Contribution of the Inquiry-based Learning to English Use in Teaching Biology Subject in Malawi, Rwanda, and Tanzania Secondary Schools

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Abstract
The contribution of the inquiry-based learning (IBL) to ensure effective teaching of biology in secondary education has not yet been fully studied in Sub-Saharan African countries. To fill the gaps, research has been conducted in Malawi, Rwanda, and Tanzania. Data were collected by using interviews, focus group discussions, and lesson observations before and after the intervention consisting of training biology teachers on inquiry-based learning and 5Es instructional model. Results showed that teacher-centred approach dominated the pre- intervention phase, while the IBL was observed in lesson planning and delivery, and there was a shift from teacher to a leaner-centred approach after the intervention. Most teachers established activities promoting the understanding of the subject content, use of the language of instruction, change of attitudes and improving the performance of students. We conclude that the intervention improved biology teaching, the language of instruction and performance of students.

Keywords : IBL, Learner-centred Approaches, Students Performances, 5Es Instructional Model

Introduction

Science education has become an urgent issue for socio-economic development. In this regard, it provides a rich context for developing 21st century skills such as critical thinking and problem-solving skills (Aktamiş and Hİğde, 2016). To fully attain these benefits, there have been several reforms in science education with the main purpose of shifting from teacher-centered learning to active learner-centred pedagogy (Adejimi et al., 2022). This increases students' attainment of learning outcomes, enhances positive attitudes, and contributes to the development of language acquisition in science education (David & Nsengimana, 2021; Adejimi et al., 2022).

With respect to active learning, inquiry-based learning (IBL) was 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 ways for students to interact with their teachers and actively plays a noticeable role in knowledge construction (Kang & Keinonen, 2018). In this regard, learners are given opportunities to explore the new situation using resources and hands-on activities to build a new biology concept. This raises students' attention and interest, and their attitude improves greatly. In turn, it has a positive impact on their performance and language acquisition skills in the subject (Conradty & Bogner, 2019). Further, under the IBL, the role of the teacher is to create opportunities that enhance a collaborative learning environment, merely facilitate, and guide learners to become independent thinkers (Duran & Duran, 2004). These are the reasons why Nsengimana et al. (2017) encourage that efforts be initiated to guide the

delivery of science and mathematics lessons away from cramming and towards a more learner-centered approach. In the same regard, Duran and Duran, (2004) advocate the implementation of IBL to illustrate constructivist, reform-based, and best teaching practices needed for this century.

There are different forms of categorizing inquiry levels that exist in literature depending on how teachers plan and provide solutions to the problem (Caswell & LaBrie, 2017). Fay et al. (2007) have proposed a rubric consisting of levels ranging from 0 to 3. The first level is 0 and entails that there are no features of inquiry present while level 3 shows inquiry at its best. According to authors, in the first level the teacher hands out instructions to be strictly followed by students, whereas at level 1, the problem and procedure are given to students to explore and interpret findings. At level 2, only the problem is provided, and students come up with the procedure. At level 3, students have a definite sense of autonomy, and just a raw idea is provided, which leaves students free to explore ideas and materials and come up with conclusions guided by a sound scientific inquiry procedure.

Smithenry, (2010) categorizes the lowest level of inquiry as "confirmation inquiry". This is because students merely follow the procedure to "confirm" an answer already known. On the other hand, when students are responsible for all activities like formulating the question, developing the procedure, doing hands-on activities and interpret findings, this is an "open inquiry". According to Fay et al. (2007), levels 0, 1 and 2 of the inquiry are consistent with guided inquiry, while level 3 is consistent with open inquiry. Ideally, level 3 (open inquiry) is effective for teaching and learning science subjects since it equips learners with critical thinking skills (Fay et al., 2007).

