Opportunities to Integrate Inquiry-Based Learning in Chemistry Subject: Evidence from Secondary Schools in Tanzania

Baraka Gaitan Luvanga*[1], Wadrine Onael Maro[2] & Selina Thomas Mkimbili[3]
[1&3]Department of Educational Psychology and Curriculum Studies, Mkwawa University College of Education, Iringa-Tanzania
Department of Educational Psychology and Curriculum Studies, University of Dar es Salaam, Dar es Salaam
Corresponding Author*[1]: barakaluvanga@udsm.ac.tz; ORCID ID: https://orcid.org/0000-0002-7471-487X
Email[2]: maro.wadrine@udsm.ac.tz; ORCID ID: https://orcid.org/0000-0001-7399-1747
Email[3]: Selinamkimbili@udsm.ac.tz; ORCID ID: https://orcid.org/0000-0002-6293-4859

Abstract

Inquiry-based learning (IBL) has been adopted globally as a student-centred approach to engage students in critical and innovative thinking. Creating an environment with opportunities for IBL has received little attention due to school contextual challenges. This study explored opportunities for integrating IBL into Chemistry subject. A qualitative research approach and a single case study design were employed. A sample of six teachers and thirty-two students was purposively selected. Data was collected through interviews, Focus Group Discussions (FGDs), classroom observations, and documentary review and analysed thematically. Findings revealed that opportunities for implementing IBL include performing practical activities, conducting discussions and presentations, and questioning and answers. This study recommends continued integration of inquiry activities in learning to cultivate the development of critical thinking skills.

Keywords: *inquiry-based learning, scientific literacy, competencies, critical thinking, problem solving*

DOI: *https://dx.doi.org/10.56279/ped.v42i2.special.8*

Introduction

The call for improved student learning in secondary schools has become a global agenda in preparing students with relevant knowledge, skills and positive attitudes towards personal and national development (Crawford, 2014; Molinero & Belart, 2022; Wheatley, 2018). The process of improving learning is geared toward supporting students to think critically, make informed decisions and solve real-life challenges (Chowdhury, 2018). In developing countries and Tanzania in particular, science education is aimed at helping students acquire scientific knowledge and a broad range of 21st-century skills (Crawford, 2014; Kasuga et al., 2022; Mkimbili, 2022). The skills emphasised include critical thinking, communication, collaboration and creativity (Chu et al., 2017; Tindangen, 2018). For supporting students' mastery of competencies, IBL is considered a powerful strategy to foster students' acquisition of relevant knowledge, skills, and positive attitudes (Chowdhury, 2018; Crawford, 2014; Kibga et al., 2021). The IBL strategy has the potential to transform how students learn by facilitating increased engagement, active learning, and increased responsibility for their own learning (Wheatley, 2018). In this study, IBL is defined as activities that engage students in learning by asking questions, conducting scientific investigations, collecting data as evidence, interpreting, and communicating the results.

Inquiry-based learning in the context of Chemistry subject in Tanzania

Chemistry is one of the science subjects that provide knowledge and skills applicable to various occupations. This study focuses on Chemistry because it connects multiple scientific disciplines and encompasses essential knowledge and skills that graduates can apply in diverse fields, including medicine, industry, and agriculture (Buchanan, 2015). To help students develop the intended competencies in Chemistry, teachers must implement effective instructional practices that actively engage students in learning activities and foster collaboration in constructing knowledge, acquiring relevant skills, and shaping appropriate attitudes. From a social constructivist perspective, inquiry-based classroom practices enhance students' interactions with content and learning resources, facilitating the development of desired skills (Chu et al., 2017).

In Tanzania, the competence-based Chemistry syllabus emphasises the use of constructivist approaches to promote active learning and social construction of knowledge through collaborative works. For example, some of the objectives advocate students designing and performing experiments, acquiring Chemistry skills, knowledge, and principles to solve daily life problems, and appreciating application of the scientific principles and knowledge in the exploitation of natural resources with the conservation of the environment (MOEVT, 2010). In line with the stated objectives, the general expected competencies include the student's demonstrated ability to develop knowledge in Chemistry by doing various activities and experiments, applying Chemistry knowledge, skills and principles to solve daily life problems, using science and technological skills in conserving and making sustainable use of the environment (MOEVT, 2010).

To attain the desired competencies, student-centred teaching strategies have been emphasised for students to actively participate in constructing knowledge and developing the senses of an inquiry mind (MOEVT, 2010; Nzima, 2016). Studies conducted in the Tanzania context have indicated that IBL is not well practised in Tanzania due to contextual challenges (Athumani, 2019; Kinyota, 2020). Scholars also argue that IBL is practised at the lower levels of inquiry due to varied Chemistry teachers' epistemological views towards IBL, consequently, affecting its implementation (Kibga et al., 2021: Kinyota, 2020). Athumani (2019) asserted that students need to learn Chemistry in a continuum of inquiry practices with emphasis on the highest levels. In particular, some studies conducted Tanzania have found that guided inquiry is an effective strategy for enhancing the learning of science compared to unguided inquiry (Mkimbili 2022; Maro, 2013). In guided inquiry, the teacher, materials, and learning environment provide students with learning support to use procedures in conducting investigations (Kinyota, 2020).

Based on these studies, there is limited knowledge on the instructional activities' potential for implementing IBL in Chemistry classrooms in Tanzania. Since previous research indicates practices of inquiry approach at lower levels, further critical analysis of IBL instructional practices is needed to broaden understanding and practices of IBL opportunities through contextual learning activities. This study sets out to explore opportunities for integrating IBL in Chemistry classrooms in the Tanzania context. In such regard, the objective of the study was to *explore Chemistry teachers' and students' instructional strategies employed as opportunities to practice IBL.* In addressing this objective, the study answered the following research question: H*ow do Chemistry teachers' and student's instructional strategies reflect opportunities for practising IBL*? This study provides insights into the need for creating a learning environment that can support the enactment of IBL as one of the student-centred teaching approaches that maximise students' engagement and development of critical thinking and problem-solving skills.

