ADDIS ABABA UNIVERSITY

COLLEGE OF EDUCATION AND LANGUAGE STUDIES

DEPARTMENT OF CURRICULUM AND COMPARATIVE EDUCATION

IMPLEMENTATION OF INQUIRY-BASED LEARNING THROUGH PRACTICAL ACTIVITIES IN GENERAL SCIENCE EDUCATION AMONG THE MIDDLE LEVEL SCHOOLS OF ADDIS ABABA, ETHIOPIA

BY

AZEB BRHANE

A DISSERTATION SUBMITTED TO THE GRADUATE STUDIES OF ADDIS ABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PhD) IN CURRICULUM STUDIES

ADVISOR -DR. SOLOMON AREAYA (ASSOCIATE PROFESSOR)

CO-ADVISOR- DR. MESERET ASSEFA (ASSOCIATE PROFESSOR)

NOVEMBER /2025

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Department of Curriculum and Comparative Education

Declaration

I, the undersigned, declare that this doctoral thesis entitled ***"Implementation of Inquiry-Based Learning through Practical Activities in General Science Education among the Middle Level Schools of Addis Ababa, Ethiopia"*** is my original research work and has been prepared and submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Curriculum Studies**.**

I further affirm that this thesis has not been submitted, either in whole or in part, to any other university or institution for the award of any degree, diploma, or other academic qualification. All sources of information used in this thesis have been properly acknowledged.

Name - Azeb Brhane Gebru

Signature ________________________________

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Abstract

The purpose of this study is to investigate the implementation of inquiry-based learning through practical activities, explore the perception of general science teachers & awareness of students on the inquiry-based learning via practical activities, and identify problems that hinder the implementation of inquiry-based practical activities in general science education in Addis Ababa middle schools. To achieve the purposes of the study, a mixed-method and descriptive design was employed. The study was conducted in Addis Ababa middle schools and data were collected from 120 science teachers, 1587 students, 11 laboratory technicians, and 11 school vice principals. Purposive samplings were used in the selection of the general science subjects and simple random sampling was used to select 22 middle schools, students, laboratory technicians and school vice principals. In addition general science teachers were selected using census sampling or all respondents taken sampling technique. The main instruments of data collection were questionnaire, observation, focus group discussions and interview. Then the quantitative data were analyzed using both descriptive and inferential statistical methods; and the qualitative data were qualitatively analyzed using thematic analysis techniques and narrated qualitatively. The study found that teachers, students, and school administrators regard inquiry-based learning through practical activities as critical and indispensable for increasing the quality of science instruction; yet, the practice of inquiry-based learning practical activities is not well-implemented in the selected schools. As a result, teachers and students in the target middle schools rely heavily on lecture-based approaches to teach general science subjects. Among the major challenges faced in schools are a lack of teachers' professional keenness and practical skills required for effective practice in inquiry-based learning practices, a lack of professionally trained laboratory technicians and principals to facilitate the practice, a lack of student motivation or appropriate guidance for student learning, unfamiliarity with hands-on activities, lack of motivation, and insufficient school authority commitment; and a lack of materials and facilities. Finally, it was recommended that, to enhance the proper practice of inquiry-based learning via practical activities in science disciplines, all educational bodies across the country, as well as the city's educational administration bureau, must step up their efforts. It is critical to promote awareness and transform the attitudes of all educational practitioners toward inquiry-based learning through practical activities, beginning with the early phases of the educational journey, to ensure their consistent development and support, particularly teachers' skills by implementing comprehensive professional development programs focused on inquiry-based learning via practical activities, encouraging teacher collaboration, providing technical support, increasing students engagement by devising strategies to actively involved in practical activities, guiding students during conducting practical activities, science clubs and promote hands-on experiences. Additionally, increase awareness among stakeholders, such as parents, community members, and policymakers, about the significance of inquiry-based science education. This will help in identifying gaps, tracking progress, and making required adjustments to improve effectiveness of different practical activities in science classes. This vow necessitates a collaborative effort to assess the needs of today's youth while also improving teachers' practical skills in educational methodologies and learning in middle schools.

Keywords: Implementation, Science Education, Inquiry-Based Learning, Inquiry-Based Practical Activities (IBPAs).

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Table of Contents

List of Tables

List of Figures

List of Acronyms Used

ANOVA: Analysis of Variance

EGECF: Ethiopian General Education Curriculum Framework

ETP: Education and Training Policy

ESDPs: Education Sector Development Program

FGD: Focus Group Discussion

GEQIP-E: General Education Quality Improvement Program for Equity

GEQIP: General Education Quality Improvement Programs

GTP: Growth and Transformation Program

IBPAs: Inquiry-Based Practical Activities

IBSE: Inquiry Based Science Education

IBL: Inquiry-Based Learning

MoE: Ministry of Education

NEAEA: National Educational Assessment and Examination Agency

NGSS: Next Generation Science Standards

NRC: National Research Council

STEM: Science Technology Engineering and Mathematics

SCORE: Science Community Representing Education

UNESCO: United Nations Educational, Scientific and Cultural Organization

UNESCO-IBE: United Nations Educational, Scientific and Cultural Organization-International Bureau of Education

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the Study

Quality education empowers individuals and societies by promoting active participation in civic life, protection the environmental, enhancing community health, advancing technological innovation, and fostering democratic, social, and economic development (UNESCO, 2015). In today's development agenda, education is widely acknowledged as the cornerstone of sustainable advancement. As nations pursue technological advancement, it is essential to cultivate students' scientific literacy, critical thinking, and ability to apply knowledge through purposeful practical activities (Millar, 2008). Given the increasingly complex demands of society, science education is indispensable for preparing learners to address the real-world challenges.

In a rapidly changing world, science education must go beyond the acquisition of factual knowledge; it must equip students to think critically, solve problems, and engage meaningfully in scientific practices. Consequently, there is sustained international focus on improving educational quality. Current global reform efforts in science education prioritize innovations in teaching and learning, shifting away from traditional methods toward modern instructional strategies emphasizes student outcomes. In this light, it is critical to reflect on current classroom culture, the barriers to student learning, and our assumptions about twenty-first-century learners.

Addressing the teaching and learning challenges in science requires the implementation of modern, student-centered teaching approaches; especially practical activities in which students actively ask questions, analyzing data, collaborate, draw conclusions, and justify their thinking. Research indicates that such approaches can enhance learners' interest in science, deepen their conceptual understanding, and strengthen scientific knowledge while supporting evidence-based decision-making for the national and global development (Valdya, 2003; Sandoval, 2005; Millar & Abrahams, 2009; Crawford, 2014; Beyessa, 2014)

Globally, science education reforms are shifting from teacher-centered pedagogies toward learner-centered approaches which prioritize active engagement, inquiry, creativity, and real-world problem-solving (Bybee, 2013; OECD, 2016). These reforms emphasize constructivist teaching approaches that foster deep learning, critical thinking and integration across Science, Technology, Engineering, and Mathematics (STEM) disciplines via participatory teaching strategies. Among these, Inquiry-Based Learning (IBL) has gained traction as a transformative pedagogical approach that stimulates curiosity, deepens understanding of scientific concepts, and enhances students' scientific reasoning skills, particularly when enacted through practical activities such as observing, questioning, experimenting, and evidence-based reasoning (National Research Council (NRC), 2000; Minner, Levy, & Century, 2010, Furtak et al., 2012).

In the Ethiopian context, major adjustments have been made to improve the delivery of quality science education in alignment with these global trends. The Ministry of Education (MoE) has introduced policy frameworks and programs targeted at enhancing education quality, especially in science and mathematics. These include the Education Sector Development Programs (ESDPs I-V), the General Education Quality Improvement Program for Equity (GEQIP-E), and the Education Development Roadmap (2018-2030); (MoE, 2009, 2018; World Bank, 2017, 2024).

Ethiopia's general education system is structured in to four levels: pre-primary, primary (grades 1-6), middle (grades 7-8), and secondary (grades 9-12). The middle level (grades 7 and 8), marks the end of compulsory education and represents a critical transition, equipping students with foundational scientific knowledge and skills essential for secondary education or vocational engagement (GECF, 2020). The General Education Curriculum Framework (GECF) serves as a comprehensive blueprint for educational transformation in Ethiopia. The framework anchored in principles of equity, inclusiveness, and competency-based learning, it aims to align educational content with national development priorities and learners' needs. The framework emphasizes core competencies across disciplines, including critical thinking, problem-solving, collaboration, communication, creativity, cultural identity, and global citizenship (MoE, 2020, pp. 17-25).

In addition, the Ethiopian general education curriculum framework specifies nine areas of study that should be taught at the different educational levels from pre-primary to grade twelve are:

> The learning areas move from those which are broader at lower levels to ones more specific at higher levels. These learning areas are the following: Language, Mathematics, General Science, Social Science Performing and Visual Arts, Moral and Citizenship Education, Health and Physical Education, Information-communication Technology, Career and Technical Education. (GECF, 2020: 29)

Among these, General Science curriculum plays a vital role in helping students understand the living and physical world. It integrates disciplines to develop students' understanding of matter, energy, and their interactions. It emphasizes scientific inquiry, data analysis, experimentation, and real-world applications through observation, modeling, recording, discussion, and investigation. Across all levels, the curriculum emphasizes practice-oriented education and training in general sciences, integrating career and technical education at the middle school level to teach fundamental competences needed for the workforce (GECF, 2020).

Furthermore, the Ethiopian General Education Curriculum Framework (GECF) underscores the integration of science, technology, and innovation as essential to accomplishing national development goals and fostering student engagement both inside and outside the classroom. Science education is designed to be participatory across all grade levels, emphasizing inquiry-based learning through laboratory work, field visits, problem-solving activities, and the use of ICT and multimedia tools. At the middle level school, the general science syllabi offers an interdisciplinary approach, incorporating Biology, Chemistry, and Physics for fostering environmental awareness, conservation, and to develop broad scientific literacy connected to everyday life supported by practical experiences.

In this context, Inquiry-based learning (IBL) through practical activities has emerged as a highly effective pedagogical approach in science education. This method encourages students to engage in observation, questioning, hypothesis formulation, experimentation, and evidence-based reasoning key processes that mirror scientific practice (Sandoval, 2005; Millar & Abrahams, 2009; NRC, 2000, 2011). Furthermore, Inquiry-Based Learning transforms students from passive recipients of information into active participants in the learning process, fostering deeper conceptual understanding (Crawford, 2014). Scholars, such as Exline (2004) and Donham (2001) also advocate for practical activities with in inquiry-based learning that illustrate how knowledge is generated and the roles played by various stakeholders, including experts, teachers, parents, and society at large. Such activities encourage students to explore their environment and apply sensory information to authentic contexts.

Distinct from traditional laboratory work, this approach emphasizes activities that connect with everyday life and underscores the importance of maintaining high-quality science education to foster a scientifically literate society. The use of practical activities in teaching science is highly emphasized in Ethiopia's policy frameworks. These practical activities include questioning, laboratory tasks, field visits, model-building, and simulations that reflect everyday applications of science (Millar, 2004; Roberts, 2002). The focus is on bridging theory and practice, enabling students to build knowledge via discovery and experience. Effective practical exercises help students form meaningful connections between hands-on experiences and scientific concepts, thereby offering both enlightenment and inspiration (Millar 2004).

At the middle level (grades 7-8), the curriculum promotes the use of the 5E instructional model an approach to enact student-centered participatory teaching method that extends practical activities beyond traditional classroom practices (GECF, 2020; General Science Syllabus, 2021). The 5E model originated in the 1980s from the Biological Sciences Curriculum Study (BSCS) and draws on learning cycle theories from Herbart, Dewey, and the Atkin-Karplus model (Bybee et al., 2006; Bastida-Bastida, 2019; Díaz et al., 2020). According to Bybee and colleagues (2006, 2015), the five phases Engage, Explore, Explain, Elaborate, Evaluate can be adapted flexibly to promote student learning. In the "Engage" phase students' curiosity is awakened; in "Explore" they pose questions, make hypotheses, collect observations and present findings; in "Explain" the findings are discussed; in "Elaborate" students apply knowledge in novel contexts; and in "Evaluate" they reflect on learning, difficulties encountered, and teamwork (Bybee et al., 2006; 2015). This instructional outline supports conceptual development and skills acquisition through planned phases that encourage dynamic inquiry-based learning with practical tasks. It invites students to "act like scientists" by forming hypotheses, conducting experiments, analyzing data, and communicating findings, while the teacher acts as facilitator (Ash, 2003; Sjøberg, 2018; Vorholzer & von Aufschnaiter, 2019).

International reviews of science curricula emphasize the need to focus on encourage students to discover how scientific understanding can improve lives and solve real problems (Marco-Bujosa et al., 2017). In this light, inquiry-based learning is a better alternative to traditional science education because it enables students to ask questions, find answers, apply knowledge, develop problem-solving skills, and undertake responsibility for their learning (Guo et al., 2021). To improve science curricula, it is therefore important to incorporate inquiry-based learning through practical activities (Scott, 2023; Trna et al., 2012). This process is structured as a cycle of inquiry (Pedaste et al., 2015). The 5E model is widely regarded as one of the most effective inquiry cycles for science education (Srisawasdi & Panjaburee, 2015; Bybee, 2009, 2015; García i Grau et al., 2018). According to these authors, the five learning phases support a thorough and insightful understanding of new material and its application in diverse contexts. Learners gain hands-on skills relevant for everyday life and future challenges, and learning is enhanced when prior knowledge serves as a foundation for new knowledge.

Thus, implementing the 5E instructional model empowers students to take more responsibility for their learning by promoting abilities such as inquiry, observation, modelling, analysis, explanation, discussion of results, and drawing conclusions all of which contribute to scientific literacy (Bybee, 2019). Studies confirm that the 5E model is more effective than traditional teacher-centered methods; it enhances students' conceptual understanding, motivation, and interest in science, as well as their critical thinking and argumentation skills, and ability to apply knowledge in practice (Bybee, 2015; Bezen & Bayrak, 2020; Bakri & Adnan, 2021; Boakye & Nabie, 2022; Varoglu et al., 2023). In addition, it fosters the development of scientific process skills such as formulating research questions and hypotheses, providing evidence, evaluating explanations, and drawing conclusions (Wale & Bishaw, 2020; Harlen, 2021; Ješková et al., 2022; Tolba & Al-Osaimi, 2023).

Ethiopia's science curriculum and syllabi adopt a competency-based, active-learning approach, underpinned by three broad outcomes, such as knowledge, skills, values and attitudes. The emphasis is on learner-centered classroom and field activities to help students to acquire knowledge and also develop problem-solving and decision-making skills, as well as positive attitudes toward the environment. Teachers are expected to help students view science as a dynamic activity by employing a variety of teaching approaches, including practical activities and field work. By using a mixture of teaching styles in each lesson, teachers can engage all students and stimulate inquiry (Grade 7 and 8 General Science Syllabi, 2021, pp. 1-7).

Furthermore, teachers are encouraged to promote personal qualities in students that are useful in real life. General Science is not treated merely as a set of static rules, but as a body of knowledge that is constantly evolving through investigation and practical activities that involve individual or group tasks where students receive hands-on experience. Consequently, this method is highly recommended and should be used whenever possible (Grade 7 and 8 General science syllabi, 2021:1-7).

In summary, the integration of inquiry-based learning through practical activities is strongly endorsed throughout Ethiopian educational policies and frameworks, emphasizing their critical role in enhancing the effectiveness and efficiency of science education and ensuring national and global future prosperity (MoE, 2009; MoE, 2020). In line with this, Vogelzang et al. (2019) argued that presenting science topics in a real-world context makes science education more engaging, relevant, and stimulating, and that science teachers are encouraged to use instructional strategies that contextualize learning and motivate students to participate actively thereby cultivating them into productive contributors to society (Damopolii et al., 2018).

Likewise, the strategy document for improving science and mathematics education in Ethiopia stated:

> Pedagogy is also essential, with the literature highlighting the importance of teacher content knowledge and teaching practices. These days, education literature promotes integrating technology, content, and pedagogy for the efficient and effective delivery of STEM subjects. An inquiry-based learning, practical and relevant approach to STEM teaching and learning produces the most favorable outcomes. (MoE, n.d, p.32)

Similarly, studies showed that STEM pedagogy emphasizes the creation of active learning environments through techniques such as project-based and problem-based learning (Wieselmann et al., 2022), and inquiry-based learning or hands-on activities in STEM laboratories and workshops, dialogue, technology-driven teaching, internships, and cooperative learning (Lytras et al., 2017). Thus, the application of inquiry-based learning through practical activities that encourage students to actively explore and investigate scientific concepts is especially effective in STEM education. This approach not only engages students but also enhances their understanding by connecting theory to practice. By incorporating real-world problems and hands-on experiments, learning becomes more relevant and meaningful, thereby producing better outcomes. Moreover, the relevance of STEM education is enhanced when linked directly to students' experiences and future career pathways. This practical relevance helps motivate students and can significantly improve their engagement and achievement in STEM subjects.

Effective STEM pedagogy, therefore, involves a dynamic and interactive teaching style that adapts the evolving technological landscape, supports active learning, and fosters critical thinking and problem-solving skills. The best practices in STEM education include a blend of strong content knowledge, innovative pedagogical strategies, and the seamless technology integration. These elements together create a vigorous environment for teaching and learning that prepares students for the challenges of the modern world. In Ethiopian context, as Tesfaye et.al (2010) stated:

> The progression of modern civilization is closely tied to advancements in science and technology. Factors such as the quality and relevance of education, teaching methodologies, human resources, scientific literacy, science process skills, higher-order thinking abilities, and the integration of science, technology, and society play a pivotal role in the development of these fields. Additionally, the quality of teachers and educational materials, such as textbooks, directly influences the effectiveness of science education. As a result, the investment a nation or region makes in science education and research is a significant determinant of its scientific and technological growth (Tesfaye et.al, 2010:2-3)

Ethiopia has articulated goals for STEM education at primary, secondary, and tertiary levels through reform plans, programs, and regulations including the Education Development Roadmap (2018-2030), the Growth and Transformation Program (GTP-I and II, 2005-2010), the ESDPs I-V (1997-2020), and the General Education Quality Improvement Program (GEQIP, 2008-2018). Despite the recognition of STEM education as a solution to socio-economic challenges and as a mechanism for developing twenty-first-century skills, implementation remains challenging in many countries (Mpofu, 2019). As noted by Lee et al. (2019), common obstacles include inadequate teacher preparation, a shortage of qualified STEM educators, limited investment in professional development for teachers, lack of collaboration in STEM research, insufficient student motivation and preparation, poor content delivery and assessment methods, inadequate laboratory facilities and instructional media, and limited hands-on training for students.

Similarly, global challenges to science education, including in Ethiopia, persist: inadequate funding, lack of adequate resources, shortage of qualified science teacher (UNESCO, 2019; World Bank, 2020). In Ethiopia specifically, factors such as poor student engagement in effective teaching methodologies, absence of necessary laboratory supplies, and poorly organized laboratory manuals severely impact science education implementation and thus students' academic achievement in the sciences (Beyessa, 2014). Furthermore, competent teachers are required in twenty-first-century classrooms to meet diverse learner needs; however, recent research (Geeltu, 2024) reveals declines in teacher quality and other key input, process and outcome indicators.

The Ethiopian Education Roadmap (MoE, 2018) indicates that outcomes in primary education have fallen short of quality expectations, attributed to students' inability to master foundational skills, lack of emphasis on problem-solving, and weak practices in continuous assessment. These challenges highlight the urgent need for pedagogical reform and innovation in science education, particularly tailored to Ethiopia's educational context. In response to these issues, this study aims to investigate the implementation of inquiry-based learning through practical activities in general science education in middle schools in Addis Ababa city Administration.

The study, emphasizes hands-on, inquiry-based learning through practical activities such as questioning, explaining, investigating, observation, laboratory activities, field visits, reflection, solution-searching, debate, sharing experiences, and exploration both inside and outside the classroom to foster deeper understanding in sciences such as biology, chemistry, and physics, and thereby rejuvenate interest and improve proficiency among students. Such an inquiry is essential to identify barriers to effective science education and to devise strategies to bridge the gap between current instructional practices and the demands of a modern scientific and technological society. Timely and context-sensitive responses to these issues could significantly improve educational outcomes and better prepare students for lifelong learning and the evolving demands of the 21st century.

Accordingly, this study contributes to the broader discourse on educational reform by examining current practices of inquiry-based learning through practical activities, identifying challenges in general science instruction, and proposing contextually relevant solutions for improving general science education in Ethiopian middle schools.

1.2. Statement of the Problem

Inquiry-based learning supported by practical activities is widely recognized as a fundamental approach to effective science education. This method emphasizes hands-on engagement, encouraging students to investigate, explore, question, and construct scientific understanding through active participation of the learners. Particularly at the middle school level, such practices play a crucial role in fostering scientific curiosity and deepening conceptual understanding. Practical science activities are essential for bridging theoretical knowledge with real-world applications, thereby promoting meaningful and lasting learning experiences (Tesfaye et al., 2010). Furthermore, science curricula should provide opportunities for students to engage in investigative processes within relevant real-world contexts, enhancing their connection to the general sciences through curiosity-driven and discovery-based practical activities (Millar, 2004).

Despite, the recognized importance of inquiry-based learning through practical activities, their implementation in Ethiopian schools in general and middle-level schools in Addis Ababa in particular remains limited and inconsistent. Therefore, practical science activities are most effective when integrated with discussions that relate observations to theoretical frameworks, helping students develop a dynamic understanding of their subjects through inquiry-oriented diverse methods, such as laboratory activities, observations, investigation, debate, field visits, reflection, and problem-solving exercises (MOE, 2010).

Supporting this studies revealed as, there is a clear need for instructional practices that foster critical thinking, reflection, questioning, collaboration, communication, and research. Accordingly, it is crucial that science teachers are equipped to guide students effectively, utilizing locally available resources to foster engagement and continuous improvement in scientific understanding (MoE, 2008; Mihret, 2014). As a result, implementing of inquiry-based learning through practical activities as an active learning method is widely seen as the best way of achieving the intended objective of science education throughout the world.

However, this fact does not seem to be true in most Ethiopian middle schools in particular and Ethiopian educational system in general where there are numerous indicators that students lack scientific knowledge, skills and proficiency. Supporting this, Villanea, (2023) stated that despite significant progress made in expanding access to high-quality education over time, low performance and accomplishment in science and mathematics at elementary and secondary school levels persist. Similarly, Ethiopian science education faces significant challenges, like reveal of research result, decline of learning outcomes, persistent and longstanding challenges in terms of educational quality, efficiency, resources and equity (NEAEA, 2020; UNESCO, 2024).

The Ethiopian Education Development Roadmap (2018-2030) also indicated that primary education has not achieved quality learning outcomes due to students' failure to master basic skills of leaning, their low attention to problem solving skills and poor practice of continuous assessment in the learning-teaching process in primary schools (MoE, 2018). Accordingly, these systemic gaps underscore the urgency of identifying contextually relevant challenges and designing timely, evidence-based interventions. In response to this need, the present study seeks to investigate the implementation of inquiry-based learning through practical activities in general science education in middle schools in Addis Ababa. The study aims to contribute to ongoing efforts to enhance instructional practices, strengthen students' scientific inquiry skills, and ultimately improve the overall quality of science education.

Therefore, a thoughtful and scholarly approach to skillful teaching method requires teachers that become knowledgeable about the strategies for delivering the instruction that promote students active learning and problem-solving abilities. Two primary reasons have initiated the researcher to conduct on this issue: personal experience of the researcher and the lack of adequate researches on the topic in middle schools in Addis Ababa and Ethiopia in general.

Firstly, the researcher's experience as a science teacher and school leader in different government and private schools has proved that different teachers use different methods of teaching and possess varying perceptions of instructional strategies. As well as the variation of students interest and achieved out comes while I am teaching in government school for the fulfillment of the course curriculum design and implementation in the PhD program of Addis Ababa University. Secondly, reviewing different literature on science education has helped the researcher identify a significant gap in research on this topic in the middle schools in Addis Ababa, Ethiopia. Consequently, this stage is known to be a bridge to enter the world of work or to continue learning on to secondary and higher education.

Hence, it is imperative that students at this stage develop critical thinking, problem-solving skills, and a broad understanding of science, as well as the ability to reason and make choices. Additionally, on the scholarly side, conducting this research fills a critical gap while many international studies highlight IBL's benefits, there is relatively little empirical evidence documenting its implementation and outcomes in Ethiopian middle-level schools. By doing so, the study contributes context-specific data to the global conversation on science pedagogy, and tests whether the benefits of inquiry-based, practical science education hold in different educational settings.

With regard to this, there are some local researches that are conducted on the implementation of inquiry-based learning in Ethiopia. Some of these include Gogile and Alemayehu, (2016); Muleta and Seid, (2016); Muleta et al., (2016); Dagnew and Sitotaw, (2019); Hussen et al., (2022); Abza et al., (2023). These studies emphasized on the implementation of inquiry-based learning in Ethiopian secondary schools, particularly regarding the general pedagogy and laboratory tasks. These studies revealed that the low implementation of hands-on practical learning contributes to poor science test scores among students. Problems with attitudes, approaches, teachers' capacity, and resources contribute to poor quality of practical activities and performance in general science education in secondary schools.

Despite the challenges, there is a critical need to enhance inquiry-based learning science education, particularly in primary and middle schools in Addis Ababa, where practical activities are often overlooked (Tesfaye et al., 2010). For these reasons, it is both practically important and theoretically justified to study how inquiry-based learning through practical activities can be implemented in Addis Ababa's middle-level general-science education. Thus, the current study aims to investigate the practices of inquiry-based learning through practical activities in middle level schools in Addis Ababa, focusing on the implementation of inquiry-based learning through practical activities in general science curricula, teachers' awareness, perception and students' awareness as well as identification of barriers that hinder the effective implementation of inquiry-based learning through practical activities in general science teaching science.

This study seeks to contribute to the state of the art in science education and the development of a scientifically literate community by improving science education practices, with an emphasis on inquiry-based learning through practical activities and gives unique insights or future directions that improve the implementation of quality science education across Ethiopia.

1.3. Objectives of the Study

The general objective of this study is to investigate the implementation of inquiry-based learning through practical activities in general science education in middle-level schools of Addis Ababa. Accordingly, the study attempted to address the specific objectives as outlined under the following three guiding specific objectives:

1. Investigate the current implementation of inquiry-based learning through practical activities:
    - Examine the extent to which teachers apply inquiry-based learning through practical activities in their science instruction.
    - Identify the most frequently used types of inquiry-based practical activities by teachers.
    - Examine the extent to which students apply inquiry-based learning through practical activities during science instruction.
2. Explore the perceptions and awareness regarding inquiry-based learning through practical activities:
    - Assess teachers' awareness of the importance of employing inquiry-based practical activities in science education.
    - Examine teachers' perceptions of inquiry-based practical activities.
    - Assess students' awareness of inquiry-based practical activities in general science instruction.
3. Identify challenges hindering the implementation of inquiry-based learning through practical activities:
    - Identify teacher-related factors affecting the implementation of inquiry-based practical activities in general science instruction.
    - Identify student-related factors affecting the implementation of inquiry-based practical activities.
    - Explore other factors that affect the implementation of inquiry-based practical activities in general science instruction.

1.4. Research Questions

Based on the general objective of investigating the implementation of inquiry-based learning through practical activities in general science education at the middle school level in Addis Ababa, the study is guided by the following research questions:

1. **Questions on the Current Implementation of Inquiry-Based Learning through Practical Activities**
    1.1. To what extent do teachers apply inquiry-based practical activities in their classroom interactions?
    1.2. What types of inquiry-based practical activities are most frequently used by teachers?
    1.3. To what extent do students engage in inquiry-based practical activities during general science instruction?
2. **Questions on Perceptions and Awareness Regarding Inquiry-Based Learning through Practical Activities**
    2.1. What is the level of teachers' awareness regarding the importance of employing inquiry-based learning through practical activities in science instruction?
    2.2. How do teachers perceive the role and value of inquiry-based learning through practical activities in science instruction?
    2.3. What is the level of students' awareness of inquiry-based learning through practical activities in general science instruction?
3. **Questions on the Challenges Hindering the Implementation of Inquiry-Based learning through Practical Activities**
    3.1. What teacher-related factors affect the implementation of inquiry-based learning through practical activities in science instruction?
    3.2. What student-related factors hinder the implementation of inquiry-based learning through practical activities?
    3.3. What other contextual or institutional factors affect the implementation of inquiry-based learning in science instruction?

1.5. Significance of the Study

This study has thus been conducted to investigate the current practices and challenges of inquiry-based learning through practical activities of general science instruction in middle level schools of Addis Ababa. Therefore, this study has the following significances.

1. The Significance of the Study for Knowledge

This study makes substantial contributions to the state of the art in science education, particularly focusing on inquiry-based learning through practical activities. By delving into the specific context of Addis Ababa middle-level schools, the study provides unique insights that enhance understanding and implementation of effective science education practices.

2. Contributions to Science Education curriculum

A. Contextual Relevance: It offers a detailed examination of how inquiry-based learning approaches are applied in a specific educational setting. This contextual focus helps bridge the gap between theoretical frameworks and practical application, offering a nuanced understanding of educational practices in the Ethiopian context.

B. Enhancement of Pedagogical Strategies: By assessing the current practices of inquiry-based learning through practical activities, the study informs on-the-ground pedagogical strategies that can be adapted or improved to suit local needs, thus advancing the quality of science education.

C. Curriculum Development: The findings can influence curriculum developers to integrate or enhance inquiry-based learning components within the science curriculum, ensuring that these methodologies are effectively embedded and supported.

3. Contribution to the Existing Literature

A. Empirical Evidence: This study adds empirical evidence to the body of literature by documenting current practices, challenges, teachers' awareness, perception and students' awareness of inquiry-based learning practical activities. Such data are vital for researchers and practitioners aiming to substantiate or reconsider the claims made about the benefits of inquiry-based learning.

B. Methodological Insights: By exploring the implementation of inquiry-based learning activities through various lenses (teacher's practice, students' engagement, and administrative support), the study contributes methodological insights that can guide future study in similar contexts.

C. Basis for Future Studies: The findings serve as a reference point for future studies, potentially guiding more extensive studies across different regions or educational levels, thus broadening the understanding of inquiry-based learning methods across diverse educational landscapes.

Generally, this study significantly enriches the existing literature by providing detailed insights into the practical implementation and impacts of inquiry-based learning in science education, highlighting its relevance and utility in the Ethiopian educational context and beyond. These contributions are pivotal not only for educational theorists and practitioners but also for policymakers seeking to foster environments that enhance scientific inquiry and learning outcomes.

1.6. Scope of the Study

In order to carry out any research to delimit the scope of the study is very important to have a manageable size. To ensure manageability and clarity, this study is delimited to selected middle-level schools within the Addis Ababa City Administration. Specifically, the research was conducted in twenty-two government middle schools. The study focuses on examining the current practices and challenges of implementing inquiry-based learning through practical activities. It also explores the awareness and perceptions of science teachers and students regarding inquiry-based learning, and identifies factors that hinder its effective implementation through practical activities. The study population is delimited to Grade 7 and Grade 8 students, their general science teachers, laboratory technicians, and school academic vice principals in the selected government middle schools.

1.7. Limitation of the Study

This study primarily focused on one city administration and twenty-two government middle schools, with two schools selected from each of the eleven sub-cities in Addis Ababa. While this sampling approach allowed for a balanced representation across the city's administrative divisions, the geographical scope remained relatively narrow. As a result, the findings primarily reflect the conditions and characteristics unique to Addis Ababa's urban schooling context. Including more regions such as rural areas, semi-urban districts, and other cities along with a wider variety of school types could provide a more comprehensive understanding of the issue under investigation. Such expansion would strengthen the reliability of the conclusions and allow the findings to reflect a broader and more diverse educational context.

1.8. Operational Definitions of Key Terms

- **General Science Curriculum:** This refers to a body of knowledge established through scientific inquiry and investigation within authentic contexts in biology, chemistry, and physics, specifically designed as general science for middle level schools in Ethiopia.
- **Inquiry-Based Learning:** A student-centered instructional approach in which learners explore scientific concepts by asking questions, conducting investigations, collecting data, and drawing conclusions. It is also an investigative approach to teaching and learning general science that provides students with opportunities to ask questions, explore problems, search for solutions, make observations, test ideas, think creatively, and engage in hands-on activities over several classes within their authentic environments. In this study, inquiry-based learning is measured through lesson observations, teacher and student practices, and the extent to which classroom and outside the classroom activities follow the inquiry cycle (questioning, exploring, experimenting, analyzing, discussing, evaluating and reflecting etc.…).
- **Practical Activities:** Hands-on science tasks, or experiments that allow students to manipulate materials, observe phenomena, and apply scientific concepts. In this study, practical activities are conducted by the teacher or the students for demonstrations, or a series of experiments and observational exercises performed by students to bridge theoretical knowledge with practical experiences in laboratories, classrooms, fields, or other locations during general science lessons at the middle-level grades.
- **Implementation:** It is the act of applying a developed program or curriculum in a real-world setting. The actual practice and extent of applying inquiry-based learning through practical activities in science classrooms. It includes teachers' planning, instructional delivery, use of materials, classroom interactions, assessment methods, and frequency/quality of inquiry-oriented practical tasks. Data will be measured through teacher questionnaires, classroom observations, and document analysis (lesson plans).

