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Teachers' Perceptions on the Effectiveness of the Inquiry-Based Learning towards Students' Achievement in Biology: The Case of schools of Rwanda

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Abstract

A learner-centered teaching approach is more emphasized in teaching and learning biology, specifically the content of cell division. The teaching method is valued for assisting learners' understanding terminologies used to describe any particular event that occurred during the cell division processes for instance, chromatids, crossing-over, chiasmata, and cytokinesis. The purpose of this study was to investigate teachers' perspectives on the effectiveness of the inquiry-based learning (IBL) on learners' achievements in biology of cell division in Rwanda secondary schools. A total of 254 learners studying the cell division in upper secondary schools and 10 biology teachers were purposively selected and participated in the study. Pre-training was assessed through the lesson observation. The feedback was used to train teachers on the IBL lesson plan and lesson delivery. The post-training consisted of preparing the lesson on cell division. Planned lessons were then delivered, and data about the improvements were collected using the lesson observation checklist. Further, data were collected using the questionnaires addressed to teachers. Data were analyzed using descriptive statistics where percentages, means and standard deviations were calculated by using Excel Software Version 2016. The findings of the study revealed that the IBL was an effective teaching method towards learners' achievement in biology. It motivates learners to follow the lesson and express their opinions, which contribute to better performance. The study recommends continuous professional development to equip teachers with skills in teaching by using the IBL.

Keywords: active learning; motivation; curiosity; attitudes; inquiry-based learning

Introduction

Nowadays, the teaching of science requires teachers to use teaching techniques that help learners to be more active in learning process so that they become productive by fulfilling the needs of the society (Damopolii et al., 2018). As said by Smith et al. (2009), a teaching method is more fruitful when learners are actively engaged. This increases the chance of finding the correct answer to the raised problem and leads to the achievements of the desired learning objectives. There are different teaching techniques that can be used to produce productive members in society; the inquiry based learning (IBL) being one of them (Michael, 2006). According to Andrini, (2016), through the IBL, learners are equipped with real life skills that allow them to work in an innovative and productive manner.

Different authors attempted to provide the definition of the IBL. According to Capps & Crawford (2013) the IBL is one of inductive teaching methods where learners are excited by questions and learn the lesson by searching for solutions. Ismail (2014) added that, during the IBL lesson teaching, the

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teacher acts as a facilitator rather than a knowledge provider. On the other hand, Herranen, Kousa, Fooladi, & Aksela (2019) defined the IBL as a method where learners are actively engaged in a scientific investigation of a given phenomenon, come up with a clear understanding of the content that help them explain facts, and justify findings by following the instructions provided by the teacher. Hence, through the IBL, teachers help learners to be active and competent in learning.

Further, different research on the difference between teaching methods, modes of instruction and learners' achievement indicated that achievement is influenced by the ways used by the teacher in teaching. Auwalu et al. (2014) showed that achievements of learners are influenced by teacher's ability to engage learners in learning, class size, and teaching methods. Other studies in science education Veselinovska et al., (2011) found that learners who are taught by using a teaching method that allows them to be fully engaged in the process outperform those who are taught using methods that make them passive receivers.

Advantages of using the IBL have also been highlighted in another study conducted in Nigeria by Opara (2011). The study showed that the incorporation of the IBL in biology empowers learners by making them more active in learning rather than passive. This idea was supported by Porozovs et al. (2019). In the perspective of the authors, effective achievement of learners in biology subject depends on effective teaching methods that allow them to get clear understanding of the subject matter, and hence become problem solvers. Further, studies conducted in other science subjects showed significant contribution of the inquiry based instruction on learners' participation and attitudes towards science subjects (Debbie, 2004). In addition, the research conducted by Bayramet al., (2013) in chemistry indicated that the inquiry develops critical thinking of learners and creates opportunities of thinking independently and understanding chemistry concepts. Aidoo et al. (2016) argue that the inquiry offers opportunities to develop positive attitudes towards science subjects and makes the study of science more realistic and meaningful.

Statement of the problem

The 21st century's curricula mainly focused on teaching methods that help learners to be able to apply their learnt knowledge and skills to provide solutions to the challenging problems faced by learners and fulfill the societal needs (Damopolii et al., 2018; Gormally et al.,2009). Unfortunately, the use of traditional teaching methods is still persisting for most teachers, while they do not meet the needs of leaners and society (Opara, 2011). Therefore, the shift from traditional methods to the application of active methods such as the IBL is necessary for better achievements in biology subject, particularly the content of cell division. The IBL has been recommended to be applied in modern and revised curricula such as the competence-based curriculum in this regard, following the 5Es (Engage/excite, Explore, Explore, Elaborate and Evaluate) instructional model (Arslan, 2014).