Literature Review and Theoretical Framework

Conceptual literature review

An overview of inquiry-based learning

Inquiry-based learning (IBL) has appeared with increasing frequency for educational reforms in science education over the past century (Artigue & Blomhøj, 2013) indicating a major educational trend. We go back to the origin of inquiry as a pedagogical concept in the work of Dewey (e.g. 1916, 1938. The strategy gained its attention from scientific inquiry practices during science education reforms

(Artigue & Blomhøj, 2013; Crawford, 2014)indicating a major educational trend. We go back to the origin of inquiry as a pedagogical concept in the work of Dewey (e.g. 1916, 1938. IBL is defined by scholars in a variety of forms, contexts and disciplinary fields (Crawford, 2014). For example, Crawford (2014) defined IBL as referring to the practices of involving students in asking questions, carrying out scientific investigations, gathering data, and communicating findings to develop an understanding of the natural world.

Using IBL is encouraged since it is an effective strategy for raising students' motivation in science subjects and increasing their understanding of scientific concepts (Athumani, 2019; Chakim & Andayani, 2021). IBL can also foster students' deep thinking and application of knowledge in real-life settings (Chu et al., 2017). Similarly, the IBL strategy contributes to increasing students' problem-solving skills to become a scientific literacy citizenry capable of addressing the challenges of the 21st century (Athumani, 2019). Learning activities that offer students opportunities to investigate Chemistry phenomena through processes that involve measuring, collecting data, analysing, and evaluating enhance activity-based learning and the development of science process skills (SPS) (Kasuga et al., 2022; Maro, 2013). Activities that prompt students to think through thought-provoking questions and carry out scientific investigations beyond recipe-based information, enable students to explain Chemistry concepts and phenomena at different levels of inquiry (Ibnu & Rahayu., 2020; Tawfik et al., 2020).

The continuum of inquiry

The continuum of inquiry is a series of development stages in learning that determines the level of thinking skills students demonstrate in the acquisition of knowledge and skills (Banchi & Bell, 2008). There are four levels of inquiry through which students can gradually develop critical thinking as they engage in inquiry-oriented activities. The continuum of inquiry includes confirmation, structured, guided and open inquiries as illustrated in Figure 1.

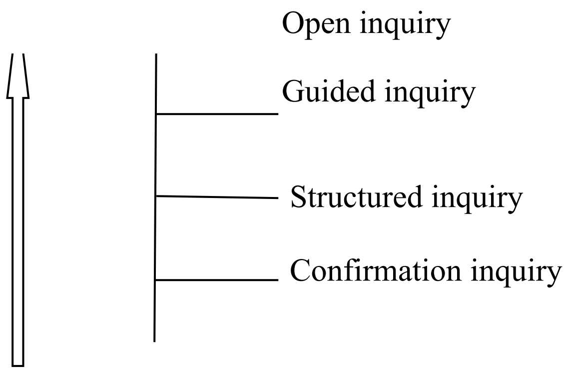

Figure 1: *The Continuum of Inquiry as Adapted from Banchi and Bell (2008)*

Figure 1 presents different levels of the continuum of inquiry learning for students that can be demonstrated as they engage in activities from the lower level of inquiry of confirmation inquiry to open inquiry. In the confirmation inquiry, students verify principles used in learning activities whose outcomes are clearly defined. In the structured inquiry, students investigate the teacher's questions by using arranged procedures. This form of inquiry is useful in supporting students understanding of SPS and acquiring procedural knowledge. For the guided inquiry, the teacher presents questions for students to investigate by using their own designed procedures (Banchi & Bell, 2008). At this level, the teacher acts as a facilitator to guide students in their investigations. In the highest level of open inquiry, students are left free to construct their own questions and procedures for carrying out the investigations (Jiang & McCosmas, 2015). As claimed by Molinero and Belart (2022), students can be engaged in inquiry activities which involve formulating problems, analysing the given procedures and executing investigations. They can further construct models, debate with each other and form coherent arguments. In this regard, instructional activities should offer students opportunities to explore information, collect and analyse data, and construct knowledge at different levels of inquiry.

Features of inquiry-based learning

The National Resource Centre [NRC] in 2007 postulated that the essential features of the IBL involve the presence of scientifically oriented questions, presentation of learning evidence in line with the scientifically oriented questions and presence of explanations developed by students from their evidence to address the scientifically oriented questions. In addition, it includes the presence of evaluation for the explanations that reflect scientific understanding and finally communicating justifications of their proposed explanations (NRC, 2007). When planning for instructional activities, features of IBL can be embedded in learning activities to support systematic investigations and students' learning through scientific inquiry.

Opportunities for inquiry-based learning in chemistry

IBL can be implemented through diverse learning opportunities that develop critical and creative thinking for students. Studies indicate that IBL can be implemented using questions that challenge students thinking, study visits, inquiry-based debates and projects (Shanmugavelu et al., 2020). Other opportunities for IBL encompass outdoor inquiry activities, laboratory practices, solving complex problems, and discovery learning (Hendratmoko et al., 2024). However, in some situations, practical activities performed by students can have little impact on promoting IBL practices due to teachers' insufficient knowledge in organising meaningful learning experiences (Kwitonda et al., 2021). A full utilisation of opportunities for IBL practices is indispensable in improving students' mastery of competencies in various learning domains.

