



Teachers' Perceptions of Inquiry-based Learning in Science Education: A Case of Selected Secondary Schools in Kirehe District, Rwanda

Jean Nepomuscene Twahirwa

Orcid: <https://orcid.org/0000-0001-6162-5758>

African Centre of Excellence for Innovative Teaching and Learning Mathematics and Science, University of Rwanda

Email: jeannepomuscenetwahirwa@gmail.com

Celestin Ntivuguruzwa, PhD

Orcid: <https://orcid.org/0000-0001-6258-4054>

African Centre of Excellence for Innovative Teaching and Learning Mathematics and Science, University of Rwanda

Email: ntivuguruzwacelestin@gmail.com

Etienne Twizeyimana

Orcid: <https://orcid.org/0000-0003-3259-3480>

Department of Educational Management and Curriculum Studies, Mount Kenya University, Rwanda

Email: etienne.twizeyimana@yahoo.com

Jeannette Nyirahagenimana

Orcid: <https://orcid.org/0000-0002-1665-3327>

African Centre of Excellence for Innovative Teaching and Learning Mathematics and Science, University of Rwanda

Email: hageniJean@gmail.com

Corresponding author: jeannepomuscenetwahirwa@gmail.com

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Abstract: This study sought to establish teachers' reflections on the role of inquiry-based learning in science education. The study was quantitative in nature and used the descriptive research design. Data was gathered through a questionnaire containing closed ended items. Respondents were eighty-two science teachers from secondary schools in Kirehe District. It is concluded that the choice of appropriate teaching and learning approaches influences understanding in science education. Inquiry-based learning is effective for acquisition of practical skills and development of higher order thinking skills. However, shortage of continuous professional development impedes teachers' implementation of the inquiry-based learning. The use of inquiry-based learning serves as a promising learning method to enhance learners' understanding. It is recommended that school administrators should understand the 5-E model that governs the inquiry-based learning as one of the best teaching and learning approaches and collaborate with teachers to find out means and strategies that may stimulate the implementation of new teaching and learning approaches in science education. School administrators should regularly organize internal workshops and training of teachers on teaching and learning approaches.

Keywords: Inquiry-based learning; science education; active learning; science teachers.

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Introduction

The emergence of new teaching modalities in the 21st century has significantly influenced practices in various sectors of learning. A study conducted by Anjarwani, Doyin and Indiatmoko, (2020) indicated that a suitable learning model follows learner-centered teaching techniques. A study by Owens and Hite (2020) and Simanjuntak and Silalahi (2022) argued that the use of problem-based learning models, discovery-learning models and inquiry-based learning (IBL) models have been considered as effective methods in teaching and learning science subjects.

The process of acquiring scientific concepts and principles involves the tremendous effort of school stakeholders with the teacher serving the core function as the bridge of knowledge and skills transfer. IBL has been effective in promoting positive attitudes of students in biology and other related sciences coupled with an enhanced understanding of complex concepts (Sandika & Fitrihidajati, 2018). Research conducted by Akinoğlu and Tandoğan (2007) asserted that during the learning process, students acquire concepts, scientific skills and attitudes when active participation is incorporated into the lesson. Whilst delivering content in a passive learning environment has been seen as ineffective because teachers are perceived as expert and knowledge producers and do not take into account the students' needs and interest during the teaching and learning process (Markowitz, Laha, Perone, Pea & Bailenson, 2018).

In inquiry-based science education, children become engaged in many of the activities and thinking processes that scientists use to produce new knowledge (Husni, 2020). Ongoing improvement in science education encourages teachers to integrate inquiry-based learning approaches in teaching and learning instead of relying on traditional teacher-centered approaches. With the inquiry-based methods, students are equipped with the necessary skills to cope with real problems in society. According to Secker (2002), the inquiry process has the following features: It engages students' interest in science, it provides opportunities for students to use appropriate laboratory techniques to collect evidence which requires students to solve problems using logic and evidence; it encourages students to conduct further study to develop more elaborate explanations and it emphasizes

the importance of writing scientific explanations based on evidence.

