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EFFECT OF INQUIRY-BASED LEARNING ON STUDENTS' ATTITUDE TOWARDS LEARNING BIOLOGY AT UPPER SECONDARY SCHOOLS IN RWANDA

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Abstract. *Attitude has been regarded as a motivating feeling for the learning of biology. However, how inquiry-based learning contributes to attitude change towards the learning of biology has not yet been studied in Rwanda. This study intends to determine the effect of inquiry-based learning on students' attitudes toward learning biology. A sample of 228 secondary school students at the upper secondary level in Rwanda was used. A quasi-experimental design with pre- and post-test was employed. One group was randomly assigned to the control group (N = 109) under the conventional teaching method, while the second group participated as the experimental group (N = 119) under the inquiry-based learning method. Biology attitude questionnaire (BAQ) was tested and a Pearson reliability of .89 coefficient was found, and hence the BAQ was adopted and used for the control and treatment groups before and after learning microbiology. Results asserted a significant effect of intervention in favor of the experimental group. However, a significant effect of the treatment on students' attitude change in relation to gender was not identified. The study recommends using inquiry-based learning to promote attitude toward learning biology as it raises students' interest to learning biology and alleviates the difficulty of its concepts.*

Keywords: *biology education, inquiry-based learning, students' attitudes, quasi-experimental design*

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Introduction

Attitude of students towards a subject is one of the factors affecting their interest and achievement. In this regard, a conducive learning environment with resources and activities that elicit learners' attention is an added condition to attract their interest in the lesson (Kortam et al., 2018). Moreover, teaching methods strongly affect students' attitude in learning science subjects (Taştan et al., 2018). Science education has become an agent for socio-economic development in many countries, contributing to better scientific knowledge and literacy (Aktamiş & Hİğde, 2016). For instance, in Sub-Saharan African (SSA) countries improvement in science teaching has led to changing knowledge-based curriculum to competence-based curriculum, equipping learners with required skills, attitudes and values that will contribute to sustainable future (Nsengimana et al., 2020). A close association between students' attitudes and achievement in science was found to be linked with the teaching approach (Kisoglu , 2018; Narmadha & Chamundeswari, 2013). In this regard, it was observed that teacher-centered methods did not encourage a positive attitude towards science (Narmadha & Chamundeswari , 2013). Hacieminoglu (2016) argued that there is a positive correlation between meaningful learning and achievement in science, which influences the attitude towards biology learning.

The decline in students' attitude toward science has led to reforms in science education, with the main purpose of bringing active teaching strategies which increase students' interest in science subjects (Adejimi et al., 2022).With respect to active learning, instructions such as inquiry-based learning were pointed out as one of the teaching methods that create an environment where students interact with each other (Aulia et al., 2018). It also paves the way for students to interact with their teachers and actively plays a big role in knowledge construction (Kang & Keinonen, 2018). In this regard, learners are given opportunities to explore the new situation using

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resources and hands-on activities to build a new biology concept. This raises students' attention and interest, and their attitude improves greatly (Conradty & Bogner, 2019). Therefore, efforts should be initiated to guide delivery of science and mathematics lessons away from the cramming to a more learner-centered approach (Nsengimana et al., 2017).

Factors such as grade level, gender, parents, teachers, and school environment were identified as major factors affecting students' attitudes toward learning science (Bizimana et al., 2022;Vlckova et al., 2019;Hu et al., 2018). For example, a study has shown that girls prefer learning biology compared with boys (Almasri et al., 2021), even though Oba and Lawrence (2014) found that gender does not have any effect on students' attitudes in learning physics. However, slight difference was noticed in favor of females. In addition, the lab environment has shown increasing motivation to learn biology at the Universities in Rwanda (Mukagihana et al., 2021a).