Under the IBL, the 5Es instructional model was pointed out as a learning cycle that improves students' attitudes towards biology subject content (Manishimwe et al., 2022). This model was developed while designing inquiry instruction for biology lessons (Patrick, 2013). The 5Es instructional 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). The inquiry model consists of a sequence of five interdependent phases: Engage, Explore, Explain, Elaborate, and Evaluate (Bybee et al., 2006), linked to the highest level of the IBL and teaching. Following the 5Es, the key question is formulated at the beginning of the lesson (Engage phase), and the roles of teachers and learners are specified under each phase (David & Nsengimana, 2021[b]). Also, under the 5Es instructional model cycle, learners contribute to knowledge construction at each stage of the learning cycle. Through the discussion among peers and support from the teacher, 5Es help students to improve skills in English mainly used as a language of instruction in most Sub-Sahara African countries (David & Nsengimana, 2021).

In Africa, countries have challenges to find different ways of promoting effective teaching and learning mathematics and science (Aina & Sofowora, 2013). To overcome this challenge, emphasis, advocacy, and adoption of IBL approaches in the curriculum have been given priority. For example, in a study conducted in Ghana to assess

the use of IBL in biology versus the traditional teaching approach, Annan et al., (2019) concluded that the IBL is a far better approach, especially with respect to retaining important subject content and promoting critical thinking for learners. However, there is little evidence for the effectiveness of the inquiry approaches (Akuma and Callaghan, 2019). This is because teachers still opt not to use them; hence, the use of teacher-dominated teaching approach is still persistent in many schools in Africa (Ramnarain & Hlatswayo, 2018; Annan et al., 2019).

In Sub-Sahara African region, most countries have shown difficulties in implementing the IBL supported by different types of instructional models (Kinyota, 2020). In Malawi, Altinyelken and Hoeksma (2021) reported that the use of IBL instructional model is a challenge and that the field of prevailing pedagogies is a rarely studied context, even though efforts to emphasize active learner-centered pedagogy have been noted. This is like a recent study conducted in Tanzania by David and Nsengimana, (2021[b]), which revealed that IBL practices are not common or fully implemented compared to teacher-centered approach, even though the IBL pedagogic approaches are not thoroughly researched in Tanzania (Kinyota, 2020). In Rwanda, the IBL has been recently introduced through the continuous professional development (CPD) courses for in-service mathematics and science teachers (UR-CE, 2020). However, the effects of the CPD are not yet fully documented at the schools having trained teachers.

This research contributes to the existing literature by adding empirical evidence on the importance of IBL in facilitating learning and enhancing the understanding of biology subject content, change of students' attitudes, and the role of IBL in supporting the improvement of learners' language proficiency. Specific objectives consist of (1) assessing the contribution of IBL to the improvement of biology teaching and learning as well as the understanding of biology subject content; (2) assessing the contribution of IBL to academic language proficiency; and (3) assessing the impact of inquiry-based instructional strategies on students' attitudes towards biology.

Theoretical framework

Different studies have highlighted that learners taught using socio-constructivism-based instructions tend to be more actively engaged and understand subject concepts better than their counterparts taught using other teaching methods (Abdi, 2014; Balta & Sarac, 2016; Ameyaw et al., 2018; Tsybulsky et al., 2018; Cairns, 2019). This is the reason why the IBL approach through the 5Es instructional model has been used in this study. The purpose was to reflect tenets of socio-constructivism-based instructions theory by presenting an opportunity to learn concepts through systematic and subsequent stages. In this regard, learners participate actively using relevant teaching aids and have the privilege of sharing ideas and exploring sources of knowledge to understand biology concepts (Mahn & John-Steiner, 2012).

Research Methodology

Data have been collected in Malawi, Rwanda, and Tanzania. In Malawi, data were gathered from 4 Community Day Secondary Schools (CDSSs). Further, data have been collected in 10 schools from Dodoma region in Tanzania, and in 6 schools from Kigali City and Southern Province in Rwanda. Details about schools, teachers, students, and classes sampled in this study are summarized in Table 1. In each country, schools were randomly selected following Cohen et al., (2007). In this regard, each school in the region, city or province received a specific code number, and was randomly picked from the list. In addition, teachers and students were purposely selected considering the conditions of being a biology teacher and learning biology at the selected school, respectively. Both qualitative and quantitative data have been collected using interviews, observation of pedagogical documents, lesson observations, lesson evaluation and focus group discussions with teachers and students. As all students could not participate in the focus group discussions, nine students randomly selected participated in this part.