The focus on cell division in this study is motivated by the fact that cell division is among the most difficult biology content Williams (1995). Studies indicated that the content on chromosomes' movement during prophase I of the first meiotic cell division, and abstraction of the terms used in cell division content such as mother cell, daughter cells, sister chromatids and sister chromosomes are confusing terms for learners (Öztap et al.,2003). As a result,

learners are always struggling to memorize the terms with a high probability of forgetting them (Ceren, 2001). Further, learners may be confused by the end-products of mitosis and meiosis processes, which are always obscure once the teaching methodology cannot make them clearer (Williams et al., 2012).

The lack of understanding of the content of cell division is hence confounded by the poor teaching techniques, as has been highlighted by Zeidan (2010). This was supported by the findings of another study conducted by Çimer (2012). The studies indicated that the teaching methodology that does not motivate learners to effectively learn complicates the understanding of concepts learnt in cell division subject content. This is why Chu (2008) recommended the development of teaching techniques that do not overload learners with memorization.

The current study is interested in the use of the IBL and explores the linkage between the inquiry-based instructional practice and achievements in biology subject, focusing on the content of cell division. The study was guided by three research questions, specifically: (1) To which extent can teachers use the inquiry teaching method through 5Es instructional model? (2) To which extent are learners' activities done in each phase of 5Es instructional model through the IBL, and (3) what are the teachers' perspectives on the use of the IBL in teaching and learning cell division?

Review of literature

According to Akçay (2009), in the IBL environment, learners express their ideas clearly and collaborate effectively to do a given task by sharing opinions. In addition, they learn to discuss issues among themselves. The importance of the IBL was also pointed out by Bybee et al. (2006) who indicated that in the IBL environment, learners discuss, develop portfolios, and communicate to accomplish learning activities. From the same perspective, Herranen (2019) argued that in the IBL, learners are given the opportunities to examine a problem and seek possible solutions. In addition, learners learn to integrate knowledge and connect skills through cooperation, and then apply the knowledge in everyday life activities (Khan et al., 2011).

Further, the IBL has significant contribution on skills development through critical thinking and skills development based on teaching and learning activity done by learners (Bayramet al., 2013b). The IBL helps also learners to construct their own knowledge while dealing with real-life problems (Sadeh & Zion, 2009). As said by Cairns (2019), an inquiry based instruction gives learners the opportunities to be active in building the knowledge rather than beong passive knowledge receivers. In this way, the IBL significantly influences learners' critical thinking skills and leads to higher achievements (Damopolii et al., 2018; Eltanahy & Forawi, 2019).

Based on learners' cognitive development, levels of inquiry were developed (Artayasa et al.,2018; Alabdulkareem, 2017; Banchi & Bell, 2008). The findings of these studies indicated that the inquiry is divided into four levels of complexity namely: (1) confirmation inquiry where learners are given questions with procedures that help them to achieve already known results; (2) structured inquiry where the teacher's involvement is limited to providing procedures and questions, while learners follow the teacher's instructions to find solutions; (3) guided inquiry where the teacher poses questions and learners determine the process of finding the unknown solutions; and (4) open inquiry where the teacher is a facilitator, and the responsibilities of learners are to develop the problem, suggest the procedure, and provide solutions to the problem.

The IBL is applied in different ways, and the most used is the 5Es instructional model (Jiun, 2012). This model is based on active learning, and it allows learners to apply what they have learnt in a new situation outside of school (Lena & Emilio, 2004). Taylor (2006) argued that the 5Es instructional model is grounded in intellectual psychology and constructive theory of learning, and it is among the best instructional methods in science subjects. As cited in the National Science Education Standards [NSES] (1996), the 5Es instructional model offers learners the opportunity to construct their own understanding of concepts through five phases, where each phase specifies teachers' and leaners' activities (Table 1).