Inquiry-based learning is one of the learning modalities that encompass essential elements of deep learning. In this approach, the process of acquiring science skills can be enabled followed by a high level of critical thinking. The Inquiry-based learning has elements of constructivism theory in which interactive learning is observed. The learner should be at the center of learning and in constructing own knowledge and skills under the instructor's guidance (Gilakjani, Leong and Ismail (2013). In this context, the science lesson becomes meaningful when learners actively apply the existing knowledge and experiences to discover and construct new facts, knowledge and skills under different facilitations offered by teachers based on the learner's level, age and interest (Zain 2018).

Approach, Resources and Motivation

Delivering instruction through traditional teaching methods, specifically through the expository teaching method, commonly known as lecturing, could not significantly facilitate students to acquire a deep understanding of concepts and principles in science subjects (Raja, 2018). Furthermore, in the traditional teaching approach, learners receive information and thus make them less confident in their ability to discover new information after the classroom sessions. Therefore, learners are uninterested and unmotivated with questioning while the course being delivered, which results in poor academic performance (Eyenaka, et al. 2013).

Additionally, uncondusive learning environment and inadequate support may prevent learners from understanding the connection between science, mathematics and real-life experiences as a result of poor performance as referenced by Banerjee (2016). According to Ndirangu (2017), science subjects become enjoyable and meaningful when the teaching and learning process involves experiments, practical problem-solving tasks, collaboration, creativity and innovation among learners as well as teachers as facilitators.

To cope with the needs of learners, education systems should therefore adopt learner-centered approaches that encourage self-confidence, creativity and innovation through an interactive environment such that students can learn at their own pace under the teacher's guidance. The

inquiry-based learning approach has been regarded as the long-term solution that could enhance understanding through empowering the student's quiddity to discover the relationship between science and everyday situations. The inquiry-based learning approach has no definite and known explanation, but researchers have attempted to explain it. Mehmood, Parvee and Dahar (2019) defined the inquiry-based learning as a learner-centered methodology that encourages the use of the 5-E (engage, explore, explain, elaborate and evaluate) model through active social learning. In this approach, learners work diligently, thus helping them build knowledge with the help of a teacher as referenced by Priawasana and Muis (2021). To support the learners, the teacher provides instructions, necessary tools, questions related to the concepts and then the job is left to the learner who has the responsibility to deal with the matter at hand (Gunduz & Hursen(2015).

Paybacks of Inquiry-Based Learning

The dedication of teachers in their educational careers is a major step in developing critical thinking and a deeper understanding of learners in science through the inquiry based learning. Ural (2016) stated that inquiry-based learning encourages the use of open-ended tasks and practical activities which enhance inquiry skills, retention rate and applicability of science in real-life. Learning by doing and construction of own understanding are enhanced through inquiry tasks, which boosts conceptualization, confidences and critical thinking in learners (Khalaf, Zin & Bt, 2018). Therefore, inquiry-based learning approach involves experimental and practical work that connects simultaneously the theory and practices which in turn helps to capture the learner's attention and concentration during science content delivery.