Further, cooperative learning, student-centered method, and resource-based teaching methods were found to improve feelings toward biology subjects (Rabgay, 2018; Njoku & Nwagbo, 2020 ; Mukagihana et al., 2021b). Therefore, factors such as gender would be of interest for researchers to well cater for both males and females inclusively. These are the reasons why educators need to lend an ear to students' attitudes and other factors that affect students' learning outcomes (Rogayan, 2019). This is because students manifest either negative or positive attitudes towards biology depending on how they have been taught and how they perform in assessments (Adejimi et al., 2022; Bizimana et al., 2022). In addition, biology tends to be difficult from the lower to upper secondary school level (Kisoglu, 2018; Vlckova et al., 2019). It was suggested that biology lessons be conducted in an environment that fosters students' interest and access to living organisms to boost their attitude towards biology (Kisoglu, 2018; Manishimwe et al., 2021).

In pursuance of inquiry-based learning influence on students' attitudes, studies revealed that when students are subjected to inquiry-based instruction, they are more engaged in the lesson (Nkurikiyimana et al., 2022; Sandika & Fitrihidajati, 2018). Interactions between students are more encouraged, and more collaborations while exploring concepts in their respective groups. Students become motivated to conduct activities given to them, searching for information and evidence to find solutions using different resources (Kang & Keinonen, 2018). In this regard, experiments are performed to satisfy students' curiosity about scientific phenomena (Wu et al., 2021) . These raise students' interest in learning and improve students' relationships. As a result, students' attitude toward science improves (Aktamiş & Hİğde, 2016). Sandika and Fitrihidajati (2018) supported the idea that inquiry-based learning method provides a scientific learning environment that stirs up students to develop scientific thinking skills and increase scientific attitude. Additionally, creative scientific thinking skills were boosted in learning biology. In this situation, students' attitude toward learning biology was improved upon the inquiry medium of teaching method (Tsybulsky et al., 2018).

Under inquiry-based learning, the 5Es educational model was pointed out as a learning cycle that improves students' attitudes toward biology. The inquiry model consists of a sequence of five interdependent phases (Nyirahagenimana et al., 2022). These are Engage, Explore, Explain, Elaborate, and Evaluate. Learners contribute to knowledge construction at each stage of the learning cycle. The model was developed while designing an inquiry instruction for biology lessons (Patrick, 2013). The 5Es educational model provides a learning environment where students are exposed to activities that foster discovering concepts or phenomena using their prerequisite knowledge (Nkurikiyimana et al., 2022).

Assessing students' attitudes before and after teaching helps determine the influence of teaching methods on students' attitudes towards learning a given subject. The learning model lies in social constructivism theory, by which students collaborate to build knowledge themselves. The learning theory was discovered by Vygotsky (Schreiber & Valle, 2013), fostering students to actively participate in their studies while facilitated by teachers. This theory corroborates our study, where students learned together and compared their attitude scores after and before learning biology.

Extensive studies have indicated the decline of interest towards science subjects, particularly biology (Adejimi et al., 2022;Shin et al., 2019). Moreover, low performance in biology was observed in literatures to be associated with negative attitude towards biology (Bizimana et al., 2022b; Hacieminoglu , 2016). There abound evidences of studies giving an impartation on how students consider biology difficult due to negative attitude towards the subject (Bizimana et al., 2022a). In all these cases, teachers' style of delivering lessons with poor pedagogy, which is teacher – centered strategy, was attributed to this trend. From the above reasons, this study sought to quench this trend by evaluating the effect of inquiry – based learning on students' attitude towards learning biology.

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Studies conducted on different learning subjects have realized the effect of inquiry-based learning on students' attitudes toward science (Aktamiş et al., 2016 ; Sen & Oskay, 2016; Yakar & Baykara, 2014). However, few pieces of research made an emphasis on biology. Attitude has been regarded as a motivating feeling for the learning of biology. Additionally, ways in which the inquiry-based learning contributes to attitude change towards the learning of biology has not yet been studied in Rwanda. This research contributes to the existing literature by adding empirical evidence on the effect of inquiry-based learning on students' interest in biology, easiness to biology, and how they find biology as important and career-lead subject. Its aim was to determine the effects of inquiry-based learning on students' attitudes towards learning biology at the upper secondary level among selected Rwandan secondary schools. It uses a quantitative approach for data collection. Students' attitudes before intervention and after were evaluated, where the control and experimental groups were compared to determine the effect of inquiry-based learning on performance and, hence, attitude change. For the reasons mentioned above, the following research questions were answered:

1) What are the effects of inquiry-based learning on students' attitudes toward learning biology?
2) Is there any significant difference between the control and experimental groups before and after learning biology using traditional and inquiry-based teaching methods?
3) What are the effects of inquiry-based learning on students' attitudes based on gender?
(4) Is there any difference between the mean scores of students on the four dimensions of the biology attitude questionnaire?