Table 1 Phases, teachers' and learners' activities (adapted from Bybee et al., 2006)

№	5E Phases	Teachers' activities	Learners' activities
1	**Engage**	The teacher presents a short experiment that engage learners through questioning to learn about their prior knowledge	Learners answer questions asked by the teacher
		The teacher provides to learners the time to express their opinions about the presented phenomena	Learners draw conclusions based on observations and ask questions
		The teacher introduces the topic in a manner that captures the learners' interest toward the lesson	Learners express their understanding of the topic under study
		The teacher works with learners to formulate the key question	Learners work together with the teacher to formulate the key question
2	**Explore**	The teacher provides activities that direct learners to explore new ideas and ask questions	Learners share ideas in small groups to do the activity suggested by the teacher
		The teacher guides learners to work on the prepared activity	Learners provide an explanation
		The teacher guides learners to get a deep understanding of the concept	Learners answer the questions from the activity
		The teacher offers learners teaching aids like books to increase their understanding	Learners use the provided materials for a deep understanding of the concepts
		The teacher initiates the activity and allows learners to discuss	Learners work on the given activities
		The teacher offers the learner's time to present the findings from the group discussion	Learners organize themselves into groups to discuss and present the findings
3	**Explain**	The teacher asks learners to share what they discussed during the explore phase	Learners present the findings from the group discussion or the experiment they did
		The teacher allows learners to provide their understanding of new concepts	Learners demonstrate understanding of the concept under study
		Explain the concept explicitly and remove misconceptions	Learners pay attention to the teacher's explanations
		The teacher asks challenging questions that direct learners to think deeply	Learners apply what they've learned in a new but similar situation
4	**Elaboration**	The teacher helps learners summarize the key points	Learners share ideas with peers for better understanding
		The teacher encourages learners in discussion and responds to questions raised by learners	Learners use previous knowledge: • To ask questions • To propose solutions • To record explanations

№	5E Phases	Teachers' activities	Learners' activities
			Learners make decisions
		The teacher provides assessment (formative or summative)	Answer open-ended questions based on prior explanations
		A teacher allows learners to reflect and evaluate their own understanding during the teaching and learning process	They must demonstrate their comprehension
5	**Evaluation**	Assess learners' understanding and provide feedback	Ask questions that encourage future investigations

Theoretical framework

Vygotsky's social constructivism theory of learning was used in this study due to its significance in helping learners to generate knowledge and create meaning based on their previous experiences (Vygotsky1978). The role of constructivism was pointed out by Serafín, Dostál, & Havelka, (2015). They argue that in a constructivist environment, every learner thinks about the knowledge to organize, intensify, and expand it through collaboration. Through the constructivism theory, learning does not rely on the transfer of known knowledge but on the reconstruction of knowledge by learners. Vygotsky's meaning of constructivism was that knowledge should be co-constructed and learners should be actively engaged in the teaching and learning process as well as help from each other (Vygotsky, 1962). It helps learners to be independent in their learning by developing their skills as well as their confidence.

Further, the study fits with Vygotsky's Zone of Proximal Development (ZPD) in the proposed social constructivism theory. The ZPD referrers to a space between those activities that a learner can independently do and those activities that a learner cannot do unless assisted by adults or experienced peers. Social constructivism theory helps to understand these activities through peer work through interactions among learners (Husain, 2018). This study was also in line with Vygotsky's scaffolding concept, which is referred to as teaching techniques that allow learners to work with the teacher or with other learners to achieve a specific objective of the lesson. Therefore, this study simply fitted with Vygotsky's theory that emphasized collaboration in learning as a baseline for constructing knowledge through negotiation. Because in an inquiry-based learning environment, learners are always working together to construct knowledge.

Research methodology

Research paradigm and research approach

A paradigm refers to a collection of philosophies, thoughts, and behaviors that are shared among scientists that deal with reality in the world (Perera, 2018). While carrying out this study, the positivism research paradigm was adopted under a quantitative approach. This paradigm assumes that the truth is there and fixed (Pham, 2018). It was chosen because it is the most applicable in quantitative research, where independent variables are manipulated to determine their effect on dependent variables (Pandey, Sharma, & Dutta, 2004), and because of its epistemological foundation, where knowledge acceptance must be based on observable and measurable evidence (Saunders, 2016).The quantitative research approach was adopted because all collected data was quantitative in nature based on the questions that have guided this study.

Research design

A quasi-experimental research design was adopted to find out the cause – effect relationships between inquiry based instructional practice as an independent variable and learners' achievements in biology as a dependent variable (Creswell,

2014). This design helped to understand if there was a difference between learners' performance in uninquiring lesson and inquiring lesson (White & Sabarwal, 2014). Specifically, we wanted to know if there a difference in implementation of inquiry before and after the training. .Simply the research design helped to know if the IBL influenced learners' performance in biology (Rogers & Revesz, 2020).