Theoretical framework of the study

The study was underpinned by social constructivism learning theory which is a collaborative form of learning based on students' interaction, active engagement and construction of knowledge in a social setting (Mishra, 2023). The theory was proposed by Levy Vygotsky (1978) proclaiming that social construction of meaning is achieved through collaborative learning, problem-solving techniques and experimentation (Vygotsky, 1978). Therefore, students can actively and collaboratively construct knowledge in a social setting using their previous experiences (Crawford, 2014). In this perspective, interaction, collaboration, and social construction of knowledge are the key tenets of the theory (Mishra, 2023). The theory provides insights into IBL instructional practices that offer opportunities for students to construct knowledge in a collaborative learning environment.

Since the central principle of social constructivism learning theory is to make learning an active process, teachers require a deep understanding of the IBL to enable students' active participants in the process of knowledge construction (Crawford, 2014; Wheatley, 2018). The theory supports IBL to be the student-centred, more engaging and fundamentally participatory strategy. Thus, chemistry teachers need to create learning situations that can evoke students' prior knowledge as they explore learning situations. Based on social constructivism theory, the overall teaching and learning should encourage students to apply scientific processes and support them to be scientifically literate (NRC, 2007). Regarding this theory, effective use of IBL is viewed to promote collaboration, active participation, interactive learning, and self-directed learning in the construction of knowledge at different levels of inquiry.

Methodology

Research approach and design

The study employed a qualitative research approach to explore instructional practices' potential for the implementation of IBL within the participants' perspectives. Creswell and Creswell (2018) contend that the qualitative research approach provides researchers with an opportunity to explore things in their natural setting and make sense of the meaning people present. In this study, the qualitative approach enhanced capturing both teachers' and students' instructional practices potential for IBL in Chemistry. Specifically, a single case study design was employed in the study. Previous studies have utilised a qualitative case study design to conduct thorough investigations into socio-cultural practices, such as FGM in Tarime, Tanzania (Pesambili, 2013; Pesambili & Mkumbo, 2018, 2024). These studies demonstrate the effectiveness of this design in enhancing thorough exploration of the instructional practices, which deemed potential for implementing IBL. As supported by Yin (2018), using a case study allows in-depth insight and a better understanding of an issue under investigation. Therefore, the design brought a deeper insight into opportunities for IBL being explored.

Sample

The study was conducted in four secondary schools in Iringa Municipality and employed a total of 38 participants (6 Chemistry teachers and 32 Chemistry students). Chemistry teachers and students were obtained using purposive sampling to participate in the study. This sampling technique was effective to be used because it focused on selecting Chemistry teachers as key informants with knowledge and expertise. Six Chemistry teachers were included in the study to attain saturation points on teachers' perspectives of IBL practice. The study focused on teachers with adequate experience and proficiency in teaching Chemistry in Form Three classes. Similarly, purposive sampling was used to select Form Three Chemistry students who were well thought-out as motivated to continue pursuing the subject, had good experiences in learning Chemistry, and had future determination to pursue careers based on Chemistry knowledge and skills. However, Form Four Chemistry students were not selected despite their experience due to the time limit following their intense preparation for the final examinations and the pressure to make revisions for the covered chemistry content from Form One to Form Four. By using simple random purposive sampling, eight students were selected from each of the four schools to participate in the FGD because all had an interest and commitment to continue learning Chemistry subject. Therefore, purposive sampling techniques were useful in obtaining participants with characteristics desired to provide credible information.

Data collection tools

Interviews

Semi-structured interviews were conducted with Chemistry teachers to gain a deeper understanding of their perspectives on instructional practices that present opportunities for implementing IBL. An interview guide was used to focus the discussion on potential opportunities for IBL and its relevance in promoting student engagement and skill acquisition. Field notes on issues raised during the interview sessions were taken. Semi-structured interviews were conducted before classroom observation to gain teachers' insight on strategies employed for the practice of IBL. Some of the interview questions asked *how do you make students engaged in the Chemistry lesson. What activities are performed to support learning through IBL?* A total of six interviews, each lasting for approximately 40-45 minutes were conducted.

Observations

Non-participant observations were also used to obtain direct evidence of the eye and experience first-hand information. As asserted by Handley et al (2020), non-participant observation facilitates the collection of data from naturally occurring situations that can highlight disparities between reported practice and actual practice. Studies also indicate that non-participant observation methods provide researchers the opportunity to systematically capture participants' social meanings, everyday activities, and the dynamics of lesson interactions between teachers and students in the classroom (Pesambili, 2020a, 2020b). In this study, non-participant observations enabled the researcher to experience activities potential for implementation of IBL in the classroom setting. This technique also enhanced an insightful understanding of students' collaboration in exploring, investigating, and performing laboratory activities and discussions. Similarly, findings from classroom observation were used for triangulation of information gathered from Chemistry teachers through interviews regarding their practice of IBL. No potential bias was vested in the study due to researchers' beliefs on expected outcomes or participants' characteristics and their responses to questions.

Documentary reviews

A documentary guide was employed to review the Chemistry syllabus and lesson plans and examine the objectives, competencies, strategies, resources and activities carried out by students as scientific practices. The documentary guide consisted of statements that required indication for the presence/absence of specific competencies, activity-oriented plans for the teaching, use of student-centred instructional strategies, and relevant resources for engaging students in the lessons. A documentary guide enabled the collection of the data relevant to the study objective.

Focus group discussions

Focus group discussions (FGDs) were employed for Chemistry students to triangulate information gathered through interviews, observation and documentary analysis. The discussion aimed to examine students' experiences towards IBL based on performed learning activities. Some of the FGD questions were stated as follows: *how does learning through IBL differ from other learning practices? Explain the learning activities you are mostly engaged within the Chemistry lesson.* A total of four FGDs which took an interval of 40 to 50 minutes each were conducted using the English language. In maintaining the trustworthiness of the qualitative data, the study ensured credibility by triangulating information using multiple sources of data including interviews, FGD, observation, and documentary analysis. Thick descriptions of the context and participants ensured the transferability of the findings whereby, thorough descriptions of the research processes enhanced the dependability of the study. Confirmability was achieved by presenting participants' voice quotes made during interviews and FGDs.