- **Awareness:** Awareness refers to the extent to which students, teachers, or other stakeholders possess knowledge, familiarity, or understanding of inquiry-based learning and its practical activities. In this study, awareness is measured through respondents' ability to: identify the principles and features of inquiry-based learning, recognize its purpose and relevance in science education, and demonstrate knowledge of how practical activities are used within IBL in science lessons. Awareness is assessed using survey items, focus group discussion, interview responses, or observation checklists that quantify participants' knowledge and recognition of IBL practices.
- **Perception:** Perception refers to the attitudes, beliefs, and judgments held by teachers, or stakeholders regarding the value, effectiveness, and applicability of inquiry-based learning trough practical activities in general science lessons. In this study perception is measured by examining respondents' views about: the benefits and challenges of implementing IBL, their level of acceptance or resistance toward IBL strategies, their feelings or attitudes toward using practical activities in science instruction. Perception is assessed through Likert-scale survey responses, interview statements, or qualitative reflections that capture participants' positive, neutral, or negative viewpoints.
- **Middle Level School:** it refers to the third level in the educational spectrum within the Ethiopian educational curriculum.

1.9. Organization of the study

The structure of this thesis is as follows: The first chapter contains all the plans and the introductions of the study about significance of inquiry-based practical activities in science teaching in middle schools. In addition in this chapter the context of implementation of the practical activities, the statement of the problem, goals, scope, significance and limitations of the study were included. The second chapter deals with the review of related literature presents a theoretical review, encompassing the concept of the science curriculum, recommended teaching methods in science, scholarly theoretical perspectives, and the importance, types, and factors related to the implementation of inquiry-Based practical activities in science education in Ethiopian schools. It also contains the theoretical framework for the study, both conceptually and empirically. The third chapter deals with a comprehensive overview of the research paradigm, design, methodology, and resources employed in the study offering a clear framework for understanding its scientific foundations. It also included research sampling; tools of data collection, procedures for organizing and managing the collected data are outlined to ensure transparency and reproducibility methods of data analysis, and ethical considerations of the study. The fourth chapter deals with the data presentation, analysis and interpretation. In fifth chapter, the research findings were discussed, and it was devoted to determining the attainment of the major findings in line with the objectives of the study. Finally, the research's conclusion and recommendation were provided.

CHAPTER TWO

2. REVIEW OF RELATED LITERATURE

Inquiry-Based Learning (IBL) is widely regarded as a powerful pedagogical approach in science education. Its core idea is to position students as active learners who ask questions, design investigations, and construct understanding through exploration, observation, discussion, reflection, analyzing etc… (e.g., Abza, Wodaj, & Edessa, 2022; Brhane, Areaya, & Assefa, 2025). Recent national reports and policy directives have underscored the significance of inquiry-based learning science education across all educational levels. This emphasizes the importance of nurturing an interest in science from an early age and addresses the challenges of implementing high-quality science instruction in primary and middle-level schools. In the context of Ethiopia and specifically Addis Ababa examining how IBL is implemented in middle-level general science classrooms is critical, given both curriculum expectations and practical constraints.

This chapter presents a theoretical review, encompassing the concept of the general science curriculum, recommended teaching methods in general science, scholarly theoretical perspectives, and the importance, types, and factors related to the implementation of inquiry-based learning through practical activities in science education in Ethiopian schools in general and middle-level schools in Addis Ababa in particular. It also includes empirical research findings on the implementation of these activities, which support or challenge existing debates in the field.

2.1. What is the General Science Curriculum about in Schools?

The general science curriculum is widely described in contemporary literature as a comprehensive and multi-dimensional framework aimed at fostering scientific literacy, conceptual understanding, and 21st-century competencies among learners. As countries revise their science education systems, comparative studies reveal significant variation in how curriculum goals are conceptualized and operationalized. For example, Norambuena-Meléndez, Guerrero, and González-Weil (2023) found distinct ideological orientations between the Bolivian and Chilean science curricula. Bolivia’s curriculum adopts a model of critical scientific literacy, emphasizing social justice, environmental responsibility, and the transformative potential of science within community contexts. Conversely, Chile’s curriculum prioritizes the practical relevance of scientific knowledge for daily life, problem solving, and civic engagement.

Globally, science curriculum reforms demonstrate a marked transition away from traditional content-heavy approaches toward competency-based, inquiry-oriented models of instruction. International frameworks emphasize the integration of scientific practices, cross-cutting concepts, and real-world applications to deepen students' understanding of science. The Nature of Science (NOS), for instance, has become a central component in major reform documents such as the Next Generation Science Standards (NGSS Lead States, 2013) and UNESCO's global education guidance (UNESCO, 2021), both of which stress the importance of understanding how scientific knowledge is generated, validated, and used. These reforms also foreground socio-scientific issues including climate change, public health, and technological innovation consistent with global calls to equip learners with the skills needed to navigate complex, science-related societal challenges (OECD, 2019).

A parallel trend involves the modernization of science content to reflect contemporary scientific and technological advancements. Countries such as Australia, Singapore, and the United States have integrated emerging topics such as computational thinking, data literacy, quantum science, and biotechnology to ensure curricular relevance in rapidly evolving knowledge societies (Australian Curriculum, Assessment and Reporting Authority (ACARA), 2022; Ministry of Education Singapore, 2020; NGSS Lead States, 2013). In many developing contexts, curricular modernization is guided by national needs, linking science education to environmental sustainability, public health, agricultural development, and community-based innovation (UNESCO, 2021). These reforms commonly call for enhanced teacher professional development, greater emphasis on hands-on and inquiry-based learning, and alignment of assessment systems with higher-order competencies rather than rote memorization (Schleicher, 2020). As Marco-Bujosa et al. (2017) note, global reform efforts increasingly seek to empower students to recognize how scientific understanding can inform decisions, improve quality of life, and address real-world problems.

A. The General Science Curriculum in the Ethiopian Context

In Ethiopia, the middle level phase, which includes grades 7 and 8, is a transitional time and level between primary and secondary education levels. Its main goal is to get students ready for more complex science courses in their future academic accomplishments and real-world applications. For individuals who leave the system, the level signifies the conclusion of compulsory schooling and the time they must leave to enter the workforce. Its main goal is to help pupils acquire lifelong knowledge, attitudes, and skills that will prepare them for the workforce when they reach working age. Additionally, it prepares them for the demands of secondary school learning and the development of technical and entrepreneurial abilities. The Ethiopian Curriculum Framework for K-12 Science Education (GECF, 2020) and the Strategy Document for Improving Science and Mathematics Education in Ethiopia (MoE, 2009) establish an ambitious vision for science learning that integrates science and real-world practices, departing from previous approaches that focused on learning content and memorization.

Furthermore, science education is the teaching and learning of science to learners, or adults in the overall community, which involves work in science content, science process, and teaching pedagogy. The science education principles set expectations for students' understanding progress throughout the course of their curriculum in each level and elsewhere. Ethiopia has been unwavering for faster improvements in educational services, with a focus on offering "quality and equitable education for all," "which is essential for fostering 21st century skills and advancing society. Accordingly, the main goal of the curriculum framework created for the nation's general education system is to create individuals who are creative, innovative, productive, self-directed, accountable, and actively involved in the advancement of the country (MOE, 2020).

Inline to this, the general science curriculum spans a broad spectrum of topics that enable students to learn about matter, energy, living and non-living things, and their interactions. This curriculum not only includes a body of knowledge and theories about the general world but also a set of methodologies for investigating and analyzing various aspects of the world and the universe. Upon completion of this course, students are expected to demonstrate a solid understanding of fundamental scientific ideas, procedures, and concepts. In addition the general sciences curriculum aim to deepen students' understanding of their environment, allowing them to observe, model, record, and discuss their findings. Middle School students are introduced to general science principles including physics, chemistry, and biology that facilitate a comprehensive understanding of these subjects.

Furthermore, the curriculum emphasizes the need for further exploration into the impact of human activities on the environment and the necessary actions for living in harmony with nature (MOE, 2020). In addition the Ethiopian curriculum framework describes the general sciences as a body of knowledge developed through science Inquiry-based practical tasks and experimentation. It highlights that students benefit from developing scientific knowledge, understanding, and skills in various ways. Engaging in scientific inquiry and experimentation enhances students' understanding of the physical and biological world, fosters a healthier lifestyle, and provides a strong foundation for advanced scientific studies or careers in scientific and technical fields (MoE, 2009).

These activities facilitate meaningful interactions between students and their environment, promoting sound scientific reasoning. By coupling these activities with explanations of underlying concepts, the curriculum demonstrates that science encompasses both content and process. This approach helps students acquire a fundamental understanding of basic science concepts and their relevance to everyday life.

The Ethiopian government has employed a number of changes based on the findings and recommendations of various studies and change policies that attempt to address the major issues in education, such as the lack of relevance of the content, the prevalence of difficult and overloaded content in textbooks, the absence of interactive participatory methodologies, the proper implementation of continuous assessment, and the introduction of new syllabi and textbooks, assessment techniques, teacher development programs, school improvement programs, expansion, etc. Similar to this a significant overhaul of the current curriculum was therefore deemed necessary in order to address the issues that continued, bring it into line with the progress of the twenty-first century, and satisfy the demands of the 2030 Sustainable Development Goals. Inline to this improvement packages on the science curriculum of middle level school also made continuously.

Moreover, the Ethiopian Curriculum Framework encourages flexibility in teaching-learning methodologies and strategies. It advocates for a shift in teachers' perspectives to include a variety of more suitable activities, enhancing student participation in their learning. Students are also encouraged to adopt a positive attitude towards their education, actively engaging and contributing to lessons through practical activities (MoE, 2009).

B. Curriculum Structure, Inquiry Orientation, and National Alignment

The Ethiopian general science curriculum for middle school adopts an integrated structure that brings together key concepts from biology, chemistry, physics, and earth science rather than presenting them as separate subjects. This design is intended to help learners perceive science as an interconnected discipline and to support the gradual development of foundational scientific understanding. The curriculum progresses from concrete, observable experiences in the earlier grades to more abstract and complex scientific ideas in the upper grades. Major themes addressed at this level include the properties and states of matter, the transformation and forms of energy, the structure and function of living organisms, ecological and environmental interactions, earth and space systems, human health and sanitation, and basic technological applications such as simple machines. To facilitate meaningful learning, the curriculum promotes participatory approach inquiry-based learning through practical activities such as, hands-on engagement, laboratory investigations, observation, modeling, and structured scientific communication in both written and oral formats.

Aligned with national education policy, the curriculum emphasizes inquiry-based learning and competence-based development. The Strategy for Improving Science and Mathematics Education in Ethiopia identifies scientific inquiry, critical thinking, and problem-solving as core priorities, urging a shift away from rote memorization toward deeper understanding of how scientific knowledge is generated and applied (Ministry of Education (MoE), 2009). Policy directives further call for the integration of local contexts and indigenous knowledge, the use of real-world examples to illustrate scientific principles, and the cultivation of students' curiosity, investigative abilities, and collaborative skills. Additionally, the curriculum encourages environmental responsibility and active citizenship, reinforcing Ethiopia's broader commitment to linking general science education with national development needs, including health promotion, agricultural advancement, technological innovation, and environmental sustainability.

These curricular directions reflect Ethiopia's ongoing efforts to modernize its education system in alignment with Vision 2030, the Education Sector Development Program (ESDP), and the Sustainable Development Goals (SDGs). Recent reforms promote the development of 21st-century competencies, creativity, and innovative thinking while seeking to ensure equitable access to quality science education. Strengthening STEM education is viewed as essential for preparing a scientifically literate and skilled workforce capable of contributing to national socio-economic growth. As articulated in the Ethiopian Curriculum Framework, science education is expected to cultivate learners who can engage meaningfully with scientific and technological challenges and participate actively in the country's development (MoE, 2020).

2.2. General Aims & Desired Activities (Syllabus for General science in Ethiopia, 2009)

The general science (Biology, chemistry & physics) grade 7&8 syllabus is designed to help the learners to:

1. Acquire knowledge and understanding about themselves and the organisms in their environment.
2. Appreciate the harmony, contrast and beauty of nature around them.
3. Develop critical thinking, reasoning and problem solving in everyday contexts through experimental science.
4. Solving problems by involving individuals, populations by integrating issues that are related to the environment, population, health, agriculture and disasters through observations, field trips and direct study of general habitats familiarize students with nature.
5. Developing positive attitudes by active participation in conservation of nature like air, water, soil and fuels in the aspects of some general properties, compositions, economical uses of resources, pollution and its prevention through environmental Chemistry.
6. Familiarize with the composition, uses of non-living materials through general and artificial vital process of living things in everyday life including food, textiles, drugs, metals, plastics, rubbers, soaps, detergents, paints, dyes, fertilizers and insecticides.
7. Study of matter & energy to obtain a better understanding of the physical world (non-living) through observation and experiments.
8. Built a well foundation for their future learning by introducing the basic ideas and principles of Physics to thinking about how the world works and why things happen.
9. Conduct practical activities using locally available materials.

Therefore, provide a meaningful interaction between students and their world in a manner encouraging sound scientific reasoning to acquire knowledge and understanding of basic concepts, the applications and relevance of these to their everyday lives (MoE, 2009 p17-19). Supporting this, different studies have been conducted to improve the relevance and quality of Ethiopian general education. Among this worth mentioning is the Education Road-map (2018). Likewise, the Ministry of Education carried out repeated monitoring and assessment of the school curriculum; and based on the research results different strategies was introduced to assured science education quality.

Accordingly, the new curriculum framework general science textbooks are prepared for middle school students (grades 7 and 8). General Science education includes physics, chemistry, and biology subjects. General Science education aims to equip students with foundational science knowledge and skill that serve as a base for secondary education. It intends to nurture scientific inquiry skills which students use on their day to day lives and in learning science. In addition, it aims to cultivate among students science processes and 21st-century skills that can be used in their day-to-day life and academic career.

Correspondingly, the Ethiopian education roadmap highlights the importance of a competence-based comprehensive approach that shifts focus from ‘what’ to ‘how’. This approach promotes practical life skills and aesthetic content to foster the development of problem-solving abilities and creative thinking (MoE, 2018). It emphasizes the critical role of the scientific inquiry method in education, aiming to make the learning-teaching process more practical and activity-oriented.

2.3. General Aims & Desired Activities (Syllabus for General science in Ethiopia, 2020)

Similar to the general science syllabus (2009), the main goals of the current general science curriculum for grades 7 and 8, which includes biology, chemistry, and physics, are: to teach students about topics related to daily life and to develop skills related to a wider range of ideas, experiences, and topics. Knowledge and comprehension of general science also helps students to comprehend the world and its workings. It requires an active learning approach that is competency-based and is based on learner-centered classroom, practical activities and field activities to support knowledge acquisition; problem-solving, decision-making, and the development of positive attitudes toward the general world in addition to helping students acquire knowledge (Grade 7 & 8 General science syllabus, 2021).

To achieve these major goals of general science education, the textbooks are prepared based on the principles of inquiry-based, problem-based and context based learning. Inquiry is the intentional process of identifying problems, critiquing experiments, and distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments. Inquiry-based learning involves posing questions, making observations, reading books to find out what others have learned, planning investigations, gathering, and analyzing information, reflecting on what was learned in the light of new evidence, and proposing explanations and predictions. It encourages students to use critical thinking skills that include designing and carrying out investigations, interpreting data as evidence, creating arguments, building models, and communicating findings to deepen students understanding through logic and evidence.

The general science syllabus emphasizes the importance of practical activities in enhancing students' academic performance by engaging them in authentic, real-life contexts. Such hands-on experiences enable learners to develop knowledge, skills, and attitudes through observation and experimentation while fostering critical thinking and problem-solving abilities. Inquiry-based learning (IBL) complements these objectives by promoting active engagement through questioning, investigation, and reflection (Aidoo, 2024). In science instruction, IBL supports not only content knowledge but also essential scientific process skills such as hypothesizing, experimenting, and interpreting data and a deeper understanding of the nature of science (NOS) (Lederman, Lederman, & Antink, 2013).

Despite its recognized benefits, translating IBL into effective classroom practice remains challenging, particularly in resource-limited settings where infrastructural, institutional, and pedagogical constraints hinder implementation (Ahmed, Mekuria, Zinabu, & Abo, 2024; Brhane, Areaya, & Assefa, 2025). This literature review critically examines global and Ethiopian perspectives on IBL in science education, focusing on practical activities, teacher's perceptions, student awareness, and barriers to effective implementation. It moves from general theoretical frameworks to localized empirical evidence, ultimately highlighting gaps that motivate the present study.

2.4. Philosophical Foundation of Inquiry-Based Learning

The philosophy of inquiry-based learning is grounded in constructivist learning theories, attributed to the works of educational theorists such as Dewey, Vygotsky, Schwab and Freire.

The foundation of inquiry-based learning is rooted in constructivist educational theories, which contend that knowledge is actively created by students as opposed to passively absorbed from outside sources (Zajda, 2022). Dewey maintained that teaching should involve more than just instructing facts rather, it should involve pupils in worthwhile activities that foster their ability to think critically and solve problems. Dewey (1997) highlighted that fundamental learning occurs when individuals are engaged in solving practical, real-world problems, advocating that curriculum and instruction should focus on integrated, community-based tasks that involve pragmatic social action with tangible value. Joseph Schwab also (1962) highlighted the crucial relevance of scientific literacy for the general population. As he pointed out, knowledge attained through inquiry is not just about facts but also how they are construed, which depends on the conceptual foundations of the investigation.

Likewise, Vygotsky (1967) and Freire (1984) both described inquiry-based learning as a process of cognitive development facilitated by social and cultural interactions, involving the analysis of theories and intellectual engagement with the real world experiences. Vygotsky elaborated that learning happens in the Zone of Proximal Development, where teachers act as mentors to guide students in using cognitive, linguistic, and physical tools, a process known as scaffolding. This allows students to tackle significant and relevant community-based or school-based problems. In addition, Freire highlighted as the identification, analysis, and resolution of immediate problems in learners' environments through a technique he termed problem-posing and problem-solving pedagogy. He argued that pedagogy must be directly relevant to students' lives, enabling them to analyze theories and engage intellectually with their worlds (Freire, 1984; Freire, 1970/1994).

In conclusion, inquiry-based learning theoretical foundations are based on constructivist educational philosophies, which prioritize critical thinking, social engagement, and active learning. Educational philosophers including John Dewey, Joseph Schwab, Lev Vygotsky, and Freire have contributed to the historical development of Inquiry-based learning, and their theories still have an impact on modern teaching practices. Inquiry-based learning fundamental tenets underline the value of student-centered learning, active participation, inquiry and investigation, teamwork, scaffolding, and reflective thinking all of which support the creation of more thoughtful and significant learning opportunities.

Supporting this research has shown that inquiry-based learning can lead to improved academic performance, increased motivation, and the development of essential 21st-century skills such as collaboration, communication, and creativity and to engage deeply with subject matter, develop critical thinking skills, and foster a lifelong learning (Almulla, 2023). Therefore, constructivism encourages active engagement, allowing students to experiment and explore, promoting deeper conceptual understanding and concerns itself with how knowledge is constructed in the world, serving as a field of inquiry for educators aiming to comprehend and describe how students learn. Consequently, teaching scientific inquiry processes and comprehending them across disciplines is encouraged by science education reforms from the past and present.

2.5. The Concept and significance of inquiry-based learning through Practical Activity in Middle schools

In today's rapidly growing world, the pace of change necessitates an adaptable approach to science education to meet contemporary classroom demands. Traditional lecture methods, while prevalent, are increasingly recognized as inadequate for imparting the skills and competencies essential for the 21st century. In science education, the term inquiry is commonly used to describe a student-led investigation that begins with a question (Crawford, 2014). Because of this, the term "inquiry" is fairly general and can refer to a variety of approaches that highlight the part that students play in the learning process.

To address this relatively unclear concept of what it means to do science, the National Research Council included "science practices" to the 21st-century scientific education requirements (National Research Council, 2012). In contrast to inquiry characterizes science practices as a more comprehensive yet defined concept of conducting science. The impression involves students going beyond experiencing inquiry by interpreting and evaluating data as evidence to developing arguments, explanations, and models (Crawford 2014). Consequently, there is a critical need to overhaul science curricula and incorporate modern, Inquiry-based activities in education (Scott, 2023; and Trna et al., 2012).

In response, the general science curriculum is primarily based on inquiry-based learning, which emphasizes learning through practical activities. This approach is vital as students must quickly grasp the importance of lifelong learning to keep pace with continual innovations. By engaging in exploring, observing, experimenting, and practicing, students become active learners, better prepared to reskill and enhance their capabilities to navigate the evolving demands of the workplace and modern life (Scott, 2023). Hence, the children those who receive an adequate science education develop their logical thinking skills and become future engaged citizens. Because, critical thinking and scientific literacy will aid in their comprehension of these problems and aid in their future attempts to tackle these significant societal issues.

Furthermore, authors such as Martin-Hansen (2002), Sutiani et al. (2021), and Martínez-Suárez (2022) define inquiry-based practical activities as multidimensional processes that include observing, organizing, conducting investigations, discussing with peers, reflecting, and presenting findings. These phases mirror well-established models of inquiry that emphasize cycles of questioning, action, and metacognition (IBO, 2018). In essence, students not only collect empirical data but also construct meaning through dialogue, reflection, and communication (IBO, 2018; Sutiani et al., 2021).

These phases are powerful because they foster the development of scientific practices (e.g., data gathering, modeling, argumentation), scientific attitudes (e.g., curiosity, open-mindedness), and scientific reasoning skills which includes formulating hypotheses, interpreting evidence, drawing conclusions (Martínez-Suárez, 2022; Sutiani et al., 2021). In addition, through these activities, students build scientific competence, they integrate conceptual, procedural, and epistemic knowledge and understanding not only scientific facts but how science works (Teig-Nani, 2019; OECD, 2016). This integration, in turn, nurtures a more authentic and deeper comprehension of the nature of science. Moreover, from a constructivist and experiential learning perspective, engaging in inquiry-based learning through practical activities does more than improve factual understanding; it boosts student motivation and engagement. When students actively explore phenomena, ask their own questions, and see the relevance of their investigations, they are more likely to internalize scientific ideas and develop a sense of ownership over their learning (Guniš, Klein, & Kireš, 2022). This kind of learning also supports long-term conceptual change by reflecting on their investigations, students can revise misconceptions and develop more scientifically accurate perspectives.

Likewise, Wei et al. (2009) highlighted that; significant and effective professional development is required for educational institutions to impact students' learning processes profoundly. Teachers equipped with extensive knowledge and advanced teaching skills are indispensable for nurturing critical thinking skills among youth and vital for thriving in the 21st century (Wei et al., 2009). It is also vital to equip science teachers with the necessary supports including well-designed resources, laboratory materials, and sustained professional development to enable effective implementation of inquiry-based practical strategies. Without such scaffoldings, teachers may struggle to guide students through the more flexible, dialogical, and reflective phases of inquiry (Akuma & Callaghan, 2025; Holstermann, Grube, & Bögeholz, 2010).

Therefore, given the clear pedagogical, cognitive, and motivational benefits, implementing inquiry-based learning through practical activities is not only appropriate but essential in general science education especially at the middle-school level, where developing strong scientific reasoning and engagement can lay a foundation for future learning.

Contemporary teaching methodologies underscore the importance of engaging students in reflective thinking about their learning processes. It is crucial for teachers to integrate class discussions, enabling students to exchange ideas, clarify misconceptions, and construct their understanding from the lessons rather than relying solely on lecture-based teaching. This shift in approach is why students often favor practical activities over other learning methods.

Authors such as (Balta, 2015; Moote, 2019; Shana & Abulibdeh, 2020) emphasized that classroom practices should offer students ample opportunities to acquire practical skills through hands-on engagement with tools and techniques. Additionally, systematic planning of instruction is vital to capture students' attention and motivate their participation in educational activities.

Lunetta et al. (2007) pointed out that the term "inquiry" in school laboratory practices often leads to confusion. While "inquiry science teaching" may refer to teaching science as an inquiry to elucidate how scientific knowledge is constructed, "teaching science through inquiry" involves students in investigative processes to foster deeper scientific understanding. Supporting to this Sjøberg (2018) stated, the methods used for teaching and instruction in school science might also be an example of inquiry. Students are expected to "act like scientists" by developing hypotheses, designing and conducting experiments, discussing the results, and drawing conclusions. Students should get an awareness of both the components and procedures of science by doing this.

Therefore, the students are expected to learn the science content and enhance their comprehension of the nature of science as a process and activity by functioning somewhat like scientists. Besides, it is promoted by numerous parties for a variety of reasons, it is stressed that active participation in research and debates aligns with fundamental concepts regarding the nature of science as a field and with the principles of a constructivist approach to education. Additionally, it is anticipated that inquiry-based science education will increase interest in science, especially among girls, and foster greater personal involvement. It is also believed that inquiry-based science education will increase people's appreciation of science and their desire to pursue careers and education in the scientific fields. To summarize, there are three distinct justifications for suggesting IBSE:

> 1. IBSE is an efficient way of teaching and learning science contents;
> 2. IBSE is instrumental for learning about the nature of science; and
> 3. IBSE will improve students' joy, interest and motivation towards science. (Sjøberg, 2018, p.195)

Practical activities extend beyond laboratory work and include varied engagements with real-world contexts that enhance students' overall academic performance (MoE, 2009). In this regard, inquiry-based practical activities encompass students observing their surroundings, utilizing local materials, posing questions, conducting research, and engaging with general objects to critically evaluate their activities. Such interactions not only augment their knowledge, skills, and attitudes from real-life observations but also bolster their critical thinking and problem-solving abilities.

Therefore, implementing inquiry-based practical activities within the general science curriculum in middle schools is essential for students to authentically experience and appreciate science in their authentic contexts.

2.6. Definitions and Types of Inquiry-Based Practical Activities in General Science

2.6.1 Definition of Inquiry-Based Practical Activities

Various scholars define the term 'practical work/activity' in diverse contexts. For example, Hodson (2005) describes 'practical work' as any classroom, laboratory, or field activity involving the use of scientific apparatus, chemicals, biological specimens, or models by either students or teachers (p. 30). Similarly, Millar (2010) considers practical work as any science teaching and learning activity where students, either individually or in groups, observe and/or manipulate the objects or materials they study, emphasizing its importance for skill development and understanding of basic science concepts (pp. 109-110).

Inquiry-based learning practical activities have been conceptualized in varied ways by different scholars, and this diversity in terminology underscores the complexity of defining them precisely. For instance, Dillon (2008) observes that terms such as practical and inquiry skills, investigative activities, independent inquiry, and experimental work are often used interchangeably in science education discourse, which can lead to conceptual ambiguity. To counter this, Dillon offers a broad but clarifying definition: practical activities are any learning experiences in which students engage with physical materials or secondary data sources to observe, explore, and interpret phenomena, thereby deepening their understanding of the natural world (Dillon, 2008). This framing emphasizes not only hands-on engagement but also intellectual engagement with data and concepts.

Complementing Dillon's view, Callister (2010) draws on Bloom's Taxonomy to argue that genuine inquiry outshines rote memorization. According to Callister, the capacity to analyze, synthesize, evaluate, or generate new insights corresponds to the highest levels of cognitive processing in Bloom's model. From this perspective, teachers must foster environments that allow students to formulate their own questions, design investigations, and apply their reasoning to real-world problems. By doing so, inquiry-based practical activities cultivate higher-order thinking; not merely reproducing known content, but enabling students to critically evaluate, create, and develop new understandings on their context.

Thus, integrating Dillon's broad definitional clarity with Callister's cognitive taxonomy approach yields a powerful argument: inquiry-based practical activities are not simply about manipulation of materials, but about facilitating deep, reflective cognition. These activities encourage students to think like scientists to question, to plan, to experiment, to reason, and to communicate which in turn advances their scientific literacy, critical thinking, and autonomy in learning.

Likewise, Millar (2004) refers to 'inquiry practical activities' as any teaching and learning activity involving student observation or manipulation of study objects and materials. In addition, the British Science Community Representing Education SCORE (2017) defines Inquiry-based practical work as practical activities where students observe, investigate, and develop an understanding of the world through direct, hands-on experiences of phenomena.

Supporting this, Sarita (2017) views inquiry-based practical activities from both teacher and student perspectives, emphasizing their role in developing abilities to analyze, synthesize, and evaluate information, crucial for higher-order thinking skills. Inquiry-based learning focuses on exploring open questions or problems, requiring students to use evidence-based reasoning and creative problem-solving. Teachers are encouraged to foster inquiry by supporting students through the exploration process and helping structure inquiry activities. Furthermore from a teacher's sight, inquiry-based teaching focuses on moving students beyond general curiosity into the realms of critical thinking and understanding. Teachers must encourage students to inquire questions and support them through the exploration process, understanding when to begin and how to structure an inquiry activity (Sarita, 2017).

Likewise Dmoshinskaia et al. (2021), explores as inquiry learning is a science teaching method that allows learners to study a subject that reflects the investigation of science. Likewise, students' desire to scrutinize and take part in different aspects of scientific study may be a display of inquiry-related interest, which can strengthen their inquiry abilities in science curriculum exploration (Wu et al., 2018). Furthermore, Morris stated inquiry-based learning is a dynamic and multifaceted approach to science education, rooted in the practices of authentic scientific investigation. At its core, inquiry engages students in asking testable questions, designing investigations, analyzing data, and creating evidence-based explanations to foster deep conceptual understanding (Morris, 2024).

In sum, the existing literature places inquiry-based practical activities as a pivotal driver for developing higher-order thinking skills among learners. Through such activities, students are not merely engaged in rote memorization but are encouraged to analyze, evaluate, synthesize, and generate new insights, competencies central to critical thinking and advanced cognitive processing (Arifin et al., 2025). The inquiry process typically begins with students gathering information using their senses observing, listening, touching, and even tasting or smelling to collect empirical data that provokes further questioning. From this sensory engagement, learners formulate their own research questions, investigate existing literature, design experiments, collect and analyze data, and ultimately interpret their findings to construct explanations and generate predictions ((Bell et al., 2025). While inquiry-based practical activities are often associated with general science in early education, their efficacy extends across all educational levels and scientific disciplines (Lee et al., 2004). This versatility derives from the fact that inquiry-based pedagogy centers on active student involvement rather than passive reception of content.

In the Ethiopian context, this aligns strongly with the aims of the national curriculum. According to the General Education Curriculum Framework (Ministry of Education, 2020), a variety of pedagogical strategies should be employed including inquiry-based learning to address diverse learning needs and foster deep conceptual understanding. Teachers are therefore expected to implement a broad array of instructional methods, such as lecture, small-group discussion, cooperative learning, role play, project-based learning, problem solving, and inquiry-based approaches (MoE, 2020).

Consequently, inquiry-based practical activities can be conceptualized as a structured but flexible sequence: generating questions, observing phenomena, reviewing prior knowledge, designing investigative methods, collecting and analyzing data, interpreting results, and constructing explanations or hypotheses for further exploration. This cycle not only deepens conceptual understanding but also cultivates scientific practices, reasoning processes, and the reflective mindset necessary for lifelong scientific literacy.

2.6.2 Types of Inquiry-Based Practical Activities

It is essential for teachers and school practitioners to be aware of the different types of inquiry-based practical activities used in teaching sciences. Various scholars identify these activities using terms like teaching strategies, approaches, phases, and types. For example, Martin-Hansen (2002), Banchi and Bell (2008), and McGraw Hill (2009) categorize inquiry-based activities into four main types:

1. **Confirmation Inquiry**: Here, the teacher provides a question, its answer, and the method to reach this answer, aiming to build investigation and critical-thinking skills. This stage, known as confirmation, helps students practice specific inquiry skills, like gathering and documenting evidence, and affirm the concepts they have previously learned. Using this approach will certify the students and questions will closely align with the standard or set of benchmarks on the syllabus. At this the teacher creates enthusiasm for an inquiry, the question, the technique, and the findings are known to pupils at the first stage of confirmation inquiry. When a teacher wants to have students practice a particular inquiry

skill, like gathering and documenting evidence, or affirm a concept they have already discussed with them, they might utilize confirmation inquiry.

To bolster or clarify the issues posed by the curriculum on scientific concepts, students might generate a variety of items through collect their data, record their trial, and assess the outcomes according to the instructions by the teacher Banchi and Bell (2008). Similarly, at this stage groups of students share their findings regarding their open inquiry and examine supportive materials, texts, electronic, periodicals for provision of their inquiry findings. The teacher poses a problem that students solve by applying their student's understanding of the standard or set of benchmarks.

2. **Structured Inquiry**: In this approach, students follow the teacher's directions to achieve a specific endpoint or product, suitable for both classroom and field settings. While the teacher still provides the question and methodology, students are expected to generate explanations supported by the evidence they gather. According to Banchi and Bell (2008), the teacher still supplies the question and methodology, but students still generate an explanation supported by the evidence they have obtained in this stage of structured inquiry. They would need to refer to the information acquired in the previous stage in order to understand the concept. To summarize the structured inquiry and confirmation are often incorporated in elementary scientific curricula, despite the fact that they are considered lower-level topics. These kinds of inquiries are essential because they enable students to develop into increasingly competent investigators of open-ended issues. They must use the method to craft an evidence-backed conclusion based on their practical activities context or answers from their visiting and searching process initiates the guided inquiry.
3. **Guided Inquiry**: This type of inquiry allows students to work in groups, to design their own investigation methods to answer a broad question posed by the teacher. It requires students to develop laboratory procedures and learn skills necessary for future, more open-ended inquiries. In guided inquiry, the instructor poses a question to the class, and the students devise a strategy (a technique) to investigate the subject and the ensuing arguments. Since this kind of inquiry is more complex than structured inquiry, it functions best when students have had ample opportunity to practice and comprehend different methods for creating experiments and collecting data. The fact that students are developing their own procedures does not mean that the teacher's role is passive. Students, on the other hand, need guidance about the reasoning behind their research proposals. Supporting this

Yıldız et al., (2021) argued, to enable change in students' conceptions of learning, the experiences that they have must last longer than the time spent for change in their autonomy in inquiry, since during guided inquiry, students still have conceptions of achieving. Using the data gathered or provided, students generate explanations, findings and students then initiate to an open inquiry.