Research Methodology

Research Design

A quasi-experimental design was employed by which quantitative data were collected and analyzed to provide an insight into the problem (Fraenkel et al., 2012). This design was employed with pre-test and post-test nonequivalent design. Two independent variables with experimental and control groups were used. Pre-and post-test scores were dependent variables, while gender-based influence was considered as an independent variable. However, other variables were extracted from the attitude questionnaire that the attention was paid to during data analysis. Groups were randomly assigned to the experimental and control group. A pre-test was administered to all groups before the intervention, while the post-test came after the intervention, where the experimental group was subjected to inquiry-based learning, while the control group was taught with a conventional teaching method.

Sample and Sampling Techniques

The population of this study comprises all senior four (grade ten) students studying biology in one district in Kigali city and two districts outside of Kigali. The selection of districts was based on urban, sub-urban, and rural districts. Purposive sampling techniques were employed to select schools in the three districts based on majoring in mathematics, chemistry and biology (MCB) at upper secondary level and having both girls and boys students. Moreover, schools which were well equipped in terms of teaching resources were considered. Referring to the mentioned criteria, two schools from each district were chosen, making a total of six schools considered as a sample size. Therefore, two hundred twenty-eight students, with 107 females and 121 males. In each district, one school was randomly assigned to either control or experimental group.

Research Instruments

Data collection was conducted using a Biology Attitude Questionnaire (BAQ) adapted from Prokop et al. (2007); Russell and Hollander (1975). The questionnaire was initially composed of 28 items to evaluate students' attitudes towards biology. The items were distributed in four dimensions (factors): interest, difficulty, importance, and career in biology. Furthermore, the items were attributed to the Likert scale ranging from strongly agree to strongly disagree. The questionnaire was reviewed by three experts in biology education from the College of Education, University of Rwanda and four researchers from the African Centre of Excellence for Innovative Teaching and Learning Mathematics and Science (ACEITLMS) to check the instrument's validity.

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Experts from the University of Rwanda, College of Education were requested to determine the content validity of the attitude questionnaire by (a) evaluating which statements clearly indicate positive or negative attitudes towards biology; and (b) classifying items to one of the four thematic unities, namely the importance of biology, the difficulty, the interest, and future career in biology. Their reports were compared to the original classification developed by Prokop et al. (2007); Russell and Hollander (1975). The feedback classified 17 statements as positive, while 11 statements were classified as negative attitude statements. Further, thirteen statements were classified as revealing interest in learning biology; five statements were classified as revealing the level of difficulty of learning biology, seven as revealing importance of learning biology, while three statements were classified as statements that reveal the career path related to the quality of teaching.

The statement "I hate learning biology" was removed because it was similar to "I do not like learning biology. "In addition, the statement "Biology is a school course that I enjoy most" was removed because it was similar to "I like Biology more than other science subjects" and "I am happier in a biology class than in any other class." Furthermore, the statement "Biology is very difficult for me" was removed because it was similar to "Biology is one of the easiest subjects for me." Thus, the variable "difficulty" was then changed to "easiness." Finally, ten statements were reformulated from those which may show negative attitudes to those raveling positive attitudes (Table 1).