Research design

Individual interviews were organized following the interview schedules, and data from lesson observations were collected using the lesson observation checklist, lesson evaluation form, and focus group discussions. To assure their willing involvement in this study, each participant signed the permission form prior to the commencement of data collection. Following the 5Es instructional model, the first lesson was observed to see the existing approaches used by teachers while teaching and learning biology and to assess the level (s) of the use of the IBL. Data were collected by utilizing prepared and validated observation checklists and assessing the role of students in each stage of the 5Es, or the main stages of the lesson, namely introduction, development, and conclusion.

The study used a mixed-methods approach through an exploratory research approach (Creswell, 2012) for gathering both qualitative and quantitative data. Specifically, the study explored (1) the contribution of the IBL to the improvement of biology teaching and learning; (2) the contribution of the IBL to the use of English academic language proficiency; and (3) the impact of inquiry-based instructional (IBI) strategies on students' attitudes towards biology. The study design was broken down into three main phases, as follows:

Phase 1 : Pre-intervention **:** The goal of the phase was to investigate biology teachers' perspectives on efficient lesson planning and assess the teaching methods used. Specific focus was on the formulation of instructional objectives, the identification of instructional teaching and learning materials, and the specification of the roles of teachers and students during the teaching and learning processes. In this phase, instructional objectives statement, selection of instructional teaching, and learning materials, as well as role sharing, facilitated effective teaching of biology, use of the language of instruction, and contribution to attitude change towards biology as a subject were assessed. Prior to the assessment of the prepared lessons, an interview with biology teachers was undertaken to

assess their grasp of good practices and procedures while planning a biology lesson. The assessment also focused on the performance of students during the ongoing assessments and school exams.

***Phase 2 : Intervention*:** To help teachers overcome the challenges identified in Phase 1, a training on the levels of IBL and the 5Es instructional model was organized at the school level. All teachers who participated in Phase 1 were invited and participated in the training. After the training, observed lessons were evaluated and revised following the IBL levels and steps of the 5Es instructional model and changes to pedagogy practices by specifying the role of the teacher and the role of learners. Specifically, the social constructivism viewpoints that inspired teaching reform were covered in this phase (Mahn & John-Steiner, 2012). After the training, one teacher was selected to teach the revised lesson in a different class from the one where it was taught previously to avoid biases. Other teachers observed the lesson using the prepared lesson observation form that has been used in phase 1. After teaching, improvements as well as points to improve were discussed as a team. Assessments given were also marked, recorded, and compared with the marks of students taught without the use of IBL or the 5Es instructional model. The last stage under this phase was an interview with teachers and students to assess changes brought by the intervention on the side of teachers and the side of leaners using pre-pared questions.

***Phase 3 : Post-intervention*:** The last part included three weeks of follow-up sessions with teachers to check if the skills learned during the training were used consistently. Data were collected through lesson observations to see whether there have been any discernible changes in the design and delivery of the lessons. Data were also collected through the analyses of marks obtained by students in the assessment given by teachers at the end of the lesson and quizzes to assess changes in performance. To comprehend the trained biology teachers' opinions on the use of the 5Es instructional model, final post-intervention interviews were also performed to assess changes in teachers' perceptions on the use of IBL following the 5Es instructional model. Findings were shared with teachers first and then with school stakeholders in two different meetings at the end of the research.

Sampling and sample size

Targeted population was learners and teachers from schools where this study was conducted. Countries, regions, number of schools, number of teachers, and the number of students per class making the sample size used are given in Table 1. The number of teachers and students is different depending on the number of schools making the population size.

Table 1: Country, Regions, Number of Teachers and Students, and the Level of Class considered (MCB: Mathematics, Chemistry and Biology, CDSSs: Community Day Secondary Schools).