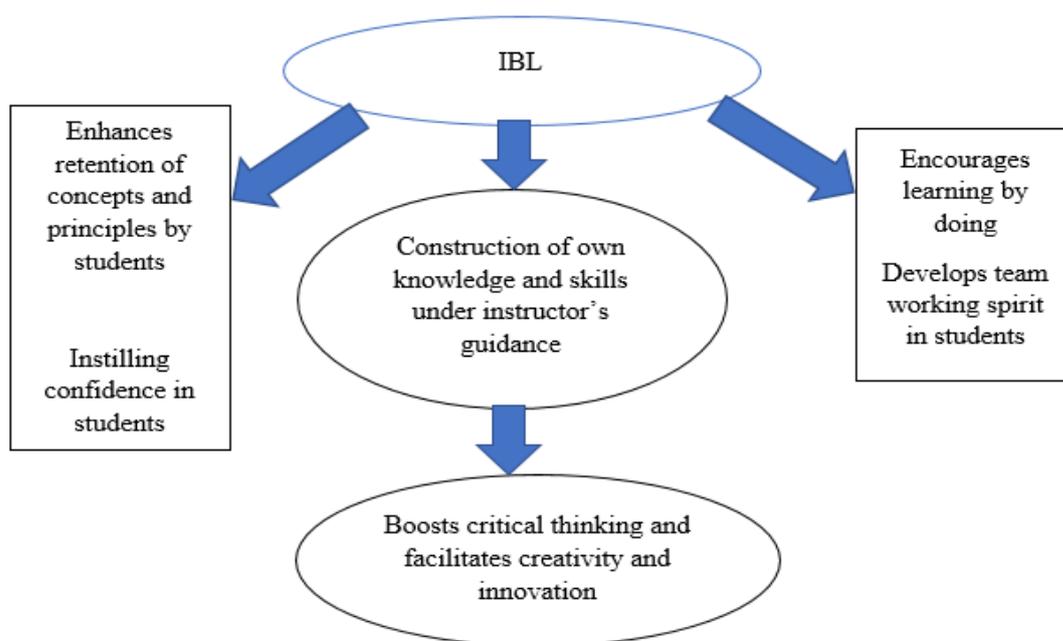


Figure 1: Overview of some advantages of inquiry-based learning approach

Learners' Attitudes toward Science Subjects

To enhance scientific reasoning, enjoyment and right attitudes, there is a need to create a welcoming guided inquiry environment. In a study undertaken by Musengimana, Kampire and Ntawiha (2021), there is no interests, internal confidence toward concepts in science when there are unfavorable or negative attitudes. According to Osborne, Simon and Collins (2003), the origin of many learners' negative attitudes is due to disliking of the subjects, low grades and

dislike of science teachers. Mushinzimana and de la Croix Sinaruguliye (2016) displayed that the negative attitude reduces the interests and concentration which in turn affects the efficacy of memory to store and retrieve the information, hence yielding the worst academic performance in science assessments. Therefore, the academic performance in science could be upgraded by ensuring that students' attitude toward guided inquiry learning approach is positive.

Teaching and Learning Resources

Fried (2011) defines teaching and learning as a process that can bring about physical, emotional, social and cognitive change. A study conducted by Sephania, Too and Kipng'etich (2017) asserted that education without adequate learning facilities and infrastructures could not instill in learners adequate knowledge and practical skills essential to understanding science. According to Akuma and Callaghan (2016), even if students are taught by a highly qualified teacher, lack of practical tools is a major obstacle because science is abstract and it needs concrete resources to connect with everyday life. A study conducted by Mupa and Chinooneka (2019) listed some factors that may hinder effective teaching and learning. Inability to manage time was taken as a factor that may hinder the smoothness of effective teaching because if a learner is not given the lesson on time, he or she will have a psychological impact which in turn may have serious effects on learners' understanding in science. Another factor is related to inadequate instructional resources including laboratories, textbooks, libraries, furniture and ICT equipment which make the students less aware of the importance of science and is more problematic when the teacher lacks pedagogical skills. Another factor regards inexperienced teachers.

Innovation and Creativity

Innovation can be defined as ways of thinking something new, which can positively impact the functioning of the engaging activities when effectively implemented. Creativity is a product of innovation as referenced by Baptista et al (2015). Research confirms that teaching that encompasses innovation and creativity increases thinking and essential skills that support one to survive permanently in the society Rif'at, Wati and Suyidno (2020). Valk, Rashi and Elder (2010) stated that majority of teachers do not have adequate teaching materials and infrastructures as a result of relying on an outdated and the expired method known as the lecturing method which does not offer the chance for learners to build autonomously creative scientific and collaborative skills. Teachers with no creativity lacks many skills including discovery skills, problem-solving skill, imagination skills and technical skills that can be used to implement various methods including the project-based method, cooperative method, exploration method and inquiry-based learning method. Therefore,

the lack of innovation and creativity will mainly hamper the effective enactment of a guided inquiry-based learning approach due to the incompetence and discretion of the teacher in the preparation of related courses with the age of learners.