Table 1
Reformulated Statements Based on the Feedback from Experts in Biology Education

	Negatively formulated statements	Positively reformulated statements
1	I do not like learning biology	I like learning biology
2	I am unable to think clearly and logically when learning Biology	I am able to think clearly and logically when learning Biology
3	It makes me annoyed to hear about Biology	It makes me pleased to hear about Biology
4	I do not feel well in Biology class	I feel well in Biology class
5	I often face difficulties in understanding Biology concepts	I often feel easy to understand Biology concepts
6	I feel being lost whenever I am learning Biology	I feel being regained whenever I am learning Biology
7	Learning Biology is not important in everyday life	Learning Biology is important in everyday life
8	I see Biology as something I will not use very often when I get out of school	I see Biology as something I will use very often when I get out of school
9	Biology knowledge is not important for my future career	Biology knowledge is important for my future career
10	During Biology lessons, I am bored	During Biology lessons, I am entertained

The questionnaire remained with 25 statements that were considered final and used for data collection and analysis. Eleven statements were related to interest, four were related to easiness, seven were related to importance, and three were related to career (See Appendix A). Each statement was rated at 5-point Likert scale, where strongly agree was assigned a 5-score, agree was assigned 4-score, neutral was assigned 3-score, disagree was assigned 2-score, and strongly disagree was assigned 1-score. A pilot study was conducted at two schools outside of the sample size. The instrument's reliability was calculated, and a Cronbach alpha of .89 was obtained, confirming the consistency of the questionnaire.

Data Collection Procedures

Ethical clearance was obtained from the University of Rwanda College of Education (URCE) before collecting data. Further explanations about the purpose of the study were given to participants. Once a participant accepted to participate in the study, both teachers and students signed a consent form. Before teaching, a pre-test consisting of BAQ was administered to all students in both groups to measure their attitude towards biology. After the intervention, all groups were administered a post-test to evaluate the effect of an intervention on students' attitudes toward biology. The whole process of data collection took three months, and teaching intervention took four weeks (April-May 2021). A couple of three days of training on inquiry-based learning through the 5Es

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learning cycle was conducted with the experimental group teachers. Lesson plans were prepared on microbiology unit-18 of the S4 syllabus of biology in Rwanda (REB, 2015) in collaboration with teachers. During the lesson delivery, teacher and students' activities were identified at all stages of the 5Es learning cycle (Table 2).

Table 2
Activities Done by the Experimental Group

5E's levels	Related activities
Engage phase	The teacher probed an introductory question that elicited learners' prior knowledge and engaged them in the lesson. Moreover, the engage phase makes students excited and provides them the opportunity to discover what they are going to study.
Explore phase	Teachers provide activities to students and allow them to collaborate using different resources in their respective groups so as to find solutions.
Explain phase	Learners were given a chance to express their responses, and teachers added on what they had not touched and relieved misconceptions.
Elaborate phase	Supplementary activities were provided for knowledge extension and transfer.
Evaluate phase	Lastly, there comes evaluate phase in which the teacher assesses learners' outcomes via oral questions and learners peer-assed each other for their progress.

The conventional teaching method, which is mainly teacher's presentation of concepts, was employed by teachers of the control group. Teachers of the control group were informed about the purpose of the research and given instructions. For instance, topics such as characteristics of different microorganisms, diseases caused by microorganisms, the economic importance of some microorganisms, and their culturing techniques were taught by chalk and board where the teacher lectured and students followed, and sometimes they were assigned to work in groups and allowed to present. Learners experience their usual teaching method and study the same biological content as the experimental group.

Data Analysis

The individual scores or class means were compared to find out if students' measured attitudes towards biology have become more positive, remained the same, or became less positive (Russell & Hollander, 1975). The scales were constructed to detect and evaluate changes in attitude toward biology but not to measure absolute attitude toward biology. Thus, the scales were designed to be used at the beginning and the end of a course. The MS Excel 16 and SPSSVs 23 software -were used for data analysis. MS Excel was used to compute the number of students who answered under five scales (from strongly agree to strongly disagree) for each statement. In this analysis, the related percentage was computed from the number of students. The five scales were narrowed down to visualize data by merging strongly agree and agree and strongly disagree and disagree together.