4. **Open Inquiry**: The most advanced level, open inquiry gives students significant autonomy to think scientifically. The students have a prior experience with a usual variety of tools and materials. The teacher gives students time and support, then displays these tools and materials and asks the students what questions they could invent using the materials provided. Students formulate testable questions, devise a plan using the materials, carry out their investigation and record and analyze their data. Students use the data to make a generalization or conclusion or further question and share the process and outcomes with peers. They pose original questions that they investigate through their own methods, and eventually present their results to discuss and expand. In addition in this level, students formulate questions, design and conduct investigations, and present their results. This level requires a solid grasp of scientific reasoning and critical thinking skills.

Furthermore, this level is most advanced level of inquiry which permits to students the greatest autonomy to think like scientists by developing questions, organizing and carrying out investigations, and presenting their results. Students need to be able to use as much scientific reasoning as possible along with critical thinking skills. Beginners in lower grades will be familiar enough with the first three stages of inquiry to successfully carry out open inquiries. This involves the capacity to obtain, document, and assess information in order to draw conclusions from the data they have obtained. Students can conduct many levels of inquiry based activities into related scientific topics in a single topic (Banchi and Bell, 2008). Supporting to this Morris, explore inquiry-based learning is not a single, static approach; rather, it operates along a continuum of instructional strategies that vary in the degree of teacher guidance and student autonomy, allowing educators to tailor inquiry to meet diverse classroom needs, from novice learners who require foundational support to advanced students who can conduct independent investigations (Morris, 2024; and 2025).

The Ethiopian General Education Curriculum Framework (MoE, 2020) underscores the value of general science instruction in helping students develop a holistic understanding of universal disciplines their interrelationships. This framework advocates for a student-centered, exploratory, and enjoyable approach to learning. In doing so, it explicitly encourages teachers to employ a variety of inquiry-based practical activities such as science-related visits, questioning, role plays, simulations, and group or peer discussions, project-based work and, reflection to deepen learners' scientific understanding (MoE, 2020; Brhane et al., 2025). In Ethiopia's middle-level schools, these activities are not supplemental they are core to realizing the curriculum's vision. Through observation, modeling, documentation, discussion, investigation, reflection and etc.…, students are expected to demonstrate competency in fundamental scientific concepts and methods, including the nature of life, matter (both living and non-living), energy, and their interconnections. The framework also emphasizes the importance of cultivating scientific literacy: students should be able to interpret changes in their environment and understand the implications of human activity on the natural world. To support this vision, the curriculum calls for a pedagogical shift: rather than positioning teachers as the sole source of knowledge, teachers are encouraged to act as facilitators and partners in the learning process. Meanwhile, students should guide their own learning journeys by asking questions, investigating phenomena, experimenting, and reflecting (MoE, 2020). This student-centered paradigm places the learner's active engagement and action at the heart of science education.

Moreover, teachers should employ a diverse collection of instructional strategies when designing and implementing lessons. These strategies can span from traditional lectures and small-group discussions to role plays, individual and group projects, brainstorming, oral presentations, debates, problem-solving exercises, autonomous learning, drill-and-practice, discovery learning, cooperative learning, differentiated instruction, and, inquiry-based learning (MoE, 2020). Such variety ensures that instruction is responsive to students' unique aptitudes, interests, prior exposure to schooling, creative capacities, and developmental levels (MoE, 2020).

In this context, inquiry-based practical activities play a central role. In this study, these activities refer to science-focused tasks that are deliberately designed in the curriculum for implementation both inside and outside the classroom or laboratory. Examples include science-related field visits, simulations (using ICT tools, models, and displays), role plays, group discussions, project-based tasks, and structured or unstructured reflection. These experiences are not peripheral but essential: they anchor student learning in real-world scientific inquiry, fostering a deeper conceptual grasp of science in middle-school settings.

However, despite the curriculum's clear endorsement, actual implementation faces significant obstacles. Empirical research in Addis Ababa's middle schools reveals a heavy reliance on teacher-centered, lecture-based methods, with minimal or ineffective use of inquiry-based practical activities (Brhane et al., 2025). Systemic barriers including inadequate resources, limited laboratory facilities, and lack of teachers professional training significantly limit teachers' ability to enact inquiry-based learning through practical activities (Brhane et al., 2025).

2.7. Importance of Inquiry-Based Practical Activities in General Science

In order to prominence scientific concepts in the classroom, inquiry-based learning has been acknowledged and encouraged as a prevalent teaching method (Ramnarain, 2018; Aidoo, 2024; Guo et al., 2021). Additionally, it assists students in gaining scientific knowledge that may be used to promote scientific inquiry and problem-solving skills so that they can understand the meaning of science. Inquiry-based learning is a better alternative to traditional science instruction because it helps students develop their knowledge, apply it, and solve challenging problems through group projects (Guo et al., 2021). It also discourages students from passive learning and gives them greater responsibility for their education (Aidoo, 2024).

Furthermore, inquiry-based practical activities epitomize a foundation of effective science education because they bring the classroom closer to the authentic processes of scientific inquiry rather than focusing solely on memorization. When students participate in inquiry-based learning, they engage in tasks that mirror real scientific work: asking questions, designing and conducting investigations, collecting and analyzing evidence, drawing conclusions, and reflecting on their findings. This approach helps foster genuine scientific literacy by embedding understanding in the practices scientists use (Pedaste et al., 2015).

In addition, inquiry-based practical activities commonly framed within Inquiry-Based Learning (IBL) are viewed as a crucial element of effective science education. They mirror the authentic practices of scientists, such as observing phenomena, formulating hypotheses, conducting experiments, collecting data, and drawing conclusions based on evidence, rather than emphasizing memorization of facts. Through this alignment with real scientific processes, students gain not only conceptual understanding but also an appreciation for science as a method of investigation and reasoning (Kotsis, 2024; Akuma & Callaghan, 2019). Pedagogically, inquiry-based learning shifts the classroom from teacher-centered instruction toward learner-centered engagement: students take ownership of their learning by generating questions, conducting investigations, analyzing data, and constructing conclusions, while teachers act as facilitators rather than sole knowledge providers. This orientation supports greater autonomy, deeper conceptual understanding, and enhanced motivation.

Likewise, studies conducted in primary school science classrooms indicate that integrating inquiry-based practical activities is vital for achieving curriculum goals. Such activities enable students to interact directly with scientific materials and real-world phenomena through experimentation, observation, discussion, and manipulation of natural objects, leading to more meaningful and authentic learning experiences (Berhan, 2022). Moreover, inquiry-based practical activities are central to high-quality science education because they mirror authentic scientific practices rather than emphasize rote memorization. By engaging learners in asking questions, designing investigations, gathering and interpreting evidence, and reflecting on results, inquiry-based learning helps cultivate genuine scientific literacy. As a result, contemporary science curricula increasingly aim to develop students' reasoning, conceptual application, and real-world problem-solving skills. Inquiry-based learning approaches meet these aims by promoting critical thinking, independent reasoning, and adaptive problem-solving; abilities essential for directing complex and dynamic challenges. By fostering open-ended exploration and evidence-based reasoning, inquiry-based learning helps students become lifelong learners capable of contributing meaningfully in a complex society. Accordingly, science teachers are urged to adopt instructional strategies that actively engage students in learning, thus preparing them to be productive members of society (Damopolii et al., 2018).

The Ethiopian curriculum strongly aligns with a competency-based approach, targeting the development of learners who are not only knowledgeable but also equipped with practical skills and sound attitudes for real-world application (MoE, 2020). By emphasizing 21st-century competencies such as critical thinking, creativity, collaboration, and self-direction, the curriculum aims to cultivate ethical, self-reliant, and globally competitive citizens. Inquiry-based learning is central to this vision, as its capacity to foster critical thinking, engage students deeply, and build a scientifically literate society is well documented (European Commission, 2007). Indeed, the Ethiopian Ministry of Education recognizes that practical activities grounded in inquiry-based learning are essential for motivating students and deepening their conceptual understanding of the world's phenomena.

Scholars such as Balta (2015), Millar (2004), and Gardner (2006) further affirm these benefits. Balta argues that hands-on use of scientific tools and techniques provides significant opportunities for developing technical and reasoning skills. Millar highlights that practical work strengthens both content knowledge and understanding of scientific methods. Gardner, invoking his theory of multiple intelligences, contends that inquiry-based learning accommodates diverse learning styles and intelligences, enhancing conceptual grasp through multiple modalities. Correspondingly, Ethiopia's Education and Training Policy underscores the importance of using a variety of pedagogical approaches, informed by the theory of multiple intelligences, thereby providing a strong foundation for diverse and adaptive instruction. In this modern educational landscape, quality teaching must integrate tasks that nurture professional and social competencies, reflect on peer and personal achievement, and drive value-based behavioral growth (Brady, 2014).

Comparative frameworks reinforce this approach. For instance, Singapore's Science Curriculum Framework (2014) emphasizes preparing students to become confident, self-directed learners and active contributors' pillars of 21st-century competency. Similarly, Ethiopia's Development Education Roadmap recognizes the role of science, technology, and innovation in achieving national development goals. In the middle school curriculum, the Ethiopian framework explicitly embeds higher-order thinking skills through STEM, prioritizing inquiry-based learning methods for exploring both the general and physical world (MoE, 2018). High-quality practical activities in general science such as labs, simulations, and collaborative investigations are thus fundamental; they nurture creativity, curiosity, and critical thinking, promote the scientific method, enable evidence-based investigation, and integrate scientific concepts with reasoning.

Beyessa (2014) points out that science education is crucial for developing technologically literate citizens who appreciate the interconnections between science, technology, and society. Thus, the diversity in inquiry-based practical activities necessitates a variety of teaching strategies to achieve the objectives outlined in science education curriculums. In support of these concepts, researchers like Hofstein and Lunetta (2004), have shown that student engagement in science inquiry and laboratory activities significantly enhances understanding and learning. The distinctive role of these activities in science education has been recognized for its profound benefits, emphasizing that scientific inquiry encompasses both the content and processes necessary for understanding our world. Harmonizing to recent research findings (e.g., Crawford and Capps, 2018; Brhane et al., 2025 etc.), inquiry-based practical science is important and has been extensively studied and acknowledged across a variety of educational settings and disciplines, demonstrating its potential to greatly improve educational outcomes.

In addition, inquiry-based learning can boost motivation, enhance academic achievement, and foster the growth of critical 21st-century abilities like creativity, teamwork, and communication within the learners' context. In light of this, research studies and policy documents in Ethiopia have emphasized the importance of promoting inquiry-based learning and practical activities; so that students can strengthen their problem-solving skills; investigating the indigenous sciences and future-ready abilities instead of merely listening to science teachers teach science concepts in the middle schools. Overall, the significance of inquiry-based practical activities stems from their ability to provide a more realistic and engaging approach to learning science, helping learners view science not merely as static knowledge, but as an active and dynamic process of inquiry and evidence-based reasoning. Finally, in a rapidly changing, knowledge-driven world, the flexibility, creativity, and problem-solving competencies developed through inquiry-based education are especially valuable. In short, because inquiry-based practical activities align with authentic science, support reasoning and real-world problem solving, center learners, and prepare them for complexity and change, they are not optional extras but indispensable components of effective science education.

2.8. Benefits of Inquiry-Based Practical Activities in General Science Teaching

Currently in science education a shift from traditional rote memorization to a more student-centered, active learning approach is reflected in the development of the inquiry-based practical activities. National education standards, significant educational theories, and technological developments have all influenced this approach. Effective education delivery by teachers is a significant component of the accomplishment of any educational paradigm.

To operate skillfully, teachers need to have a solid considerate of the teaching and learning process. Teachers must understand and carry out each phase of the teaching and learning process in order to assist students in achieving the desired outcomes. With this in mind, the benefits of teaching science subjects using inquiry-based learning methods are presented by various scholars in the field. Research from both theoretical and empirical studies strongly highlights the numerous benefits of integrating inquiry-based learning (IBL) and hands-on investigative activities in science classrooms. Among the most frequently cited benefits is the significant improvement in students' conceptual understanding and long-term retention. When learners engage directly in questioning, hypothesis testing, data collection, and evidence-based reasoning, they construct deeper and more durable scientific knowledge compared to students who rely solely on passive instructional methods.

In addition, IBL further prepares students to apply scientific knowledge to real-world challenges. By grounding learning in authentic contexts such as environmental exploration or hands-on manipulation of natural materials students gain practical problem-solving abilities and a more relevant understanding of science in everyday life (Berhan et al., 2022; Kotsis, 2024). Likewise, inquiry-driven learning supports long-term intellectual development by fostering independence, adaptability, and self-directed learning. As students learn to investigate, question, and reason autonomously or collaboratively, they build lifelong learning dispositions and the cognitive flexibility necessary for continuous growth beyond the classroom (Aslam, 2020).

Furthermore, Sarita (2017) and Guido (2017) highlight several benefits of employing Inquiry-based practical activities including:

1. Activating Learning and Reinforces Curriculum Content: These activities stimulate both teachers' and students' brains, preparing them for learning,
2. Deepening Understanding of the content: They inspire a deeper comprehension of the content being taught actively,
3. Rewarding Learning: inquiry-based methods make learning more gratifying for students,
4. Encouraging Initiative and Self-Direction: Students develop self-reliance and initiative,
5. Versatility: This approach is adaptable to almost any classroom setting, and
6. Supporting Differentiated Instruction: It offers tailored educational experiences based on individual student needs.

Likewise, (Said, Friesen and Al-Ezzah, 2014; Achimugu, 2021) also emphasize that to boost students' motivation, effective practical activities should focus on enhancing students' understanding of science, developing practical skills in using equipment, and fostering an understanding of scientific investigations. Additionally, the advantages of practical activities in science education, including skills development, equipment manipulation, observation, analysis, experiential learning, testing theories, problem-solving strategies, and teamwork. These activities not only empower students to build self-confidence but also support diverse learning styles and promote independent learning. This helps students to engage with the material at their own pace and level, fostering a differentiated learning environment.

To summarize, scholars specializing in science education emphasize that implementing science through hands-on, inquiry-based practical activities yields numerous advantages to both teachers and students. These benefits include, but are not limited to, the enhancement of students' motivation, sparking curiosity for discovery, amalgamation of theory, cultivation of essential skills, comprehension of indigenous techniques within specific contexts, and the development of various critical abilities such as inquiry, planning, investigation, evaluation, precise observation, recording, motivation for explanation, effective information management, making experiences tangible, stimulating interest, and fostering logical skills and thought processes (SCORE, 2008). It also involves fostering an understanding of how science operates, elucidating concepts of the scientific process, promoting collaborative work, ensuring reproducible results, and encouraging fair testing (Abrahams & Millar, 2008).

Overall, the benefits of inquiry-based practical activities extend far beyond improved content mastery; they shape learners into thoughtful, motivated, and capable problem-solvers equipped with the cognitive, social, and practical skills essential for scientific and personal development.

2.9. Implementation of Inquiry-Based Practical Activities in General Science Education

The term implementation is simply defined as the process of bringing an agreed plan, decision, proposal, idea, or policy to realization by curriculum specialists and subject experts in a classroom or school setting. It also includes giving teachers organized support to pledge that the most effective teaching techniques and the recently created syllabus are truly used throughout the classroom. Any program's implementation process includes assisting the student in gaining information or experience; the student sits at the center of the process, while the teacher's acts as the main agent of curriculum implementers, while at the same time students, parents, school administrators can be directly or indirectly involved in the implementation process. Implementation occurs when the learner gains the experiences, information, abilities, concepts, and dispositions that are designed to help them function well in a society (Selvan, 2021; and Bediako, 2019).

Regarding to this, science, technology, engineering, and mathematics (STEM) education is highly valued in Ethiopia, according to the current country's Education and Training Policy

(ETP), which promotes the development of science curricula that not only impart theoretical knowledge but also encourage inquiry-based and hands-on learning, the country places a high value on STEM education. In order to prepare students for the demands of a competitive global marketplace, the policy also highlights how important it is to provide them with real-world experiences that connect what they learn in the classroom to practical applications.

Likewise, Ethiopia's General Education Quality Improvement Program for Equity (GEQIP-E) aims to raise the standard and relevance of science education across the board. These initiatives focus on developing teacher ability, updating curricula, and offering instructional resources including lab equipment and teaching aids to ensure that science instruction meets modern educational standards. The policy framework also promotes ongoing professional development for educators, with a focus on giving them the gears and pedagogical strategies needed to provide high-quality science instruction. Ethiopia has embraced a more learner-centered approach to the implementation of its science curriculum, encouraging learners to participate in practical investigation, critical thinking, and inquiry-based practical learning. This shift aligns with the broader goal of fostering scientific literacy and empowering students to apply scientific concepts to solve real-world problems. The curriculum promotes the use of diverse teaching methods and instructional materials to make science education more engaging and effective (MoE, 2023).

Furthermore, in Ethiopia there is a significant emphasis on using science and technology as tools for learning and development. Schools are encouraged to act as centers for scientific inquiry and technological development. The introduction of STEM education is crucial for fostering creativity and developing new skills. This approach aims to produce critical thinkers, innovators, and problem solvers by integrating academic concepts with real-world challenges and promoting collaborative learning. Thus, the role of the teacher in Inquiry-based settings is to facilitate rather than direct learning. Teachers should monitor students' development of information-processing and critical thinking skills, helping them build a deep understanding of the subject matter through active engagement in practical activities. Complementing this, a meta-analysis comparing various scientific problem-solving pedagogies (including IBL, PBL, and STEM-integrated approaches) reported that such approaches enhance students' creative capacities and interdisciplinary problem-solving skills (Ammar & Al-Thani, 2024). These findings collectively support the implementation of IBL can effectively cultivate not only conceptual knowledge but also scientific reasoning, creativity, and complex problem-solving skills.

Even though inquiry-based STEM education is widely regarded as a solution to socioeconomic problems and the development of 21st century skills, its implementation remains difficult in many countries (Mpofu, 2019). A comprehensive review of science teacher training across African countries finds that teacher education systems often suffer from lack of qualified science teachers, poor resources for science teaching, weak infrastructures, and conflicting educational policies all factors that hinder effective adoption of inquiry-based approaches (Soares et al., 2021).

In practice, several structural and pedagogical obstacles hinder effective adoption of IBL. Teachers face constraints such as limited instructional time, heavy syllabus content, large class sizes, and lack of teaching–learning materials. These pressures often encourage teachers to favor quick, manageable tasks rather than deeper, sustained scientific inquiry (Ramnarain & Hobden, 2015; Ramnarain & Hlatswayo, 2018; Twizeyimana et al., 2024). Additionally, many teacher-preparation or pre-service programs continue to emphasize traditional, lecture-based teaching, rather than developing the advanced pedagogical skills required for fully inquiry-based learning, student-centered instruction (Twizeyimana et al., 2024; Soares et al., 2021).

In resource-constrained settings including many parts of sub-Saharan Africa these challenges are especially acute. For instance, a study reviewing IBST (inquiry-based science teaching) in selected Sub-Saharan countries reported a significant discrepancy between curriculum statements endorsing IBST and actual classroom practices: classrooms remained teacher-centered, practical work was recipe-based, and contextual obstacles such as scarce resources, inexperienced teachers, exam-focused culture, and large class sizes severely undermined effective IBST (Mkimbili, 2023,). Similarly, more recent research confirms that even when science curricula formally include inquiry-based practical activities, actual classroom practice often reverts to lecture-based delivery, due to inadequate materials, large classes, and unmanageable content load (Ramnarain & Hobden, 2015; Ramnarain & Hlatswayo, 2018; Twizeyimana et al., 2024).

For contexts such as middle-level schools in Addis Ababa and for Ethiopia more broadly these findings are therefore highly relevant. Effective IBL implementation would demand investment in teacher professional development, provision (or improvisation) of practical materials, and scheduling that allows sufficient time for inquiry cycles. In addition, assessment practices may need reconsideration: rather than relying solely on traditional exams, educators should consider performance-based, project-based, or portfolio assessments that capture students' process skills, reasoning, collaboration, and conceptual understanding.

In conclusion the literature supports the pedagogical value of inquiry-based learning in science education but realizing its benefits requires more than tagging a curriculum inquiry-based learning. It demands structural investment, strong teacher support, thoughtful design, and contextual sensitivity. In light of this, a research study investigating the implementation of inquiry-based learning through practical activities in Addis Ababa's middle-level science classes would be timely and valuable not only to highlight opportunities, but to identify concrete barriers and inform policy and practice for more effective and practical science education.

Therefore, the study's results provide insight into the implementation of inquiry-based practical activities in middle schools, addressing the issues raised and offering future directions for raising the pub for science education by demonstrating the significance of integrating inquiry-based practical activities to meet science education goals.

2.10. Factors Hindering the Implementation of inquiry-based Practical Activities in General Science Curriculum

The success and efficiency of any educational process or program implementation depends on many delivery services. For example, educational services should be designed to provide access to all resources, including all learning process requirements. In addition, educational institutions should encourage innovation, create strong collaborative relationships with all stakeholders, it should establish relationships such as receiving expert services, provide opportunities for teachers and students to learn in real-life situations, extend the institution's services to teachers and students through continuing education programs, and enhance problem-solving capabilities through projects and research in their context.

Recent international research shows that despite broad support for inquiry based practical work (IBPW) in science education, its implementation in real classrooms remains highly problematic. For instance, in a foundational study of early adopter high school science teachers in Australia, teachers reported that "extreme time restrictions," lack of sufficient professional development, absence of clear models of inquiry instruction, and shortage of resources made it difficult to enact IBPW in everyday teaching (Fitzgerald et al., 2019). They noted that even when teachers were positively inclined toward inquiry based teaching, systemic constraints such as heavy curriculum load, limited contact hours, and inadequate equipment or lab access undermined sustained adoption of inquiry methods (Fitzgerald et al., 2019). Similarly, a global review of practical work in natural sciences at secondary schools identified inadequate laboratory infrastructure (e.g., missing or insufficient lab equipment and supplies), lack of laboratory manuals, inadequate laboratory rooms, large class sizes, and limited ICT access as regular challenges hindering practical science across many countries especially in developing contexts (Chala, 2019). According to this review, a second major cluster of obstacles involves teacher and technician-related issues, including teachers' motivation and perceptions, competence in practical work, workload, and availability (or lack) of lab technicians (Chala, 2019).

As we have seen from the research results above, it is clear that the strategies set out are not being implemented as intended. The existing knowledge of literature and educational researchers suggests certain evidence for the potential key factors that influence pre-planning, program characteristics, training and technical support, integration of the program, organizational and implementer characteristics. Turning to the Ethiopian context, empirical studies paint a similar often more critical picture as well as factors and shortcomings to the successful implementation of inquiry-based practical activities can be multidimensional. According to Michael et al. (2023), a number of criteria are necessary for the successful implementation of science curricula, including the alignment of curriculum design with pedagogical practices and the availability of resources and support for teachers. One of the fundamental factors influencing the level of curriculum implementation is the methodology embedded within the curriculum.

Related to this, the SCORE (2008) report and studies from various African countries highlight significant challenges impede the effective implementation of inquiry-based practical activities in general science education lists such as inadequate laboratory facilities, predictable experiments, and a lack of engagement with hands-on scientific exploration. Another study conducted by Babalola F. et al., (2019 and 2020) shows that in several countries of the Sub-Saharan Africa, the qualification assessment processes completely ignore practical work, and lack of confidence in the ability to run meaningful practical examinations have led to the use of stereotyped predictable experiments. Similar to this, local studies (Gogile and Alemayehu, 2016; Mathewos.et.al, 2016; Muleta and Seid, 2016; Muleta et al., 2016; Shitaw, 2017) also show that the major problems which hinder the implementation of practical activities in Ethiopian schools are: lack of laboratory rooms, inadequate supply of lab equipment's, reagents and facilities, absence of trained laboratory technicians/teachers, lack of commitment and interest of teachers, lack of regular schedule for laboratory activities, poor management, monitoring and evaluations of laboratory activities, no system for grading and assessment of laboratory examinations are the major problems. Furthermore recent studies Ethiopia has listed a number of issues when it comes to providing high-quality science education, including inadequate funding, out-of-date curricula, low student participation in efficient teaching techniques, a shortage of laboratory supplies, disorganized lab manuals, large class sizes and inadequate teacher preparation often prevent the effective inquiry-based practice in science classroom (Abdulbasit & Mekuria, 2021; UNESCO, 2022; and Geletu, 2022). A 2022 qualitative study of primary schools in Addis Ababa likewise reported that inquiry-based practical activities were nearly absent: lack of professional training for teachers and lab technicians, scarcity of materials and facilities, low teacher commitment, and a general lack of awareness among participants were major impediments (Berhan, 2022). Taken together, these global and local findings highlight a complex interplay of factors that hinder the implementation of inquiry-based practical activities in general science. This convergence suggests that simply suggesting inquiry-based practical activities is not enough; successful implementation depends on coordinated support across resources, training, institutional design, and teacher development.

In summary, the review of different research reports shows that applying inquiry-based practical activities within the science curriculum often encounters obstacles, as a result of various factors that hinder implementation in schools. Accordingly, it is important to continually examine and evaluate how the curriculum is delivered and assessed including teaching methods and evaluation approaches to ensure effectiveness. Thus, identifying the main factors that impede the use of inquiry-based practical activities in middle school general science curricula is essential in order to address them in a timely manner.

2.11. Empirical Evidence on the implementation of Inquiry-Based Practical Activities in General Science curriculum

Over the past decade, empirical research has increasingly examined how inquiry-based science education (IBSE) and practical inquiry-based activities affect students' learning, engagement, process skills, and long-term attitudes toward science. Evidence from multiple international studies suggests that, when implemented with care, inquiry-based practical activities in science education can substantially enhance students' motivation, active participation, and their development of scientific knowledge and research skills. For example, specially designed inquiry-based modules in secondary science combining experiments, authentic tasks, and problem-based learning have been associated with deeper student engagement, enhanced conceptual understanding, and improved abilities in scientific reasoning and communication (Kotsis, 2024; Vilela et al., 2025). Additionally, inquiry-based practical activities or IBSE appears to support not only cognitive and skills-based outcomes but also affective dimensions students exposed to inquiry-based instruction often report greater interest in science and increased confidence, and in some cases, such exposure correlates with heightened aspirations toward STEM-related careers (Gomez et al., 2025).

Certainly, inquiry-based practical science activities are widely recognized as an essential component of science education and instruction in schools because they can foster students' interest while providing critical scientific knowledge and skills (Crawford, 2014; Wale & Bishaw, 2020; Antonio & Prudente, 2023; Strat et al., 2024; and etc.). As a result, the effective implementation and practice of science education in schools currently gained a high consideration by many countries in the world.

Empirical research underscores the critical role of inquiry-based practical activities in science education. These activities are shown to enhance students' engagement, promote critical thinking, and improve problem-solving skills. For instance, studies indicate that inquiry-based teaching methods result in better educational outcomes compared to traditional lecture-based instruction. Scholars such as Crawford (2014); Li and Yuan (2022); Orosz et al. (2022); and Kožuchová et al. (2023) have noted that inquiry-based teaching is a relatively new approach that comes from the scientific aspect and is associated with a variety of procedures that researchers use to examine the world around them and present their findings that are supported by scientific indications. Inquiry is centered on activities that aid students in learning, grasping scientific concepts, principles, etc., and observing how researchers operate. Students are given exceptional chances to solve challenges, explore their surroundings, and gain knowledge through hands-on experiences.

In the context of inquiry-based method, problem-solving skills are indispensable because they enable students to investigate, discover, and find solutions to their questions. Since they are interdisciplinary and not subject-specific, their development should be incorporated into the curriculum for all subjects (math, technical subjects, science, humanities, language instruction, and other subjects) as well as into the execution of activities within overarching themes, like environmental education. As a result, inquiry-based education has recognized to be a promising educational approach and may serve as the groundwork for future educational creativities.

The science education literature indicates that inquiry-based practical activities encourage students towards engaging in science; however, it is significant to look for means how this encouragement could be effectively transferred to the areas such as development of critical thinking, problem solving, analyzing data, and reporting them. It is also vital to go beyond pleasure and guide students to learn the scientific content covered in practical activities. There is no one procedure for success however, some pedagogical approaches to transforming educational practice like inquiry-based practical activities offer a potential in supporting students to become thoughtful, motivated, collaborative and innovative learners capable of engaging in their own inquiries and successful in a world of constant modification.

Pauli (2009) statement support this if we are only teaching what we know, our children can only do as bad as we are doing, and this is the challenge we are facing, we have to go beyond it. Therefore, in process inquiry-based learning, the teacher serves as the students' facilitator, support system, and source of feedback (Kong & Song, 2014). Depending on how much direction the teacher gives, the inquiry process can occur at various levels or in particular stages (Vorholzer & von Aufschnaiter, 2019; Pedaste et al., 2015). At the same time, however, the literature cautions that IBSE is not a guaranteed route to improved science achievement. A cross-national analysis of data from 2015 PISA (covering six OECD countries) found that students who reported experiencing high frequencies of inquiry-based instruction actually had lower scores in scientific literacy than peers taught via teacher-directed or adaptive instruction (Oliver et al., 2021). Moreover, longitudinal research in England similarly found little evidence that frequent inquiry-based teaching predicted better science performance on subsequent assessments (Jerrim et al., 2019). These findings underscore that the effectiveness of IBSE depends heavily on how inquiry is implemented.

A research investigations from under-resourced settings highlight a persistent gap between inquiry-based practical activities or IBSE's theoretical promise and its real-world implementation. A mixed-methods survey among secondary science teachers in Namibia revealed that despite national curricular endorsement of learner-centered, inquiry-based teaching, many teachers continued with traditional "cookbook-style" experiments, citing lack of materials, insufficient professional development, and entrenched teaching habits (Shivolo et al., 2024). Similar findings emerged from studies in Ghana in junior high schools IBSE implementation was found to be rare; and when it occurred, it varied significantly by school type and location (Mohammed et al., 2020). These patterns illustrate that without structural support resources, teacher training, institutional commitment IBSE often remains on paper rather than in practice. Indeed, more recent scholars argues for a balanced, evidence-informed approach rather than unrestricted "open inquiry," a guided-inquiry model where teachers provide structured scaffolding, design tasks carefully, and guide students' reasoning appears most effective. Such design helps manage cognitive load, support scientific reasoning, and align inquiry practices with learning objectives (Kotsis, 2024).

Thus, while inquiry-based science education holds considerable promise for fostering deeper learning, scientific thinking, and engagement, its success is contingent on quality of implementation**,** teacher competence and support, and contextual factors such as resources, class structure, and scaffolding. Without careful design and supportive infrastructure, inquiry-based practical activities in science may fall short of its potential. Therefore, 5E teaching paradigm is considered to be one of the most well-liked and effective cycles for inquiry-based learning (Srisawasdi and Panjaburee, 2015; Sotáková and Ganajová, 2023). The five learning phases or stages in this model engage, explore, explain, elaborate, and evaluate all begin with the letter "E" (Bybee, 2009), hence the name.

The findings of multiple studies (e.g., Bybee, 2015; Chu et al., 2017; Wale & Bishaw, 2020; Garcia et al., 2021; Harlen, 2021; Ješková et al., 2022; Varoglu et al., 2023) support the notion that the 5E model is more effective than teacher-centered teaching techniques. Understanding scientific knowledge is developed, students' motivation and interest in studying science are increased, critical thinking and argumentation skills are developed, and the ability to apply the knowledge in practice is enhanced. It also makes it easier for students to develop inquiry skills, also known as scientific process skills, which include formulating research questions and hypotheses, providing evidence, evaluating explanations, and drawing conclusions.

Additionally, the 5E model promotes the development of scientific literacy and has effect on long-term learning (Bybee, 2019; and Garcia et al., 2021). Therefore, inquiry based learning places students' questions, ideas and observations at the center of the learning experience, combining the best approaches to instruction, including explicit instruction, small group, individual guided learning, experiment to build on students' interests and ideas. It can finally move students forward in their paths of academic curiosity and understanding of science necessary.

Likewise, research studies conducted by different scholars such as (Bybee, 2019; Duschl et al., 2007) have shown that inquiry-based practical activities has a positive effect on students' learning in science education, especially when compared with traditional instruction that seems minimally effective in meeting the educational goals. In line to this, research studies by Abdi (2014); Wale & Bishaw, (2020); Harlen (2021); Sotáková and Ganajová (2023), revealed that inquiry-based learning produces positive results to develop understanding of scientific knowledge and skills to create scientifically literate population and there is substantial empirical and theoretical evidence that inquiry-based instruction is a starting point for personal construction of meaning and can lead to higher achievement of all students.

As the body of literature indicates, curriculum documents have been introduced by education authorities worldwide, including Canada (Alberta Education, 2013; British Columbia Ministry of Education, 2013; Ontario Ministry of Education, 2013), highlight the importance of teachers involving their students in inquiry processes to build their capacities in these areas (Scott et al., 2018). Likewise, many nations have also implemented curricula that highlight the importance of inquiry-based learning for pupils. Moreover, many countries, such as Finland, Denmark, Sweden, Norway, and Australia, as well as Indonesia and China, are renowned for integrating this method into their curricula.

Developing African countries, such as Rwanda, South Africa, Kenya, Tanzania, Ghana, and Nigeria, are noteworthy for actively integrating and investigating inquiry-based learning into their curricula, especially through Competency-Based Education (Sjøberg, 2018; Scott et al., 2018). Like the other African countries Ethiopian Educational System has integrated different reforms in the science education to improve science teaching and learning at all educational levels by emphasizing skills development over rote learning. This approach aims to equip students with the necessary skills to engage effectively with science and technology, thereby addressing local and global challenges.