Data analysis techniques

The qualitative data were analysed using thematic analysis, a technique designed to identify, organise, and interpret patterns of meaning (themes) across the dataset (Braun & Clarke, 2012). This process involved six stages, as suggested by Braun and Clarke (2006). First, the researcher familiarised themselves with the data by immersing in the textual data, reading and re-reading interview and FGD transcripts, and listening to audio recordings. The second stage involved generating initial codes, which helped in identifying and labelling data relevant to the research question. In the third stage, the researcher searched for themes by actively reviewing the coded data to identify areas of similarity and overlap between codes. The fourth stage required reviewing potential themes by re-reading all the data to ensure that the coded themes meaningfully captured the entire dataset. The fifth stage involved defining and naming themes, selecting extracts to present and analyse. Finally, in the sixth stage, the report was produced by logically and meaningfully connecting the themes (Braun & Clarke, 2006, 2012).

The coding process was conducted by the first author and cross-checked by co-authors by selecting phrases and sentences that form the building blocks for the anticipated themes according to the research objective. The agreed coded information was benchmarked in view of the objective. Observation data was thematically coded whereby, field notes collected using a pre-determined observation guide were read repeatedly to capture information for supporting themes. Observation indicators examined teachers' preparedness for the lesson in line with IBL practices and students' engagement in learning by connecting prior knowledge, asking questions, carrying out investigations, collecting and analysing data, interpreting, and drawing conclusions.

Findings and Discussions

This study aimed to explore Chemistry teachers' and students' instructional strategies employed as opportunities for the practice of IBL. Findings revealed that instructional practices demonstrated by both teachers and students to reflect on the potential for the implementation of IBL included performing practical activities, conducting discussions and presentations and questioning and answers. The findings for these themes are presented as follows:

Performing practical activities

The findings of the study revealed that the potential for IBL can be demonstrated when students are engaged in conducting practical activities. For example, through interview, one of the Chemistry teachers (T3) from school A said that:

> I always perform demonstrations and thereafter students use the procedures to perform practical activities in the laboratory. Students interpret procedures and carry out scientific investigations. When students are engaged in performing practical activities on their own, they can improve their way of thinking, analysing and presenting the findings (Interview, Chemistry Teacher T3 at school A).

In addition, a Chemistry teacher (T5) from school A elaborated on the opportunities for Chemistry practical activities in implementing IBL by proclaiming that:

> When performing practical activities, students become creative learners. By doing these activities on their own, students develop curiosity and can construct new information on specific Chemistry concepts and relate its application to their real-life situations (Interview, Chemistry Teacher T5 at school A).

Findings from teachers' responses demonstrate that practical activities are deemed essentially opportunities for the implementation of IBL. As asserted by Chemistry teacher (T3) responses, when students are engaged in scientific investigations, they can think about given procedures, perform activities, record data, analyse, interpret and present the findings. These skills are considered important in increasing students' critical thinking. As voiced by the Chemistry teacher (T5), when students perform practical activities, they increase chances for the occurrence of IBL and develop curiosity and the ability to construct and apply the acquired knowledge in real-life situations. Engaging students in practical activities is likely to promote the development of SPS and critical thinking skills.

Findings from Chemistry teachers' interviews on the potential of practical activities in implementing IBL were also evidenced by students through FGD. For example, a student (S6) from school C said that:

> ……. we mostly performed practical work. For example, in the preparation of Oxygen, the teacher demonstrated first and a few of us repeated the same demonstration in front of the class for our fellow students. Thereafter, we performed practicals by ourselves by using the given procedures in a textbook (FGD, student S6 at school C).

In addition, a student (S4) from school A demonstrated an understanding of activities performed in the classroom by saying:

> There are several practical activities that we perform in the learning process. The teacher insists on performing practical activities using scientific steps. For example, when learning the topic of volumetric analysis, the teacher assigned us to prepare all the apparatus required for titration. We identified useful apparatus such as a burette, pipette and beaker. The teacher asked us about the use of each apparatus, then allowed us to read, interpret procedures and conduct practical works in the determination of molar concentration, molar mass, percentage purity, and atomic mass of an element in a given compound (FGD, student S4 at school A).

Findings from students' voices, through FGD elaborate on the potential of practical activities in supporting students' involvement in carrying out scientific investigations. As asserted by the student (S6), teachers use demonstration to guide students in doing practical activities correctly. Following the response by the student (S4), students can engage in learning when they prepare laboratory facilities, interpret procedures and perform practical activities. These findings imply that engagement of students in doing practical activities and exploration of both physical and chemical properties of substances seems to increase opportunities for IBL.

Findings through documentary review revealed an integration of practical activities that offer students opportunities to carry out investigations. For example, findings from teachers' T1, T2, T4 and T6 lesson plans indicated some practical activities to be performed by students. An example of practical activities involves investigating the effects of concentration on the rate of reactions, analysing whether the evolution of carbon dioxide gas (CO_2) from hydrochloric acid (HCl) varies with the sample size of calcium carbonate ($CaCO_3$) and finding out whether Methyl Orange (MO) indicators could be made from locally available hibiscus flowers. The summary of some of the IBL activities planned for students to engage with are presented in Table 1

Table 1

Practical Activities Indicated in the Teachers' Lesson Plans for IBL

Schools	Form	Sub-topic	Investigative activities
A	III	Factors affecting the rate of chemical reaction	Experimenting to investigate the effects of the surface area of $CaCO_3$ on the rate of evolution of CO_2 when added with dilute. HCl
B	III	Acids and bases	Carrying out chemical tests using litmus paper on the presence of acids and bases in mango juice and wood ashes.
C	III	The concept of hardness of water	Performing experiments to investigate the effect of hard water and soft water when washed with soap
D	III	Indicators	Investigation of the presence of MO indicator in flowers by preparing indicators from red, pink and yellow flowers