The SPSS was used for descriptive and inferential statistics to answer all research questions. We first computed the average for each student across all 25 statements. Averages were also narrowed down to each of four attitude factors. Since data were collected in both pre-and post-tests, we secondly used repeated-measures ANOVA. These were done twice. Firstly, the pre-test and post-test among teaching intervention (control and experimental groups) and gender (female and male students) were used. Secondly, using average scores for attitude factors among teaching intervention and gender for both pre-and post-test. The third analysis was extended to reveal differences between the control and experimental groups as statistical significance is concerned in the post-test attitude questionnaire across four attitude factors: interest, easiness, importance, and career.

Research Results

Table 3 encompasses descriptive statistics for experimental and control groups before learning and after learning. Note that among each group, male and female students were compared. Before intervention on both sides of all groups, female and male students scored almost the same mean (3.7, $N = 5$). After the intervention, there was an attitude change in all groups regardless of the type of teaching methods students went through.

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On the side of the control group, attitude change for female students increased from 3.7 ±.21to 4.1± .40 mean score and standard deviation, while for male students, the attitude changed from 3.7 ± .24 to 4.2 ± .41mean score and standard deviation. Males scored slightly higher compared to female students.

On the other hand, the attitude changed from 3.7± .19 to 4.5± .20 mean score and standard deviation for female students and 3.7± .29 to 4.4 ± .22 mean score and standard deviation for male students. There was a mean difference of 0.2 between male students from the control and experimental group in favor of the experimental group. A mean difference of 0.4 was identified between females of both groups in favor of the experimental group.

Table 3
Descriptive Statistics among Control and Experimental Groups at Both Pre-and Post-Test

	Intervention	Gender	*M*	*SD*	*N*
Pre-test_all	Control group	Female	3.72	.21	49
		Male	3.70	.24	60
		Total	3.71	.23	109
	Experimental group	Female	3.77	.19	59
		Male	3.70	.29	60
		Total	3.73	.25	119
	Total	Female	3.75	.20	108
		Male	3.70	.26	120
		Total	3.72	.24	228
Post-test_all	Control group	Female	4.14	.40	49
		Male	4.22	.41	60
		Total	4.18	.40	109
	Experimental group	Female	4.53	.20	59
		Male	4.47	.22	60
		Total	4.50	.21	119
	Total	Female	4.35	.36	108
		Male	4.35	.35	120
		Total	4.35	.35	228

Table 4 portrays the influence of the intervention on students' attitude change concerning gender through repeated measures analysis of variance (ANOVA). Students in both groups statistically significantly performed well after learning ($F = 637.27$, $df = 1$, $p < .001$) with an effect size of .74. Likewise, the experimental group outperformed the control group. Thus, students taught about inquiry-based learning statistically raised their attitude significantly ($F = 37.13$, $df = 1$, $p < .001$). However, neither inquiry-based learning nor conventional teaching method brought a significant difference in attitude change between male and female students ($F = 1.197$, $df = 1$, $p > .05$).

Table 4
Inferential Statistics for Teaching Intervention and Gender

Effect	Pillai's Trace Value	*F*	Hypothesis *df*	Error *df*	*p*	Partial Eta Squared of Effect Size
Tests	.74	637.27b	1.00	224.00	<.001	.74
Tests * Intervention	.14	37.13b	1.00	224.00	<.001	.14
Tests * Gender	.006	1.38b	1.00	224.00	.24	.006
Tests * Intervention * Gender	.005	1.19b	1.00	224.00	.27	.005

a. Design: Intercept + Intervention + Gender + Intervention * Gender
Within Subjects Design: Tests
b. Exact statistic

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Table 5 shows that students' attitude changes factor to factor before and after learning. By comparing attitude change based on interest factors, both experimental and control groups were at the same level at 3.7 out of 5 mean scores. After learning, there was an increase in positive attitude at the mean of 4.2 on the side of the control group and a mean of 4.5 on the side of the experimental group. This shows that inquiry-based learning has boosted students' interest in biology more than the conventional teaching method. Looking at the easiness factor, both groups were almost at the same level at 3.2 and 3.3 for the control and experimental groups. After learning, the group who received treatment (inquiry-based learning) greatly increased their mean score from 3.3 to 4.5, while in the group who received conventional teaching techniques, their mean score increased from 3.2 to 3.5. It is worth saying that inquiry-based learning makes biology easier than the conventional teaching method.