In conclusion, inquiry-based practical activities are vital for the effective teaching and learning of general sciences. They encourage students to engage actively with content, fostering a deeper understanding and appreciation of scientific concepts. The implementation of these activities requires careful consideration of local conditions and resources to ensure that educational objectives are met effectively.

2.12. Conceptual Framework

In the evolving educational landscape, the ability to pose questions, devise solutions, interpret information, and cultivate lifelong learning skills increasingly valued by academia, employers, and society at large. This shift from the rote memorization to the student-centered participatory approach calls for educational strategies that foster these crucial competencies (Cummins & Davison, 2007; Nasser, 2020). According to Millar (2008), the complexity of teaching science in the 21st century necessitates more creative approaches, greater integration of information and communications technology (ICT), and highly skilled educators to successfully navigate the curriculum. Likewise, according to Sotáková and Ganajová (2023), the public of today has to be scientifically educated in order to comprehend contemporary problems and determine how to address them. Science education that is Inquiry-based can raise students' comprehension of scientific concepts and help them acquire 21st-century abilities (Chu et al., 2017). Conferring to Harlen (2021), Inquiry-based activities are essential for developing a scientifically literate youth population capable of addressing significant issues for food, energy, health, water conservation, and climate change adaptation. By engaging in hands-on, inquiry-based learning, students gain the skills and judgement needed to make wise, responsible decisions in both their personal lives and broader society.

This approach is strongly supported by the design of Ethiopia's middle-school curriculum under the General Education Curriculum Framework (GECF, 2020). The Framework names natural sciences (science and technology) as foundational for national development and technological progress, with aims that include fostering "scientific and technological literacy," nurturing "creativity, productivity and problem-solving capabilities," and enabling learners to think critically, solve problems, and contribute to economic and social development (Ministry of Education, 2020). Moreover, the GECF envisions students who are self-reliant, responsible and active contributors to national development, equipped with competencies essential for life, further learning and employment; including the ability to apply science meaningfully in real-world contexts. Thus, the assertion that inquiry-based practical understanding empowers youth to tackle challenges in food, energy, health, water, and climate aligns strongly with Ethiopia's own educational policy (MoE, 2020).

The effectiveness of inquiry-based practical activities is further strengthened by Millar and Abrahams (2009), who developed a framework for designing and assessing science practical work. Their model emphasizes that practical work should not merely allow students to observe phenomena, but more importantly engage them cognitively: linking observations to scientific ideas, reflecting on data, and deriving meaningful insights. When practical work is implemented with clearly defined learning objectives, thoughtful task design, and support for conceptual reasoning, it becomes a powerful tool for scientific literacy and sustained student engagement (Millar & Abrahams, 2009).

Thus, combining the national curriculum vision (GECF) with the research-based framework of Millar and Abrahams (2009) provides a strong, evidence-based foundation for the claim that inquiry-based practical science education equips youth to address critical issues food, energy, health, water, and climate while building the scientific literacy and decision-making capacity that societies need.

Millar & Abraham's Framework for Effective Practical Activities

1. Objective Setting:
    - Learning Objectives: These are defined based on the educational context, available resources, assessment strategies, students' perceptions of science, and the appropriateness for the students' age and educational stage.
    - Activity Design: Objectives are translated into specific tasks designed to achieve the intended learning outcomes.
2. Implementation and Assessment:
    - Effectiveness 1 (Implementation): Observing whether the actual classroom events and student actions align with what was intended by the activity's design.
    - Effectiveness 2 (Learning Outcomes): Evaluating if students learn what they are expected to learn, acknowledging the complexity of measuring learning outcomes, which may be influenced by a series of lessons rather than a single activity.

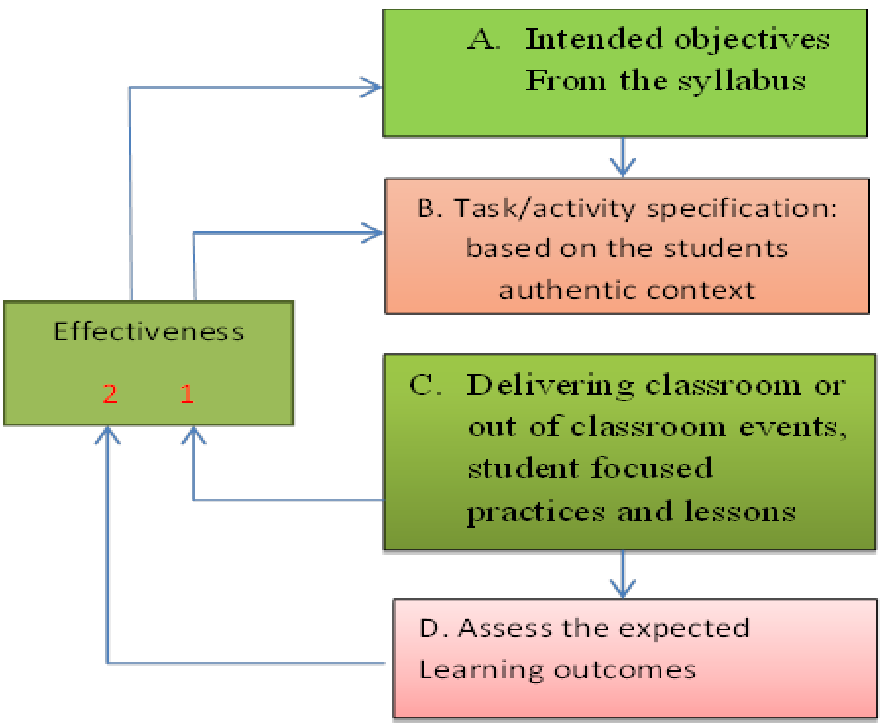

Figure 2. 1: Model for the process of developing and implementing effective practical tasks (from Millar & Abraham, 2009)

Millar & Abraham caution against the tendency of practical work to devolve into mere 'recipe following,' where students mechanically perform tasks without understanding their purpose. They argue that for an activity to be effective at fostering learning (Effectiveness 2), it must first succeed in engaging students as intended (Effectiveness 1). Overly prescriptive instructions may ensure the activity is carried out correctly, but they do not guarantee that students will engage deeply with the underlying scientific concepts.

Inquiry-based practical activities at the heart of a general science curriculum offer far more than simple demonstrations: when they are well designed, they combine hands-on experiences with minds-on thinking, enabling students to link concrete observations with abstract scientific concepts, cultivate inquiry skills, and apply scientific understanding meaningfully to real-world problems (Kotsis, 2024; Millar & Abrahams, 2009). As Millar and Abrahams (2009) argue, science practical work easily risks devolving into mechanical "recipe-following," where students carry out procedures without grasping the underlying rationale, limiting learning to superficial, observational tasks. To guard against this, they distinguish two forms of effectiveness: "Effectiveness 1", where students successfully carry out the tasks and observe the intended phenomena, and "Effectiveness 2", where deeper learning occurs students internalize scientific ideas, reflect on observations, draw connections, and transfer the understanding beyond the immediate activity (Millar & Abrahams, 2009). They note that many tasks may achieve Effectiveness 1 but fail to reach Effectiveness 2, underscoring that hands-on activity alone does not guarantee meaningful scientific understanding.

Inquiry-based practical activities in science teaching builds directly on this insight by inserting practical tries inside a broader investigative cycle: students ask questions, formulate hypotheses, design investigations, collect and analyze data, draw evidence-based conclusions, and relate findings to larger scientific principles (Kotsis, 2024). Empirical research confirms that when experiments are embedded in inquiry-based practical activities, students not only become more engaged, but also achieve deeper conceptual understanding, enhanced critical thinking, and improved application of scientific methods moving well beyond rote memorization (Kotsis, 2024).

For a general science curriculum to bind this potential, practical activities must be intentionally designed with explicit learning objectives that define not only what students will do (e.g., operate apparatus, observe phenomena), but also what they are to learn the underlying scientific concepts, reasoning processes, and connections to real-world contexts. In addition, curricula should provide scaffolding for "minds-on" engagement (through reflection, data analysis, hypothesis evaluation), progressively increase complexity (from structured procedures to open-ended investigations), integrate inquiry activities across different science domains (biology, chemistry, physics, earth science), and tie practical activities to real-life issues (e.g., environmental monitoring, public health, sustainability).

Enhancing Practical Science Activities

To counteract the limitations of traditional 'recipe following,' practical activities must be deliberately designed to connect hands-on experiences (what students do and see) with brains-on analysis (interpreting observations through scientific concepts). SCORE (2009b) categorizes effective practical activities into:

- **Core Activities**: These include investigations, laboratory procedures, and fieldwork that develop practical skills and enhance understanding of scientific phenomena.
- **Related Activities**: These involve teacher demonstrations, experiencing phenomena, designing investigations, analyzing results, and using ICT to enrich students' firsthand scientific experiences.

Furthermore, Bybee (2015) privileges that the 5E Instructional Model is an experiential learning model that necessitates active student participation, is an excellent tool for learning facilitation, and that teachers have a big responsibility to provide well-planned and organized learning opportunities based on the students pace of learning and real context. Under this study each of the learning phases are related with the level of effective implementation of inquiry-based practical activities developed by Millar & Abraham (2009). These are:

1. Engage aims to stimulate students' interest in participating in their own learning, while; Teachers have the opportunity to connect new content with prior knowledge to make learning meaningful.
2. Explore includes creating a variety of creative and hands-on activities that allows students to conduct guided experiments and explore similar activities.
3. Explain, students explain in a simple way in their own words the concepts worked on, the knowledge acquired and share them with the rest of the class, as well; the teacher searches with accuracy and precision for scientific vocabulary, connecting the knowledge provided by the students with other abstract and conceptual terms.
4. Elaborate, helps students apply acquired knowledge to new learning experiences.
5. Evaluate, at this stage students can understand their own learning, in addition this step is not done at the end of the process; beside it can be done at any time of the five phases (Garcia i Grau et al., 2018).

By integrating the inquiry-based practical activities, the educational framework supports the development of a robust scientific understanding, enabling students to link empirical experiences with theoretical knowledge. This approach fosters a more engaging and comprehensive educational experience in science, encouraging students to become active, thoughtful participants in their learning journeys.

Moreover, the following figure illustrates the core elements of inquiry-based practical activities in general science in schools, aimed at assisting teachers and students through practical activities that relate to real-world environments and incorporate various skills; because the steps are developed as a teaching and learning sequence with the purpose of promoting the adaptation, integration of scientific concepts and knowledge, the context in which these concepts and knowledge make sense, the ways in which knowledge is constructed, critical thinking, problem solving, creativity and collaboration (Zárate-Moedano et al., 2023).

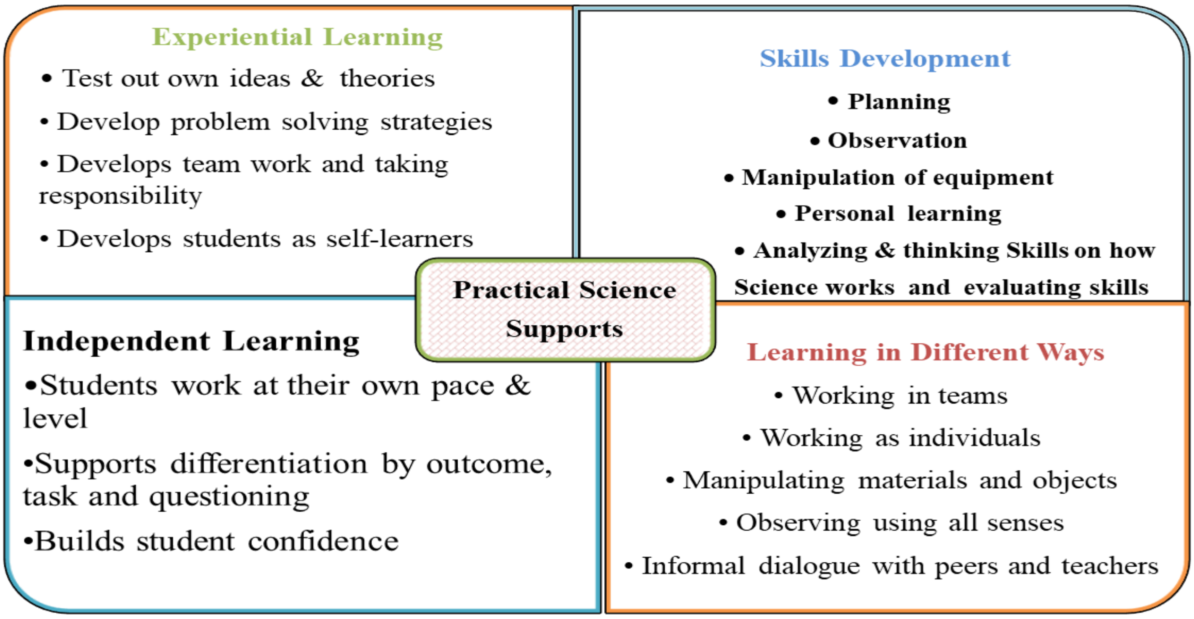

Figure 2. 2: Support for Practical Activities to Integrate Various Skills in Science (adapted from a framework for practical science in schools, SCORE, 2009a).

According to SCORE (2009a), a significant portion of science learning activities connected with practical work occurs through discussions about observations made during these activities, both among peers and with the teacher. Consequently, each practical activity should be followed by a discussion period to analyze observations, such as similarities, differences, relationships, trends, and interpretations. Thus, implementing the general science curriculum effectively in schools requires using the authentic contexts of learners and teachers and applying inquiry-based practical activities through the recommended instructional model. This approach fosters both scientific understanding and the development of various skills necessary for managing scientific knowledge.

The aforementioned figures highlight the importance of considering practical tasks and outcomes from the design of syllabus objectives up to the delivery of lessons students and teachers go through the different tasks such as engage to observe the situation, explore the observed situation and write up the events through involving all sense organs and the students elaborate the situation based on their pace of understanding through group and, or individual reflection. The teacher's guide every progress of students in the series of debate in supporting or opposing of students reflection. Additionally both students and teachers continuously evaluate their process or results to motivate or re-correct the misconceptions of the general science syllabus by integrating the indigenous knowledge in sciences for further investigation.

The design of inquiry-based practical activities should also take into account the students' environments and use diverse practical strategies to ensure the quality of the science curriculum in schools. In support of this, Bybee et al. (2006) contend that an Inquiry-based strategy is a student-centered approach to teaching and learning that involves students in their education, acknowledges their previous knowledge and beliefs, and authorities them to investigate the spectacle before coming up with scientific clarifications and drawings of their progressing understandings. Students can expand their understandings through student-planned inquiries owing to the model's elaborate phase. In the last assessment stage, students demonstrate their conceptual knowledge and consider their educational experiences.

Supporting to this recent research also stated as, the conversation away from traditional lecture-based instruction and toward inquiry-oriented, student-centered approaches is revealing of a universal pedagogical trend and it has become a cornerstone of contemporary science education, championed by frameworks like the Next Generation Science Standards (NGSS), (National Research Council, 2012) have transformed science education in grades K–12 by promoting scientific thinking and conduct in students and reinforcing the importance of scientific literacy. At its core, inquiry incorporates exploration, explanation, and argumentation, emphasizing both hands-on investigation and intellectual engagement with scientific ideas (Morris, 2025; Nawanidbumrung et al., 2022). Unlike traditional methods that treat science as a static body of facts, inquiry-based approaches emphasize the dynamic and iterative nature of science, encouraging students to connect their observations to broader scientific principles.

The next conceptual framework outlines to basics of general science subjects (Chemistry, Physics, and Biology) through inquiry-based practical activities and their integration with the 5E instructional model when implemented in schools to achieve the intended goals by relating to real-world environments.

Accordingly, this study adapt and recommend the next conceptual framework outlines the basics of general science subjects (Chemistry, Physics, and Biology) through inquiry-based practical activities and their integration with the 5E instructional model when implemented in schools to achieve the intended goals by relating to real-world environments.

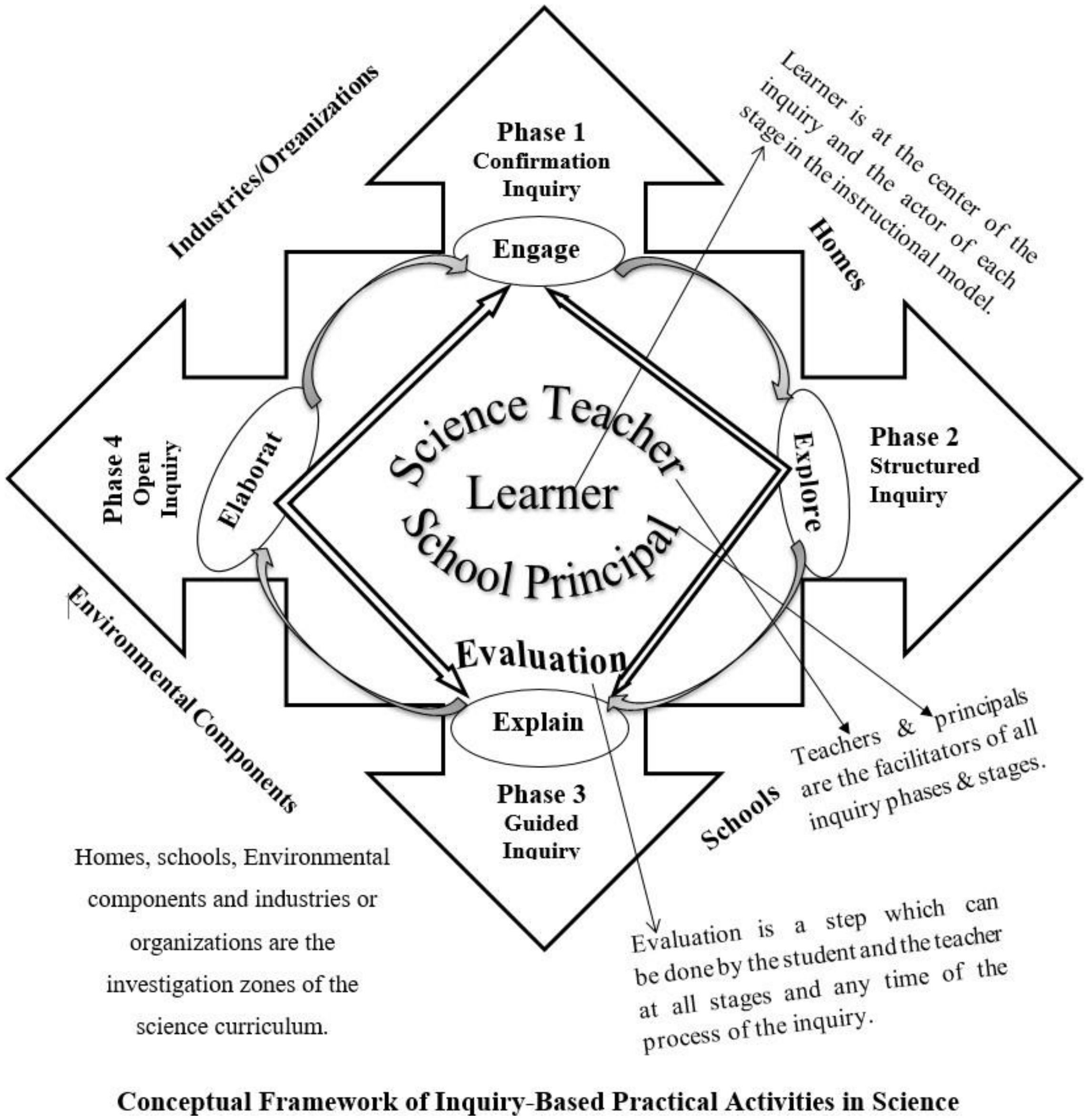

Figure 2. 3: Conceptual Framework for Implementing Inquiry-based Practical Activities in Science (adapted from Getting Practical: A Framework for Practical Science in Schools, SCORE, 2009a and Bybee, 2006).

This conceptual framework builds on foundational work by Millar & Abraham (2009) and Bybee (2006), which emphasize the need for well-defined, measurable objectives, thoughtful instructional design, and assessment aligned with learning goals for effective science practical activities. In this study, a research-informed model of inquiry-based practical activities serves as the structural backbone, enriched with scaffolding, contextual relevance, collaborative practices, and continuous assessment.

At its core, the framework aligns with the widely accepted 5E Instructional Model (Engage, Explore, Explain, Elaborate, and Evaluate) embedded within an overarching inquiry-based learning (IBL) paradigm. This alignment is supported by cognitive science and constructivist learning theories, which contend that learners build durable conceptual understanding when they have opportunities to activate prior knowledge, explore phenomena, construct explanations, apply concepts to new contexts, and reflect on their learning (Ruiz-Martín & Bybee, 2022). Empirical research confirms that 5E-based instruction enhances conceptual understanding, science achievement, reasoning skills, and students' interest and positive attitudes toward science (Ruiz-Martín & Bybee, 2022; De La Peña & Maatubang, 2025; Ong et al., 2024).

A. Structure and Parts of the Framework

1. Contextualized Inquiry-based learning phases and 5E instructional model

The framework places the learner at the center, supported by both science teachers and school administration. Rather than restricting inquiry-based practical activities in science curriculum to traditional laboratory settings, it embeds learning within authentic "investigation zones" (homes, community environments, local ecology, industry or other organizations). This contextualization allows science learning to connect with real-world phenomena, enhancing relevance, fostering motivation, and facilitating transfer of learning beyond the classroom. Similarly, in implementing this model, the framework emphasizes that learning objectives must be clearly defined and aligned with both pedagogical design and assessment schemes. Inquiry-based practical activities from syllabus design through lesson delivery should be purposefully crafted so students move sequentially (or cyclically) through the inquiry-based learning phases and 5E instructional model aligned as:

Phase 1 Confirmation / Initial Inquiry (Engage): This stage seeks to capture learners' interest and curiosity. It introduces phenomena, problems, or questions often drawn from authentic contexts or "investigation zones." The aim is to activate students' prior knowledge, surface their existing conceptions or misconceptions, and formulate compelling questions that will guide the direction of inquiry.

Phase 2 Structured Inquiry (Explore): In this phase, students actively investigate through experiments, observations, data collection, or manipulation of materials. Under teacher facilitation, they test hypotheses, examine phenomena, and explore relationships. This phase emphasizes hands-on experimentation and discovery, allowing students to build an initial understanding without immediate formal instruction.

Phase 3 Guided Inquiry (Explain): Here, students and the teacher collaborate: learners articulate their observations, interpretations, and tentative explanations. The teacher scaffolds the process by introducing scientific vocabulary and formal definitions, clarifying misconceptions, and linking students' findings to conceptual or theoretical frameworks. Through this guided discussion and reflection, learners transform raw data and experiences into conceptual knowledge.

Phase 4 Open / Environmental Inquiry (Elaborate): During this stage, students apply their newly constructed understanding to new situations, preferably in real-world or authentic contexts drawn from investigation zones. They may design new investigations, pursue further questions, or explore deeper relationships and broader applications. This phase supports generalization of understanding, fosters transfer to different contexts, and strengthens competence in applying inquiry skills.

It is important to note that while the phases are presented in sequence, they are not strictly linear. The arrows in the model show the dynamic, cyclical nature of inquiry learners may shift between phases as understanding deepens or as investigations evolve. As recognized in the 5E instructional model, inquiry is inherently iterative and cyclical: learners often loop back to re-engage, re-explore, or re-explain particularly when new questions arise, misunderstandings persist, or new contexts emerge. Furthermore, the inquiry-based practical model supports ongoing cycles. Accordingly elaboration or even after exploration or explanation learners may encounter new questions, notice inconsistencies, or identify further phenomena. These trigger a return to "explore", or even "engage", enabling repeated cycles of testing, reflection, revision, and expansion of understanding. Such cycles continue until understanding stabilizes, a contextually relevant application is achieved, or the investigation reaches its goals. This cyclical nature mirrors real scientific processes, where hypotheses are refined, experiments repeated, and contexts revisited underscoring that the model is not only pedagogical but also epistemological, reflecting how real-world inquiry actually works.

Evaluate: improved with scaffolding, differentiated support, institutional facilitation, authentic real world contexts, collaborative practices, and continuous formative evaluation. At its center sits the learner as an active constructor of understanding, while teachers and school leadership assume the roles of facilitators, guides, and scaffolds rather than mere transmitters of content. Moreover, evaluation is not treated as a one-time final exam; instead, assessment is woven into every phase of the learning process.

From the “engage” stage onward, formative assessment helps reveal students’ prior knowledge, misconceptions, and readiness to learn. During the “explore” and “explain” phases, continuous feedback supports development of scientific reasoning, conceptual clarity, and procedural skills. When students reach the “elaborate” phase, assessment shifts toward application examining how well learners transfer their knowledge and solve real-world problems. Furthermore, self-evaluation, peer review, and teacher feedback deepen metacognition and self-regulation, while collaborative assessment encourages shared reflection and growth. Empirical research supports that such formative and continuous assessment practices improve students’ cognitive strategies, promote self-regulated learning, and enhance conceptual understanding often more effectively than traditional summative-only approaches (Unas & Buldur, 2025; Goloi & Osman, 2018).

2. **Pedagogical Supports: Scaffolding, Collaboration, and Continuous Assessment**

Recognizing that pure discovery without support can lead to superficial understanding, this framework integrates scaffolding and differentiated support: during exploration and explanation phases, teachers guide students through prompts, modeling, structured data-collection, and reflective discussion gradually withdrawing support as students gain competence. Empirical evidence supports that such scaffolding, including peer assessment in collaborative inquiry contexts, enhances the quality of students’ inquiry outputs (research questions, data collection, conclusions) and supports metacognitive regulation and deeper learning (Wu & Rau, 2025; Vo et al., 2024).

Moreover, the framework insists on contextualizing science learning in authentic, real-world environments. Rather than restricting investigations to textbook or standard laboratory settings, students can draw on their community environment, local ecology, industry, or everyday experiences as “Investigation Zones / Contexts.” These investigation zones / contexts represent real-world settings such as homes, schools, natural environment, industries or community organizations where inquiry doesn’t happen in isolation but is connected to authentic problems, phenomena, or contexts that provide grounding for inquiry. By embedding inquiry in these zones, the model helps students: see how scientific concepts and investigations relate to life beyond the classroom (authenticity). Draw on their own experiences, environment, local community or surroundings as sources of inquiry questions or data. Transfer learning to concrete, relevant situations bridging theory and real-life contexts. This contextualization enhances relevance, enables real-life application, and supports the transfer of scientific understanding beyond the classroom contributing to scientific literacy and meaningful engagement. In science education, it is crucial to create various inquiry-based practical strategies for both teachers and students, whether in the classroom, school, or external environments. This approach allows teachers to prepare more thoroughly rather than relying solely on textbook content, and it enables students to engage by asking questions, reflecting on their experiences, and sharing ideas during discussions.

Collaboration, social learning, and peer interaction are also central. Through group investigations, shared reasoning, peer discussion, and peer assessment, students co-construct understanding. Research shows that inquiry-based learning in science instruction combined with cooperative or collaborative learning strategies leads to improved academic outcomes, deeper reasoning, and better engagement than traditional teacher-centered instruction. These collaborative approaches also foster communication, argumentation, collective problem-solving, and social dimensions of learning all essential for scientific literacy and 21st-century competencies.

Finally, this framework establishes continuous formative and summative assessment, alongside metacognitive reflection, throughout all phases of inquiry. Teachers, peers, and learners themselves engage in ongoing feedback, evaluation, and reflection on their observations, reasoning, and conceptual understanding; this iterative process helps identify misconceptions, refine thinking, and consolidate learning. Studies show that when metacognitive scaffolding is incorporated into inquiry-based learning practical activities, students improve not only in conceptual understanding but also in creative thinking and self-regulated learning skills crucial for long-term retention, and nurture self-regulated learning and transferability (Ruiz-Martín & Bybee, 2022; Gillies, 2023).

3. Educational Purpose and Outcomes

Through integrating the pedagogical strengths of the 5E learning cycle with evidence-based scaffolding, collaborative practices, real-world contextualization, and continuous assessment, this framework offers a solid, flexible, and realistic blueprint for science education. It aligns with contemporary educational goals such as scientific literacy, critical thinking, metacognition, and real-world applicability. In practice, this design enables learners to build knowledge, skills, and attitudes derived from direct, contextualized observation and inquiry-based practical activities. It fosters critical thinking, problem-solving abilities, and scientific habits of mind. Within the context of general science education bridging disciplines like Biology, Chemistry, and Physics it encourages integrated learning, conceptual transfer across disciplines, and meaningful engagement with science as it relates to everyday life, society, and the environment.

Therefore, this framework highlights the importance of considering the inquiry-based practical activities and outcomes from the design of syllabus objectives up to the delivery of lessons students and teachers go through the different tasks such as engage to observe the situation, explore the observed situation and write up the events through involving all sense organs, explain their lived experience; and the students elaborate the situation based on their pace of understanding through group and, or individual reflection.

The teacher’s guide every progress of students in the series of debate in supporting or opposing of students reflection. Additionally both students and teachers continuously evaluate their process or results to motivate or re-correct the misconceptions of the science syllabus by integrating the indigenous sciences for further investigation. This design of inquiry-based practical activities should also take into account the students’ environments, community, industrial/organizational inputs and general habitats etc.…are used for the investigation inputs to use diverse practical strategies to ensure the quality of the science curriculum in schools. All stakeholders especially science teachers and school principals are the facilitators and guiders of the actor or the learner at the process of science delivery in schools.

Furthermore, when designing objectives for science subjects, it is essential for teachers to align the goals of each subject to develop authentic solutions for science concepts. For example, general sciences such as Chemistry, Physics, and Biology utilize common methods practical laboratory activities, general observations, field trips, discussions, project-based learning, and reflections. These subjects share content focusing on living and non-living things, general habitats, matter, energy, conservation methods, and their impacts on living organisms and the environment. The aim is to cultivate well-rounded citizens with problem-solving skills, critical thinking abilities, and a scientific understanding of how science affects society and the world at large. Thus, students might apply chemistry objectives within biology or solve physics problems using chemistry concepts. Another key aspect involves preparing students to apply their theoretical knowledge in real-life situations through effective teaching strategies, placing them at the center of knowledge construction during science lessons.

Furthermore, students in schools may become more engaged if inquiry-based practical activities are incorporated into the teaching and learning of science topics. Students can investigate, watch, try, and interact with instructional strategies using this approach as well as it encourages a wide range of adequate practical activities that might improve students' engagement with their education in the authentic contexts of their environments, communities, and schools (Brhane et al., 2022). These techniques support students' academic progression in critical thinking, reflection, and argumentation in a diversity of situations since meaningful learning incorporates more than just imparting theoretical knowledge. Therefore, it pursues to develop the competence and applicability of education by supporting students in comprehending and using their cognitive, social-emotional, and other skills in practical settings through the practice of pedagogical procedures such as inquiry-based practical activities (Sotáková and Ganajová, 2023; Harlen, 2021).

Additionally, to achieve the main objectives of teaching general science, science textbooks are created using the concepts of inquiry-based, problem-based, and context-based learning. As part of inquiry-based learning, students ask questions, observe, read books to learn from others, plan investigations, collect and evaluate data, consider what they have learned in light of new knowledge, make predictions, explanations, identifying issues, evaluating experiments, separating options, organizing studies, investigating hypotheses, gathering data, building models, arguing with colleagues, and developing convincing arguments are all deliberate steps in the inquiry process. These tasks help students to develop and apply critical thinking skills such as designing and carrying out investigations, interpreting data as evidence, creating arguments, building models, and expressing findings in order to expand their understanding using logic and evidence. Suppose to this, the Ethiopian general science syllabus for middle level schools underscores the significance of practical activities in boosting students' overall academic performance and it emphasizes authentic engagements with real-world contexts within their environment (MoE, 2009).

Therefore, considering students' level of understanding and applying different types of inquiry allows for the effective implementation of the science curriculum, ultimately achieving the intended educational goals in the middle level schools. Inquiry-based practical activities inherently motivate students to explore various learning avenues, as depicted in the above conceptual framework. Thus, the curriculum is designed to help students perceive the pursuit of science as meaningful and practical. At the foundation of inquiry are the knowledge, concerns, and questions about the roles of science in society, the environment, and daily life. In sum, this refined and integrated inquiry-based practical activities in science education framework integrates the pedagogical strengths of the 5E instructional cycle with evidence-based scaffolding, teacher support, institutional facilitation, contextual relevance, collaborative practice, and continuous assessment. It serves as a vigorous, flexible, and realistic blueprint for science education aligned with contemporary educational goals including scientific literacy, critical thinking, metacognition, and real-world applicability.

To summarize the above arguments, these tangible, real-world interactions enable learners to cultivate knowledge, skills, and attitudes derived from direct observations. It has the potential to elevate students' critical thinking and problem-solving abilities. Therefore, the execution of the general science curriculum's objectives in schools through inquiry-based practical activities is indispensable and significantly enriches the existing literature by providing detailed insights into the practical implementation and impacts of inquiry-based learning in science education, highlighting its relevance and utility in the Ethiopian educational context and beyond.

CHAPTER THREE

3. METHODOLOGY OF THE STUDY

This chapter provides a comprehensive overview of the research paradigm, design, methods, and resources employed in the study offering a clear framework for understanding its scientific foundations. It examines the sources of data and data collection tools, detailing participant demographics, their relevance to the study, and the rationale behind the chosen sample size and sampling techniques to ensure representativeness and reliability. The data collection instruments are thoroughly described, emphasizing their validity and appropriateness for capturing the required information. Procedures for organizing and managing the collected data are outlined to ensure transparency and reproducibility. Finally, the chapter concludes by addressing the ethical considerations maintained throughout the research process.