Country	Region	Number of Schools	Number of teachers	Number of students	Class

Rwanda	Kigali City	2	2	69	S4 MCB
	Southern province	4	4	162	S4 MCB
Tanzania	Dodoma	10	40	400	Form IV
Malawi	Lilongwe	4	6	285	CDSSs
Total		**20**	**52**	**916**	**-**

Data analysis

Qualitative data from the interview were analysed using thematic analyses, where emerging themes were recorded and given special consideration. Also, those that were less emerging but had key implications for the objectives of the study were treated with special focus. Further, data collected from quantitative sources, such as changes in marks, use of IBL and stages of the 5Es instructional model, have been analysed using frequencies (%), means, and standard deviations. Significance differences were calculated and indicated by the letters based on P values.

Control of threats to internal validity

A review of the Lesson Observation Checklist (LOC), and Lesson Evaluation Form (LEF) was conducted by professionals in the field of biology education and used for a pilot study outside of the schools concerned by the study. The main purpose was to test the validity of data collection tools and decide about the items to remove, change, or review the items of the check list and the form. Items were maintained if they scored 0.75 (75%) out of 1 or above. They were reviewed when they scored between 0.70 (70%) and 0.74 (74%) out of 1; and they were removed when they scored less than 0.70 (70%) out of 1. During the pilot study, three interviews, three lesson plans, and three lesson observations were organized at two schools outside of the sample size in each country.

Ethical considerations

The research permit was granted by the University of Rwanda, College of Education (UR-CE) and equally by the local authorities in Tanzania, Malawi, and Rwanda. Besides, a consent form was completed to protect participants from ethical harm. This was either done in writing or verbally depending on the choice of the participant in the study. Students did not sign a consent form, an authorization from school authorities was considered enough for the protection of students. The study's objectives were also explicitly explained to the participants, who were also given the assurance that confidentiality would be strictly upheld by utilizing participant codes rather than names.

Results

The study investigated the contribution of the IBL, 5Es instructional model to the improvement of biology teaching and learning, improvement of academic language proficiency, and impacts of IBL, 5Es instructional model on students' attitudes towards biology learning. Findings are presented following the objectives of the study.

Objective 1 : The contribution of IBL to the improvement of biology teaching and learning

The visit of pedagogical documents showed that most of stated objectives were not instructional, and teaching and learning resources could not contribute to the achievement of stated objectives because they could not be used by learners during the leaning process. The most reported materials were chalks, chalkboards, and books. The pre-intervention lesson observation portrayed that most classroom practices were dominated by teachers' activities. Table 2 shows features of the lesson plan and hallmarks of lesson observation during teaching and learning. The IBL attributes were not fully found in visited lesson plans and observed teaching practices during the lesson observations. Performance of students was hard to judge during the pre-intervention phase because many students (greater than 80% at each school) scored well in the evaluation given at the end of the lesson, but the questions given were very basic, not linked with the instructional objectives, and required a high level of memory.

Table 2 : Lesson planning and observation during the pre-intervention

S/N	Guiding questions	Lesson plan observation	Classroom lesson observation
1	Does the teacher prepare a learner centred lesson following the IBL?	None of the IBL features was observed	Teachers spent much time giving facts and explaining concepts on the chalkboard.
2	Is the prepared lesson in line with the 5Es instructional model?	No trace of the IBL and 5Es approach was noticed in the lesson plan	Most of teachers use lecturing as a dominant teaching technique. Students are mainly passive and could sometimes answer to the questions asked by the teacher.
3	Does the teacher formulate clear and achievable instructional objectives?	Lesson instructional objectives were clearly formulated	Lesson outcomes were verbally communicated to students
4	Does the teacher consider students with special needs?	Teachers did not clarify how they would support learners with special needs. They simply write:" no student with special need".	Learners were all treated equally. However, slow learners could not get any support from teachers.
5	Does the teacher indicate the instructional teaching and learning materials?	Books, chalkboards, and chalks were reported as teaching and learning materials by many teachers.	No instructional materials to be manipulated by students during the lesson were observed.
6	Are stages of the lesson being well planned?	Stages of the lesson such as the introduction, development, and conclusion were indicated.	A completed section of the lesson stages was observed as indicated in the lesson plan.