Table 5
Factors into Attitude Scale – Descriptive Statistics

Factors	Intervention	*M*	*SD*	*N*
Interest_Pre-test	Control group	3.77	0.30	109
	Experimental group	3.78	0.31	119
Easiness_Pre-test	Control group	3.25	0.60	109
	Experimental group	3.31	0.64	119
Importance_Pre-test	Control group	3.84	0.32	109
	Experimental group	3.84	0.45	119
Career_Pre-test	Control group	3.81	0.59	109
	Experimental group	3.89	0.70	119
Interest_Post-test	Control group	4.24	0.50	109
	Experimental group	4.50	0.26	119
Easiness_Post-test	Control group	3.59	0.71	109
	Experimental group	4.37	0.32	119
Importance_Post-test	Control group	4.30	0.46	109
	Experimental group	4.50	0.27	119
Career_Post-test	Control group	4.49	0.63	109
	Experimental group	4.67	0.36	119

Comparing attitude change an important factor; before learning, both groups were at the same level a 3.8 mean score. After the intervention, the mean score increased from 3.8 to 4.3 on the side of the control group. Similarly, the mean score increased from 3.8 to 4.5 on the side of the experimental group. This shows that the experimental group finds, after treatment, biology more important than the control group subjected to usual teaching methods. Lastly, on career factor, all groups were at the same level with an attitude mean score of 3.8. After learning, the attitude mean score changed from 3.8 to 4.4 on the side of the control group and from 3.8 to 4.6 on the side of the experimental group. A slight mean difference of 0.2 was identified, meaning that the group who received treatment scored higher than the group taught with the conventional method.

Reference to Table 5, the pre-test showed that both treatment and control have a positive attitude at almost the same level of interest, importance, and career factors. Exception to easiness factor, both groups manifest a low score in the test, which indicates that biology seems to be difficult for students. On the other hand, students' attitudes toward biology in the experimental group improved moderately in all dimensions of the attitude questionnaire compared to students in the control group after the intervention. Mean score on interest factor gives an insight into how an intervention has boosted students' interest in biology on the side of the experimental group. For example, mean sore increased from 3.78 to 4.50 while it increased from 3.77 to 4.24 for their counterparts. Looking at the easiness factor, the experimental group finds biology easy compared to the control group after being subjected to inquiry-based learning. For instance, in the experimental group mean scores increased

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from 3.31 in pre-test to 4.37in post-test while students in the control group taught using the teacher-centered method had a slight mean gain from 3.25 in pre-test to 3.59in post-test. Moreover, experimental students find biology a more important and career-led subject than students in the control group.

Table 6 shows the influence of intervention as statistical significance is concerned. The table shows a statistical significance difference from intervention to attitude factor at $p < .001$ (.001) level of significance. One can see that the attitude factor depends on the intervention given. There was a statistically significant difference between students who learned with inquiry-based learning and the poor teaching method in favor of those who learned with the inquiry method. However, from factor to gender, there is no statistically significant difference with $p > .05$ (0.61). This gives an insight into how attitude change according to factors has not shown a difference between male and female students. Similarly, no significant difference was identified from intervention to factor concerning gender at $p > .05$ (0.51).

Table 6
Factors into Attitude Scale – Inferential Statistics

Effect	Pillai's Trace Value	*F*	Hypothesis *df*	Error *df*	*p*	Partial Eta Squared of Effect Size
Factor	.80	130.21b	7.00	218.00	<.001	.80
Factor * Intervention	.33	15.63b	7.00	218.00	<.001	.33
Factor * Gender	.02	.76b	7.00	218.00	.61	.02
Factor * Intervention * Gender	.02	.89b	7.00	218.00	.51	.02

a. Design: Intercept + Intervention + Gender + Intervention * Gender
Within Subjects Design: Factor
b. Exact statistic