3.1. The Research Paradigm

A research paradigm is the foundation of any serious academic investigation. It is the lens through which researchers view and engage with the subject of their study. As pointed out by Lincoln et al. (2011) and Creswell and Clark (2011), it's built upon the philosophical beliefs that dictate not just the questions researchers ask, but also the methods they use to find answers. This particular study takes a pragmatic approach by focusing further on undertaking real-life issues than spearing firmly to the predetermined notions about what knowledge should look like. Unlike some traditional frameworks that are tied to specific views on the nature of knowledge, pragmatism is flexible and adaptable. It lets researchers use both qualitative and quantitative methods, offering a versatile perspective to examine multifaceted issues. Similarly, its utility-driven nature prioritizes research that is valuable and applicable, appealing to practitioners and policymakers by aligning research efforts with real-world problem-solving and decision-making processes. These features make pragmatism a relevant approach to this research as its goal is to generate practical, implementable outcomes. This way, the results are more likely to make sense and be relevant in both social and general settings. This method lines up well with what Creswell (2014) describes, suggesting that pragmatism gives researchers the freedom to utilize various tools and methods as needed.

At its heart, pragmatism places humans first as it cares about what matters how to adapt, and what works in real life- which basically aligns most with the principles of inquiry-based practical activities. By bringing together different views, ways to gather information, and methods to break it down, this approach demonstrates how complex life is. For example, Morgan (2007) shows how mixing research methods helps experts connect big ideas to actual facts leading to deeper understanding. Creswell (2009) also stresses how important it is to make sure research fits with what people think is right so the results can help society.

A pragmatic approach welcomes everyone and responds to change asking researchers to get into the essentials of human life. It clearly indicates that one way of doing things does not have all the answers; instead, it cheers on new ideas and teamwork- letting researchers come up with answers that are just as complicated as the problems they are trying to solve. This way of looking at things turns research into more than just school stuff; it develops a way to understand, connect, and make real changes that matter. Accordingly, the methodology framework is displayed as follows consolidating all the procedures used in the study:

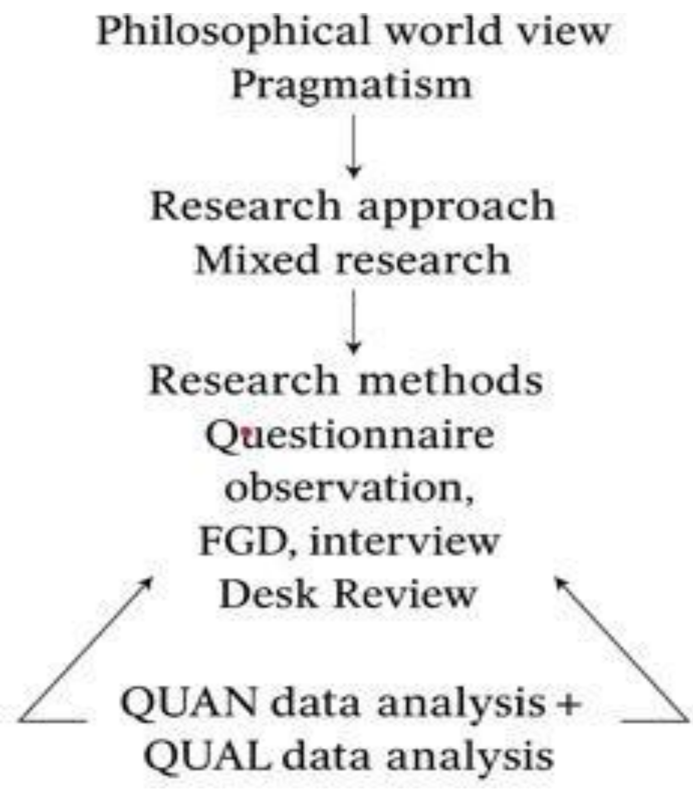

Figure 3. 1: Research methodology framework (Adapted from Creswell, John W. and Creswell, J. David, 2018, p.53)

3.2. Research Design

A clear research design is vital for any kind of research. A research design is a real guide to a researcher, as it enlightens the researcher about what to do and/or what not to do. It commonly comprises the strategies of the methodology and detailed methods for data collection. Mixed method approach is employed in this study since it best captures the essence of qualitative and quantitative research approaches by balancing the use of qualitative and quantitative data in conducting research within a setting. This approach enables a better degree of understanding to be formulated than if a single approach were adopted for specific studies (Creswell and Plano Clark, 2011).

The use of both quantitative and qualitative methods, in combination, provides a better understanding of the research problem and question and a great prospect to promote shared accountability in the quest for accomplishing answerability for practical educational quality (Creswell, 2012). In addition, a mixed-method research design helps extend the coverage and variety of an inquiry, helps to address the need for researching complex social phenomena with a view to understanding their complexities and enables researchers to explain seemingly contradictory outcomes evolving from the use of different methods. In addition, using data coming from a number of methods, or converging data from multiple sources, produces more credible findings, which could strengthen research conclusions and implications (Dawadi et.al, 2021).

The current study is being conducted to investigate the implementations of inquiry-based practical activities within one region of Ethiopia, Addis Ababa City Administration. Therefore, this study employs a mixed methods approach through a concurrent mixed method design. It is an effective and prevalent approach to mixing methods and the two different approaches, specifically qualitative and quantitative methods to obtain triangulated results and the integration of both data helps the researcher gain a complete understanding of the one provided by the quantitative or qualitative results alone. Similarly, the two data sets are combined to get a complete picture of the issue being explored and to validate one set of findings with the other (Creswell and Plano Clark, 2018).

Thus, this approach is chosen because it allows collecting the qualitative and quantitative data, to analyze data in parallel and then merged for a complete understanding of a phenomenon or to compare individual results as it happens. Consequently, quantitative data collection process helps to gather data on students' awareness about the inquiry-based practical activities, teachers view on inquiry-based practical activities, implementation of the strategies of inquiry-based practical activity in its real context, and factors affecting the practices of inquiry-based practical activities in middle-level school setting. Thus, the quantitative data provides the opportunity to gather data from a large number of teachers and students and generalize results, whereas the qualitative data permits an in-depth exploration of a few individuals, such as the science teachers, laboratory technicians and school principals, to describe the research problem.

The concurrent design procedure implemented in this study is displayed as follows:

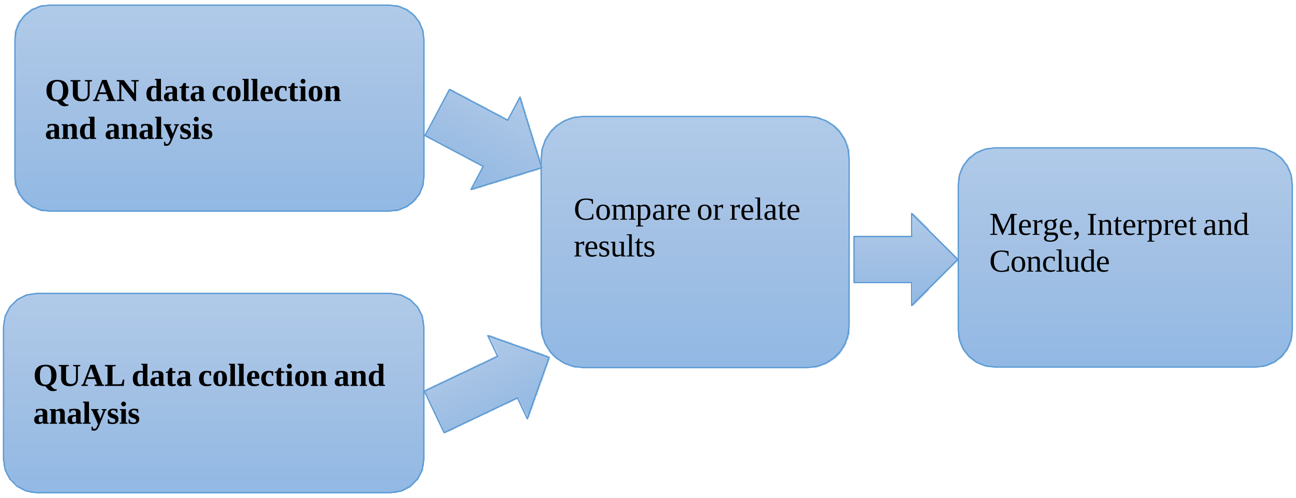

Figure 3. 2: Concurrent design procedure (Adapted from Creswell, John W. and Creswell, J. David, 2018, p.343)

Accordingly, in this study, quantitative and qualitative data were collected concurrently, analyzed separately and finally the results were mixed for interpretation. This separation permits for an attentive scrutiny of each dataset's distinctive contributions: qualitative data provides in-depth insights into participants' experiences and perspectives, while quantitative data offers quantifiable, generalizable patterns. By analyzing them independently, we can preserve the uniqueness of each method, guaranteeing that the findings are not oversimplified. This approach aligns with best practices in mixed methods research, where separate analysis is often employed to respect the epistemological differences between qualitative and quantitative paradigms and to avoid potential biases that may arise from premature integration. To enhance the credibility and validity of the research findings, triangulation was employed. Triangulation involves using multiple methods, data sources, investigators, or theoretical perspectives to address a research question, thereby reducing bias and increasing confidence in the results. This approach allows for cross-verification of findings, compensating for the limitations inherent in any single method and offering a more strong interpretation of the data.

3.3. Sampling Techniques

The data was collected from February, 2022 to December, 2024. For the purpose of this study, data were gathered from different respondents: science teachers, middle school level vice principals, science laboratory technicians and 7th and 8th grade students who may have adequate information about the implementation of inquiry-based practical activities in general science subjects in the middle level schools of Addis Ababa city-administration.

3.3.1. Sources of Data

The source population is comprised of government middle level schools in Addis Ababa city administration. This includes 249 Government Middle-level Schools with a total of 73, 909 students in Addis Ababa.

3.3.2. Sample size Determination

Creswell (2014) asserts that sample loss planning is important for survey and field research, particularly when using mixed methodologies. Accordingly, the sample size of student participants was determined using a 95% confidence level and a 5% margin of error to ensure the validity and reliability of the study's findings. The target population and estimations of variability indicated that a minimum of 697 individuals were needed. However, the sample size was increased by 33% in recognition of the possibility of nonresponse, inadequate data, and participant attrition. This adjustment increased the target population number to 6649 student participants, ensuring that sufficient valid data would remain for analysis even in the event of participant loss.

The sample size calculation used in this study followed the method proposed by Kothari (2004), which generated a minimum required sample of 697 students. However, to improve confidence and enhance the representativeness of the findings, the actual sample was expanded to include 1,589 students.

3.3.3. Multistage Sampling Techniques

In this study, multistage cluster sampling was used. This sampling technique is more comprehensive and representative of the population. In this type of sampling, primary sample units are inclusive groups and secondary units are subgroups within these ultimate units. By progressively narrowing the sample from large clusters to individual units, it reduces cost and complexity while still aiming for representativeness.

Thus, this sampling technique can be more efficient than other sampling methods, especially when the population is large and geographically dispersed like that of the eleven sub cities of Addis Ababa. First, the total numbers (249) of middle schools found in each of the eleven sub-city administration are clustered. Then, two governmental middle level schools were randomly selected from each sub-city in Addis Ababa City Administration based on the clustering. As a result, 22 government middle level schools were selected. These schools can be taken as representative samples since there is homogeneity among all the schools with regard to human and material resources, demographic and socio economic background, pedagogical approach and administrative procedures of the government structure.

The general science curriculum at this level, which is named as general science subjects (biology, chemistry, and physics) were also purposely selected to see the implementation of Inquiry-based practical activities. From the randomly selected 22 middle-level schools, a relevant number (33%) of sample students were selected from grade 7^{th}& 8^{th} students using appropriate simple random sample determination formula for the data collection through questionnaire.

In this study, the total target population comprised 6649 students of which a sample of 1589 students was selected and questionnaires were distributed to them. Remarkably, 99.8% of the questionnaires (1587) were effectively collected. For the focus group discussions (FGDs), six students were randomly selected from each of the sample middle-level schools to participate in these discussions.

Regarding teacher respondents, 120 general science teachers (Biology, Chemistry and Physics) were involved in teaching general science teaching in all the middle-level schools under investigation. All the available number of general science teachers or all respondents (120) was selected on account of the manageable number of teachers and the aim to gather wide-ranging data from the entire group. In addition, 20 science department heads and 11 laboratory technicians from the 22 schools participated in the study after they were randomly selected. Regarding the vice principals, each school had two (44 in the 22 sample schools); thus, 11 vice principals were selected using simple random sampling for the interview. It was employed with the assumption that it helps to get representative sample of a population for it gives equal and independent chance of being selected for each and every population of sample population (Yount, 2006).

The general science subjects (Biology, Chemistry, and Physics) were purposely selected to assess the execution of inquiry-based practical activities, aligning with the researcher's educational background and teaching experience in the field of general sciences curriculum from primary to higher institution. Teachers participate directly in the planning and execution, and students have direct engagement in the teaching learning practice, making them the vital individuals to detect issues impeding this process. Teachers and students engaged in hands-on learning and Inquiry-based practical activities are the only parties capable of providing more effective and practical options. The need to select laboratory technicians as a data source was evident due to their involvement in the practical strategies of the teaching-learning process in science curriculums. School vice principals were selected due to their responsibility as decision-makers in facilitating program implementation and assisting teachers. Furthermore, the table below summarizes the overall sample determination used for the study.

Table 3. 1: Population and sampling

Population Category	**Population Size (N)**	**Sample Size (n)**	**Sampling Method**
1. Middle-level Schools in Addis Ababa	249	22	Multistage (random sampling)
2. Teachers	120	120	All respondents (Census sampling)
3. Students	6649	1589	Simple random sampling
4.School vice principals	44	11	Simple random sampling
5. Laboratory technicians	22	11	Simple random sampling

Furthermore, students' textbooks, teachers' guide, sample lesson plans, sample laboratory reports, and sample students' assessment sheets used in the three subjects were analyzed to get data on the implementation of inquiry-based practical activities in the general science or general subjects in the middle-level schools under study.

Students, teachers, laboratory technicians, and school principals are the respondents selected from a random sample of two schools from the eleven sub-cities in Addis Ababa. In implementing and practicing activities in schools, teachers and students are directly involved in the fields and face problems regarding the learning and teaching process. Hence, teachers and students involved in the actual implementation of practical activities in schools are considered the most reliable sources for obtaining authentic data.

The selection of laboratory technicians as respondents in this study is on account of their fundamental role in the practical aspects of the general science curriculum. They are essential for preparing and handling the materials and equipment necessary for science practical activities, confirming safety protocols are followed, and supporting both teachers and students during laboratory sessions.

Furthermore, the inclusion of school principals in this study is justified by their leadership role in strategizing the teaching-learning process for the general science curriculum, reflecting their decision-making capacity in supporting teachers and students in program implementation.

To validate the data obtained from these sources, various documents, such as the general science student's textbook, teacher's guide, annual plans, weekly plans, laboratory reports, and students' assessment checklist documents were used. Primarily, textbooks and teachers' guides were examined to identify the anticipated practical activities outlined in the curriculum. Then, lesson plans, laboratory reports, and assessment checklists were examined to triangulate the data gathered from interviews and assess their applicability to the actual implementation of practical activities in middle-level schools in Addis Ababa.

3.4. Data Gathering Instruments

In order to gather information, the researcher used multiple methods of data collection instruments which are believed to open room for triangulation and provide the researcher with ample information. Accordingly, the following instruments were used: a semi-structured questionnaire for teachers and students, observation (classrooms, laboratory rooms and desk review), focus group discussion for students, and interview for teachers, laboratory technicians' and school vice principals. These methods were used to obtain comprehensive information on the actual practices of inquiry-based practical activities in the middle-schools of Addis Ababa city-administration.

3.4.1. Questionnaire

Questionnaire was used to gather data from both students and teachers on their attitudes toward the inquiry-based practical activities and to get information on the extent to which teachers implement the inquiry-based practical activities in general science classrooms. A separate Likert scale questionnaire was developed to examine teachers' attitudes and students' awareness of inquiry-based practical activities in general science instruction. It was also used to gather data on the factors that hinder the implementation of practical activities in the sample middle school.

In this explanatory descriptive research, the researcher administers a questionnaire to collect data because questionnaire is widely used in educational research to obtain information about certain conditions and practices, to inquire into opinions and attitudes of individuals or groups (Creswell, 2009). Similarly, Kaul (1996) and Taherdoost (2021) explain that questionnaire is widely used in educational research to gather data from different individuals, groups, and companies simply about certain conditions and practices, to inquire into opinions and attitudes of individuals or groups. In this study, two kinds of questionnaire were prepared, teachers questionnaire and students' questionnaire.

A. Teachers' Questionnaire

The questionnaire included both open-ended and closed-ended questions, systematized into four sections (see Appendix C). The first section congregated demographic information from teachers to assess their professional profiles regarding gender, qualifications, teaching experience, and pedagogical training. The second section explored teachers' acquaintance with inquiry-based practical activities, their current implementation of such activities, students' awareness and motivation regarding these methods, and teachers' preferences for various teaching techniques, aiming to determine the frequency of inquiry-based learning practices. The third section emphasized on teachers' perceptions of inquiry-based practical activities, evaluating their level of agreement with the effectiveness of these methods in science instruction within their schools. The fourth section identified challenges faced in employing inquiry-based practical activities within the school context. The questionnaire was administered to 120 teachers, all of whom completed and returned it.

B. Students Questionnaire

This instrument contains three parts (see Appendix D). The first part contains items which were designed to assess students' awareness on inquiry-based practical activities. The second part contains items which were designed to assess the extent to which different instructional techniques are implemented by teachers and students in sciences subjects. The third section comprises items intended to identify factors impeding the implementation of inquiry-based practical activities in schools. The questionnaire was distributed to 1589 students, with 1587 completed responses collected, resulting in a response rate of 99.8%.

3.4.2. Observation

Observation checklists were developed to assess the implementation of Inquiry-based practical activities in science classrooms, focusing on two main areas: teaching practices and laboratory facilities. As noted by Naylor & Sayed (2014), classroom observation is highly valuable as direct measures of teacher worth as they are usually the most authentic, reliable and strong evidences. Observation has occupied an important place in descriptive educational research that focuses on recording what actually occurs in the authentic life situation (Naylor & Sayed, 2014). Regarding teaching practices, the checklists evaluated how effectively Inquiry-based methods were integrated into science instruction. This included measuring if students were actively engaged in formulating questions, conducting investigations, and analyzing data, in line with the principles of Inquiry-based learning. On the other hand, the checklists related to laboratory facilities assessed the appropriateness of the physical environment to support practical science activities. This comprehended evaluating the availability and organization of equipment, and the overall conduciveness of the space for practical learning experiences.

A. Classroom Observation

Classroom observation was employed to obtain data about the actual practice of Inquiry-based practical activities by students and teachers in the general science classrooms. Accordingly, the researcher employed classroom observations to assess the extent to which Inquiry-based practical activities are implemented in general science subjects at selected middle schools in Addis Ababa. Thus, the data obtained through classroom observation provided useful insights into the exchanges between students and teachers in general science classes. The researcher attended the participants' classrooms during their regular sessions and employed an observation checklist to systematically document what was observed, heard, and experienced over a series of lessons. Among the 120 general science teachers for grades 7 and 8 across the 22 sampled middle schools, 33% (40 teachers-13 female and 27 male) were randomly selected for observation. Totally 80 classroom observations were made. Each of the 40 selected teachers was observed twice, and the sessions were audio recorded with the consent of the participants.

B. Laboratory Observation and document review

The other data gathering instrument employed in this study was a laboratory observation checklist that was used to see the actual implementation strategies and school contexts by observing the environmental setup, which is found to be very decisive in this study. Therefore, this self-developed tool was used to see the implementation of practical activities and to explore the extent to which science teachers consider the strategies of practical activities during their planning of the lesson.

These laboratory observation and document review checklists were prepared based on three major themes related to the implementation of practical activities in general/general science subjects. The first laboratory checklist contained five questions assessing the availability of laboratory equipment and the appropriateness of the facilities in the laboratory. The second checklist encompassed six questions addressing factors affecting the execution of practical activities in the laboratory. Thirdly, six items were designed to get data from the planned laboratory plans, as well as subject-specific annual and weekly plans, to evaluate the extent to which teachers incorporated practical activity strategies. Document analysis was also employed to compare teachers' reported knowledge with their actual classroom practices. Observations were conducted in twenty out of the twenty-two schools which have laboratory rooms; the remaining two laboratories were not observed due to the maternity leave of the respective laboratory technicians.

The data obtained from laboratory observations and document review- including annual and daily lesson plans, as well as assessment checklists of teachers observed in classroom- provided valuable insights into the Inquiry-based practical activities employed. These documents also helped evaluate whether teachers incorporated Inquiry-based practical activities into their science subject planning.

3.4.3. Focus Group Discussion

Focus group discussion was another tool employed to obtain necessary data from students. Here, questions were prepared to understand students' awareness of practical activities in general science instruction, what strategies their science teachers practiced in the schools, what practical activities they applied, and what problems they faced during the teaching-learning practice of general science subjects. The participants were randomly selected from each section considering gender balance: three male and three female students. This was done first by separating the list of female and male students of each section and then randomly selecting three students from each sex category. Therefore, a total of 132 students participated in the FGDs, conducted across 22 sample middle schools. Each session was audio-recorded with the participants' consent, and notes were taken by one of the FGD members and the researcher. Thematic analysis was employed to group the data into five thematic areas based on the FGD guidelines.

3.4.4. Interview

Interview was another tool employed to obtain necessary data from science department heads, laboratory technicians and school principals about the implementation of Inquiry-based practical activities in the sample middle schools.

A. Science Department Head Teachers Interview

Interviews facilitate a level of response depth that is difficult to attain through other data collection methods. This approach is essential for its flexibility in outlining and questioning to understand the interviewee's interpretations are critical in explaining and understanding proceedings, patterns, and behavior practices (Bryman, 2012). A semi-structured interview was desired over a structured interview because of the springiness of such interviews which enable the investigators to ask any kind of relevant questions during the interviews to collect rich data.

This approach is particularly effective in exploring how study participants conceptualize and perceive the practical activities involved in teaching general or general science subjects. In addition, it is used to get reliable information on the actual practice of inquiry-based practical activities in general/ general science instruction. In this study, semi-structured interviews were employed to collect comprehensive information, aiding as a valuable tool for triangulating data obtained through other methods such as questionnaires, classroom observations, students' focus group discussions, and laboratory observations. This methodological triangulation reinforces the validity and reliability of the research findings by cross-verifying information from various sources. A total of twenty randomly selected science department head teachers participated in the interviews, providing diverse perspectives that enriched the study's analysis.

B. Laboratory Technicians Interview

Data were also collected from laboratory technicians due to their vital role in the practical aspects of teaching and learning within the general and general science curriculum. Eleven laboratory technicians were randomly selected to participate in this study, considering their dual responsibilities as both implementers and expediters of practical activities. They also supervise and facilitate the execution of practical sessions, assisting teachers in the planning and demonstration of experiments, and guaranteeing the safe and efficient operation of laboratory equipment. This collaborative effort between teachers and technicians is crucial for creating a conducive learning environment that enhances students' hands-on experience and understanding of scientific concepts.

C. School Vice Principals Interview

This method subsidizes answering the research questions by investigating how the school vice principals perceive the practical activities and supporting teachers during teaching general/general science subjects in their school. The interview questions were prepared to secure information on the extent of practical activities conducted, their role in facilitating the program, the strategies employed by science teachers, the challenges encountered during the teaching-learning process, and the solutions implemented within the schools. Eleven randomly selected school academic principals were also interviewed. All interviews were audio-recorded with the participants' consent to accurately capture the discussions.

3.5. Validity and Reliability

Checking the validity and reliability of data collection tools is crucial in ensuring that the data collected are accurate, consistent, and meaningful. Content validity assesses whether the content of the tools adequately represents the construct being measured. Internal consistency, on the other hand, measures the consistency of responses among items within the tool (Kombo and Tromp, 2006). Accordingly, the content validity is checked by peer reviewers, experts with diverse backgrounds in educational research, and my advisors. Their collective expertise ensures that the tools accurately capture the intended concepts. The internal consistency is also checked using Cronbach's alpha, which measures the correlation between different items in the tool. As both teachers and students questionnaire contains diversified questions to get an appropriate data based on the research question items was checked their internal consistency on each specific part to avoid a misleadingly low reliability score. A high Cronbach's alpha value (See Appendix L) indicates strong internal consistency, reinforcing the reliability of the data collected.

3.6. Procedures of Data Collection

All the data gathering instruments were developed taking into account the basic questions, purposes of the study and the reviewed literature. Before using the instruments to the main study, they were reviewed by different colleagues and pilot tested. Prior to the actual data collection, a pilot test was conducted to assess the clarity, reliability, and appropriateness of the instruments. The pilot test was conducted at two randomly selected middle-level schools which were excluded from the main study. Based on the pilot study and comments from reviewers, a necessary modification was made on the data collection tools and procedure. Students' questionnaire and FGD protocol questions were translated into Amharic. A standard backward translation procedure was followed to ensure the accuracy and conceptual equivalence between the English and Amharic versions of the research instruments. First, the original English version of the questionnaire was translated into Amharic by a bilingual expert with a strong background in educational research. Then, a second independent translator, who had no prior exposure to the original English version, translated the Amharic version back into English. The two English versions; the original and the back-translated were compared for uniformity in meaning, terminology, and cultural appropriateness.

Inconsistencies identified during this comparison were discussed and resolved by the translators and the researcher. Feedback from the pilot test helped the refinement of wording and confirmed the validity of the translated instruments. This process assisted to ensure that the translated version preserved the intended meaning of the items and maintained linguistic and conceptual equivalence.

Firstly, the researcher received the cooperation letter from Addis Ababa University and collected the total number of middle-level schools in each sub-city from Addis Ababa Education Bureau. Then, the researcher determined the sample schools and procedures. During the data collection phase, the researcher formally approached school directors by providing a copy of the permission letter and explaining the purpose of the research to obtain their consent. Similarly, the sample population was selected with the harmonization of the school directors after getting the total number of 7th and 8th grade students and general science teachers in each middle school. The school directors introduced the researcher to their students and teachers, informing them about the researcher's visit and the study's objectives.

The participants' consent was also received before the actual data collection process. Then, both qualitative and quantitative data were gathered concurrently or at the same time on the bases of the arrangements made. Data were collected using a combination of methods to ensure a comprehensive understanding of the research topic. Initially, document reviews and observations were conducted to examine the relevance, scope, and nature of lesson plans, laboratory reports, and student assessment checklists utilized in science subjects. This preliminary analysis informed the design of subsequent data collection tools. Then collection of data through classroom and laboratory room observation was preceded other instruments before participants could adjust their behaviors based on prior exposure to questionnaires.

This data collection helps to see how teachers and students implement practical activities in their classes and practical lessons in their general or authentic context. Following the observations, questionnaires were administered to students and teachers by the researcher to gather additional data on their experiences and perceptions. This data collection tool helps to collect data about students' awareness and teachers' perception on practical activities, extent of practicing teaching strategies and factors affecting the implementation of inquiry-based practical activities. Thirdly, focus group discussion was conducted with students to get information about their awareness and the extent to which they implement practical activities. Finally, the semi-structured interview was conducted with science department heads teachers, laboratory technicians and school vice principals to get data related to their outlook and factors affecting the implementation of inquiry-based practical activities in their subjects in the middle schools under study.

3.7. Method of Data Analysis

Data obtained through the questionnaire were entered into SPSS version 25 for analysis. It was quantitatively analyzed using both descriptive and inferential statistical methods. Descriptive statistical techniques such as frequency, mean, standard deviation, and correlation were computed for each construct. Relevant inferential statistics techniques were computed to see the relationship between and/or among the variables and significance level of results in the study. Specifically, Analysis of Variance (ANOVA) was used to compare the practices of the different teaching techniques. In addition, the practice of each teaching technique among the different sub-cities is also identified using ANOVA.

Data obtained through the document review, classroom observation, interview, and focus group discussion were qualitatively analyzed using thematic analysis techniques through three steps. First, codes were developed and applied**.** Coding can be explained as the categorization of data. A code can be a word or a short phrase that represents a theme or an idea. All codes need to be assigned meaningful titles. A wide range of non-quantifiable elements such as events, behaviors, activities, meanings, etc. can be coded. Next, themes, patterns, and relationships were identified**.** Analytical and critical thinking skills were applied to bring a significant role in data analysis in qualitative studies**.** Thirdly, the data was summarized**.**

At this stage, research findings were linked to research question and aim. In writing the results, noteworthy quotations were used from the transcript to highlight major themes within findings and possible contradictions. Finally, the data obtained through these tools were jointly discussed by supporting the view of scholars and research findings.

3.8. Ethical Considerations

Regarding to Ethical considerations, entirely cited resources are acknowledged and participants of the study were preserved well and confidentiality has been rigorously maintained. To uphold ethical standards, the researcher obtained prior permission letter (Ref. No. C&I/32/2022, Azeb) from the Curriculum and Instruction Department at Addis Ababa University before starting data collection. Additionally, permission was secured from the Addis Ababa Education Bureau to access the schools for the study.

These steps were taken to ensure that participants were fully informed and their rights respected throughout the research process. The researcher properly understood that researchers have a big duty to follow good professional ethics in their research works. That is, the quality of their work depends on how well they handle possible ethical problems. Bryman (2008) points out that not being ethical like not getting permission, lying, invading privacy, or hurting people can cause big issues for both the people involved and the trust in the research.

To avoid these risks in this study, the researcher took a careful, people-first approach putting the respect, privacy, and safety of all participants first. It has been worked hard to keep personal information safe and private, with clear steps to stop any misuse or accidental sharing. This focus on being ethical not only kept the participants safe but also built trust and openness throughout the study. What is more, ethical considerations were carefully integrated into every phase of this study, starting with obtaining clear and informed consent from all participants and the relevant organizations.

The researcher made a significant effort to explain the study's purpose in easy way to understand language, ensuring that participants were fully aware of their roles and rights before agreeing to participate. Anonymity was regarded as paramount; no identifying information was kept, and all contributions were anonymized to effectively protect participants' identities. Additionally, confidentiality was maintained through healthy protections ensuring that sensitive data remained off-limits to unauthorized individuals.

By acknowledging all sources used and strictly adhering to ethical guidelines, the researcher also demonstrated a persistent commitment to accountability and respect for the participants' contributions. This thoughtful approach aimed not only to fulfill ethical duties but also to honor the dignity of those who placed their trust in the researcher with their stories and experiences.

CHAPTER FOUR

4. DATA PRESENTATION, ANALYSIS AND DISCUSSION

This chapter presents, analyzes, and discusses the empirical data gathered for the study. The data were collected using multiple methods such as questionnaires, classroom observations, focus-group discussions (FGDs), and interviews to provide a comprehensive understanding of how inquiry-based practical activities are implemented in general science instruction in Addis Ababa middle-level schools.

A total of 22 schools were selected for the study, with two schools drawn from each sub-city of Addis Ababa, in order to ensure broad representation across the city. The study sample comprises 1,587 students, 120 science teachers, 22 laboratory technicians, and 22 academic vice-principals. The subsequent sections are organized to present findings systematically, beginning with demographic and school-profile data, followed by results linked to each research question, and concluding in an integrated discussion that interprets findings in light of existing literature.

The chapter is structured to first present key findings through summary tables, descriptive statistics, thematic summaries, and illustrative quotations. Following the presentation, analysis and interpretation examine patterns, relationships, and divergences across respondent groups and data collection methods. Finally, the discussion situates these results within the broader scholarly context, comparing them with findings from prior research, exploring implications for theory and practice, and highlighting challenges and opportunities for implementing inquiry-based learning through practical activities in general science subjects in the local educational context.

Through this combined presentation, analysis, and discussion, the chapter aims to provide a clear, evidence-based narrative of what was observed in the field, how these observations answer the research questions, and what they suggest for science education policy and practice in Addis Ababa. The findings of the study are presented in the sections that follow.

4.1. Analyses of Teachers' Responses

4.1.1. Background of Teachers

As shown in Table 4.1, a total of 120 teachers were involved in this study. The teachers are almost evenly distributed across three departments: Biology with 34.2%, Chemistry with 34.2% and Physics with 31.7%. This suggests balanced staffing across the science departments. There is a significant gender imbalance among the teachers, with males comprising 70.8% and females constituting 29.2% of the total. This indicates a male dominated environment within the science teaching staff.

Table 4.1: Background characteristics of teachers

Variable	Category	Count	%
Department	Biology	41	34.2
	Chemistry	41	34.2
	Physics	38	31.7
Sex	Male	85	70.8
	Female	35	29.2
Qualification	Diploma	61	50.8
	BED	0	0.0
	BSc/MSc	22	18.3
	BSC+PGDT	37	30.8
pedagogical training during	On job/in-service	31	25.8
	Undergraduate/ pre-service	98	81.7
Teaching experience	<5	29	24.2
	6-10	34	28.3
	11-15	13	10.8
	16-20	21	17.5
	>=21	23	19.2

The qualifications of the teachers vary. The data reveals that 50.8% of the teachers hold a Diploma, and no teacher has a Bachelor of Education (B.Ed.), indicating a possible gap or oversight in teacher education specific to education degrees, 18.3% of the teachers hold either a Bachelor's or Master's (BSc/MSc) degree in science, and 30.8% have a Bachelor of Science with Postgraduate Diploma in Teaching (BSC+PGDT), suggesting a significant proportion have enhanced their education degree with a teaching qualification. The majority of teachers, 81.7% received their pedagogical training as part of their undergraduate or pre-service education, indicating that the foundational teacher training occurs predominantly before entering the profession. Only 18.3% of the teachers have received pedagogical training on the job or through in-service programs, highlighting a potential area for improvement in continuous professional development.