7	Does the lesson indicate how achievements will be evaluated at the end of the lesson?	Each planned lesson had the evaluation. However, it was more summative with memorizing questions only.	Students answered to the evaluation questions by writing. Some teacher marked them in the classroom first and call students to answer on the chalkboard, other teachers collected them to be marked later, few others asked questions orally and picked some students to answer orally without writing.

The feedback from the interview in the pre-intervention revealed that teachers were aware of the inquiry-based teaching and learning strategies (IBL/IBT), but not 5Es instructional model. However, they reported that it is hard to use the IBL considering the teaching load, the number of students and the amount of the content to cover. In addition, even though teachers did not apply the IBL before the intervention, they had varied and positive attitudes on how the IBL could support the understanding of biology concepts by students (Table 2).

Table 2: Perceptions of teachers on effectiveness of the IBL (SA: strongly agree, A: Agree, N: Neuter, D: Disagree, SD; Strongly disagree)

Items	Statements	SA (%)	A (%)	N (%)	D (%)	SD (%)
1	The IBL can help learners to understand the biology concept matter	10	60	10	10	10
2	The IBL teaching methods allows learners to connect biology content with real life	20	70	0	10	0
3	I prefer to use the IBL in all topics of biology that I teach because it is a productive teaching method	80	20	0	0	0
4	The IBL encourages learners to be more actively engaged in teaching and learning process	20	60	0	20	0
5	The IBL offers the opportunities for learners to share their prior knowledge	10	90	0	0	0
6	The IBL reduces the number of absent-minded learners	50	30	10	10	0
7	The IBL helps learners to create new knowledge rather than memorizing the existed one	80	20	0	0	0

8	The IBL encourages learners to ask questions	30	70	0	0	0
9	The IBL piques the curiosity of learners that helps them to deepen the understanding of biology concepts	40	50	0	10	0
10	The IBL helps learners to be more independent in their learning and to reach their goals	30	60	0	10	0

After the intervention, the contribution of IBL was viewed in terms of how teachers formulate the instructional objectives, prepare, and use instructional materials in teaching and learning process. It was found that teachers still do not involve learners in the preparation of materials, contrary to what the curriculum demands. In terms of learners' performance in the assessment given at the end of the lesson, IBL was found to be fruitful in promoting students' achievement in biology. Many learners (60%) performed well in the assessment as they scored > 50%. Table 3 shows observable changes in pre and post intervention for each step of 5Es instructional model.

Table 3: Overall analysis of the IBL following 5Es cycle (letters a and b show significant differences, $P < 0.05$)

Items	Stages of 5Es	Pre-intervention	Post-intervention	Observable change
1	Engage	2.3 ± 0.0^{a}	3.4 ± 0.8^{b}	Teacher introduces a lesson with a short video, discrepant event or a story that engage leaners. Language issues such as correction of the words and pronunciation were considered in this phase. Students could ask questions. At the end of the phase a key question has been formulated.
2	Explore	0.5 ± 0.3^{a}	2.5 ± 1.0^{b}	Teacher provides instructional materials, helps leaners to understand the activity, and could assist learners with challenges. Further, leaners could ask questions while working in groups.
3	Explain	0.6 ± 0.4^{a}	2.1 ± 0.7^{b}	The explanation phase was dominated by teacher and the role of learners was not fully detectable. The teacher could often ask questions to students to check if they are paying attention. Explanations were based on the presentations of students from group work by using instructional materials.