Research area, population, and sampling technique

This research was conducted in the Burera district of the Northern Province of Rwanda. This area was selected because of poor performance in biology for upper secondary schools, which was attributed to the dominance of the teacher-centered approach. The researcher was interested in seeing whether this teaching method affected the learner's performance in biology in rural areas as much as it affected those learners in urban areas. The target population was learners and teachers from the schools where this study was conducted. Schools were purposively selected from public, mixed-ability, boarding schools, and have learners studying biology at an advanced level (Tongco, 2007). A purposive sampling method was also used targeting learners that study cell division at an advanced level and teachers that teach biology in those classes. Among the participants, there were 3 female teachers, 7 male teachers, 137 female learners, and 117 male learners. Lesson observation was carried out in senior five classes, but all biology teachers from the selected schools were trained on IBL and then filled out a five-point (strongly agree, agree, neutral, disagree, strongly disagree) Likert scale questionnaire.

Procedures of collecting data

Data were collected on Saturday from 8:00 – 11:00 AM and in extra times from Monday to Friday at respective schools to avoid disruptions in school activities and timetable. Before the start of data collection, all participants filled out the consent form to ensure their voluntary participation in this study. The first lesson observation was carried out to see the current methodology applied by teachers and check if there are some traces of the IBL, following the 5Es instructional model. Data were collected using observation check lists that focused on the activities of learners in each phase of the 5Es instructional model. The considered criteria in each phase were adapted (Table 1). The 5Es instructional model was preferred in this study to implement the IBL due to its effectiveness in the time learners were encountered with new concepts because it offers opportunities for learners to adjust to new knowledge by reflecting on previous ideas through its complete learning cycle (Taylor, 2006).

Further, (Baydere, Ayas, & Çalik, 2020) argued that the 5Es significantly increase learners' scientific knowledge. The same authors argued that the 5Es instructional model assists teachers in creating a unique learning experience for learners while also assisting learners in developing a strong understanding of knowledge through active participation in the teaching and learning process. In addition, it is the most applicable model in science subjects (Jiun, 2012). The feedback from the lesson observation was used to verify the gaps and plan for the training on the inquiry teaching method for the content of cell division. After the training, teachers had to improve the prepared lesson and select one of teachers to teach the lesson. Changes in lesson plan and lesson delivery were once again observed by using the same observation check list.

Observation check list was also used to collect data on behaviors of learners,

specifically their motivation to follow the lesson. This offered information about learners' interactions and involvement in learning process, used to assess the extent to which teachers were able to support leaners following the steps of 5Es instructional model. Nonetheless, the levels of inquiry were assessed based on the structure of the activities given to learners and how learners explored the learning material.

Results

IBL and the teaching and learning of biology

Findings of this study indicated that all teachers could partially use the IBL as some phases could be observed in the first lesson observation. The most observed steps are the engage and evaluate phases. The engage phase was not well implemented as it was limited to recalling questions in relation to the previous lesson and introduces the new lesson. There was not any engaging activity or questions to excite learners.

The explore phase could be observed, but not fully related to the IBL lesson. Teachers could provide activities to be done by learners in groups, as the teaching resources were not available. However, some teachers tried to use videos, where learners could observe and answer the questions from teacher and asking questions as well. However, limitations with the process were observed as the questions were given after watching the video and it was hard for learners to recall what they observed in the video. Further, the use of videos was not efficient as one laptop was not enough to show details to a class of more than 45 learners. This problem was added to the lack of speakers, which could be used to increase the voice, and hence allow all leaners to hear details from the video. Therefore, majority of learners were not able to explore questions related to the learning topic; hence the teacher centered approach dominated the teaching and learning process.

Furthermore, majority (60%) of teachers could use figures to clarify concepts. However, this also had limitations as it was not possible to find the figures equal to the number of groups. Nevertheless, once the figure was hung in front of learners, it was not easy for all learners, especially those sitting behind, to observe all the details of the figure. Lack of resources was also among the issues faced by biology teachers. During the lesson observation, we found that the number of books available was not enough compared to the number of learners. As a result, it was not easy for teachers to give the working activity, and hence they always had to write all the details on the chalk board. Teachers were also forced to rush with time, and hence use lecturing methods to cover the content of the lesson. Within this situation, no trace of a learner-centered process was applied, and the first phase of the 5Es instructional model was mainly applied in all schools. In explain phase, the feedback from group discussion was not fully explored as there was no presentation of the findings from groups. In addition, there were no questions raised by learners. Teachers could only ask questions, and some learners could provide answers. Teaching and learning process were dominated by teacher's talk, which means that learners were highly passive instead of being active in learning process.