The distribution of teaching experience among the teachers is varied, 24.2% of the respondents have less than 5 years of experience, indicating a notable portion of relatively newer teachers. 28.3% of them have between 6 to 10 years of experience, representing the largest experience category. Few teachers that account 10.8% fall into the category with11 to 15 years of experience. Those with 16 to 20 years and more than 21 years of experience make up a significant portion covering 17.5% and 19.2% respectively, suggesting a seasoned cohort that provides a backbone of experience to the teaching staff.

The data suggest several key implications such as:

1. Gender Imbalance: Initiatives to attract more female teachers could help balance the gender distribution.
2. Qualification and Training Gaps: The absence of teachers with B.Ed. degrees may indicate a need for targeted educational programs or incentives to pursue education-specific qualifications. Additionally, enhancing in-service training could be beneficial for ongoing professional development.
3. Experience Distribution: With a fairly young teacher base (less than 10 years of experience) making up over half the staff, there may be opportunities for mentorship programs leveraging the expertise of more seasoned teachers.

This analysis points towards balanced departmental staffing but indicates gaps in gender distribution, specific educational qualifications, and continuous professional development which could be addressed to enhance the educational environment.

4.1.2. Teachers’ familiarity and Engagement on Inquiry-based Practical Activities

Concerning the familiarity and engagement in Inquiry-based practical activities, the teachers have been asked a total of 9 questions Table 4.2, 4.3, 4.4 and 4.4) respectively as follows: The response reveals insights into the teachers’ practices and responses regarding the incorporation of Inquiry-based activities in their classes.

“The tables below (Table 4.2, 4.3, 4.4 and 4.4) present the distribution of responses for each survey item, along with the mean score per item. For binary Yes/No questions, responses were coded as Yes = 1 and No = 0. For ordinal frequency questions, responses were coded on a three point scale (3 = usually (or Always), 2 = Sometimes, 1 = Not at all). Similarly, (3= High (or Very well), (2= Average (or Well), (1=Low (or poor)".

Table 4.2: Familiarity and Conditions

Familiarity related survey items	**Yes (1)**	**No (0)**	**Mean**
Familiarity with inquiry-based practical activities	55 (45.8%)	65 (54.2%)	0.46
Use of inquiry-based practical activities in delivery of science subjects	21 (38.2%)	34 (61.8%)	0.38
Giving inquiry-based practical activity tasks to students to conduct outside class/school	103 (85.8%)	17 (14.2%)	0.86
		Grand mean	0.56

The above analysis has shown how familiar teachers are with inquiry-based practical activities and how often they apply it in science instruction. The response reveals insights into the teachers' practices and responses regarding the incorporation of inquiry-based activities in their classes. First, when respondents were asked about their familiarity with inquiry-based activities, only 45.8% of them indicated that they are familiar. Of those teachers who are familiar; only 21 (38.2%) of them incorporate inquiry-based practical activities in their delivery of science subjects. Moving beyond the classroom, a noteworthy 85.8% of respondents revealed that they provide practical activities or assignments for students outside of their class or school. The grand mean score of 0.56 also reflects a moderate overall level of familiarity and engagement with inquiry-based practical activities but a noticeable gap between conducting practical activities strategies in general science instruction.

Table 4. 3: Frequency of Practice

Practice related items	**Usually (3)**	**Sometimes (2)**	**Not at all (1)**	**Mean**
The extent of using practical activities in science classes	4 (3.3%)	21 (17.5%)	95 (79.2%)	1.45
Extent of relate lessons with daily life activities or environmental realities	6 (5.0%)	19 (15.8%)	95 (79.2%)	1.47
Extent of conducting practical activities in laboratory classes	3 (2.5%)	21 (17.5%)	96 (80.0%)	1.43
			Grand Mean	1.45

As indicated in the above table general science teachers feel there is a strong need for improvement in inquiry-based practical tasks in science education. The frequency of practical activities varied significantly among teachers and the results showed consistently low usage of practical activities across all areas. In the first item, regarding the use of practical activities in science classes, only 3.3% of respondents reported that they were used "Usually," while few (17%) and the majority (79.2%) selected sometimes and "Not at all," resulting in a mean of 1.45.

Similarly, in the second item about relating lessons to daily life or environmental realities, the teachers' connections between lessons and real-life activities or environmental realities are explored. In this regard, the majority respondents felt lessons were not connected to real-world applications, with a substantial 79.2% of the respondents stated that they do not use practical activities at all in their science classes leading to a mean of 1.47; and 5.0% of them reported to make these connections usually, and 15.8% showed that they create such connections so rarely.

Lastly, with regard to conducting practical activities in laboratory classes, 80.0% of the respondents revealed that they do not conduct practical activities in laboratory classes at all with a mean of 1.43; 2.5% of them reported that they usually present practical activities, while 17.5% use these activities rarely. These results recommend that practical activities are significantly not well implemented in science instruction in the middle schools. Similarly, the grand mean of 1.45 shows a general lack of practical and real-world activities in general science teaching in the target middle schools. Thus, the findings illustrate a range of practices and perspectives among teachers regarding the incorporation of inquiry-based and practical activities in science education.

Table 4. 4: Frequency of Practice

Practice related items	Weekly **(3)**	Monthly **(2)**	In a semester **(1)**	**Mean**
How often teachers give practical activities to students to conduct outside class/school?	1 (1.0%)	5 (4.9%)	97 (94.2%)	**1.07**

As one can see from the above data, teachers indicate that practical activities assigned to students outside of class or schools occur infrequently. The data shows that only 1.0% of respondents reported that these activities are given weekly, and 4.9% indicated they occur monthly. However, a significant 94.2% of respondents stated that practical activities are assigned only once a semester**.** The mean score suggests that practical activities are not a regular part of students' learning experiences the inside of the school classroom and or outside of the school.

Table 4. 5: Perceptions to Practice

Perception related items	High **(3)**	Average **(2)**	Low **(1)**	**Mean**
Students' motivation to conduct practical activities while teachers give the activities?	6(5.0%)	15 (12.5%)	99 (82.5%)	1.22
Students' awareness of applying practical activities in the school?	Very well (3)	Well (2)	Poor (1)	**Mean**
	6 (5.0%)	16(13.3%)	98(81.7%)	1.23

The results reveal a concerning perception among teachers regarding students' engagement with inquiry-based practical activities in general science classes. Among the respondents only 5.0% of teachers thought that students are highly motivated to conduct practical activities when assigned, while a majority 82.5% ranked student motivation as low. The mean score of 1.22 indicate that students are largely unmotivated to participate in practical tasks, even when directed by their teachers. In addition teachers also asked to rate their observation on students' awareness of applying practical activities in school settings. Concerning student' awareness of applying practical activities in the school context, 81.7% of the respondents perceived that students have poor awareness, while 5.0% reported that students are well aware, and 13.3% of them claimed that students are aware to some extent.

The corresponding mean score of 1.23 reinforces the perception that students lack understanding of the importance and purpose of hands-on science activities. These findings suggest that students may view practical activities as disconnected from their learning, which likely contributes to low interest and involvement. The data points to a need for teachers and schools to better connect the value of inquiry-based practical activities, design more engaging and relevant tasks, and integrate these activities more meaningfully into the general science instruction to improve both student motivation and awareness in the middle schools.

4.1.3. Inquiry-Based Practical Strategies and Instructional Tactics

Table 4.6 presents the frequency distribution of teaching techniques and practices employed by science teachers in middle schools under the study. The table classifies instructional strategies into five major types: Traditional/one-way approaches, Structured Inquiry, Confirmation Inquiry, guided and Open Inquiry methods. For each instructional activity, the number and percentage of teachers who reported using the activity "not at all," "sometimes" or always" is provided, along with the corresponding mean scores and standard deviations. This classification permits a stronger understanding of the extent to which inquiry-based practical activities are integrated into science teaching compared to more conventional teacher-centered methods. The data offers a foundational basis for analyzing prevailing teaching outlines and assessing the alignment of classroom practices with inquiry-based practical science education goals.

Table 4. 6: Frequency distribution of teaching Techniques and Practices among teachers

Teaching technique	**Activity**	**Not at all (1)**		**Sometimes (2)**		**Always (3)**		**Activity**	
		Count	**%**	**Count**	**%**	**Count**	**%**	**Mean**	**SD**
Traditional/one way	Demonstration	55	45.8	46	38.3	19	15.8	1.70	0.73
	Lecture/Explanation	0	0.0	13	10.8	107	89.2	2.89	0.31
Structured Inquiry	Question & answer	7	5.8	93	77.5	20	16.7	2.11	0.46
	Modeling	73	60.8	41	34.2	6	5.0	1.44	0.59
	Written responses	72	60.0	32	26.7	16	13.3	1.53	0.72
Confirmation Inquiry	Group works	70	58.3	36	30.0	14	11.7	1.53	0.70
	Observation	83	69.2	26	21.7	11	9.2	1.40	0.65
	Laboratory- based activities	88	73.3	17	14.2	15	12.5	1.39	0.70
	Reflecting findings	100	83.3	12	10.0	8	6.7	1.23	0.56
	Individual/peer presentation	79	65.8	24	20.0	17	14.2	1.48	0.73
Guided Inquiry	Inquiry- based investigation	103	85.8	12	10.0	5	4.2	1.18	0.48
	Generate findings	104	86.7	12	10.0	4	3.3	1.17	0.46
Open Inquiry	Project works	87	72.5	17	14.2	16	13.3	1.41	0.72
	Field visits	102	85.0	16	13.3	2	1.7	1.17	0.42
	Reflection	98	81.7	18	15.0	4	3.3	1.22	0.49
	Discussion with classmates	72	60.0	30	25.0	18	15.0	1.55	0.74

As part of the study, science teachers were invited to provide insights into their classroom teaching methodologies and techniques.

The frequency distribution of ratings for the approaches and practices of inquiry-based activities, scored on a scale of 1 to 3 (1 = not at all, 2 = sometimes, 3 = always), is summarized in Table 4.6. This tabulation provides a clear overview of how teachers perceive and engage with inquiry-based practical activities, shedding light on the prevalence of different levels of implementation. As the summary statistics presents, including mean and standard deviation, offering a quantitative perspective on the effectiveness and variability associated with the five teaching techniques employed, including Traditional/one way, Structured Inquiry, Confirmation Inquiry, Guided Inquiry, and Open Inquiry.

As one can see from table 4.7, demonstration as the Traditional/One-way technique is not frequently used by 45.8% of teachers; 38.3% of the respondents sometimes employ this technique, and only 15.8% of them always apply it. The mean score is 1.70, indicating low usage and the SD of 0.73 shows moderate variability in its usage. This means, the combination mean = 1.7 and SD = 0.73 suggests that while a few teachers may use demonstration occasionally or more often, the dominant tendency across the group is toward low or infrequent use. Lecture/Explanation is the most consistently used technique, with no teachers reporting they never use it. 10.8% of the respondents sometimes use lecturing, and a significant 89.2% of them always use it. The mean score is 2.89, showing high usage, with a low SD of 0.31, indicating consistent application across teachers.

Among Structured Inquiry Techniques, the data depicted that Question and Answers most frequently used. This means 77.5% of the respondents sometimes use it; 16.7% of them always use it, while 5.8% do not use it. The mean score is 2.11, suggesting moderate usage, with a low SD of 0.46. Modeling is less frequently used by the respondents, where 60.8% of them reported that they do not use it; 34.2% of them sometimes apply it, and only 5.0% tend to use it always. The mean score is 1.44, indicating low usage, with an SD of 0.59, suggesting moderate variability. On the other hand, written responses are less frequently used by the respondents, where 60.0% of them reported not to use it; 26.7% of them apply it sometimes, and only 13.3% claimed that they always use it. The mean score is 1.53, with an SD of 0.72.

As part of Confirmation Inquiry Techniques, Group Works seemed to be infrequently used. Here, 58.3% of the respondents showed that they do not use it; 30.0% of them use it sometimes, and 11.7% of them reported to apply it always. The mean score is 1.53, with an SD of 0.70. Another technique is observation with low usage, where 69.2% of the respondents claimed that they do not use it; 21.7% of them use it sometimes, and only 9.2% always apply it. The mean score is 1.40, with an SD of 0.65. 73.3% of the respondents reported that they do not use laboratory-based activities, while 14.2% of them use it sometimes, and the remaining 12.5% of the respondents always apply it. The mean score is 1.39, with an SD of 0.70. among the confirmation inquiry techniques, reflecting findings is the least frequently used as 83.3% of the respondents depicted that they do not use it, whereas 10.0% of them use it sometimes, and only 6.7% reported to use it always. The mean score is 1.23, with an SD of 0.56. Individual/Peer Presentation is infrequently used, where 65.8% of the respondents do not use it; while 20.0%

of them claimed to use it sometimes, and 14.2% of them tend to use it always. The mean score is 1.48, with an SD of 0.73.

From the Guided Inquiry Techniques, Inquiry-based Investigation is rarely used by teachers since 85.8% of the respondents do not use it. However, 10.0% of them use it sometimes, and only 4.2% always use it. The mean score is 1.18, with an SD of 0.48. Moreover, Generate Findings is rarely used by teachers here, 86.7% of the respondents do not use it, whereas 10.0% of them use it sometimes, and only 3.3% always apply it. The mean score is 1.17, with an SD of 0.46.

Among Open Inquiry Techniques, Project Works are infrequently used by teachers, where 72.5% of the respondents do not use it at all, while 14.2% of them use it sometimes, and only 13.3% of them reported to use it always. The mean score is 1.41, with an SD of 0.72. Field Visits are rarely used by teachers. Here, 85.0% of the respondents do not use this technique, whereas 13.3% of them depicted that they apply it sometimes, and only 1.7% tend to apply it always. The mean score is 1.17, with an SD of 0.42. Furthermore, Reflection is rarely used among teachers. Data showed that 81.7% of the respondents do not use this technique, while 15.0% of them sometimes use it, and only 3.3% of them always apply it. The mean score is 1.22, with an SD of 0.49. Discussion with Classmates is the least frequently used, and the data showed that 60.0% of the respondents do not use this technique. On the other hand, 25.0% of them tend to use it sometimes, and 15.0% of them always apply it. The mean score is 1.55, with an SD of 0.74 displays moderate inconsistency in its practice.

Regarding the distribution of the different teaching techniques among the teachers, rating the aggregate mean of the teaching strategies is displayed in table 4.7 below. The analysis uses the aggregate mean and standard deviation values of each strategy to gauge the frequency and consistency of their implementation in the middle school general science practice. Traditional/one way, Confirmation inquiry, Structured inquiry, Guided inquiry, and Open inquiry are the five general categories into which the teaching methods are divided to assess the dominant teaching approaches and identify trends that reflect the nature of classroom instruction. These statistical values are derived from teacher responses indicating how frequently they implement each activity, typically measured on a Likert scale (Example, “not at all,” “sometimes,” “always”). This is also crucial for understanding the existing landscape of general science teaching practices within the study context. It reveals the degree to which educators rely on traditional, lecture-based instruction versus engaging students in more participatory learning experiences. This helps to highlight the extent to which teachers implement student-centered, inquiry-based practical activities versus more conventional, teacher-dominated methods.

Table 4. 7: Distribution of practices of teaching techniques on a scale of 1 to 3 among teachers

Teaching technique	Teaching Activity	Activity		Aggregate	
		Mean	SD	Mean	SD
1. Traditional/one way	Demonstration	1.70	0.73	2.30	0.39
	Lecture/Explanation	2.89	0.31		
2. Structured Inquiry	Question & Answer	2.11	0.46	1.69	0.38
	Modeling	1.44	0.59		
	Written responses	1.53	0.72		
3. Confirmation Inquiry	Group works	1.53	0.70	1.41	0.32
	Observation	1.40	0.65		
	Laboratory based activities	1.39	0.70		
	Reflecting findings	1.23	0.56		
	Individual/peer presentation	1.48	0.73		
4. Guided Inquiry	Inquiry- based investigation	1.18	0.48	1.18	0.32
	Generate findings	1.17	0.46		
5. Open Inquiry	Project works	1.41	0.72	1.34	0.35
	Field visits	1.17	0.42		
	Reflection	1.22	0.49		
	Discussion with classmates	1.55	0.74		

As one can see from the above comprehensive summary of the teaching strategies and particular classroom practices used by general science teachers in the schools under this study the analysis of teaching techniques among teachers reveals as follows:

1. Traditional/One-Way Teaching technique

Traditional teaching emerged as the most dominant instructional approach. The high (2.30) aggregate mean indicates frequent usage, particularly through lectures and explanations, which received the highest individual activity score (Mean = 2.89). Demonstrations were also moderately used. The relatively low SD suggests consistent implementation across educational settings. This reveals a teacher-centered model where information is primarily transmitted from teacher to student with minimal interaction.

2. Structured Inquiry Teaching technique

Structured inquiry represents a moderately used approach with aggregate mean (1.69). Activities such as Question & Answer (Mean = 2.11) indicate some level of student engagement, while modeling and written responses were less frequent. The moderate standard deviation indicates some variation in implementation.

3. Confirmation Inquiry

The aggregate mean (1.41) aggregate standard deviation (0.32) indicates confirmation inquiry had a lower overall practice compared to structured inquiry. Strategies such as group work, observation, and laboratory-based tasks were executed to a limited extent. The consistently low scores indicate limited integration of hands-on and collaborative strategies, despite their potential to reinforce learned concepts. The low SD reflects constant underutilization across the middle schools in contexts.

4. Guided Inquiry

Guided Inquiry received the lowest aggregate mean (1.18), indicating minimal use. Activities focused on inquiry-based investigation and generating findings were less applied. The low SD (0.32) suggests that this trend is consistent across most classrooms. The results reflect a significant gap in implementing partially student-led learning situations that foster exploration and problem-solving.

5. Open Inquiry

The Aggregate Mean (1.34) and aggregate standard deviation (0.35) of open inquiry, which emphasizes student autonomy through projects, field visits, reflections, and discussions, also rated low in usage. Among the activities, classroom discussion received slightly higher engagement (Mean = 1.55), while others remained low. The limited use of Open Inquiry suggests challenges in facilitating student-directed learning in current teaching practices.

To sum up the analysis of teaching techniques based on aggregate mean and standard deviation values reveals a strong preference for Traditional/One-Way teaching techniques, mainly lecture-based instruction, which is the most frequently and consistently used approach. Structured Inquiry, involving semi-interactive methods like Question & Answer, is moderately applied, indicating some effort toward student engagement. Conversely, more student-centered approaches such as Confirmation Inquiry, Guided Inquiry, and Open Inquiry are used far less regularly.

The teachers' ratings and a comprehensive comparison of various teaching methods are presented in Table 4.8. This table presents a comparative analysis of the execution of teaching techniques such as, Traditional/One-way technique, structured inquiry, confirmation inquiry, guided inquiry, and open inquiry across in the target middle schools of general science class in the eleven sub-cities. Disparity in teaching technique implementation across sub-cities expected stems from differences in school infrastructure, teacher capacity, and local context**.** Some sub-cities may lack adequate lab facilities or instructional materials, making inquiry-based or practical science instruction difficult and pushing teachers toward lecture-based methods (e.g., traditional, one-way teaching).

Teacher training, experience, and workload may also differ from one area to another, affecting readiness and motivation to carry out structured or guided inquiry. Moreover, class size and community socio-economic context can play a role: large classes or limited parental/community support can make practical activities hard to organize, while smaller classes and stronger support may enable more frequent inquiry-based practical activity lessons. As a result, classrooms across different sub-cities may show substantial variation in use of inquiry-based learning through practical activities against traditional teaching methods.

For each sub-city, the data includes mean scores and standard deviations that reflect the extent and consistency of each teaching technique's use in the classroom. The mean values indicate the average frequency or emphasis of each approach, while the standard deviations show the variation in their application. This analysis aims to highlight differences in instructional practices across each sub-city and provide insight into the prevailing instructional trends within each sub-city.

Table 4. 8: Comparison of teaching techniques among sub-cities based on the rating of teachers

Sub-city	Traditional/one way		Structured Inquiry		Confirmation Inquiry		Guided Inquiry		Open Inquiry	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1. Arada	2.30	0.35	1.77	0.39	1.44	0.26	1.15	0.24	1.33	0.41
2. Gulelie	2.15	0.43	1.72	0.33	1.26	0.25	1.04	0.14	1.33	0.39
3. Addis Ketema	2.10	0.21	1.70	0.25	1.28	0.29	1.00	0.00	1.43	0.35
4. Bole	2.50	0.38	1.58	0.30	1.30	0.21	1.06	0.18	1.22	0.21
5. Kirkos	2.25	0.46	1.79	0.43	1.55	0.40	1.19	0.37	1.44	0.42
6. Kolfie Keraniyo	2.43	0.32	1.42	0.27	1.24	0.19	1.07	0.18	1.18	0.18
7. Lideta	2.23	0.47	1.88	0.45	1.64	0.36	1.27	0.34	1.36	0.44
8. Yeka	2.25	0.46	2.04	0.42	1.68	0.43	1.50	0.46	1.56	0.48
9. Nefas Silk Lafto	2.25	0.34	1.75	0.41	1.48	0.28	1.42	0.42	1.33	0.27
10. Lemi Kura	2.38	0.39	1.42	0.29	1.25	0.23	1.06	0.17	1.23	0.31
11. Akaki Kaliti	2.39	0.42	1.93	0.22	1.64	0.31	1.33	0.43	1.47	0.29

1. Traditional/One-Way Teaching Technique

Based on the data in table 4.8, Bole has the highest mean score of 2.50, indicating a highest preference or utilization of traditional teaching methods. On the other hand, Addis Ketema has the lowest mean score of 2.10, indicating a lower preference or utilization of traditional teaching methods. Lideta has the highest SD of 0.47, showing a wider variability in the use of traditional teaching methods among teachers. Addis Ketema, however, has the lowest SD of 0.21, depicting more consistency in the use of traditional teaching methods among teachers.

2. Structured Inquiry Teaching Technique

Data in table 4.8 shows that Yeka has the highest mean score of 2.04, and it indicates a higher preference or utilization of structured inquiry methods. However, Kolfe Keraniyo and Lemi Kura have the lowest mean scores of 1.42 and 1.42 respectively, showing a lower preference or utilization of structured inquiry methods.

Lideta has the highest SD of 0.45, indicating a wider variability in the use of structured inquiry methods among teachers. On the other hand, Akaki Kaliti has the lowest SD of 0.22, and this reveals more consistency in the use of structured inquiry methods among teachers.

3. Confirmation Inquiry Teaching Technique

With regard to this technique, Yeka has the highest mean score of 1.68, indicating a higher preference or utilization of confirmation inquiry methods, yet Gulelie has the lowest mean score of 1.26, and it indicates a lower preference or utilization of confirmation inquiry methods. The standard deviations are not provided for this category, which limits the analysis of variability.

4. Guided Inquiry Teaching Technique

As far as this technique is concerned, Yeka has the highest mean score of 1.68, indicating a higher preference or utilization of guided inquiry methods. Gulelie has the lowest mean score of 1.26, indicating a lower preference or utilization of guided inquiry methods. The standard deviations are not provided for this category, which limits the analysis of variability.

Bole sub-city shows a strong preference for traditional methods that account 2.50 but a lower preference for structured inquiry with 1.58. This suggests a potential area for professional development to encourage more Inquiry-based methods. Addis Ketema shows the lowest preference for traditional methods with a mean value of 2.10 and structured inquiry with a mean score of 1.70, indicating an overall lower use of both teaching techniques. Lideta with a standard deviation value of (0.45) shows high variability in structured inquiry, indicating differing levels of adoption among teachers, whereas Akaki Kaliti with the standard deviation value of 0.22 shows more consistency, potentially due to more uniform training or support.

Yeka sub-city stands out with the highest mean scores for both confirmation and guided inquiry 1.68 and 1.5 respectively, indicating a balanced approach to utilizing Inquiry-based techniques. Gulelie has the lowest scores for both confirmation and guided inquiry 1.26 and 1.04 respectively, suggesting a need for increased support in adopting these methods. The data reveals varying preferences and consistencies in teaching techniques across different sub-cities. Sub-cities like Bole and Yeka show distinctive trends that could guide targeted professional development and support initiatives. The variability in standard deviations suggests differing levels of adoption and consistency, which could be addressed through more uniform training and resource allocation.

Furthermore the teachers' ratings and a comprehensive comparison of various teaching methods are presented in bar chart in Figure 4.1. The examination of mean scores for the five teaching techniques across sub-cities offers nuanced insights into the diverse perceptions of instructional methods. "Traditional/one way", including Demonstration and Lecture/Explanation and "Structured Inquiry", including Question and Answer, Modeling, and Written Responses emerge as consistently implemented methods across all sub-cities. Bole and Kolfe Keraniyo sub-cities exhibit the highest mean scores for "Traditional/one way", indicating a relatively positive reception of this method. "Structured Inquiry" achieves a higher mean score in Yeka sub-city. "Confirmation Inquiry", including Group Works, Observation, Laboratory-based Activities, Reflecting Findings, and Individual/Peer Presentation, attains the second rank with a higher mean score in Yeka sub-city, followed by Lideta and Akaki Kaliti sub-cities with equal mean scores.

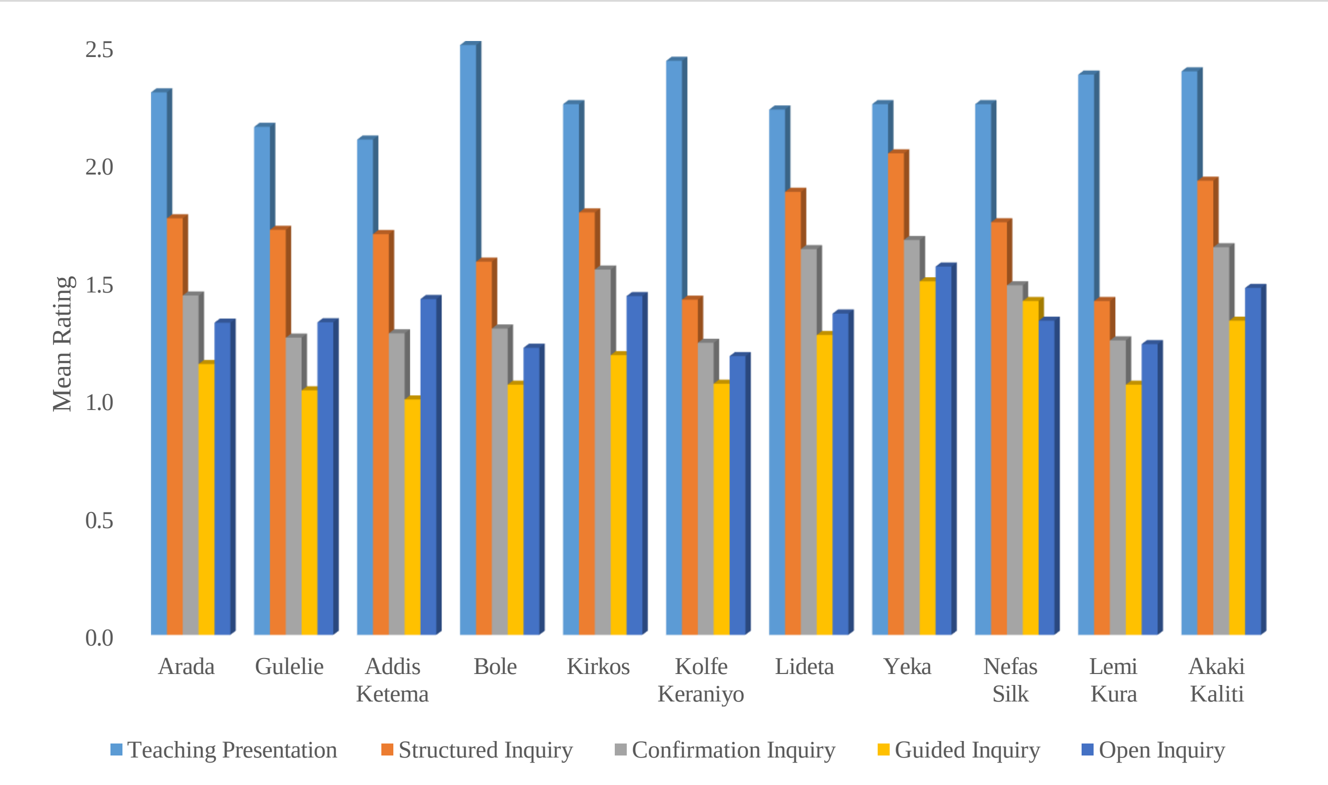

Figure 4. 1: Bar chart for comparison of teaching techniques among sub-cities based on the rating of teachers

A. Science Teachers Perceptions on Inquiry-Based Practical Activities

Table 4.9 presents the frequency distribution of teachers' responses concerning the perceived importance of inquiry-based practical activities (IBPA) in general science instruction. The data are based on ten positively framed statements that highlight various benefits of IBPA, measured on a five-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5). Each statement arrests a clear dimension of IBPA's educational value, such as its contribution to enhancing students' conceptual understanding, encouraging peer learning, collaboration, fostering independent and self-directed learning, and promoting the development of problem-solving and interpersonal skills. The table also contains the mean and standard deviation for each item, providing a quantitative overview of teachers' insights regarding the effectiveness and significance of IBPA in classroom practice.

Table 4. 9: Frequency distribution on the importance Inquiry-based practical learning among teachers

Importance of Inquiry-based practical activities (Positive Impacts)	**SD (1)**		**D (2)**		**U (3)**		**A (4)**		**SA (5)**		**Mean**	**SD**
	n	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**		
1. IBPA are easy to implement and enable learners to solve their problems.	0	0.0	10	8.3	23	19.2	87	72.5	0	0.0	3.64	0.63
2. IBPA provide learners with better understanding science concepts in their environment/context.	0	0.0	4	3.3	9	7.5	92	76.7	15	12.5	3.98	0.58
3. IBPA help the learners to share experiences &learn from each other.	0	0.0	17	14.2	20	16.7	76	63.3	7	5.8	3.61	0.80
4. IBPA develop self-confidence and independent learning for the teacher.	0	0.0	9	7.5	27	22.5	76	63.3	8	6.7	3.69	0.71
5. IBPA develop self-confidence and independent learning for the learner.	0	0.0	0	0.0	18	15.0	76	63.3	26	21.7	4.07	0.60
6. IBPA prepare the learner to solve real problems in the society.	0	0.0	6	5.0	26	21.7	83	69.2	5	4.2	3.73	0.62
7. The role of teacher is facilitating the learning process rather than controlling.	0	0.0	0	0.0	0	0.0	93	77.5	27	22.5	4.23	0.42
8. Using IBPA helps to develop students self-learning abilities and skill.	0	0.0	14	11.7	44	36.7	61	50.8	1	0.8	3.41	0.70
9. IBPA strategies promote the development of students' interpersonal skill.	0	0.0	0	0.0	31	25.8	78	65.0	11	9.2	3.83	0.57
10. IBPA strategies promote the students to learn from practical world than the theoretical one.	0	0.0	41	34.2	24	20.0	39	32.5	16	13.3	3.25	1.07
											Grand Mean	3.74

Table 4.9 provides data on teachers' perceptions of inquiry-based practical activities (IBPA) across various statements. The summary of responses regarding the perceptions of science teachers on inquiry-based practical activities is related to its positive and negative impacts. The table shows varying degrees of agreement among teachers on the efficacy and impact of IBPA in the educational context. The mean scores for each statement range from 3.25 to 4.23, suggesting that most of the teachers view IBPA positively. The highest agreement is for the statement "The role of the teacher is facilitating the learning process rather than controlling," with a mean of 4.23, and this highlights a strong endorsement of facilitative teaching roles in inquiry-based settings. The lowest mean score of 3.25 is associated with the statement regarding the preference for practical over theoretical learning. This reflects some reservations about fully prioritizing practical learning over traditional methods.

A significant majority that accounts 72.5% of the respondents agree that IBPAs are easy to implement and help learners solve their problems, indicating a positive view of the practicality and effectiveness of IBPA. 89.2% of the respondents acknowledge that IBPA helps learners understand science concepts within their environment or context better. Statements regarding the development of self-confidence and independent learning for both teachers and learners score above 3.5 on average, and this signifies a strong belief in the personal development benefits of IBPA. Teachers also largely agree that IBPA prepares learners to address real-world problems, reinforcing the practical value of this teaching approach. There is a nearly unanimous agreement that the role of a teacher should be more about facilitating rather than controlling, which underscores a paradigm shift in teaching perspectives among the respondents. Responses show that teachers believe IBPA contributes to the development of self-learning abilities and interpersonal skills among students.

The grand mean across all items is approximately 3.74. This value indicates a generally positive perception among teachers regarding the importance and effectiveness of inquiry-based practical learning, where respondents leaning towards agreement on most statements. The standard deviations ranging from 0.42 to 1.07 are relatively low, where most are found under 0.80, and it indicates a general consensus among the responses. However, the highest SD associated with learning from practical versus theoretical worlds suggests some variability in opinions on this aspect.

The data supports further integration of IBPA into curricula as teachers recognize its benefits in enhancing practical understanding, developing skills, and fostering independent learning.

Educational policymakers should consider these insights to promote more hands-on learning environments. Given the strong endorsement of facilitative teaching roles, professional development programs might focus on training teachers to be facilitators who empower students rather than control the learning process. The positive reception to IBPA underscores the need for adequate resources, such as laboratory equipment and materials, to implement these activities effectively.

Despite the enthusiasm for practical learning, the variability in opinions regarding the balance between practical and theoretical education suggests that a blended approach might be necessary to cater to diverse learning needs and preferences. Overall, the data from Table 4.9 reveals a strong endorsement of inquiry-based practical activities, with implications for teaching practices, curriculum development, and educational policy.

The analysis and discussion of the data presented in Table 4.9 reveals four key insights.