4	Elaborate	1.5± 0.1[a]	2.6 ± 0.9[b]	Teacher gives activities based on the lesson and linked questions with daily life challenges outside of the school. Teacher could also assist leaners with difficulties to do the activities. Further, leaners could ask questions to better understand the task.
5	Evaluate	1.0 ± 0.0[a]	2.8 ± 1.0[b]	Teacher formulates questions linked with instructional objectives, instructional materials, and the key question. Questions followed a hierarchy level of thinking. Students answered by writing and answer sheets were collected and marked to assess the level of performance. Correction and feedback were given to students before starting the new lesson.
	Overall	**1.2[b] ± 0.2[a]**	**2.7 ± 0.8[b]**	

Objective 2 : The contribution of the IBL to the academic language proficiency

Problems related to the use of English as a language of instruction were less observed in Malawi, as both teachers and students could use English at an appreciable level without too many challenges. When the teacher asked the question, there was prompt feedback from students in correct English language, even though the answer could be wrong. Further, the teacher could ask challenging questions to guide students to find the correct answer. In the pre-intervention interview, biology teachers showed that they use active teaching and learning methods in biology subject, despite the type of teaching techniques. This might be the reasons why, the participation of learners in the lesson was moderately good. Furthermore, the willingness of teachers to continue using active teaching methods was indicated by the feedback from the interview after the intervention. However, this might be challenged by a big class size and lack of adequate teaching and learning materials. One of teachers replied that: "*…I think we need to emphasize the use of IBL in teaching practices. However, for its effective implementation, adequate resources should be provided, and it is well applied in a school with a low teacher-learner ratio (Teacher from rural CDSS 3).*

In Tanzania, findings revealed that students' writing and speaking abilities have been improved under the IBL-driven lessons. Students have improved the ways they give answers to the evaluation questions. Improvements were also observed in reading and writing skills, according to the answer sheet for the evaluation questions given at the end of the lesson. The evidence from leaners can serve to support changes in the use of English language after learning the classification of animals: *"I found it difficult to learn biology, especially the classification of animals, using the English language. I could learn it better when the teacher introduced some participatory ways where I could learn in groups*

and ask my peers how to read and write some words such as echinoderm, earthworm, acoelomate…". (Student 1 from Tanzania). Another student said that: *"It was difficult for us to communicate in English. Once more, when we attend biology class, the focus seems to be on memorising what the teacher teaches to do well during the tests and examinations. However, we have seen our biology teacher changing the ways of teaching, and we could be able to report our conclusions from group work in English and perform well in the tests at the end of the lesson"* (Student 2 from Tanzania).

In Rwanda, teachers could force students to use English during the pre-intervention phase. Students could not answer questions without referring to the national language. Frequently, teachers could react to the feedback with different statements: "*In English, please, why answering in Kinyarwanda, who can try in English? What is the correct meaning in English please? Who can support and put it in English? No one can try?*" (A teacher XX from Rwanda). After the intervention, changes were observed. Students could use the English language despite the errors in speaking and writing. This was due to changes in teaching practices, where most teachers could rephrase the questions until students were able to give the answer in English. During the group work, the discussion was done in the local language, but the report was written in English and the presentation was in English.

To verify writing skills and correct errors, teachers asked leaners to present by reading the answer from the worksheet first, and then write the answer on the chalkboard. Most teachers could appreciate the feedback from leaners by using appreciation statements such as: *Excellent, correct, very well, fantastic…. Do you agree with the way the word is written? Who can support and write in a correct way? Is the pronunciation fine? Let me help you, this is how to pronounce it properly…. please repeat, ...and this is how to write it, fine?".* (A teacher XY from Rwanda). More support to improve the English language was provided during the Explore, Elaborate, and Evaluate phases in Tanzania, while more support was observed in Engage, Explore, and Elaborate phases in Rwanda.

Objective 3: The impact of Inquiry-based instructional strategies on students' attitudes towards biology

Students from all schools reported positive thoughts on how the IBL promoted biology learning and understanding. The study revealed that students who were taught using inquiry-based learning had a noticeably greater change in attitude than their counterparts who were taught using traditional teaching techniques, which were characterized primarily by instructors' idea presentations. Looking at attitude as a learning outcome, the IBL has contributed to enhancing students' attitudes towards biology. Quantitatively, the ANOVA set forth a significant difference in attitude change between students taught with IBL and those taught with conventional teaching methods in favour of those subjected to inquiry instructional strategies ($P < 0.001$). For the four dimensions of attitude investigated (interest, difficulty, importance, and career), findings disclosed an increase in all dimensions.