A one-way analysis of variance (ANOVA) was computed for all attitude factors to show the effect of intervention at post-test, as represented in Table 7. In all factors, a statistically significant difference was identified in which the *p*-value is smaller than the .05 significance level at one degree of freedom ($df = 1$). It means that the intervention has brought a difference in attitude change between experimental and control groups in favor of the experimental group in each attitude factor. Thus, inquiry-based learning increased students' interest ($F = 23.90$, $df = 1$, $p < .001$), easiness of biology concept ($F = 23.90$, $df = 1$, $p < .001$), importance to learn biology ($F = 15.59$, $df = 1(226)$, $p < .001$), and career path connected to daily life ($F = 7.28$, $df = 1(226)$, $p < .001$).

Table 7
One-Way ANOVA for Attitude Factors at Post-Test

Factors	Analysis	*SS*	*df*	*MS*	*F*	*p*
Interest_Post-test	Between Groups	3.72	1	3.72	23.90	<.001
	Within Groups	35.18	226	.15		
Easness_Post-test	Between Groups	34.80	1	34.80	23.90	<.001
	Within Groups	67.06	226	.29		
Importance_Post-test	Between Groups	2.21	1	2.21	15.59	<.001
	Within Groups	32.09	226	.14		
Career_Post-test	Between Groups	1.89	1	1.89	7.28	.007
	Within Groups	58.78	226	.26		

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Discussion

The present study aimed to explore the effects of inquiry-based learning on students' attitudes toward biology among upper secondary schools in Rwanda. Findings portrayed that the students taught with inquiry – based learning had a remarkable increase in attitude change compared to their counterparts in conventional teaching methods characterized mainly by teachers' presentation of concepts. This was evident with statistical significance of mean scores after learning in favor of experimental group. This can be attributed to the teaching styles implemented in inquiry-based method, which provide an opportunity to learners to explore biology concepts in groups with interesting hands-on activities. With this learning environment, students became more engaged in learning, interact with each other, and share ideas. In doing so, their attitude improves. This corroborates with Kisoglu (2018) who asserted that biology lessons should be taught in a manner fostering students' interest so as to improve their attitude toward the subject.

Before learning, results have indicated that students in both groups presented a positive attitude towards learning biology almost at an equal level. Conversely to the easiness dimension, students had a less mean score. This can be explained by the fact that both groups answered the statement before the intervention and hence were at the same level. Upon intervention, either inquiry-based learning or conventional teaching method influence an increase in attitude change. This was confirmed by Rogayan (2019); Mukagihana et al. (2021a), asserting that after learning, students improve their attitude towards biology regardless of the teaching techniques they went through. Nevertheless, statistical results with a one-way variance analysis showed a significant difference in attitude change between the two groups in favor of the experimental group taught with inquiry-based learning at a .05 significance level. This difference between groups can be explained by poor teaching techniques (Nzeyimana & Ndihokubwayo, 2019), which are teacher-centered and found in conventional that did not promote an increase in attitude change (Narmadha & Chamundeswari, 2013).

Besides statistical findings, this study indicated how the inquiry learning model has changed the learning into enjoyable activities susceptible to promote self – direct learning that develops a habit of searching information from different sources by students regardless the order from the teacher. This has implicated students in the lesson and motivated them to like biology subject, developed critical thinking skills (Conradty & Bogner, 2019; Tsybulsky et al., 2018). Further, it raised the curiosity to identify the importance of biology in real life and opportunities it offers on labor market. Hence, their attitude toward learning biology increased (Wu et al., 2021). Contrary to control side subjected to teacher-centered method, students were accumulating information from teacher with less enthusiasm and could not develop the habit of asking and searching more information.