- Positive Reception: The data overwhelmingly indicate that teachers perceive Inquiry-based practical learning (IBPA) as a beneficial educational approach. High mean scores across various items demonstrate either agreement or strong agreement that IBPA enhances educational outcomes, including problem-solving, self-learning, and interpersonal skills.
- Specific Strengths: Notably, the highest level of agreement pertains to the role of teachers as facilitators with a mean score of 4.23. This indicates strong consensus on the importance of a facilitative teaching role and the development of learners' confidence and independence that received a mean score of 4.07. These findings highlight robust support for these critical aspects of IBPA.
- Areas of Concern: A lower mean score of 3.25 and a higher standard deviation of 1.07 for the item concerning learning from the practical world suggest some reservations about the effectiveness of IBPA compared to traditional or theoretical methods. Additionally, the varied perceptions of other IBPA principles indicate inconsistencies in acceptance and implementation, pointing to potential areas that require additional support, resources, or methodological adjustments.
- Consistent Understanding: The low standard deviations associated with most items suggest that there is a consistent understanding and appreciation among teachers of

the benefits of inquiry-based learning, aligning well with their educational goals and perceptions.

In general, this analysis underscores a strong endorsement of inquiry-based learning through practical activities within the educational process, emphasizing its significance in fostering a practical, interactive, and learner-centered educational environment.

B. Teachers' Perceptions on the Implementation of Inquiry-Based learning through Practical Activities in Science Lessons

Table 4.10 presents the frequency distribution of teachers' responses concerning perceived challenges of inquiry-based practical activities (IBPA) in general science instruction. The data are based on ten statements related with the challenges and negative impacts outlined with implementing inquiry-based learning through practical activities in schools. Using a 5-point Likert scale ranging from Strongly Disagree (5) to Strongly Agree (1), the responses reflect varying levels of agreement with statements that express potential difficulties in using IBPA. The analysis includes mean scores and standard deviations for each item, offering insights into the extent and consistency of these perceptions.

Table 4. 10: Teachers' Perceived Challenges in Inquiry Based Practical Activity Implementation: Frequency Distribution

Statement	SD (5)	D (4)	U (3)	A (2)	SA (1)	Mean	SD
It is too difficult to practice IBPA in schools.	18 (15.0%)	59 (49.2%)	4 (3.3%)	30 (25.0%)	9 (7.5%)	3.39	1.23
Learning is occurring when learners are silent & passive receivers of information from the teacher.	36 (30.0%)	63 (52.5%)	8 (6.7%)	10 (8.3%)	3 (2.5%)	3.99	0.97
IBPA take time so, traditional methods are preferable to implement.	14 (11.7%)	88 (73.3%)	11 (9.2%)	7 (5.8%)	0 (0.0%)	3.83	0.66
Learning is effective when teachers narrate subject matter knowledge rather than how to teach.	4 (3.3%)	79 (65.8%)	12 (10.0%)	16 (13.3%)	9 (7.5%)	3.44	1.02
Lecture is helpful because it fills learners' minds quickly.	13 (10.8%)	81 (67.5%)	1 (0.8%)	17 (14.2%)	8 (6.7%)	3.49	1.07
In IBPA, teachers are the source of knowledge.	1 (0.8%)	81 (67.5%)	8 (6.7%)	27 (22.5%)	3 (2.5%)	3.42	0.93
IBPA doesn't promote learning from the practical world.	0 (0.0%)	26 (21.7%)	53 (44.2%)	35 (29.2%)	6 (5.0%)	3.18	0.83
IBPA strategies are for lab classes only.	7 (5.8%)	76 (63.3%)	29 (24.2%)	8 (6.7%)	0 (0.0%)	3.32	0.69
IBPA doesn't prepare learners to solve societal problems.	1 (0.8%)	65 (54.2%)	12 (10.0%)	37 (30.8%)	5 (4.2%)	3.17	1.02
IBPA makes science lessons difficult.	0 (0.0%)	38 (31.7%)	6 (5.0%)	70 (58.3%)	6 (5.0%)	2.63	0.99
						Grand Mean	3.39

The summary of responses in Table 4.10 provides a comprehensive view of science teachers' perspectives related to negative impact statements related with inquiry-based practical activities. The overall data recommends that while inquiry-based practical activities in educational settings are generally favored for their participatory approach, however there are prominent concerns regarding their practical application, in terms of different limitations and the perceived difficulty in implementing these strategies.

Regarding the statement, "It is too difficult to practice IBPA in schools", respondents reflect a mean score of (3.39) indicates that a substantial portion perceive implementing inquiry-based practical activities in schools as a difficult task. However, there is a significant amount of variety in the replies, as perceived by the huge standard deviation of (1.23), regarding to some people may find IBPA challenging to implement, but others might not feel the same way. This implies that perceived difficulty may vary depending on the situation, with certain schools, subjects, or teacher experience levels affecting the perception on implementation.

In response to the statement "Learning is occurring when learners are silent & passive receivers of information from the teacher", the participants expressed a mean score of 3.99, signifying a strong disagreement with the notion that passive learning is effective. This aligns with modern educational philosophies that prioritize active learning and student engagement. Moreover, the low standard deviation of 0.97 indicates strong consensus among respondents regarding the scantiness of passive learning methods.

Teachers were asked about their perceptions of the IBPA teaching style, by asking them if they believed that the traditional method is preferable because IBPA takes time. The majority of them disagreed with this notion. The average score of 3.83 shows a definite disagreement with the notion that traditional procedures should be chosen just because of IBPA's time constraints. Despite the time pledge, respondents strongly think that IBPA is valuable, as indicated by the relatively low standard deviation (0.66). This demonstrates the prevalent belief that the advantages of active, inquiry-based learning exceed the difficulties brought on by the extra time commitment. It also suggests a desire for more innovative teaching strategies as opposed to conventional lecture-based methods.

Teachers were also asked to respond to the question: "Learning is effective when teachers narrate subject matter knowledge rather than how to teach." According to the mean score of (3.44), which indicates a slight disagreement with the statement, the majority of respondents prefer a more active approach to learning, one that underscores teaching methods alongside content delivery. The standard deviation of 1.02 suggests some variability in responses, in which the majority of respondents disagree with the statement, and a few still worth the importance of teacher narration.

Supporting the claim that "lecture is helpful because it fills learners' minds quickly", teachers gave a mean score of 3.49, which leans towards "Disagree." This indicates that, despite the fact that lectures can impart knowledge fast, most respondents do not think of them as the most effective teaching approach. The moderate variety of opinions indicated by the standard deviation of 1.07, suggests a significant portion of teachers that account 20.9% view the lecture method as beneficial for transmitting knowledge efficiently, while others do not.

Teachers also expressed a positive outlook on their role in the inquiry-based approach, disagreeing with a Mean score of 3.42 and SD of 0.93, with the idea that teachers should primarily be sources of knowledge rather than facilitators.

However, there is notable doubt concerning the effectiveness of IBPA in promoting practical over theoretical learning. This is reflected in the mean score of 3.18, which supports slightly toward disagreement, suggesting some uncertainty about IBPA's practical focus. Similarly, the high proportion of unsure answers (44.2%) illustrates the diversity of viewpoints, indicating that while some participants associate IBPA with practical learning, many remain uncertain. This doubt extends to the applicability of IBPA; the idea that IBPA is only used in lab classes is rejected by a mean score of 3.32, which supports the wider use of IBPA in a variety of educational settings. The low standard deviation of 0.69 further indicates strong agreement among respondents that IBPA can be effectively implemented beyond just laboratory environments.

A strong majority of respondents that account 85%, with a Mean of 3.17 and SD of 1.02, indicates that while the majority disagrees with the statement, there is some variation in responses, with a portion of participants unsure about the effectiveness of IBPA in this regard. Furthermore, the statement is agreed with by a significant majority of respondents, as shown by the mean of (2.63), which suggests that IBPA makes teaching science more difficult. A moderate response spread is revealed by the standard deviation of (0.99), suggesting that many teachers find IBPA complicates the delivery of general science lessons, emphasizing the challenges of implementing these methods in educational settings.

While respondents generally show a substantial level of agreement with the potential benefits of IBPA, they also recognize its limitations and inconsistencies in their ability to apply this understanding in actual practice, as indicated by the grand mean of 3.39. This score demonstrates an understanding of the importance of IBPA in promoting critical thinking, student involvement, and active learning. In addition, items with means above 3.50 (for example, items 2 and 3) show strong disagreement with the negative views, supporting the value of IBPA. Nevertheless, it also highlights the difficulties that respondents have, especially those that are related to time limits, implementation difficulties, and the unique situations in which IBPA might not work or implement in general science instruction classes.

Generally, the research points to inquiry-based practical activities as a useful teaching approach even though its success largely depends on how well it is incorporated into instructional practice, the availability of resources, and the quality of training provided to teachers. Since of this, future educational improvements should concentrate on giving teachers with adequate resources, professional development opportunities, and time management techniques to help them successfully apply IBPA. The results also emphasize how crucial it is to make sure that IBPA may be modified for use in a variety of learning contexts and subjects in order to optimize student learning.

Furthermore, to infer more on the perceptions of inquiry-based practical activities among middle-level science teachers were also analysed using disaggregated data based on demographic variables such as department, gender, qualification, and teaching experience. Respondents disaggregated by demographic variables will presents as follows:

Table 4.11 presents analysis of respondents' perceptions related with the benefits and implementation related challenges linked with executing inquiry-based practical activities (IBPA) in general science education in the middle schools of Addis Ababa. The data is classified by key demographic and professional variables, including department, sex, educational qualification, and teaching experience. Mean scores and standard deviations (SD) are provided for each group with respect to their views on both the benefits (overall grand mean = 3.74) and challenges (overall grand mean = 3.39) of IBPA.

Table 4. 11: Respondents disaggregated by demographic variables

Variable	Category	Respondents	Benefits of IBPA (Grand mean=3.74)		Challenges to IBPA (Grand mean=3.39)	
			Mean	SD	Mean	SD
Department	Biology	41	3.74	0.22	3.39	1.23
	Chemistry	41	3.73	0.21	3.99	0.97
	Physics	38	3.75	0.22	3.83	0.66
Sex	Male	85	3.75	0.22	3.44	1.02
	Female	35	3.73	0.21	3.49	1.07
Qualification	Diploma	61	3.77	0.20	3.42	0.93
	BSc/MSc	22	3.70	0.26	3.18	0.83
	BSC+PGDT	37	3.73	0.22	3.32	0.69
Teaching experience	<5 years	29	3.76	0.24	3.17	1.02
	6-10 years	34	3.74	0.20	2.63	0.99
	11-15 years	13	3.74	0.21	2.52	0.26
	16-20 years	21	3.68	0.23	2.63	0.33
	>=21 years	23	3.78	0.20	2.65	0.29

The results in Table 4.11 present the perceived benefits and barriers of Inquiry-based practical activities (IBPA) across various demographic categories of teachers, with means and standard deviations (SD) for both benefits and challenges.

Subject Specialization and Perceptions

Looking at the department, across academic departments all three departments reported nearly identical levels of perceived benefits (around 3.74-3.75), indicating a shared belief in the value of IBPA across disciplines. Furthermore, Physics teachers reported the highest perceived benefits (M = 3.75, SD = 0.22) with high challenge score (M = 3.83), indicating practical difficulties despite seeing the highest benefits; Biology showed balanced perceptions, with benefits equal to the grand mean (3.74) and challenges also exactly matching it (3.39), indicating a moderate and stable view. Whereas Chemistry teachers identified the highest level of challenges (M = 3.99, SD = 0.97) suggesting strong perceived barriers. This consistent recognition on the benefits of IBPA across disciplines indicates that the concept of inquiry-based learning booms well with science ability, regardless of specialization. However, the inconsistencies in perceived challenges point to discipline-specific barriers that may impact the effective implementation of IBPA. The significantly high challenge rating among Chemistry and Physics teachers despite reporting the highest perceived benefits suggests that different obstacles in the implementation and addressing these barriers may simplify inquiry implementation in general science education in the middle schools.

Gender and Perceptions of Inquiry-Based Practical Activities

As illustrated in the above Table on the perceptions of male and female teachers regarding inquiry-based practical activities (IBPA), the mean scores for the benefits of IBPA show minimal difference between males with mean of 3.75 and females with mean of 3.73, suggesting that both genders perceive similar advantages from IBPA. This marginal difference suggests that gender does not play a significant role in shaping teachers' perceptions of IBPA as both groups demonstrate a similar spread of opinions. However, females report slightly more challenges with a mean of (3.49) as compared to males with a mean of (3.44). This indicates that while the perceived benefits are nearly identical, females may face marginally more obstacles, potentially linked to external factors, like workload or access to resources. The low standard deviations for both benefits and challenges reflect a high level of consistency in the responses within each gender group, and the lower means for both genders highlight shared challenges or constraints, indicating a need for targeted interventions to enhance overall perceptions.

Qualification as a Determinant of Perceptions

Table 4.11 sheds light on the influence of educational qualifications on teachers' perceptions. Regarding qualifications, 61 teachers with Diploma holders, 37 BSc+PGDT and 22 BSc/MSc general science teachers comprised.

The result shows diverse patterns in the ways that general science teachers with various backgrounds view the advantages and difficulties of putting IBPA into practice. The major perceived benefits (M = 3.77) and perceived challenges (M = 3.42) were indicated by diploma holders. This infers that even while these teachers are passionate about the benefits of IBPA, they do not have the professional pedagogical knowledge or self-control to use it successfully. Their increased sense of difficulty may result from their previous training's greater reliance on organized, teacher dominated approaches, their limited exposure to instructional styles, or their lack of professional development chances etc...

Teachers with BSc/ MSc degrees, on the other hand, conveyed the lowest challenge scores (M = 3.18) and slightly lower perceived benefits (M = 3.70). This group may feel more professionally prepared and capable of incorporating IBPA into their teaching, possibly because they have access to higher-level teacher education and stronger theoretical bases. Their slightly lower benefit score may reflect a more realistic or critical view of IBPA, shaped by more experience or familiarity with its practical limitations. Teachers with a BSc and PGDT qualification fall in between the two other categories in terms of perceived obstacles (M = 3.32) and rewards (M = 3.73). This implies a more impartial perspective, probably as a result of their formal pedagogical background and subject-matter experience. While they could be more prepared than those with diplomas, they lack the academic sophistication of those with more advanced degrees.

This suggests that teachers with foundational qualifications might perceive the advantages of IBPA more favorably compared to those with higher academic qualifications. Likewise, this indicates that advanced qualifications and additional professional training, such as the PGDT, are associated with more favourable perceptions of IBPA. Despite these differences, some groups fall significantly below the grand mean, underlining systemic challenges that transcend qualifications. On average, BSc/MSc-qualified educators agree that IBPA is beneficial. The relatively low standard deviation (SD = 0.26) suggests that their responses were closely clustered, meaning there was strong consensus among them about these benefits. However, the higher standard deviation (SD = 0.83) (0.83) means their opinions were more varied, suggesting that while some found implementation manageable, others faced more difficulty.

Influence of Teaching Experience

Finally, table 4. 11 explore how teaching experience correlates with perceptions of IBPA. As experience increases, challenge ratings consistently decrease, reaching the lowest point among teachers with 11-15 years of experience (M = 2.52). This suggests that educators in this range may have reached an optimal stage of professional confidence, pedagogical skill, and adaptability to implement IBPA effectively with fewer perceived barriers. However, perceptions of challenges show a more distinct down trend as teaching experience increases. Teachers with less than 5 years of experience reported the highest challenge level (M = 3.17), indicating that novice educators may feel less prepared or more overwhelmed by the demands of implementing inquiry-based strategies.The moderate variability in responses across experience levels further highlights diverse perceptions influenced by both personal and professional factors.

Thus, the results highlight that while demographic factors, such as department, sex, qualification, and teaching experience do influence teachers’ perceptions of IBPA, and the overall trends indicate a general agreement regarding its benefits. However, challenges associated with IBPA tend to vary slightly across different groups, with certain demographics, such as those with more teaching experience etc.… These insights can help inform strategies for the broader adoption of IBPA, particularly in addressing the specific challenges faced by different groups of educators. Furthermore, the analysis reveals that qualifications, teaching experience, and to a lesser extent, subject specialization influence perceptions of IBPA.

Teachers with foundational and higher qualifications (Diploma and BSc +PGDT) and younger-career experience demonstrate relatively positive attitudes, underscoring the importance of advanced education and balanced professional growth. Nevertheless, the consistently low aggregate means across all demographic groups, relative to the grand mean, emphasize systemic issues, such as resource constraints, lack of targeted training, and institutional support.

To address these challenges, comprehensive training programs should be prioritized. Professional development initiatives can deepen teachers’ understanding of Inquiry-based practical activities in general science teaching-learning, enhance practical implementation skills, and foster positive attitudes toward change. Tailored interventions, such as mentorship for less experienced teachers and targeted workshops for veteran educators, can address specific needs and barriers.

Additionally, providing subject-specific resources and fostering collaborative learning communities can further support the effective adoption of inquiry-based methodologies. By investing in such strategies, educational institutions can improve teachers’ perceptions and implementation of IBPA, ultimately enhancing students’ engagement and learning outcomes in science education. Descriptive statistics were used because the objective of this study is to document how frequently different teaching methods are used in the surveyed sample not to generalize findings to all schools. Descriptive measures (means, standard deviations, frequencies, and percentages) provide an accurate reflection of the actual behavior of the sampled teachers.

4.1.4 Factors Hindering Inquiry-Based Learning through Practical Activities in Schools

Table 4.12 presents the response analysis of general science teachers related with the factors impeding the implementation of inquiry-based learning through practical activities, significant barriers identified by teachers. The study results reveal significant challenges in the implementation of inquiry-based practical activities within the educational context will present.

Table 4. 12: Frequency distribution of hindering factors of inquiry based practical activities implementation in schools in the view of teachers

Hindering factors	Yes		No	
	n	%	n	%
1. Lack of sufficient and suitable materials	106	88.3	14	11.7
2. Shortage of time	103	85.8	17	14.2
3. Shortage of finance	107	89.2	13	10.8
4. Teacher's tendency to use the traditional lecture	102	85.0	18	15.0
5. Need for additional training on Inquiry-based practical activities	106	88.3	14	11.7
6. Lack of interest	92	76.7	28	23.3
7. Proper assessment on practical implementation	17	14.2	103	85.8

Based on table 4.12 on, 88.3% of the respondents reported the perceived lack of sufficient and suitable materials, indicating a substantial hurdle in resource availability for inquiry-based practical activities. Additionally, the majority of teachers that account 85.8% express the influence of time constraints on the actual practices of Inquiry-based practical activities, pointing to a significant challenge in integrating these activities into the constrained academic schedule.

Financial support is identified as another crucial factor with 89.2% of teachers indicating its impact on the actual practices of inquiry-based practical activities and emphasizing the need for adequate funding to facilitate effective implementation. Furthermore, 85.0% of the teachers believe that the traditional lecture method has affected the practices of inquiry-based practical activities, underscoring a potential clash between conventional teaching approaches and more interactive, inquiry-based methods.

The study also highlights a strong demand for additional training on inquiry-based practical activities with 88.3% of the teachers expressing the need for professional development. Motivational factors are acknowledged as a key concern as 76.7% of the teachers believe that teachers' lack of interest has affected the practices of inquiry-based practical activities in the school. Lastly, the findings show a potential gap in support mechanisms as only 14.2% of teachers feel that their schools assess the problems of teachers in practicing hands-on activities and provide immediate solutions.

When asked about the adequacy of their schools' equipment, only 6 of the 120 teachers (5 %) rated the available instructional materials as highly suitable for conducting inquiry-based practical activities; 18 teachers (15 %) judged the materials to be of moderate suitability; and the large majority 96 teachers (80 %) rated them as poorly suited. Thus, addressing these hindering factors, including resource limitations, time constraints, financial support, and the need for training and motivation, is crucial for fostering effective and widespread adoption of inquiry-based learning through the practical activities methodologies in the sampled middle schools.

4.2. Analyses of Students' Responses

4.2.1. Students Awareness on Inquiry-Based Practical Activities

A total of 1587 students have been involved in this study. Table 4.13 presents the survey analysis of students finding in indicate a vigorous awareness and positive insight of inquiry-based practical activities among the students.

Table 4. 13: Frequency distribution of awareness of students about inquiry-Based practical activities

Awareness		**Yes**		**No**	
		n	**%**	**N**	**%**
1. Do you have any knowledge about inquiry- based practical activities?		1424	89.7	163	10.3
2. Do you think that an inquiry-based practical activity is better than lecturing method?		1457	91.8	130	8.2
3. Do you think that inquiry-based practical activities resulted in greater quality of teaching than traditional lecture method?		1473	92.8	114	7.2
4. Students outlook towards inquiry-based practical activities	Positive	1520	95.8	-	-
	Negative	-	-	67	4.2
5. Do you think that using inquiry-based practical activities help to develop students self-learning abilities and skills?		1541	97.1	46	2.9

A total of 1587 students have been involved in this study, and the findings in Table 4.13 indicate a vigorous awareness and positive insight of inquiry-based practical activities among the students. Indeed, a significant 89.7% of the students report that they have awareness about inquiry-based practical activities. Furthermore, 91.8% of the students express a preference for inquiry-based practical activities over traditional lecturing methods, reflecting a positive inclination towards more interactive and participatory teaching approaches. Also, 92.8% of the students believe that inquiry-based practical activities result in a higher quality of teaching compared to traditional lectures, suggesting a strong endorsement of the effectiveness of inquiry-based methods in enhancing the overall teaching experience.

Moreover, 97.1% of the students acknowledge that the use of inquiry-based practical activities contributes to the development of students' self-learning abilities and skills. This high level of agreement highlights a higher awareness and favorable attitude towards inquiry-based practical activities among students. Also, a substantial 95.8% of the student respondents, totaling 1520 out of 1587, express a positive outlook on inquiry-based practical activities. In contrast, only a small fraction, comprising 4.2%, or 67 students, hold negative views. This overwhelming endorsement from the student group underscores a favorable acceptance and enthusiasm for inquiry-based practical activities. Such a high level of student positivity suggests that these methods not only align with their learning preferences but also contribute positively to their educational experiences.

4.2.2. Inquiry-Based Learning Practical activities and Instructional techniques

The students' view regarding the teaching techniques, including Traditional/one-way, structured inquiry, confirmation inquiry, guided inquiry, and open inquiry, and associated activities employed by science teachers is summarized in Table 4.14. Here, a 4-point rating is used (1 = not at all, 2 = sometimes, 3 = rarely, 4 = always) with corresponding means and standard deviations calculated to assess central tendencies and variability.

Table 4. 14: Frequency distribution of inquiry-based learning through practical activities and practices within the view of students

Teaching technique	**Activity**	**Not at all (1)**		**Rarely (2)**		**Sometimes (3)**		**Always (4)**		**Activity**	
		n	**%**	***n***	**%**	***n***	**%**	***n***	**%**	**Mean**	**SD**
Traditional /one way	Demonstration	805	50.7	175	11.0	576	36.3	31	2.0	1.64	0.75
	Lecture/ Explanation	1	0.1	51	3.2	8	0.5	1527	96.2	3.96	0.24
Structured Inquiry	Question and answer	766	48.3	94	5.9	605	38.1	122	7.7	1.73	0.88
	Modeling	1375	86.6		1.0	194	12.2	2	0.1	1.15	0.39
	Written responses	779	49.1	135	8.5	659	41.5	14	0.9	1.61	0.68
Confirmation Inquiry	Group works	876	55.2	97	6.1	610	38.4	4	0.3	1.51	0.62
	Observation	1299	81.9	27	1.7	259	16.3	2	0.1	1.20	0.45
	Laboratory based activities	1108	69.8	38	2.4	441	27.8	0	0.0	1.33	0.52
	Reflecting findings	1411	88.9	12	0.8	164	10.3	0	0.0	1.12	0.35
	Individual/peer presentation	816	51.4	161	10.1	606	38.2	4	0.3	1.59	0.68
Guided Inquiry	Inquiry-based investigation	1316	82.9	20	1.3	251	15.8	0	0.0	1.18	0.42
	Generate findings	1483	93.4	6	0.4	98	6.2	0	0.0	1.07	0.27
Open Inquiry	Project works	976	61.5	74	4.7	535	33.7	2	0.1	1.43	0.59
	Field visits	1445	91.1	9	0.6	133	8.4	0	0.0	1.10	0.31
	Reflection	1460	92.0	12	0.8	114	7.2	1	0.1	1.09	0.32
	Discussion with classmates	1045	65.8	88	5.5	453	28.5	1	0.1	1.40	0.60

As shown in the table 4.14, the results based on each teaching technique are indicated as follows**.**

1. **Traditional/One-Way Techniques**

50.7% of the students reported that demonstration, with a mean of 1.64 and an SD of 0.75, does not occur at all. The high percentage of "Not at all" responses and the relatively low mean imply that demonstrations are infrequently used. Most students that account 96.2% showed that lectures and explanations happen "Always," resulting in a high mean of 3.96 and a low SD of 0.24. This indicates a heavy reliance on traditional lectures.

2. **Structured Inquiry**

Nearly half of the students that account 48.3% reported that Question and Answer activity, with a mean of 1.73 and an SD of 0.88, does not occur at all, indicating moderate variability in students' experiences. A significant majority of students that account 86.6% depicted that modelling activity, with a mean of 1.15 and an SD of 0.39, does not occur at all; and this implies that modelling is rarely utilized. Similarly, as reported by 49.1% of the respondents, Written Responses, with a mean of 1.61 and an SD of 0.68, has not been used at all, indicating low but somewhat variable use.

3. **Confirmation Inquiry**

Here, 55.2% of the students reported that Group Work activity, with a mean of 1.51 and an SD of 0.62, does not occur at all. . As reported by 81.9% of the students, Observation, with a mean of 1.20 and an SD of 0.45, has been reported not to occur at all, indicating very low usage. 69.8% of the students showed that Laboratory-based Activities, with a mean of 1.33 and an SD of 0.52, do not seem to occur at all , indicating infrequent occurrence, and 88.9% of the respondents claimed that Reflecting Findings, with a mean of 1.12 and an SD of 0.35, do not occur at all, showing very low engagement. Similarly, 51.4% of students reported that Individual/Peer Presentation, with a mean of 1.59 and an SD of 0.68, has not been used at all, showing some variability.

4. **Guided Inquiry**

While 82.9% of the respondents depicted that Inquiry-based Investigation, with a mean of 1.18 and an SD of 0.42, does not occur at all , indicating very low usage, 93.4% of the respondents reported that Generate Findings, with a mean of 1.07 and an SD of 0.27, has not occurred at all , indicating very infrequent occurrence.

5. Open Inquiry

Project Works, Field Visits, Reflection, and Discussion with Classmates are all reported not to occur at all by most of the respondents of 61.5%, 91.1%, 92% and 65.8% the respondents respectively..

The data indicates a predominant reliance on traditional/one-way teaching techniques, particularly lectures/explanations, which are reported as occurring almost always. This traditional approach contrasts starkly with the low frequency of inquiry-based strategies, such as structured, confirmation, guided, and open inquiries.

Low Engagement in inquiry-based Activities: The infrequent use of activities, like modelling, group works, laboratory-based activities, inquiry-based investigations, and project works suggests that students are not often engaged in hands-on or collaborative learning experiences. These activities are essential for fostering critical thinking, problem-solving skills, and a deeper understanding of scientific concepts. The high percentages of "Not at all" responses in these categories highlight a significant gap in the implementation of inquiry-based learning.

Variability in Students' Experiences: The standard deviations for most activities are relatively low, indicating consistent students' experiences across the board, albeit predominantly negative in terms of engagement with inquiry-based methods. However, some activities, like question and answer sessions, individual/peer presentations, and discussions with classmates show moderate variability, suggesting that while these activities are not frequently used, their occurrence might vary more significantly across different classes or schools.

The findings suggest a need for a shift towards more interactive and student-cantered teaching methods. Increasing the frequency of inquiry-based activities could enhance students' engagement, foster a deeper understanding of scientific concepts, and develop critical thinking skills. Professional development for teachers, along with institutional support, may be necessary to facilitate this shift.

In conclusion, the current reliance on traditional teaching techniques limits the potential for students' engagement and effective science learning. There is a clear need for a strategic shift towards more inquiry-based approaches to foster a more dynamic and interactive learning environment in science education.

Table 4.15 presents the summary statistics (mean and standard deviation) of students' ratings of inquiry-based practical activities is presented as follows:

Table 4. 15: Summary statistics of students' ratings about inquiry-based practical activities and instructional techniques

Teaching technique	**Activity**	**Activity**		**Aggregate**	
		Mean	**SD**	**Mean**	**SD**
1. Traditional/one way	Demonstration	1.64	0.75	2.80	0.40
	Lecture/Explanation	3.96	0.24		
2. Structured Inquiry	Question & Answer	1.73	0.88	1.50	0.45
	Modeling	1.15	0.39		
	Written responses	1.61	0.68		
3. Confirmation Inquiry	Group works	1.51	0.62	1.35	0.28
	Observation	1.20	0.45		
	Laboratory based activities	1.33	0.52		
	Reflecting findings	1.12	0.35		
	Individual/peer presentation	1.59	0.68		
4. Guided Inquiry	Inquiry- based investigation	1.18	0.42	1.13	0.26
	Generate findings	1.07	0.27		
5. Open Inquiry	Project works	1.43	0.59	1.25	0.25
	Field visits	1.10	0.31		
	Reflection	1.09	0.32		
	Discussion with classmates	1.40	0.60		

As can be seen in table 4.15, it is obvious to see that "Lecture/Explanation" is the top one with a mean score of 3.96, followed by "Question and Answer" with a mean score of 1.73, and "Demonstration" with a mean score of 1.64. Concerning the constructs, "Traditional/one way", Demonstration and Lecture/Explanation and "Structured Inquiry", including Question and Answer, Modeling, Written responses, are the top two implemented teaching techniques, with mean scores of 2.80 and 1.50 respectively.

Table 4.16 presents a comparative analysis of various teaching techniques across different sub-cities in Addis Ababa based on students' ratings. The teaching techniques include Traditional/One-Way, Structured Inquiry, Confirmation Inquiry, Guided Inquiry, and Open Inquiry. The table provides the mean and standard deviation (SD) for each technique, reflecting the students' perceived effectiveness of these methods.

Table 4. 16: Comparison of teaching techniques among sub-cities based on students' ratings

Sub city	Traditional/ one way		Structured Inquiry		Confirmation Inquiry		Guided Inquiry		Open Inquiry	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Arada	3.25	0.34	1.89	0.56	1.58	0.39	1.22	0.37	1.52	0.33
Gulelie	2.87	0.32	1.39	0.35	1.29	0.24	1.09	0.26	1.23	0.27
Addis Ketema	2.58	0.20	1.11	0.22	1.24	0.27	1.08	0.23	1.08	0.17
Bole	2.55	0.24	1.28	0.26	1.26	0.20	1.06	0.16	1.20	0.20
Kirkos	2.57	0.19	1.48	0.23	1.40	0.22	1.19	0.28	1.19	0.19
Kolfe	2.45	0.19	1.29	0.25	1.43	0.32	1.12	0.22	1.25	0.23
Lideta	3.01	0.42	2.28	0.36	1.36	0.39	1.09	0.25	1.21	0.23
Yeka	2.83	0.34	1.26	0.34	1.21	0.18	1.04	0.16	1.17	0.18
Nefas Silk	2.71	0.31	1.63	0.36	1.41	0.23	1.32	0.33	1.30	0.24
Lemi Kura	2.98	0.43	1.48	0.33	1.32	0.21	1.11	0.25	1.31	0.25
Akaki	2.96	0.37	1.36	0.29	1.39	0.20	1.04	0.14	1.31	0.23

1. Traditional/One-Way Teaching Technique

The Traditional/One-Way teaching method, characterized by a teacher-cantered approach, is rated the highest in Arada with Mean of 3.25 and SD of 0.34 and Lideta with Mean of 3.01 and SD of 0.42. These high mean suggest that students in these sub-cities perceive traditional teaching as more effective compared to others. Conversely, Kolfe has the lowest rating with Mean of 2.45 and SD of 0.19, indicating a lesser preference for traditional methods. The standard deviations are relatively low across all sub-cities, and this suggests a consistent perception among students regarding this method.

2. Structured Inquiry

Structured Inquiry, which involves guided teacher support while allowing students to explore, shows the highest mean of 2.28 and SD of 0.36 in Lideta. This indicates a positive reception towards this method in Lideta. In contrast, Addis Ketema with (Mean of 1.11 and SD of 0.22 and Yeka with Mean of 1.26 and SD of 0.34 show lower means, suggesting less effectiveness or preference for structured inquiry in these areas. The variability (SD) in student ratings is moderate, reflecting some differences in perception within each sub-city.

3. Confirmation Inquiry

Confirmation Inquiry, where students confirm known concepts, is consistently rated lower across all sub-cities compared to traditional and structured inquiry techniques. Arada has the highest mean of 1.89 and SD of 0.56, while Gulelie with Mean of 1.39 and SD of 0.35 and Addis Ketema with Mean of 1.11 and SD of 0.22 are among the lowest. The higher standard deviation in Arada indicates more varied opinions among students.

4. Guided Inquiry

Guided Inquiry, which encourages students to explore with some guidance, is fairly consistent across sub-cities. Arada with Mean of 1.58, Gulelie with Mean of 1.29, and Addis Ketema with Mean of 1.24 have the highest and lowest means respectively. The means are close, suggesting a relatively uniform perception of this method's effectiveness. The standard deviations are relatively small, indicating less variation in students' ratings.

5. Open Inquiry

Open Inquiry, which allows students to investigate independently, shows a consistent trend of lower means compared to other methods. The highest mean is found in Kolfe with Mean of 1.43, while Yeka with Mean of 1.21 has the lowest mean. The uniformity in low means indicates a general perception of open inquiry being less effective or preferred among students. Standard deviations are minimal, suggesting uniform agreement on the method's effectiveness.

