by allowing them to have more research than to merely be given knowledge. They would then have more time to cover the content, and be more practical, in order to cope with the scientific names and practical activities, apart from what was done by culturing micro-organisms. The following are some of the extracts from the students:

> *"Time was limited so; we were rushing. The majority did not cover one hundred per cent of all the units, so time was not on our side. I also have seen that before and aftrewards, we need further time for research. Research is necessary; we only have a library, books are not enough for research; and the ICT is always occupied even when the connection is slow. I have seen that there is not enojgh time for research."*

> *"More practical work should be prepared, like those we had in culturing micro-organisms; and laboratory equipment should be provided. For me, the difficulty I faced there was a lot of scientific words, and by the way, when we went to the science lab while we wanted to find ou about Rhizopus, it was somehow difficult to use a microscope; because it was my first time viewing those moulds on the slide, which rendered it difficult."*

## 4. Discussion

This study has pointed out the effect of enquiry-based learning on improving students' attitudes towards biology. Students subjected to enquiry-based instruction were compared with their counterparts taught with conventional teaching methods characterised by teachers' demonstration and talk. It is apparent that students of the experimental group taught with enquiry exceeded the control group under conventional methods in almost all of the probes of focus group discussion. Exceptionally, the control group showed excessive difficulties in learning biology, and more need for improvement. This concurs with Tsybulsky et al (2018); Kang & Keinonen (2018), stating that students subjected to active learning methods, such as enquiry-based learning instructions become more involved in the learning process. Correspondingly, their interest in learning biology as a subject increased drastically; hence, their attitude towards biology courses improved (Rabgay, 2018; Akinbadewa & Sofowora, 2020).

In contrast, Gormally et al. 2009 found that students who received traditional teaching methods were more confident in learning science compared to students under enquiry-based learning.

In fact, students subjected to enquiry-based learning were more committed to exploring biological concepts in their group-work activities. Mutual work was promoted, and self-preparedness and self-study were thereby encouraged. This

was confirmed by their scores of 81% in group activities. "On the other hand, group-work was not extensively used, but once in a while only was this method used; and the score was 19%. The low scores of the control group, which signify a negative attitude, can be attributed to the conventional teaching method dominated by a teacher that did not encourage the attitude of students towards biology (Byukusenge et al., 2022; Island et al., 2022; Chidubem & Adewunmi, 2020).

In addition, the students proposed ways of improving teaching and learning biology. It was noticed that the control group presented more difficulties in learning biology; and they suggested more ways of improvement in learning than students in the experimental group. They proposed the need for active learning, field trips, and teachers' support. This indicates that they need more support compared to their counterparts. All the groups proposed the need for learning resources, such as more practical work, access to the internet, and provision of enough books. The experimental group proposed additional time to cover the learning content, the need for research, and more practical, in orders to cope with the scientific names. Generally, students taught with enquiry-based instructional strategies manifested a higher positive attitude towards biology than those taught with conventional methods, as witnessed by their score on each probe and oral extract.

The control group recalled what they had learned. In remembering, the treatment group was good at thinking back on what they had learnt, with deep understanding at 68%, whereas their counterparts in the conventional method scored only 32%. They were able to extend their knowledge into another situation. This can be explained by the learning benefit offered by enquiry-learning instruction, helping students to transfer their knowledge or skills acquired into real-life situations (David & Venuste, 2021; Khalaf & Zin, 2018; Tsybulsky et al., 2018).

Regarding what students liked in the lesson, all the groups liked the practical work of culturing micro-organisms, diseases caused by viruses, and how yeasts are used to manufacture beer. There were no big differences between the two groups; the treatment scored 58%, and the control group scored 42%. This aligns with the findings of Mukagihana et al. (2021); regardless of the type of teaching method, students improved their attitude toward biology after learning.

In view of the method used, while studying microbiology lessons, both groups were used for research and laboratory, but it was extensively accentuated on the side of the experimental group. Additionally, the treatment group used group work, and watched the video during the lesson. This enhanced their attitude towards biology (Manishimwe et al., 2022). Enquiry-based instruction was considered to help students grasp scientific phenomena; consequently, they comprehended the concepts better and applied them in real life (Byukusenge et al., 2022). Contrary to the control group, the teacher's demonstration and teacher talk prevailed in the lesson. This does not promote a positive attitude towards biology, as witnessed by the overall scores of 44% in the control group and 56% in the experimental group (Bizimana et al., 2022).

Particularly, this study revealed that enquiry-based learning helped students to find the relationship between biology and other science subjects. It was observed that students in the experimental group were open-minded and could find more links in the middle of biology and other science subject. Furthermore, additional difficulties in learning were identified in the side-control group; while mentioning that concepts was not explained; since, there was a lack of procedure for practical work, and insufficient skills to use a microscope. The experimental group found difficulties in drawing the life- cycles of micro-organisms; and there were time-constraints to cover the concepts. All the groups experienced insufficient laboratory activities and struggled with scientific names.

## 5. Conclusion and Recommendations

According to the findings of this study, it is evident that enquiry-based learning improved students' attitudes towards biology. In all those dimensions, students subjected to enquiry-based instructions overtook those taught by conventional teaching methods, with a positive attitude towards biology. The results reported a great extent of commitment to exploring biological concepts at 81% scores on the side of the experimental group. On the other hand, a poor commitment was noticed of 19% on the side of the control group. Conversely, more difficulties were faced during learning, and more proposals for improvement were identified on the side of the control group. This indicates that they needed more support in teaching methods and resources when compared to the experimental group,

The findings revealed that enquiry-based instructional strategies offer a learning environment that helps the learner to actively play a role in the learning process and to develop an interest in the subject; and their attitude then improved. The recommendation is made to educational stakeholders and educators to apply enquiry-based learning in teaching and learning biology, and also to extend it to other subjects, in order to enhance students' attitudes towards biology. This would also affect their achievement and interest in pursuing biology careers in the future. This study was limited to focus-group discussions; however, an individual interview is suggested for more exploration in the next study.

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