Language Barriers

The effective implementation of IBL in science education requires the facilitator to be proficient, possessing strong communication skills. Henderson and Wellington (1998) asserted that Listening and speaking skills in academic environment are the key to enhancing students' ability to develop and construct meaningful learning. In addition, the lack of communication skills by facilitators could hinder the use of learner-centered methodologies which comprise higher-order thinking skills in science sessions. According to Kagwesage (2013), low level of proficiency in English undermines teachers as primary implementers of teaching and learning approaches.

Inability to Work Independently

Compared with other methods used in education, the inquiry-based learning approach was selected to be the responsive to enhance the learner's internalization of concepts, mainly in science education Husni (2020). Furthermore, this method qualifies to promote individual learning, which seems to be robust on the side of learners in the learning process because learners are responsible for fully constructing the meaning of concepts before formal guiding or explanation. The effective use of this approach involves an ICT part that helps in the exploration process. According to Adiguna and Sutapa (2019), most learners in African countries, including Rwanda are ICT illiterate. This problem does not encourage discovery and exploration process because of lacking the efficacy on the learner's side to construct their knowledge autonomously even when the ICT resources are available.

The following set of questions was formulated to direct the researcher throughout the whole process of the study.

1. What is the perception of teachers on the usefulness of the IBL approach in the teaching and learning process?
2. What is teachers' Perception regarding the IBL approach?

3. What is the perception of teachers on difficulties encountered in the use of IBL approach?

Methodology

Research Design

The study adopted descriptive research design where numerical data were gathered among secondary school science teachers through data collection. The instrument utilized in the study was secondary school science teachers' questionnaires (3STQ) containing closed ended items designed and disseminated in the form of a link using communication platforms such as WhatsApp and emails to the science teachers. These questionnaires were designed intentionally to get teachers' insights and perceptions about IBL when incorporated properly in science education. Data was analyzed through descriptive statistics.

Population and Sampling

The study was composed of 82 science teachers purposely selected from 46 secondary schools in Kirehe District based on their expertise in teaching science subjects. The researchers ensured that their views addressed research questions. Among the sampled 82 science secondary school teachers, 70 were holders of bachelor's degree while 12 were holders of A1 diplomas. All dispatched questionnaires were returned, analyzed and kept for further steps.

Data Collection Procedures

The researchers received the ethical approval from the directorates of research, ACEITLMS/UR-CE that was submitted to the Kirehe District to authorize the research. In the three days waiting for the feedback from the district, the researchers presented the questionnaires having a five-point Likert scale to three experts in the University of Rwanda, College of education for the sake of assuring validity of the instruments. Based on their impressions, 5 among 20 items in three questionnaires were removed, remaining with 15 harmonized items.

Thereafter, various steps were set and followed during the data collection process. In the first step, the researchers consulted a few science teachers to help obtain their colleague's emails and phone numbers or WhatsApp. In the second step, after receiving their contacts, an introduction letter and the district authorized letter were handled concurrently to the eighty-two science teachers who included 30 physics teachers, 27 chemistry teachers and 25 biology teachers. All targeted study participants showed a positive impression, appreciated the rationale of IBL and accepted to participate freely in the research. In the third step, the researchers designed and disseminated an online consent form to the eighty-two participants using communication platforms such as email and WhatsApp to be sure of their availabilities and voluntarily participation.

The fourth step was the verification of signed consent forms. Thereafter, the researchers administered an online designed survey in a form of a link using the aforementioned channels for the science teachers to detect their perceptions when IBL is integrated in science education. In the last step, the researchers checked the google form to see participants' responses. The whole process of the data collection took four months.

Results and Discussions

Demographics of Respondents

The study comprised 60 (73.2%) male and 22 (26.8%) female secondary school science teachers, with their ages ranging from 20-30 and 30-40 with 62.2% and 37.8% respectively. The study participants comprised 12 A1 diplomas and 70 bachelor's degree holders, corresponding to 14.6% and 85.4%, respectively. Among study participants, 26 were science teachers in the ordinary level while 56 were science teachers in the advanced level, corresponding to 31.7% and 68.3%, respectively.