In the elaborate phase, teachers were expected to ask questions that required learners to apply the learnt knowledge in a new but similar situation. The majority of teachers (90%) failed to create these types of questions. The observed questions were almost like those in the explanation phase. This indicates that teachers were unable to guide learners in a new situation. In the evaluate phase, most teachers could give a written assessment consisting of 2 to 3 questions. Learners had to answer by writing. Few teachers could provide feedback to learners, and the assessment of the marks

obtained by learners in the assessments indicated poor performance as the majority of learners (greater than 85%) could get less than 50% of the scores in the assessment. And some learners submitted their papers without answering at least one question. Poor performance was a sign that learners did not understand the subject content, probably due to the inadequately used teaching methods that did not involve learners in the teaching and learning process. In a nutshell, it was observed that most teachers are still using teacher-centered approaches in their teaching activities. The collected data on this first lesson observation was shown in Table 2: teacher one, lesson one (T1L1) in terms of means and standard deviations.

The role of the IBL to improve teaching and learning biology

After identifying the extent to which teachers could use IBL in their daily teaching activities, IBL training was provided at the school level, with a focus on the levels of the inquiry and to the stages of the IBL lesson following the 5Es instructional model. After the training, every teacher had to prepare an inquiry-based learning lesson, based on the scheme of work, but always under the unit of cell biology. After discussing on the quality of the lesson plan and identifying the effectiveness of teaching and learning materials, every teacher had to deliver the prepared lesson, following the phases of 5Es instructional model (Table 2).

The collected data during the second lesson observations indicated the improvement in teaching and learning the content of cell division. Specifically, on mitosis and meiosis, the majority of teachers (90%) could engage learners using the short video and formulate the key question of the lesson. In this phase, teachers asked a few questions to elicit learners' prior knowledge and allowed them to express their opinions within a short time. Majority of teachers (90%) could capture learners' interest in the lesson by asking questions that provoke learners' curiosity about things that were not discussed in the first lesson. Moreover, they could encourage learners to ask questions. More improvements were found in the second lesson, which was indicated in Table 2 by L2 as teachers were familiar with the new teaching method.

For instance, there was a shift from what is mitosis to what do you think if mitosis does not occur? The second lesson was mostly dominated with learners. They answered majority of the questions from teachers, asked curious questions and demonstrated a strong willingness to express their opinions during the teaching and learning process. As a result of sharing understandings on the topic under study, there was increased interest in the lesson (Table 3). In the explore phase, most of teachers could prepare the activities to be done by learners in groups after watching the video. Learners were more active in building the knowledge compared to the previous case, where they relied on the activities in the books which were not really engaging, in addition to the limited number of books. The teacher could manage group discussion and assist learners having difficulties with the activity. Every group had to present the findings on the chalkboard.

During the explain phase, the majority of teachers (80%) could explain the content using learners' ideas presented during the group work. They were also able to guide learners to the right answers and delete the content that was not correct. Together with learners, most teachers could elaborate the summary of the lesson and give the alternative activities in relation to everyday life for the learners in the elaborate phase. The feedback was also presented by learners, and then teachers and learners could work

together to summarize the feedback and come up with the correct content.

Nevertheless, in the elaborate phase, teachers were observed asking challenging questions that directed learners to think deeply. They also gave additional activities that required learners to apply knowledge and skills from the lesson in a new, but similar situations and could help and encourage learners to discuss and summarize the key points. In this phase, the improvement in doing each and every activity was observed. In the second lesson, both teachers and learners were enjoying the lesson. This was shown by the active participation of learners, not only limited to asking questions, but also providing feedback on the questions asked by teachers. Raised hands could be observed for every question from all learners. This was also indicated by the commitment of learners to carry out the activities by themselves in groups, asking questions when they didn't understand, recording the findings and consulting books to verify the findings in groups.

Nonetheless, the evaluate phase was dominated by formative assessment. In the first lesson, most teachers used oral questions to assess whether the desired objective (s) had been achieved and encouraged learners to assess their abilities by doing different activities from their books. In the second lesson, most teachers gave written questions in addition to the oral questions. Furthermore, learners responded to open-ended questions by referring to previous explanations, demonstrating the findings by proving them, and then asking questions that encourage future investigations. In this regard, more improvement in learners' performance was observed when compared to their performance in the first lesson. In this lesson, the average score obtained by those learners was 65%, whereas in the first lesson, the majority of them (85%) received marks below 50%.