Table 4.1 highlights the practical activities through which students engaged in investigating Chemistry phenomena, involving various Chemistry concepts. These findings suggest that students can be engaged in different practical activities for active learning to develop curiosity and acquire higher-order thinking skills of analysis, synthesis and evaluation. As evidenced in research findings, engaging students in conducting practical activities to explore, explain and analyse the data obtained from the investigation process enhances the development of critical thinking skills. Similar findings were reported by Yakar and Baykara (2014) that inquiry-based laboratory practices are effective in developing SPS for the students involved in performing practical work. Smallhorn et al (2015) also assert that engaging students in IBL laboratory work promotes a sense of inquiry mind and has measurable impacts both on students' learning outcomes and their satisfaction with learning. In the view of social constructivism theory, practical activities with challenging problems enhance active learning and develop curiosity and

innovative thinking (Kibga et al., 2021; Wheatley, 2018). When students conduct investigations, the overall learning process becomes activity-oriented (Maro, 2013). Putri et al (2021) argue that practical activities foster the use of the SPS and provide opportunities for students to focus on the steps required to complete their investigations in becoming scientifically literate. As asserted by Molinero and Belart (2022), involving students in exploring investigation procedures fosters increased critical thinking and the development of higher-order thinking skills.

Engaging students in practical activities during IBL enhances understanding of both basic and integrated SPS (Crawford, 2014; Kasuga et al., 2022). The presence of well-equipped laboratory facilities in schools can increase opportunities for students to practice IBL by actively participating in scientific investigations, collecting and analysing data and subsequently presenting the findings. However, literature alerts that in some situations, some practical activities can have little impact on the realisation of IBL in a classroom context (Kibga et al., 2021; Kwitonda et al., 2021). Practical activities that rely heavily on factual-based procedures and detailed recipes for student recall have limited potential for fostering IBL (Kwitonda et al., 2021). For example, findings by Pérez and Furman (2016) reveal that, due to a lack of IBL knowledge, most science teachers do prepare practical activities that require students to memorise procedures. This implies that teachers have insufficient skills for innovating practical activities that feature the IBL characteristics. As revealed by Kibga et al (2021), practical activities should aim to promote scientific practices and offer students an avenue for experimenting and developing critical thinking and problem-solving skills. Therefore, Chemistry teachers can design practical activities that create avenues for students to think and carry out scientific investigations at different levels of inquiry in the process of constructing knowledge.

Participating in the discussions and presentations of Chemistry concepts

Findings through interviews, FGDs and classroom observations revealed that discussion and presentation of Chemistry concepts are also potential for the implementation of IBL. For example, one of the Chemistry teachers (T6) from school C held that:

> We have an opportunity to implement inquiry-based learning through discussions. During the discussion, students think about the given questions and share ideas to provide answers according to what they have discussed. After discussion, students explain the concepts learned through a presentation (Interview, Chemistry Teacher T6 at school C).

In addition, a Chemistry teacher (T5) from school A elaborated on the potential of discussion and presentation by asserting that:

> Through inquiry-based learning, I place students into small groups and provide tasks for students to work on. During the discussion, I normally give tasks that require them to think and find how relevant are the concepts to their real life. After discussion and preparing a summary, students make a presentation so that knowledge from both groups can be shared by all students (Interview, Chemistry Teacher T5 at school A).

The quotes presented highlight the learning practices of using discussion and presentation as potential strategies for implementing IBL. According to the responses from the Chemistry teacher (T5), providing opportunities for students to make presentations enhances their ability to share acquired knowledge and recognise the relevance of Chemistry concepts in real-life situations. These findings suggest that when discussions are guided by activities that encourage students to explore, investigate, and construct knowledge, they are more likely to foster IBL, thereby promoting critical thinking and a deeper understanding of concepts.

Findings from the analysis of teachers' schemes of work and lesson plans from schools A, B, C, and D showed discussions and presentations as teachers' common approaches used in teaching and learning. For example, in school C, discussions and presentations enabled students to elaborate on the raw materials for the preparation of ammonia and its corresponding properties. Likewise, findings from classroom observations revealed that students in small groups of 4 to 6 use questions provided by the teacher to carry out discussions and make presentations on different concepts of the subject matter. It was further revealed that students used guiding questions in a lesson for brainstorming and exploring concepts related to specific sub-topics under discussion. For example, at school C, the discussion where the core learning activities for the preparation of ammonia are as shown in the extract of the lesson in Figure 2.

Sub-Topic: Ammonia

Specific Competence:
To enable students have the ability to describe the properties of ammonia

Guiding Questions for Discussion

i. What are the raw materials for the laboratory preparation of ammonia?
ii. Write a balanced chemical equation for the industrial preparation of ammonia on a large scale.
iii. How can you prepare small-scale ammonia in the chemistry laboratory?
iv. State the properties of ammonia

Lesson Development

Stage	Teaching activities	Learning activities
Introduction	Reviewing the previous lesson about Nitrogen through questions and answers	Students should respond to questions by reviewing the lesson about Nitrogen.
New knowledge	Formulating groups and guiding students to discuss the given questions and make presentations.	Students should discuss in groups of six each of the questions and present the answers discussed.
Application	Guide students to explain the chemical test for Ammonia	Students should explain the chemical test and alkaline properties of Ammonia.
Reflection	Summarising the lesson through questions and answers on general properties of Ammonia.	Students should explain the general properties of Ammonia.
Consolidation	Providing questions as a class assignment to name other chemicals used to prepare Ammonia	Students should respond to the questions as a class assignment.