Table 1: Demographic description of study participants

Gender	F & %	Age range	F & %	Qualification	F & %
Male	60 (73.2)	20-30	51 (62.2)	Diploma (A1)	12 (14.6)
Female	22 (26.8)	30-40	31 (37.8)	Bachelor's degree (A0)	70 (85.4)
Taught level	F & %	Specialization	F & %		
Lower secondary	26 (31.7)	Biology	25 (30.5)		
Upper secondary	56 (68.3)	Physics	30 (36.6)		
		Chemistry	27 (32.9)		

Table 2: Teachers' Perception about the Usefulness of Inquiry-based Learning

Inquiry-based learning teachers' usage questionnaire items	S. D	D	N	A	S. A	Total
	Frequencies and percentages					
IBL encourages active participation and collaboration in science education		8 (9.8)		42 (51.2)	32 (39.0)	82 (100)
IBL instills confidence in the learner				20 (24.4)	62 (75.6)	82 (100)
IBL encourages critical thinking, creativity, and innovation.				27 (32.9)	55 (67.1)	82 (100)
IBL encourages the use of open-ended tasks and practical activities that enhances retention rate.				60 (73)	22 (27)	82 (100)
IBL encourages learning by doing and learner's participation in designing own learning experiences.	4 (5.0)		7 (8.0)	41 (50.0)	30 (37.0)	82 (100)

S.D: Strongly Disagree; D: Disagree; N: Neutral; A: Agree; S.A: Strongly Agree

Table 3: Difficulties Encountered by Teachers

Teachers' IBL met difficulties questionnaire	S. D	D	N	A	S. A	Total
	Frequencies and Percentages					
Insufficient regular workshop, pieces of professional trainings on teaching and learning methodologies are challenges towards implementation of IBL.				1		
			6 (7.3)	8 (22.0)	58 (70.7)	82 (100)
Inquiry-based learning requires long time to prepare for teachers to facilitate each student during learning process.		5 (6.0)		31 (38)	46 (56.0)	82 (100.0)
Inquiry-based learning encourages the use of the 5-E learning model (Engagement, Exploration, Explanation, Elaboration, and Evaluation) during instruction delivery.			5 (6.0)	36 (44.0)	41 (50.0)	82 (100)
Ineffective cooperation and interaction between teaching staff members impede the implementation of inquiry-based learning in science subjects.		4 (5.0)		62 (75.6)	16 (19.4)	82 (100)
Teaching and learning that incorporates the inquiry tasks require enough materials including but restricted to the computer, infrastructures, libraries, and equipped laboratories.			2 (2.4)	49 (59.6)	31 (38.0)	82 (100)
The negative attitude of the teacher, inadequate skills of English, lack of creativity and innovation leads to the poor implementation of IBL.				6 (7.4)	76 (92.6)	82 (100)

S.D: Strongly Disagree; D: Disagree; N: Neutral; A: Agree; S.A: Strongly Agree

Research Question 1: What is the perception of teachers on the usefulness of the IBL approach in the teaching and learning process?

As shown in Table 2, taking into consideration teachers' perspectives on utilization of the inquiry-based learning in teaching and learning activities, responses obtained from predetermined five assumptions indicate that most of the study participants either agreed or

strongly agreed with the statements, which shows the usefulness of IBL in classroom practices.

This study indicates that the inquiry-based learning approach is of paramount importance in teaching and learning sciences. This is because all procedures followed during the implementation of IBL are centered on the learner and the teacher is considered as the facilitator during the process. The results of this study are in line with those obtained from previous studies (Ruzaman, 2020)

which explained the paradigm of inquiry-based learning as the most useful approach in science education. Through the proper use of inquiry-based learning, learners are expected to construct their knowledge under the guidance of the teacher.

Research Question 2: What is the perception of teachers on difficulties encountered in the use of IBL approach?

With reference to results presented in Table 3, considering difficulties encountered by teachers while trying to engage in the implementation phase of IBL, the majority of participated respondents either agreed or strongly agreed with

the items, with exceptions of low number of participants who remained neutral. These findings indicate the existence of difficulties, which potentially prevent teachers from using IBL confidently.