Discussion

The pre-intervention phase findings revealed that teaching was dominated by teachers and the role of students was limited as they could only answer the questions from the teacher. This is different from the recommendation of the study conducted by Richardson (2009), where students' learning should be based on the use of instructional materials, and students must be given time to manipulate them. Further, this research showed that, in terms of fostering academic language skills, the IBL method employing the 5Es instructional model varied for the five phases before the intervention. A study conducted in Tanzania emphasized that it is essential to explain the variances of the model during the intervention to help teachers effectively use the IBL and 5Es steps while teaching biology to improve the understanding of the subject content and the English language skills (David and Venuste, 2021).

After the intervention, results showed that writing skills of biology concepts, especially during the presentation of findings from group work, significantly improved during Explain and Explore phases, but reading was seldom seen in any of the 5Es model's phases mainly in Tanzania. Reading could not be fully evaluated in Rwanda, as the content of the lesson mainly focused on group work and presentation. The lack of improvements in language skills in all phases of the 5Es might be because teachers concentrated on certain components of the IBL to improve the development of knowledge in subject content rather than the development of language competences. This is normal as they are not English language teachers but biology teachers, specifically focusing on how the English language can be improved and contribute to the understanding of biology subject content.

In general, the IBL was susceptible to improve the English language, especially in a multilingual context as it was found in Tanzania. This is in line with another study that has been conducted in sub-Saharan Africa (Mokgwathi and Webb, 2013) which showed that IBL allows teachers to operate in an environment that regards explanations in English or local language and exploration of biological species. However, there is a sense that Tanzania started to include the agenda of using both Kiswahili and English in their teaching (Nomlomo and Vuzo, 2014), which is not the case in Rwanda, where teachers are encouraged to absolutely use English without mixing English with the national language. In essence, evidence points towards a systematic use of familiar language (considering IBL) to unlock abstract concepts in the development of academic language proficiency.

Findings also revealed that students taught using the IBL had a noticeably greater change in attitude than their counterparts taught using traditional teaching techniques characterized by teachers' idea presentations. It could imply that IBI offers a conducive learning environment that facilitates social interactions. Students learn in collaboration and become motivated by the lesson. Hence, the attitude towards biology improves. This is in consonance with other studies which have revealed that the IBL furnishes a social learning that promotes attitude change in learning science (Nkurikiyimana et al., 2022; Nyirahagenimana et al., 2022). This is related to the ability of the IBL to stimulate students' commitment to exploring concepts. It was observed that learners own the learning process and manifest initiatives

while building their knowledge. Additionally, self-directed learning was encouraged, and students were confident in sharing their findings. This can be attributed to the anticipation given by the inquiry teaching method for the learners to actively get involved in learning. We conclude that students taught with traditional teaching methods are less confident in learning science subjects than students taught with inquiry-based instructional strategies (Gormally et al., 2009), and hence have low attitudes towards biology subject.

In relation with performance, this research showed that the intervention contributed to the understanding of biological concepts as 60% of students concerned by the study scored greater than 50% in the assessments. This is in line with a study conducted by Kaçar et al., 2021, which reported that the IBL makes students active inside and outside of the classroom, enables students to work in groups, conduct research, present their research findings, and increase academic success. Another study conducted in Tanzania by David and Nsengimana (2021[a]) indicated that performance is mainly influenced by the teaching and learning process where the roles of teachers and students are well indicated during the IBL process. Further, learning activities and materials are well prepared in advance. As a result, students can explain biological concepts in a clear academic language (David & Nsengimana, 2021[b]).

Conclusion and recommendations

The study concludes that the IBL promotes effective biology teaching and learning through a learner-centered approach, improves the use of English as a language of instruction, improves students' academic performance in the assessments given at the end of the lesson, and contributes to the attitude change towards biology subject. It recommends more studies on the use of IBL and 5Es instructional model in biology and other science subjects in other countries to verify the findings of this study.

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