Figure 2: *A lesson extract on the preparation of ammonia at School C*

The lesson extract in Figure 2 shows that discussions and presentations were the strategies used by students in searching for answers to the given questions in the laboratory preparation of ammonia. As evidenced through classroom observations, discussions and presentations coupled with questions and answers strategy were used in reviewing previous lessons, introducing the new lesson, examining new knowledge and summarising the lesson. These findings imply that the engagement of students in explaining and analysing concepts for the preparation of Ammonia is likely to contribute to an increased understanding of concepts and ability to explain Chemistry phenomena in different situations. During FGD with students, similar views emerged to strengthen the potential use of discussions and presentations in the implementation of IBL. For example, one of the students (S7) from school C said that:

> We are involved in the lesson by presenting what we have discussed. When we have a discussion, we share our understanding of the concepts because we differ in thinking. This makes the class active. Any of the students from the group can make a presentation followed by teachers' comment on concepts that needs clarification (FGD, Student S7 at school C).

In addition, the Chemistry student (S6) from school A supported the potential of using group discussion for executing IBL by articulating that:

> We always have group discussions where we share knowledge with other students and one of us presents what we discussed in front of others. This activity enables us to learn many concepts and gives us confidence in explaining what we have learnt (FGD, Student S6 at school A).

Findings from student's perspectives indicate that discussions and making presentations are potential IBL practices in supporting students' thinking, sharing knowledge and building confidence for what they learn. As responded by students (S7), during discussions, the teacher can clarify some concepts for students to have a complete understanding. These findings suggest that discussion and presentations seem to be a suitable opportunity for implementation of IBL by enabling students to engage in explaining, analysing and interpreting information. Creating a learning environment for discussions that align with students' learning experiences is likely to promote students' cognitive skills for working with little guidance. Students' involvement in the discussion that prompts asking questions, investigating and presenting the results of investigations have increased opportunities for the social construction of knowledge. As evidenced in the findings, discussions and presentations guided by inquiry activities offer opportunities for IBL. These findings corroborate those revealed in a study by Tindangen (2018) on an inquiry-based learning model to improve higher-order thinking skills that, discussion and presentations are effective IBL activities in the preparations of scientific reports as students carry out investigations related to specific topics or sub-topics. Discussions foster students' development of higher-order thinking and the ability to generate learning evidence. Learning by integrating inquiry practices in students' discussion, makes easier understanding of concepts and creates curiosity and interest in learning (Chakim & Andayani, 2021; Wheatley, 2018).

Questioning and answers

Findings through interviews with Chemistry teachers revealed that questioning and answers are potential instructional activities for the implementation of IBL. For example, a Chemistry teacher (T3) from school A said that:

> I ask questions to make my students think and share their knowledge during learning. Once the knowledge is shared, I can select any student to respond to the asked questions. Students can also ask and answer questions among themselves to promote their thinking. (Interview, Chemistry Teacher T3 at school A).

In addition, the Chemistry teacher (T4) from school D supported the potential for executing IBL through questioning and answers by saying that:

> The activities that are performed in the class with students include questions and answers. I normally teach them and pose different questions for about five minutes so that they can think and answer those questions (Interview, Chemistry Teacher T4 at school D).

Based on teachers' views, the potential for IBL implementation is enhanced through questioning and answers that can offer students opportunities to think and share knowledge. From the Chemistry teacher's (T3) views, questioning encourages thinking for students.

Findings from classroom observations revealed that questioning and answers were the frequent IBL activities demonstrated by students during the learning process. For example, in one of the Chemistry lessons on the effects of surface area on the rate of reactions, the teacher asked the following questions; *why it is easy to cook chips rather than the whole potato?* In addition, in a sub-topic of factors affecting the position of chemical equilibrium, a student asked; *why other factors such as catalyst and surface area do not affect the position of chemical equilibrium.* Moreover, students asked; *how is the knowledge of chemical equilibrium useful in daily life?* These questions can make students think critically by reflecting on their daily life experiences as they search for answers. These findings affirm that using thought-provoking questions that are more predictive, analytical and evaluative can trigger students' ability to formulate other questions for further investigations.

In the light of the presented findings, students used the teacher's prepared procedures for conducting investigations whereby, the practice of posing questions was demonstrated by both. On such a stance, this study fits into the continuum of inquiry in three levels confirmation, structured, and guided inquiry. The study acts as a driving force in integrating skills for open inquiry into the curriculum to develop students into full inquiry. The findings indicate that using thought-provoking questions to question students can foster critical thinking and support the effective implementation of IBL. Questioning serves as the foundation for students' cognition and thinking during the teaching and learning process. Therefore, it is essential for teachers to understand the theoretical taxonomy of question-asking to guide students' reasoning processes, which is crucial for meaningful learning in IBL (Tawfik et al., 2020). Questioning practices that encourage students to engage in reasoning, gather information, and explain and interpret data contribute to the development of higher-order thinking skills (Crawford, 2014; Santoso et al., 2018). These findings align with those of Ibnu and Rahayu (2020), who argue that questioning is a key driver of students' thinking and an important factor in implementing IBL.

Lombard and Schneider (2013) support that IBL is driven by questions that can promote discussion with peers and the use of authentic resources. Using questions that require students to think critically increases chances for IBL by engaging students in the exploration of the subject matter and the construction of knowledge (Tawfik et al., 2020). Questioning in the classroom helps students to debate on issues and make concrete arguments supported with scientific explanations, consequently, improving their thinking skills. With scaffolding through questioning, students can formulate questions and ask other questions among themselves (Santoso et al., 2018). Encouraging students to ask questions and answer among themselves drives students to conduct authentic investigations.