The findings substantiate those by Kang and Keinonen (2016) that shortage of continuous professional development impedes the implementation of IBL for teachers. Trautmann, MaKinster and Avery (2004) indicated that teachers doubt on their ability to inquiry learning in classroom practices. Ramnarain (2016) established that the absence of professionals trainings, time and insufficient resources affect negatively the proper implementation of IBL.

Table 4: Teachers' Perception Regarding IBL

IBL and learners' understanding questionnaire	S. D	D	N	A	S. A	Total
Frequencies and percentages						
Inquiry-based learning imparts problem-solving skills in learners through higher order thinking activities, which contribute to students' deep understanding of concepts in science subjects.		4 (4.9)		62 (75.6)	16 (19.5)	82 (100)
Inquiry-based learning is one of the learner-centered approaches where learners themselves construct knowledge under the guidance of teachers.			33 (40.2)	49 (59.8)		82 (100)
In an inquiry-based learning environment, the teacher allocates enough time for learners to deeply investigate and explore the tasks assigned using various resources such as textbooks, computers connected to the Internet, learning models and other learning materials.				29 (35.4)	53 (64.6)	82 (100)
Inquiry-based learning helps learners to connect theories to the living situations thus, equipping them with required competencies of the 21 st century.		4 (4.9)		16 (19.5)	62 (75.6)	82 (100)

S.D: Strongly Disagree; D: Disagree; N: Neutral; A: Agree; S.A: Strongly Agree

Research Question 3: What is teachers' Perception regarding the IBL approach?

With respect to findings portrayed in Table 4 regarding teachers' perception toward the IBL approach, a considerable number of respondents agreed or strongly agreed that IBL enhances learners' understanding in physics. The findings in this study explored that IBL facilitates teachers to impart problem-solving skills in learners through higher order thinking activities, which contribute to students' deep understanding of concepts in science subjects. As the learning approach, IBL is a learner-centered methodology through which the learner constructs knowledge under the guidance of the teacher. In addition, IBL environment dictates the teacher to allocate enough time for

learners to deeply investigate and explore the tasks assigned using various learning resources. Lastly, theories in IBL environment are connected to living situations, which forms the bridge to proper acquisition of the required 21st century skills.

The findings are in agreement with findings of previous studies such as that of Alfieri, Brooks, Aldrich, and Tenenbaum (2011) who certified inquiry-based approaches facilitate students to develop systematic practices and to develop high-level intellectual skills. According to Bush, Sieber, Seiler, and Chandler(2017), IBL presents numerous benefits in any teaching and learning environment where students own the whole process of learning from designing to

implementation under the guidance of the teacher acting as the facilitator

Conclusions and Recommendations

Conclusions

It is concluded that the choice of appropriate teaching and learning approaches influences understanding in science education. Interestingly, inquiry-based learning seemed to be effective for acquisition of practical skills and development of higher order thinking skills. However, the shortage of continuous professional development impedes teachers' implementation of the inquiry-based learning. The use of inquiry-based learning serves as a promising learning method to enhance learners' understanding. Effective use of IBL could not be achieved without sufficient regular pieces of in-service trainings on the teaching and learning approach.

Recommendations

To maintain quality education, learners' interest and active participation during the instruction delivery in science subjects, various stakeholders in the education sector should work cooperatively towards the common goal of achieving fruitful outcomes. Stakeholders in education sector such as REB, RIGHT TO PLAY and USAID should provide adequate resources, teaching materials, workshops and training for teachers to ensure that they are creative in teaching sciences. Rwanda Education Board should regularly organize school supervisions to offer advice regarding teaching and learning methods. School administrators should understand the 5-E model that governs the inquiry-based learning as one of the best teaching and learning approaches and collaborate with teachers to find out means and strategies that may stimulate the implementation of new teaching and learning approaches in science education. School administrators should regularly organize internal workshops and training of teachers on teaching and learning approaches. Teachers should be encouraged to use improvised materials in support of the few standard instructional materials available. Finally, teachers should create a conducive environment for students and ensure that interactive learning is taking place for better learning results.

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