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Table 2 Means rankings of the performance of 4 teachers from four different schools in each phase of the 5Es instructional model

No.	Phases	M / SD	Lesson 1 T1	Lesson 1 T2	Lesson 1 T3	Lesson 1 T4	Overall Mean	Lesson 2 T1	Lesson 2 T2	Lesson 2 T3	Lesson 2 T4	Overall Mean
1	Engage	M	2.5	2.25	2.2	2.0	2.23	3.0	3.0	3.5	2.75	3
		SD	0.6	0.6	0.5	0.8		0.8	0.8	0.95	0.5	
2	Explore	M	2.2	2.4	2	2.0	2.15	2.6	3	2.8	3.0	2.85
		SD	0.8	0.9	0.7	0.7		0.5	0.7	1.0	1.4	
3	Explain	M	2.2	3	2.5	2.0	2.4	2.75	3.5	3.0	3.0	3
		SD	0.9	0.8	1.0	0.8		0.5	0.5	0.8	0.8	
4	Elaborate	M	2.7	2.7	2.5	2.5	2.6	3.0	3.2	3.0	2.75	3
		SD	0.5	0.5	0.5	0.5		0.8	0.9	0.8	0.9	
5	Evaluate	M	3.0	3.5	2.0	2.5	2.75	3.5	3.5	2.75	2.75	3.12
		SD	0.8	0.6	0.8	0.6		0.6	0.6	0.5	0.5	

Note: M → Mean; SD → Standard Deviation; T → Teacher

Table 3 Means rankings of the performance of teachers from four different schools in each phase of the 5Es instructional model

No.	Phases	M& SD	Lesson 1 Sc-A	Sc-B	Sc-C	Sc-D	Overall Mean	Lesson 2 Sc-A	Sc-B	Sc-C	Sc-D	Overall Mean
1	Engage	M	2.0	2.7	2.25	2.5	.3	3.0	3.25	3.25	3.5	3.25
		SD	0.8	1.3	1	1.3		0.8	1.0	1.0	0.6	
2	Explore	M	2.3	2.5	2.0	1.75	2.1	3.0	3.5	2.75	3.0	3.06
		SD	0.9	0.6	1.16	0.5		0.8	1.0	0.5	0.8	
3	Explain	M	2.25	2.5	2.7	2.3	2.4	3.0	3.25	2.75	3.0	3
		SD	1	1.3	0.9	0.9		0.8	1.0	1.3	0.8	
4	Elaborate	M	2.25	2.5	2.25	2.25	2.3	3.0	3.0	3.3	2.75	3.6
		SD	0.5	0.6	0.96	0.9		0.8	0.8	0.9	0.5	
5	Evaluate	M	2.0	1.6	2.0	2.0	1.9	3.0	3.0	2.6	3	2.9
		SD	1.0	0.6	0.0	1.0		1.5	1.0	1.1	5.1	

Note: M → Mean; SD → Standard Deviation; Sc → School

On the other hand, results (Table 2 & 3) revealed that if teachers were equipped with adequate and enough training on IBL, this would greatly contribute to effective implementation and, later, to better involvement and participation of learners, which would improve performance. The data in Tables 2 and 3 are supported by teachers' positive attitudes towards the effectiveness of the IBL in biology teaching, specifically cell division (Table 4)

Teachers' perspectives on the use of the IBL in teaching and learning cell division

Findings from the questionnaire revealed that the training equipped most teachers with the skills to use IBL while they are teaching. Most teachers (80%) positively agreed that the IBL method reduced absent-minded learners by making learners more interested in the learning process. Furthermore, teachers reported that the IBL encouraged learners to create knowledge rather than memorize it. Others reported that the IBL can be used to help learners discover and remove misconceptions. For example, one teacher reported that before the use of the IBL, learners understood daughter and mother cells as the cells having the female sex. Through the IBL, they reported that being called mother or brother doesn't have anything to do with sex. Other teachers reported that since the time they started using the IBL method, the class attendance has been regular compared to before. Referring to the observed changes, all teachers confirmed that they are going to continue using the IBL while teaching biology. Their perceptions of the effectiveness of the IBL are detailed in Table 4.