However, various studies revealed that students struggle with questioning in line with IBL principles, making it hard to develop critical thinking skills (Farahian & Rezaee, 2012; Ibnu & Rahayu, 2020; Santoso et al., 2018). Ineffective questioning techniques are among the reasons for students' failure to ask thoughtful questions (Farahian & Rezaee, 2012). Findings have also indicated that teachers often ask low-cognitive questions with an emphasis on knowledge (Ibnu & Rahayu, 2020; Mustika et al., 2020). Questions that require students to memorise information have little impact on students' critical thinking skills. As revealed by Mustika et al (2020), divergent questions that call for multiple perspectives can stir up the IBL and development of higher-order thinking skills. Findings from these scholars imply that effective questioning in IBL challenges students' thinking to analyse, apply, synthesise and evaluate information. Ensuring questioning is an integral part of IBL, it can contribute to students' increased thinking capabilities. By reflecting on opportunities demonstrated through IBL, the inquiry practice more demonstrated in the course of learning includes posing questions, conducting investigations, collecting data and presenting learning evidence.

Conclusions and Recommendations

This study has found that there are activities conducted in Chemistry classrooms by teachers and students which are the potential for executing IBL involving performing practical activities, conducting discussions and presentations, and questioning and answering. Although studies conducted in Sub-Saharan countries state that IBL is less practised, teachers can increase contextual innovation for the learning activities to support IBL. This study recommends continued integration of inquiry activities in learning to cultivate students' development of critical thinking skills. Moreover, the findings of the study demonstrate that questions and answers are among the opportunities to practice IBL. Further, research can be conducted to examine teachers' competencies in questioning to support IBL practices.

References

Artigue, M., & Blomhøj, M. (2013). Conceptualising inquiry-based education in mathematics. *ZDM*, *45*(6), 797–810. https://doi.org/10.1007/s11858-013-0506-6.

Athumani, J. J. (2019). Assessing knowledge levels of selected integrated science process skills of Morogoro biology secondary students-Tanzania. *International Journal of Science and Research, 8*(9),254-261. https://www.suaire.sua.ac.tz/handle/123456789/2973.

Banchi, H. & Bell, R. (2008). The many levels of inquiry. *Science and Children*, *46*(2), 26-29.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa.

Braun, V., & Clarke, V. (2012). Thematic analysis. *American Psychological Association*, *2,*57-71. https://doi.org/10.1037/13620-004.

Buchanan, M.S., (2015). 'Drugs, religion and chemistry in Tanzania': an interactive seminar for chemistry students. *Chemistry Education Research and Practice*, *16*(3), 552–560. https://doi.org/10.1039/C5RP00009B.

Chakim, L., & Andayani, E. (2021). *Inquiry and discussion methods: interest in students learning*. 5th Asian Education Symposium 2020 (AES 2020), Bandung, Indonesia. https://doi.org/10.2991/assehr.k.210715.054

Chowdhury, R. (2018). *Investigating inquiry-based learning: Teachers perspectives at a k-12 school*. The University of Memphis. https://digitalcommons.memphis.edu/etd/2497.

Chu, S. K. W., Reynolds, R. B., Tavares, N. J., Notari, M., & Lee, C. W. Y. (2017). *21st-century skills development through inquiry-based learning*. Springer. https://doi.org/10.1007/978-981-10-2481-8.

Crawford, B. A. (2014). From inquiry to scientific practices in the science classroom. *In*: Lederman, N. & Abell, S. (Eds.), *Handbook of Research on Science Education*. *Rutledge.*

Creswell, J. W., & Creswell, J. D. (2018). *Research design: qualitative, quantitative, and mixed methods approaches (5th Ed.)*. Sage publications.

Farahian, M., & Rezaee, M. (2012). A case study of an EFL teacher's type of questions: an investigation into classroom interaction. *Procedia-Social and Behavioral Sciences*, *47*, 161-167. https://doi.org/10.1016/j.sbspro.2012.06.631.

Handley, M., Bunn, F., Lynch, J., & Goodman, C. (2020). Using non-participant observation to uncover mechanisms: insights from a realist evaluation. *Evaluation*, *26*(3), 380-393. https://doi.org/10.1177/1356389019869036.

Hendratmoko, A. F., Madlazim, M., Widodo, W., Suyono, S., & Supardi, Z. A. I. (2024). Inquiry and debate in science learning: a potential strategy for improving students' scientific argumentation skills. *International Journal of Education in Mathematics, Science and Technology*, *12*(1), 114-138. https://doi.org/10.46328/ijemst.3152.

Ibnu, S., & Rahayu, S. (2020). The effectiveness of new inquiry-based learning for improving multiple higher-order thinking skills of prospective Chemistry teachers. *European Journal of Educational Research*, *9*(3), 1309-1325. https://doi.org/10.12973/eu-jer.9.3.1309.

Jiang, F., & McComas, W. (2015). The effects of level of openness in inquiry teaching on student science achievement and attitudes: evidence from propensity score analysis with PISA 2006 data. *International Journal of Science Education*, *37*(3), 554-576. https://doi.org/10.1080/09500693.2014.1000426.

Kasuga, W., Maro, W., & Pangani, I. (2022). Effect of problem-based learning on developing science process skills and learning achievement on the topic of safety in our environment. *Journal of Turkish Science Education (TUSED)*, *19*(3), 872–886. https://doi.org/10.36681/tused.2022.154.

Kibga, E. S., Gakuba, E., & Sentongo, J. (2021). Developing students' curiosity through Chemistry hands-on activities: a case of selected community secondary schools in Dar es Salaam, Tanzania. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(5), 1–17. https://doi.org/10.29333/ejmste/10856.

Kinyota, M. (2020). The status of and challenges facing secondary science teaching in Tanzania: a focus on inquiry-based science teaching and the nature of science. *International Journal of Science Education*, *42*(13), 2126 – 2144. https://doi.org/10.1080/09500693.2020.1813348.

Kwitonda, J.D., Sibomana, A., Gakuba, E., & Karegeya, C. (2021). Inquiry-based experimental design for enhancement of teaching and learning of chemistry concepts. *African Journal of Educational Studies in Mathematics and Sciences*, *17*(2), 13-25. DOI: https://dx.doi.org/10.4314/ajesms.v17i2.2.