Regarding gender aspect, inquiry –based learning did not show significant differences in attitude change between male and female students. This can be associated with opportunity given by inquiry teaching methods to female students and male students to participate equally in the learning activities. Apart from statistical results, all students manifest the same feelings towards biology irrespective of gender. This study concurs with other studies showing no statistical difference between male and female attitudes in both groups (Uitto, 2014). In contrast with Vlckova et al. (2019), who observed that female students present higher positive attitudes than male students. Looking at inquiry-based learning, students' subjects to this treatment did not significantly differ in attitude change about gender. One can consider that inquiry-based learning shows no gender disparities and provides an equal chance for male and female students to participate in the learning process, as affirmed by Erbas and Yenmez (2011). However, although gender was found to not affect students' attitudes, Oba and Lawrence (2014) found a slight difference in favor of females and recommended stakeholders consider differences in males' and females' attitudes in the development and implementation of the curriculum.

Looking at all factors of attitude used in this study, attitude change in all dimensions was found on the experimental side. This research has specifically revealed how inquiry-based learning makes biology more interesting and easier for students to understand biological concepts. This can specifically be seen in the inquiry-based learning method used in an experimental group of students, which is an active learning method that offers a learning environment that facilitates learners to collaborate and actively engage in their learning (Nkurikiyimana et al., 2022; Nyirahagenimana et al., 2022). This study is in agreement with other studies revealing that teaching methods that actively engage learners in biology lesson with resources improve students' attitude toward learning biology (Armbruster et al., 2010; Fančovičová & Prokop, 2008; Kisoglu, 2018; Mukagihana et al., 2021a; Prokop et al., 2007).

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Conclusion and Implications

Generally, this study confirms the effect of inquiry-based learning in promoting a positive attitude toward learning biology. The study seeks to determine the student's attitude either in the control group or in the experimental group before learning and after learning microbiology. Students were at the same level responding to attitude statements before learning. After learning, the statistical results revealed a significant difference between the control group taught with the conventional teaching method and the experimental group taught with inquiry-based instruction in favor of the experimental group. It is evident that the inquiry-teaching method was more efficient than the conventional teaching method in improving the attitude change of students toward learning biology.

It is worth saying that poor teaching method did not facilitate students to improve attitudes toward learning biology and did not foster students' interest in biology. It was observed that female and male students do not present statistically significant differences in attitude change towards learning biology irrespective of the teaching methods they went through. Thus, even though inquiry-based learning did not present gender disparities in attitude change toward biology, it showed strength in raising students' interest learning biology and made different biological concepts easy to learn than teacher's presentation method can do.

The study recommends the integration of inquiry-based learning in teaching biology to assist teachers in improving students' attitudes toward learning biology to boost their learning outcomes. Training on inquiry-based instructions using the 5Es learning cycle should be provided to biology teachers to effectively implementing active teaching methods that foster a positive attitude toward learning biology. This study does not hint at student-teacher relationships. Further studies can examine the effect of inquiry-based learning on student-teacher relationships.

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Declaration of Interest

The authors declare no competing interest.

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Appendix A

Final Attitude Questionnaire

		Attitude statements	5	4	3	2	1
Interest	1	I like learning biology					
	2	I like Biology more than other science subjects					
	3	Biology is very interesting, and I enjoy it					
	4	Biology is self-inspiring to me.					
	6	The biology lesson is very interesting					
	10	It makes me pleased to hear about Biology					
	12	I feel well in Biology class					
	18	I am happier in a biology class than in any other class					
	20	Biology gives me a feeling of satisfaction					
	23	I would like to have Biology lessons more often					
	24	During Biology lessons, I am entertained					
Easiness	5	I am able to think clearly and logically when learning Biology					
	25	Biology is one of the easiest subjects for me					
	14	I often feel easy to understand Biology concepts					
	16	I feel being regained whenever I am learning Biology					

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		Attitude statements	5	4	3	2	1
Importance	9	I like Biology because it gives me a clear picture of how living organisms are related to each other					
	11	Biology helps me in learning other school subjects					
	13	All students should be required to understand Biology due to its importance					
	17	Learning Biology is important in everyday life					
	19	Biology knowledge is essential for understanding other subjects related to life science					
	27	Knowledge acquired in Biology will help me to learn other science subjects					
	28	Learning Biology has helped me to understand the diversity of living organisms					
Career	8	Biology knowledge is very important for my future career					
	21	I see Biology as something I will use very often when I get out of school					
	22	Biology knowledge is important for my future career					

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