Table 4 Teachers' perceptions on the effectiveness of the inquiry-based learning (IBL)

Items	SA (%)	A (%)	N (%)	D (%)	SD (%)
1. IBL can help your learners to understand the concept matter	10	60	10	10	10
2. IBL teaching methods allows learners to connect cell division with real life	20	70	0	10	0
3. I prefer to use IBL in all topics that I teach because it is a productive teaching method	80	20	0	0	0
4. IBL encourages learners to be more actively engaged in teaching and learning process	20	60	0	20	0
5. It offers the opportunities for learners to share their prior knowledge	10	90	0	0	0
6. IBL reduces the number of absent-minded learners	50	30	10	10	0
7. IBL helps my learners to create new knowledge rather than memorizing the existed one	80	20	0	0	0
8. IBL encourages my learners to ask questions	30	70	0	0	0
9. IBL piques the curiosity of learners that helps them to deepen their understanding	40	50	0	10	0
10. IBL helps learners to be more independent in their learning and to reach their goals	30	60	0	10	0

Discussion

IBL and the teaching and learning of biology

Findings of this study indicated that all teachers could partially use the IBL as some phases could be observed in the first lesson observation. In addition, differences in the implementation of the IBL were observed among teachers. This is due to the difference in qualification as well as teaching experience and teachers' beliefs about the IBL method, as most teachers believe that the use of the IBL is a difficult teaching method that may take a long time (Silm et al., 2017). The attitude change after the training is a sign that when teachers get training on a new teaching method, they can increase the willingness to implement leant skills (Capps & Crawford, 2013).

In this regard, continuous professional trainings development may be the key for teachers to be able to innovate. A study indicated that through training, teachers may change beliefs related to a new teaching method and then focus on its contribution to attaining the desired objectives (Ramnarain & Hlatswayo, 2018). The findings of another study indicated that the training may help teachers appreciate and use the 5Es instructional model (Duran & Duran, 2004). The 5Es were seen as a guide for teachers in preparing lessons in a way that could yield desired skills and attitudes among learners. Further, it pushed learners to be independent in their learning as they were showing the willingness to participate in classroom activities and not wait for answers from teachers. This was supported by Machemer & Crawford (2007), who argued that the active learning method helps learners to be the main actors in the learning process.

The active participation of learners found in this study is also in line with the study of (Madden, 2011). The author showed that

through the IBL lesson, learners have a chance to share ideas, and this could enhance collaborative learning through which communication skills are improved, as well as the ability to answer various activities related to the learnt topic and then improve performance. In the IBL, learners are producers of knowledge instead of knowledge consumers (Cairns, 2019). Furthermore, the IBL reduces absent-minded learners where it makes them more interested in the lesson. This was observed during the time where most learners could raise their hands to express and share with others' ideas on the given task. This was enhanced by the effective use of teaching and learning materials that were manipulated by learners, helped by the teacher.

The role of the IBL to improve teaching and learning biology

The IBL was also seen as an effective teaching method that allows teachers to collaborate with learners while they are building knowledge. For example, the literature (Crawford, 2000 ; Marx et al., 2004 ;Palmer, 2009; Debbie, 2004) demonstrated that a teaching method in which the teacher collaborates with learners in the learning process motivates learners. This is enhanced by the time given to learners to share previous knowledge, as they do not come with an empty mind (Palmer, 2009). Additionally, the respectful relationship was emphasized so that learners work as a single unit, which in turn encourages learners to ask questions for better learning and hence achieve the learning objectives (Madden, 2011). Further, he argued that group assignments greatly motivate learners as they help each other to better understand the content in a collective manner.

The IBL was also seen as the best tool that a teacher could use for learners' better performance as they were providing correct answers to asked questions, sharing good ideas in the learning process, and the majority of them got above 65% in a given written assessment during the last 10 minutes of the lesson. This is because, through the IBL, the teacher becomes able to assess whether or not learners have attained desired learning objectives as it was supported by the findings of the study conducted by (Duran & Duran, 2004), which showed that the IBL helps teachers to assess particular skills in learners. For Gormally et al., (2009), the IBL elicited the learners' confidence in the learning of science. Further, Abdi (2014) argued that learners taught by using the IBL attain better achievements than those taught by the lecture teaching method.

Teachers' perspectives on the use of the IBL in teaching and learning cell division

In addition, most teachers had knowledge of cell division, but they failed to deliver it through a teaching method that involved learners and helped them understand the subject content. Therefore, there is a need for training on pedagogical knowledge and skills to help teachers get the skills to innovate in teaching practice. This was supported by Guerriero (2013), who argued that in addition to content knowledge, teachers need to be equipped with adequate skills related to the methodology. Further, Ulferts, (2019) argued that having the content is not enough for teachers to effectively teach. Therefore, we cannot ignore the quality of teaching methodology to help both teachers and learners meet the aims of education. Hence, both pedagogical and content knowledge have a more positive impact on learners' performance.