Lombard, F. E., & Schneider, D. K. (2013). Good student questions in inquiry learning. *Journal of Biological Education*, *47*(3), 166-174. https://doi.org/10.1080/00219266.2013.821749.

Maro, W. (2013). *Design and evaluation of professional development programme to support activity-based Biology teaching and learning in Tanzania secondary schools* [Published PhD thesis]. University of Southampton.

Mishra, N. R. (2023). Constructivist approach to learning: an analysis of pedagogical models of social constructivist learning theory. *Journal of Research and Development*, *6*(01), 22-29.

https://doi.org/10.3126/jrdn.v6i01.55227.

Mkimbili, S. T. (2022). Do biology syllabi provide opportunities for secondary school students to engage with critical thinking skills? *Journal of Biological Education*, *58*(2), 444-459. https://doi.org/10.1080/00219266.2022.2067582.

MoEVT. (2010). *Chemistry syllabus for ordinary secondary education (Forms I-IV)*. Tanzania Institute of Education.

Molinero, M. N., & Belart, Z. S. (2022). Fostering kindergarteners' scientific reasoning in vulnerable settings through dialogic inquiry-based learning. *In: Fostering Inclusion in Education* (pp. 229-243). https://doi.org/10.1007/978-3-031-07492-9_11.

Mustika, N., Nurkamto, J., & Suparno, S. (2020). Influence of questioning techniques in EFL classes on developing students' critical thinking skills. *International Online Journal of Education and Teaching*, *7*(1), 278-287. http://iojet.org/index.php/IOJET/article/view/774.

National Resource Centre. (2007). *Implementing inquiry-based learning.* National Resource Centre, 1-21.

Nzima, I. (2016). *Competence-based curriculum (CBC) in Tanzania: Tutors' understanding and their instructional practices [Published Dissertation]*. Linnaeus University.

Pérez, M. D. C. B., & Furman, M. G. (2016). What is a scientific experiment? The impact of a professional development course on teachers' ability to design an inquiry-based science curriculum. *International Journal of Environmental & Science Education*, *11*(6),1387-1401. doi: https://doi.org/10.12973/ijese.2016.353a.

Pesambili, J. C. (2013). Consequences of female genital mutilation on girls' schooling in Tarime, Tanzania: Voices of the uncircumcised girls on the experiences, problems and coping strategies. *Journal of Education and Practice*, *4*(16), 109–119.

Pesambili, J. C. (2020a). An exploration into the encounter between Indigenous and Western education at Noonkodin School in Eluwai, Monduli, Tanzania. *Compare: A Journal of Comparative and International Education*, *52*(1), 56–74. https://doi.org/10.1080/03057925.2020.1733390.

Pesambili, J. C. (2020b). Exploring the responses to and perspectives on formal education among the Maasai pastoralists in Monduli, Tanzania. *International Journal of Educational Development*, *78*, 1–9. https://doi.org/10.1016/j.ijedudev.2020.102267.

Pesambili, J. C., & Mkumbo, K. A. K. (2018). Implications of female genital mutilation on girls' education and psychological well-being in Tarime, Tanzania. *Journal of Youth Studies*, *21*(8), 1111–1126. https://doi.org/10.1080/13676261.2018.1450969.

Pesambili, J. C., & Mkumbo, K. A. K. (2024). Beyond the surface: unpacking the methodological and ethical challenges of researching into a sensitive female genital mutilation practice. *SN Social Sciences*, *4*(22), 1–20. https://doi.org/10.1007/s43545-023-00822-4.

Putri, L. A., Permanasari, A., Winarno, N., & Ahmad, N. J. (2021). Enhancing students' scientific literacy using virtual lab activity with inquiry-based learning. *Journal of Science Learning*, *4*(2), 173-184. https://doi.org/10.17509/jsl. v4i2.27561.

Santoso, T., Yuanita, L., & Erman, E. (2018). The role of student's critical asking questions in developing student's critical thinking skills. *Journal of Physics: Conference Series*, *953*, 012042. https://doi.org/10.1088/1742-6596/953/1/012042.

Shanmugavelu, G., Balakrishnan, A., Parasuraman, L., Ariffin, K., Kannan, B., & Vadivelu, M. (2020). Inquiry method in the teaching and learning process. *International Journal of Education,8* (3*)*,6-9. https://doi.org/10.34293/education. v8i3.2396.

Smallhorn, M., Young, J., Hunter, N., & Burke Da Silva, K. (2015). Inquiry-based learning to improve student engagement in a large first-year topic. *Student Success*, *6*(2), 65–71. https://doi.org/10.5204/ssj.v6i2.292.

Tawfik, A. A., Graesser, A., Gatewood, J., & Gishbaugher, J. (2020). Role of questions in inquiry-based instruction: towards a design taxonomy for question-asking and implications for design. *Educational Technology Research and Development*, *68*, 653-678. https://doi.org/10.1007/s11423-020-09738-9.

Tindangen, M. (2018). Inquiry-based learning model to improve higher-order thinking skills. *Asian Social Science*, *14*(7), 39-46. https://doi.org/10.5539/ass.v14n7p39.

Vygotsky, L.S. (1978). *Mind in the society: the development of higher psychological process*. Harvard University Press.

Wheatley, K. (2018). Inquiry-based learning: effects on student engagement. *Honors Projects, 417*, 1–27. https://scholarworks.bgsu.edu/honorsprojects/417.

Yakar, Z., & Baykara, H. (2014). Inquiry-based laboratory practices in a science teacher training program. *EURASIA Journal of Mathematics, Science and Technology Education*, *10*(2) 173-183. https://doi.org/10.12973/eurasia.2014.1058a.

Yin, R. K. (2018). *Case study research and applications (6th ed.)*. SAGE Publications.