In addition, the importance of teaching and learning materials was also highlighted in this study. For teachers who used audio-visual techniques, one laptop was not efficient, and speakers were needed to help

learners to listen the content of the video. Therefore, schools need to be equipped with adequate and enough teaching materials so that learners can be able to learn effectively. The most needed materials include the internet for virtual learning, textbooks, charts, and models, as indicated in another study (Ismail, 2014). Then, for the IBL to be effective, the classroom must be enriched with learning resources that stimulate learners to learn. This will direct learners to explore scientific knowledge and to deepen their understanding, which leads to a better performance.

Further, results of this study indicated that most teachers have a positive attitude toward applying the IBL while teaching. However, they reported heavy workload as a barrier to always using the IBL. This was also raised by teachers in other (Kang & Keinonen, 2006; Trautmann et al., 2004), w argued that most teachers do not use the IBL because it creates extra work and needs more time for preparation.

Conclusion and Recommendations

The use of the IBL in teaching and learning biology is a successful teaching method. Through the inquiry-based lesson, most learners developed positive behaviors that led to better achievements. Findings from the study showed that the training is essential and motivates teachers to implement the new teaching method. It helps them to change their minds, and their perceptions show that they are committed to continuing the implementation of the IBL at school level. In addition to this, the IBL stimulated learners to develop positive behaviors and perform well. These behaviors include active participation in the classroom, motivation for asking questions, sharing opinions, showing interest, and trying to relate the learned subject content to the real world.

We also conclude that the training develops confidence for teachers and equips them with the ability to use inquiry in teaching practices. In addition, collaborative learning for teachers improves the use of inquiry-based learning while teaching. We recommend further studies to verify the findings of this study on the extended sample size.

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Appendices

Appendix 1: Learners' observation checklist

5E Phases	Learners' activities		Ranks			
			Excellent (4)	Good (3)	Fair (2)	Poor (1)
Engage	1	Learners answer questions asked by teacher				
	2	Draw conclusions based on observation				
	3	Ask questions of curiosity				
	4	Express their understanding about the topic under the study				
Explore	5	Sharing ideas in small groups				
	6	Explain their thinking				
	7	Provide explanation in their own words				
	8	Recreate information				
	9	Prove their answers				
Explain	10	Referring to previous activities provide answers to other related questions				
	11	Demonstrate what they understand on the concept under study.				
	12	Listen to others' explanation				
	13	Try to understand teacher's explanations				
Elaborate	14	Apply learnt skills in new but similar situation				
	15	Sharing ideas with peer for better understanding				
	16	Use previous knowledge to:				
		To ask questions				
		To propose solutions				
		To Record explanations in their notebooks				
		Make decisions				
Evaluate	17	Answer open-ended questions based on prior explanations				
	18	Demonstrate their understandings				
	19	Ask questions that encourage future investigations				

Appendix 2: Teacher's observation checklist

5Es Phases	№	Teacher's activity	Ranks			
			Excellent (4)	Good (3)	Fair (2)	Poor (1)
Engage	1	Ask questions that help him/her to know learners' prior knowledge and knowledge gaps				
	2	Providing to learner's time for expressing their opinions about the topic				
	3	Introduce the topic in the manner that capture learners' interest toward the lesson				
	4	Asks short questions that provoke curiosity				
Explore	5	Provide activities that direct learners to explore new ideas and asking new questions				
	6	Guide learners indirectly				
	7	Teacher guides learners to get deep understanding of the concept				
	8	Initiates activity and allow learners to discuss				
	9	Offers to learner's time to present their understanding				
Explain	10	Asks learners to share what they discussed on during exploration				
	11	Offers to learners teaching aids like books in order to increase their understanding				
	12	Allow learners to provide their understanding about new concept				
	13	Explain the concept explicitly				
Elaborate	14	Asks challenged questions that direct learners to think deeply				
	15	Provides additional activities to learners that require them to apply their understanding				
	16	Helps learners to summarize the key points				
	17	Encourage learners in discussion and responds to questions raised by learners				
Evaluate	18	Encourage learners to assess their abilities				
	19	Provides assessment (formative or summative				
	20	Allow learners to reflect and evaluate their own understanding during teaching and learning process				
	21	Assess learners understanding and provide suggestions to them				