The data from Table 14.16 highlights significant variations in the perceived effectiveness of different teaching techniques across sub-cities. Traditional/One-Way teaching methods tend to be rated higher in older and more established sub-cities, like Arada and Lideta, possibly reflecting a cultural or institutional preference for traditional methods. On the other hand, Structured Inquiry is more appreciated in Lideta, indicating a possible openness to more interactive and student-dominated learning methodologies in this sub-city.

Confirmation Inquiry and Open Inquiry are generally rated lower, implying that these methods may not be as effective or preferred in the current educational context of Addis Ababa's middle schools. The relatively low ratings for Guided Inquiry, despite its balance between teacher support and student independence, indicate a need for better implementation or more support for this method. Thus, the students' ratings suggest a preference for more structured and traditional teaching methods. This could imply a need for teacher training and curriculum development to enhance the effectiveness of inquiry-based methods, ensuring they are more engaging and better received by students. Future interventions could focus on balancing traditional methods with innovative inquiry-based techniques to improve students' engagement and learning outcomes.

The following figure also clearly shows that "Traditional/one way", including Demonstration and Lecture/Explanation, are being consistently practiced in all sub-cities, as per the observations of students. "Structured Inquiry" covering Question and Answer, Modeling, Written responses and "Confirmation Inquiry", including Group works, Observation, Laboratory-based activities, reflecting findings, Individual/peer presentation can be considered the second most highly practiced techniques in each sub-city. "Structured Inquiry", having Question and Answer, Modeling, Written responses is being implemented most in schools in the Lideta and Arada sub-cities.

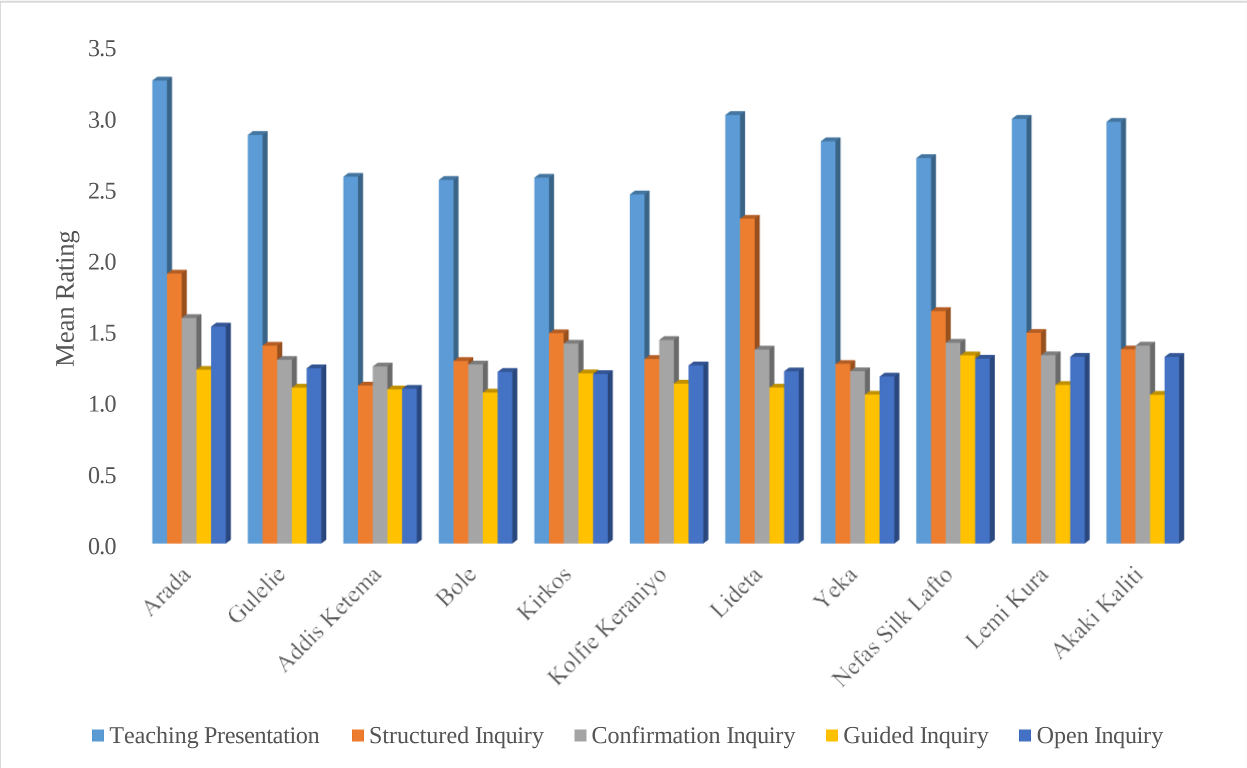

Figure 4. 2: Bar chart for comparison of teaching techniques among sub-cities based on students' ratings

4.2.3. Hindering Factors of Inquiry-Based learning via Practical Activities

Table 4.17 and table 4.18 presents the responses of students regarding hindering factors in inquiry-based practical activities implementation in schools.

Table 4. 17: Frequency distribution of hindering factors of Inquiry-based practical activities in the view of students

Hindering factors	**Yes**		**No**	
	n	**%**	***n***	**%**
1. Do you think that there are sufficient and suitable materials used in implementing practical activities in your school?	62	3.9	1525	96.1
2. Do you think that shortage of time and finance influence the actual practices of Inquiry-based practical activities in your school?	1477	93.1	110	6.9
3. Do you think that your teachers' tendency to the traditional lecture method has affected the implementation of practical activity in science?	1472	92.8	115	7.2
4. Do you think that your teachers' lack of necessary training affected the full implementation of practical activities in science classes in your school?	1503	94.7	84	5.3
5. Teachers' lack of interest has affected the implementation of practical activities in the schools?	1413	89.0	174	11.0
6. Does the school initiate students to develop team sprit on practical activities in science?	139	8.8	1448	91.2

Based on table 4.17, 96.1% of the students express concerns about the insufficiency and inadequacy of materials used in practical activities, indicating a challenge in resource availability. Moreover, 93.1% of the students perceive the combined influence of time constraints and financial limitations on the implementation of inquiry-based practical activities.

To continue with, 92.8% of the students believe that their teachers' tendency towards the traditional lecture method adversely affects the incorporation of practical activities in science classes. Additionally, 94.7% of the students feel that the lack of necessary training for teachers hampers the full implementation of practical activities, emphasizing the critical role of professional development. Furthermore, the result reveals that 89.0% of the students attribute the challenges in practical activity implementation to teachers' lack of interest, emphasizing the need for increased engagement.

Lastly, only 8.8% of the respondents indicate that their schools initiate students to develop team spirit in practical activities, suggesting a potential gap in fostering collaborative learning environments. Thus, addressing these hindering factors will be instrumental in overcoming barriers and enhancing the successful integration of practical activities in science education within the surveyed schools.

Table 4. 18: Students' ratings regarding to instructional material availability and implementation

Material availability and implementation	Very Low		Low		Medium		High		Very High	
	n	%	n	%	n	%	n	%	n	%
1. How is the school equipped with the necessary instructional materials to implement practical activities learning strategies?	565	35.6	809	51.0	195	12.3	16	1.0	2	0.1
2. To what extent do your science teachers implemented practical activity techniques while they teach science in your school?	1	0.1	1133	71.4	397	25.0	55	3.5	1	0.1

As can be seen from Table 4.18, a significant majority of students that account, 35.6% characterize the school's instructional material availability as "Very Low", and 51.0% of them consider it "Low." Some respondents, accounting 12.3% and 1.0%, view the availability of material as "Medium" and "High" respectively. In addition, 0.1% of the respondents describe the instructional material availability as "Very High". These means the schools are not equipped with the necessary instructional materials/resources to implement practical activity learning strategies.

With regard to the extent to which science teachers implement practical activity techniques varies among students, a minimal 0.1% of the respondents perceive the implementation as " Very Low," while a significant 71.4% of them describe it as " Low." Additionally, 25.0% of the respondents consider the implementation as "Medium", and 3.5% of them view it as "High." Other 0.1% of the respondents categorize the implementation as "Very High." These responses indicate a broad spectrum of perceptions regarding the integration of practical activity techniques by science teachers, with a substantial portion of students acknowledging a lower level of implementation.

4.3. Correlation between Teachers' and Students' Responses

The comparison of teaching techniques across different sub-cities provides valuable insights into the variations in instructional practices and perceptions among teachers and students. Table 4.19 highlights the diversity of perspectives on teaching techniques across sub-cities, emphasizing the importance of considering both teacher and student viewpoints to tailor educational strategies.

Table 4. 19: Correlation between the teachers' (T) and students (S) ratings of the teaching techniques

Sub-city	Traditional/ One-way		Structured Inquiry		Confirmation Inquiry		Guided Inquiry		Open Inquiry	
	T	S	T	S	T	S	T	S	T	S
1. Arada	2.30	3.25	1.77	1.89	1.44	1.58	1.15	1.22	1.33	1.52
2. Gulelie	2.15	2.87	1.72	1.39	1.26	1.29	1.04	1.09	1.33	1.23
3. Addis Ketema	2.10	2.58	1.70	1.11	1.28	1.24		1.08	1.43	1.08
4. Bole	2.50	2.55	1.58	1.28	1.30	1.26	1.06	1.06	1.22	1.20
5. Kirkos	2.25	2.57	1.79	1.48	1.55	1.40	1.19	1.19	1.44	1.19
6. Kolfe Keraniyo	2.43	2.45	1.42	1.29	1.24	1.43	1.07	1.12	1.18	1.25
7. Lideta	2.23	3.01	1.88	2.28	1.64	1.36	1.27	1.09	1.36	1.21
8. Yeka	2.25	2.83	2.04	1.26	1.68	1.21	1.50	1.04	1.56	1.17
9. Nefas Silk	2.25	2.71	1.75	1.63	1.48	1.41	1.42	1.32	1.33	1.30
10. Lemi Kura	2.38	2.98	1.42	1.48	1.25	1.32	1.06	1.11	1.23	1.31
11. Akaki Kaliti	2.39	2.96	1.93	1.36	1.64	1.39	1.33	1.04	1.47	1.31
Correlation	**-0.11**		**0.22**		**0.09**		**0.17**		**-0.28**	

Based on the above table, Bole sub-city stands out with the highest mean score of 2.50 for "Traditional/one way" among teachers, indicating a relatively positive reception of this method.

In contrast, Gulelie has the highest mean score of 3.25 among students for "Traditional/one way", suggesting a more favorable perception of this teaching technique from the students' perspective. For "Structured Inquiry", Yeka sub-city records the highest mean score both teachers and students with mean value of 2.04 and 1.26 respectively, indicating a relatively positive perception of structured inquiry activities in this sub-city.

The correlation between teachers and students perceptions of the "Structured Inquiry" is 0.22, and this suggests a weak positive relationship. As far as "Confirmation Inquiry" is concerned, Yeka sub-city again stands out with the highest mean score of 1.68 among teachers, while Lideta has the highest mean score of 1.36 among students. The correlation between teacher and student perceptions of "Confirmation Inquiry" is 0.09, and it indicates a weak positive relationship. As for "Guided Inquiry", Yeka sub-city has the highest mean score of 1.50 among teachers, while Bole has the highest mean score of 1.06 among students. The correlation between teacher and student perceptions for “Guided Inquiry” is 0.17, and this implies a weak positive relationship. Lastly, for “Open Inquiry”, Yeka sub-city records the highest mean score among both teachers and students with mean values of 1.56 and 1.17 respectively. The correlation between teacher and student perceptions of “Open Inquiry” is -0.28; this suggests a weak negative relationship.

In general, the correlations provide insights into the alignment or divergence of perceptions between teachers and students for each teaching technique. This implies that there is a lack of consensus or understanding on the significance of inquiry-based practical activities that support teachers and students in teaching science in the classrooms of all sub-cities in Addis Ababa Middle schools under the study.

4.4. Inferential Analyses

4.4.1. Practices of Teaching Techniques between Teachers and Students

Table 4.20 highlights the analysis of teachers and students’ responses to different teaching techniques, including traditional method, structured inquiry, confirmation inquiry, open inquiry, and guided inquiry, revealed significant differences in mean scores. An ANOVA was conducted to assess mean differences across these teaching techniques for both teachers and students. The results indicated statistically significant findings ($p < 0.001$) for both groups.

Further investigation delved into pairwise comparisons within each group to elucidate specific differences. It was discerned that the practice of the traditional teaching Method garnered significantly higher scores than all other teaching methods ($p < 0.001$). Following this trend, Structured Inquiry demonstrated significantly higher scores than Confirmation Inquiry ($p < 0.001$). Confirmation Inquiry exhibited no significant difference compared to Structured Inquiry ($p = 0.108$). Lastly, Guided Inquiry revealed significant differences when compared to all other teaching techniques ($p < 0.001$).

Table 4. 20: Comparison of the mean practice scores of teaching techniques

Respondents	Teaching Techniques	Count	Mean		Pairwise p-value			
Teachers	Traditional method	120	2.30		<0.001			
	Structured Inquiry	120	1.69			<0.001		
	Confirmation Inquiry	120	1.41				0.108	
	Open Inquiry	120	1.34					<0.001
	Guided Inquiry	120	1.18					
Students	Traditional method	1587	2.80		<0.001			
	Structured Inquiry	1587	1.50			<0.001		
	Confirmation Inquiry	1587	1.35				<0.001	
	Open Inquiry	1587	1.25					<0.001
	Guided Inquiry	1587	1.13					

Similarly, students also rated the Traditional Teaching method the highest, significantly surpassing all other teaching techniques ($p < 0.001$). Structured Inquiry received significantly higher ratings than Confirmation Inquiry ($p < 0.001$). Conversely, Open Inquiry scored significantly lower than both the Traditional Teaching Method and Structured Inquiry ($p < 0.001$). Finally, Guided Inquiry was rated the lowest among students, exhibiting a significant disparity compared to the Traditional Teaching Method and all other teaching techniques ($p < 0.001$).

These findings imply variations in perceptions between teachers and students regarding the utilization of different teaching techniques. The consistent preference for Traditional Teaching Method, as indicated by higher mean scores, underscores its perceived practice among teachers and students. Structured Inquiry also emerged as a common approach for both groups. Conversely, Confirmation and Open Inquiry received lower ratings, suggesting areas for improvement in their implementation. These insights provide valuable guidance for educators and curriculum developers in tailoring instructional approaches to better improve Inquiry-based practices.

Figure 4.3 highlights a significant revelation: students perceive a greater prevalence of traditional teaching methods compared to their teachers. In a simple expression, students believe that traditional approaches to teaching are more frequently employed by teachers in the classroom. On the other hand, students indicate lower levels of involvement in other teaching methodologies, particularly Inquiry-based practices, in contrast to their teachers.

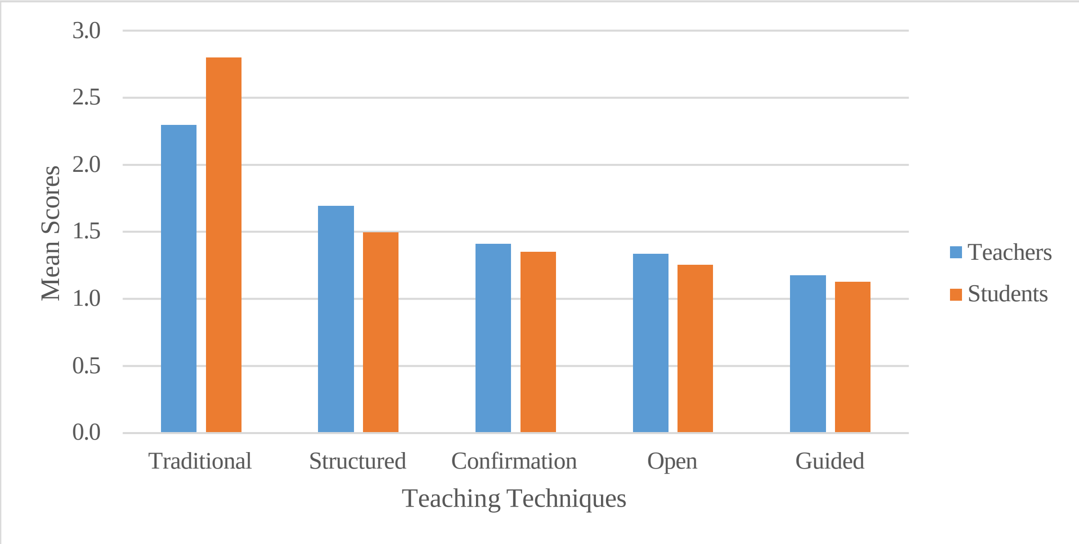

Figure 4. 3: Bar chart of the mean practices of teaching methods

This analysis underscores a discrepancy between the perceptions and practices of students and teachers regarding instructional methods. It implies a disconnection wherein teachers may believe they are integrating some inquiry-based activities, while students perceive a heavier reliance on traditional methods. This misalignment has the potential to impact students' learning experiences and outcomes significantly.

To address this disparity, strategies may include enhancing teacher training in inquiry-based pedagogy, fostering student-centered learning environments, and facilitating open communication between teachers and students. These approaches aim to bridge the gap between teachers' intentions and students' perceptions, thereby promoting more effective and engaging instructional practices in the classroom.

4.4.2. Comparison Teaching Techniques among Sub-Cities

A comparative analysis of teaching techniques across the 11 sub-cities of Addis Ababa reveals notable differences. Employing ANOVA, significant variations emerge among the sub-cities regarding students' perceptions of each teaching technique.

Table 4.21 reflects the comparison of the mean score based on the implementation frequency of inquiry-based practical activities according to students' and teachers' response.

Table 4. 21: Comparison of the mean practice scores of teaching techniques

Teaching Techniques	Teachers			Students		
	Subcity	Count	Mean	Subcity	Count	Mean
Traditional Method	Arada	101	3.25	Bole	8	2.50
	Lideta	145	3.01	Kolfie Keraniyo	15	2.43
	Lemi Kura	242	2.98	Akaki Kaliti	9	2.39
	Akaki Kaliti	119	2.96	Lemi Kura	16	2.38
	Gulelie	173	2.87	Arada	10	2.30
	Yeka	126	2.83	Kirkos	8	2.25
	Nefas Silk Lafto	169	2.71	Yeka	8	2.25
	Addis Ketema	112	2.58	Nefas Silk Lafto	12	2.25
	Kirkos	101	2.57	Lideta	11	2.23
	Bole	112	2.55	Gulelie	13	2.15
	Kolfe Keraniyo	187	2.45	Addis Ketema	10	2.10
Structured Inquiry	Lideta	145	2.28	Yeka	8	2.04
	Arada	101	1.89	Akaki Kaliti	9	1.93
	Nefas Silk Lafto	169	1.63	Lideta	11	1.88
	Lemi Kura	242	1.48	Kirkos	8	1.79
	Kirkos	101	1.48	Arada	10	1.77
	Gulelie	173	1.39	Nefas Silk Lafto	12	1.75
	Akaki Kaliti	119	1.36	Gulelie	13	1.72
	Kolfe Keraniyo	187	1.29	Addis Ketema	10	1.70
	Bole	112	1.28	Bole	8	1.58
	Yeka	126	1.26	Kolfie Keraniyo	15	1.42
	Addis Ketema	112	1.11	Lemi Kura	16	1.42
Confirmation Inquiry	Arada	101	1.58	Yeka	8	1.68
	Kolfe Keraniyo	187	1.43	Akaki Kaliti	9	1.64
	Nefas Silk Lafto	169	1.41	Lideta	11	1.64
	Kirkos	101	1.40	Kirkos	8	1.55
	Akaki Kaliti	119	1.39	Nefas Silk Lafto	12	1.48
	Lideta	145	1.36	Arada	10	1.44
	Lemi Kura	242	1.32	Bole	8	1.30
	Gulelie	173	1.29	Addis Ketema	10	1.28
	Bole	112	1.26	Gulelie	13	1.26
	Addis Ketema	112	1.24	Lemi Kura	16	1.25
	Yeka	126	1.21	Kolfie Keraniyo	15	1.24
Guided Inquiry	Nefas Silk Lafto	169	1.32	Yeka	8	1.50
	Arada	101	1.22	Nefas Silk Lafto	12	1.42
	Kirkos	101	1.19	Akaki Kaliti	9	1.33
	Kolfe Keraniyo	187	1.12	Lideta	11	1.27
	Lemi Kura	242	1.11	Kirkos	8	1.19
	Lideta	145	1.09	Arada	10	1.15
	Gulelie	173	1.09	Kolfie Keraniyo	15	1.07
	Addis Ketema	112	1.08	Bole	8	1.06
	Bole	112	1.06	Lemi Kura	16	1.06
	Yeka	126	1.04	Gulelie	13	1.04
	Akaki Kaliti	119	1.04	Addis Ketema	10	1.00
Open Inquiry	Arada	101	1.52	Yeka	8	1.56
	Lemi Kura	242	1.31	Akaki Kaliti	9	1.47
	Akaki Kaliti	119	1.31	Kirkos	8	1.44
	Nefas Silk Lafto	169	1.30	Addis Ketema	10	1.43
	Kolfe Keraniyo	187	1.25	Lideta	11	1.36
	Gulelie	173	1.23	Nefas Silk Lafto	12	1.33
	Lideta	145	1.21	Gulelie	13	1.33
	Bole	112	1.20	Arada	10	1.33
	Kirkos	101	1.19	Lemi Kura	16	1.23
	Yeka	126	1.17	Bole	8	1.22
	Addis Ketema	112	1.08	Kolfie Keraniyo	15	1.18

Specifically, based on students' responses, Traditional Teaching Method, Confirmation Inquiry, and Open Inquiry are markedly more prevalent in the Arada sub-city compared to others. Meanwhile, Structured Inquiry and Guided Inquiry exhibit higher practice rates in Lideta and Nifas Silk sub-cities respectively.

Conversely, from the teachers' perspective, significant differences are observed in the practice of Structured Inquiry, Confirmation Inquiry, and Guided Inquiry across sub-cities. However, no significant differences are found for Traditional Teaching Method and Open Inquiry. Teachers in Yeka sub-city demonstrate higher practice levels of all these three teaching techniques compared to their counterparts in other sub-cities.

4.5. Observation Results

In this study, observations were conducted classroom, laboratory room and documents, such as annual plans, daily plans and assessment checklists.

4.5.1. Classroom observation Results

Classroom observations were conducted while teachers were teaching practical activities in their classes to observe practical lessons in their general context. The observation result of middle level school general science teachers is organized and presented as displayed in table 4.22.

Table 4. 22: Characteristics of Observed Science Teachers

Department	**Sex**		Qualification			Teaching experience					**Total Count**
	F	**M**	Diploma	BSC+PGDT	BSc	<5	6-10	11-15	16-20	>=21	
Biology	7	8	9	3	3	3	7	2	3	1	15
Chemistry	4	10	9	3	2	-	2	3	4	5	14
Physics	2	9	7	2	2	2	3	1	1	4	11
Total	13	27	25	8	7	5	12	6	8	10	40

Based on the above table, from the sample school 120 science teachers, 33% of them, around 40 teachers, were randomly selected and observed, of which 13 of them are females, and 27 of them are males.

Regarding the teachers' qualification, 25 (62.5%) of them have diploma; 8 (20%) of them have BSC+PGDT, and 7 (17%) of them have BSC only that did not take the pedagogies of teaching as a teacher. As far as their experience is concerned, 85.5% of the teachers have above 6 years of teaching experience. From this, one can deduce that most (82.5% and 85.5%) of the teachers fulfilled the minimum requirement of qualification for the level and good teaching experience in teaching.

The classes of 40 science teachers who teach general science subjects: (Biology, Chemistry, and Physics) in the selected schools were observed. Among these teachers, 40 of them were observed two times each. Altogether, the researcher observed eighty instructional periods. Each period lasts for 45 minutes. The data obtained through classroom observation helped to see everything in the classroom, including students' engagement, teachers' involvement, and materials related to the planning and implementation of the science curriculum in the general environment.

The audio recorded lesson and observed events were tabulated and described. The data obtained through classroom observation are presented in three stages: pre-lesson activities, while-lesson activities, and post-lesson activities based on the structure of the observation checklist. This analysis presents a comprehensive examination of instructional activities in a classroom setting, as all the implementers interaction is visible. The executions of the practical activities were assessed across four sets as: Not Observed (NO), Needs Improvement (NI), Satisfactory Used (SU), and Effectively Used (EU). In table 4.23 below, six questions were listed under the Pre-Lesson phase.

Table 4. 23: Pre-lesson activities

No	Instructional activities of teacher and students	Descriptions **(80= observed classrooms)**							
		NO		NI		SU		EU	
		n	%	n	%	n	%	n	%
1	Revision of the previous lesson through inquiry questions.	58	60.4	18	18.7	4	4.1	-	-
2	Gives chance to students to answer questions.	47	49.4	23	24.2	10	10.4	-	-
3	Introduces the day's lesson by giving examples related to daily life activities.	44	45.8	20	20.8	11	11.4	5	5.2
4	Encourage students to ask and answer questions	59	61.4	16	16.6	5	5.2	-	-
5	Students actively participate in asking and answering questions	41	42.7	23	24.2	11	11.4	5	5.2
6	Facilitate and shape students' answer	61	63.5	10	10.4	9	9.3	-	

Key: No= not observed, NI= needs improvement; SU=satisfactorily used; EU=effectively used

These questions focus on the procedures teachers are expected to implement in practical activities, such as asking inquiry questions and introducing the lesson by motivating students to answer or display their knowledge to bridge the previous lesson with the present one. The analysis of instructional activities in the pre-lesson activities within the observed classrooms reveals a significant difference in the implementation of Inquiry-based practical activities.

A majority of observed general science classes indicated that essential strategies such as revising previous lessons through inquiry questions (60.4%), encouraging students to ask and answer questions (61.4%), and facilitating or shaping students' answers (63.5%) are never observed during the class room instruction. Similarly, almost half of the observed teachers do not regularly provide students with opportunities to respond to questions (49.4%) or introduce lessons using examples from daily life (45.8%).

Student participation remains remarkably low, with 42.7% indicating that students are not actively engaged in classroom discussions. Among the observed teachers few (11.4% and 5.2%) of them apply the pre-lesson activities satisfactory and effectively used respectively. However, the majority of the observed teachers started the day's lesson by writing notes on the blackboard and ordering students to copy that, except in the ten observed lessons. In addition, the observed teachers didn't motivate or appreciate students to ask or answer questions by facilitating the pre-lesson activities to guide students' answers. Whereas, in the ten observed lessons, teachers tried to help students by giving extra chances and clue based on students' response to simplify the lesson by connecting to learners authentic life activities.

These results suggest that teaching practices in the observed middle school classrooms context predominantly reflect a traditional, teacher-centered approach, characterized by minimal student engagement, limited use of authentic connections with the students' environment, and a lack of scaffolding techniques that motivate the deeper learning.

Similarly, seven items were used to assess activities during the actual delivery of the lesson. This helped to observe students' engagement in practical activities and their teachers' assistance in the process and presented in the following table 4.24.

Table 4. 24: While lesson delivery activities

No	Instructional activities of teacher and students	**Descriptions (80= observed classrooms)**							
		NO		NI		S U		E U	
		N	%	n	%	n	%	N	%
1	Present the lesson through participatory activities rather than explanation/lecture method	67	83.8	13	16.2	-	-	-	-
2	Students passively listening to teacher's presentation	13	16.2	-	-	10	12.5	57	71.3
3	students actively participate in peer/group-discussion	62	77.5	18	22.5	-	-	-	-
4	students actively participate in group reflection	59	73.8	14	17.5	7	8.7	-	-
5	Teacher use teaching aids to support the lesson through demonstration	67	83..8	3	3.7	10	12.5	-	-
6	Teacher gives chance for students to demonstrate	58	72.5	14	17.5	8	10	-	-
7	Teacher gives tasks, such as class work and homework, for students	45	56.3	27	33.7	8	10	-	-

Key: No= not observed, NI= needs improvement; SU=satisfactorily used; EU=effectively used

In the above table, items related to practical activities, such as requesting students to discuss the topic by relating it with their environment, showing models for students, asking students to display the model, reflecting their idea, discussing to share their experiences, were expected to be implemented by students and teachers. The findings reveal a major reliance on teacher-dominated instructional tactics, with slight integration of participatory learning strategies while in the lesson delivery phase. A substantial majority of the observed teachers (83.8%) not ever present lessons through participatory activities, a common preference for the traditional lecture method. This is further supported by the fact that (71.3%) of the observed classes reflected students are usually engaged in passive listening during lessons. In contrast, active learning practices such as peer or group discussions and group reflections are rarely implemented, with (77.5% and 73.8%) respectively noting these are never observed using of practical strategies.

Similarly, the use of teaching aids to support demonstrations is absent in 83.8% of observed classes, a chances for students to demonstrate their learning are also not provided in (72.5%) of the observed science classes. Even predictable practices such as giving classwork or homework are inconsistently applied, with over half (56.3%) stating these are never given, and only 10% of teachers practiced occasional.

However, during the observation, the practical activities expected from teachers and students were not implemented in all of the observed classrooms, except some of classrooms where students reacted to the questions raised by teachers although the approach was in the form of one-way communication. On the other hand, practical technique questions were raised from both directions, the answer was also generated from students guided by teachers.

Table 4.25 presents the Post lesson activities phase, based on the five items that deal with assessment conducted in the class or outside the class (classwork and home take activities) are included.

Table 4. 25: Post lesson activities

No	Instructional activities of teacher and students	Descriptions (80= observed classrooms)							
		NO		NI		SU		EU	
		n	%	n	%	n	%	n	%
1	Teacher gives tasks, such as group works and assignments for students	58	72.5	15	18.8	7	8.7	-	
2	Teacher plan laboratory activity in his/her annual & monthly plans from the syllabus	36	45	39	48.5	5	6.2	-	
3	Teacher promote students to practice field works	71	88.8	-		9	11.2	-	
4	Teacher promotes students to write laboratory or field visit activity reports	63	78.8	13	16.2	4	5	-	
5	Teacher records individual or group project works done by students	61	76.3	8	10	11	13.7	-	

Key: No= not observed, NI= needs improvement; SU=satisfactorily used; EU=effectively used

The items in Table 4.25 focused on issues expected of the teachers and students to practice the practical activities in the classroom or outside the classroom through given practical tasks for the next class or collecting tasks given former. The recorded results from the post lesson activities during the classroom observation illustrate a concerning underutilization of practical activities, observed, and reflective learning practices in the instructional process. A significant majority (72.5%) of the observed teachers rarely assign group work or student tasks such as assignments.

Similarly, the mixing of laboratory activities into teaching plans looks least, with (45%) teachers not conducted and (48.8%) of the observed teachers inconsistently implemented. Integrating a post-lesson revision phase into the inquiry-based learning cycle is both pedagogically sound and practically necessary. Doing so transforms inquiry from a sporadic activity into a sustainable, responsive, and improving process. By scheduling laboratory/practical activities in annual or monthly plans and revising them based on classroom observations and student feedback, teachers ensure alignment among curriculum objectives, pedagogical design, and student learning. This approach closes the circle promoting coherent, context-sensitive, and continuously refined general science instruction. The presence of fieldwork is almost absent; with 88.8% of respondents indicating it is never used. Likewise, the practice of having students write reports on laboratory or field visit activities is lacking, with (78.8%) in the observed classes not observed. Finally, documentation of students individual or group practical tasks, project work, rarely conducted by few teachers, yet (76.3%) of observed teachers not practiced or recorded students mark to motivate the students.

In addition, in the observed classrooms, teachers did not guide or give extra assessment/activities in all classes or did not collect any project work or report from the previous lesson, except few classes. In the observed classes some teachers gave classwork and oral assignments to students but they didn't assist students to participate or react. Therefore, one can assert that teachers focused on explaining science subjects theoretically to students rather than engaging them in practical activities to interact in class with their classmates or with the teacher.

4.5.2. Laboratory room and desk review observation Results

Data were collected using laboratory observation checklists by observing the documents to get data on the relevance of the lesson plans, laboratory reports, and student assessment checklists to the practical activities in the science curriculum in the selected primary schools. These laboratory observation and document review checklists were prepared based on three major themes related to the implementation of practical activities in general science subjects.

The first laboratory checklist contained five questions related to the availability of necessary laboratory materials or equipment and the appropriateness of the facilities in the laboratory. Secondly, six questions related to factors affecting the implementation of practical activities in the laboratory were included. Thirdly, six items were designed to get data from the planned documents, such as laboratory plans, subject annual and weekly plans to identify the extent to which teachers used the strategies of practical activities. Documents were also used to check and compare what the teachers say they know with what they do in class.

As shown in table 4.26, out of the twenty two schools, twenty laboratory rooms, one from each school, were observed, but two laboratory rooms from two schools were not observed due to the maternal leave of the laboratory technicians. The data from laboratory observations and document review, including annual plan, daily lesson plans, assessment checklists of teachers in class room, helped to consider the instructional practices conducted in class room either teachers consider during planning the general science subject related to the inquiry-based practical activities.

Table 4. 26: Data from laboratory observation and document review

Items	**Description**	
	Yes	**No**
Conduciveness and facility		
1. Is there a trained laboratory technician in the school?	20	-
2. Does the teacher have laboratory (practical) period allocated in his/her weekly or monthly timetable?	2	18
3. Is the laboratory well-found with adequate equipment's and materials?	6	14
4. Does the teacher have laboratory annual or monthly plan as practical activity?	3	17
5. Is the Lab-room arrangement suitable to implement practical activities?	6	14
Major barriers		
6. Safety concern challenges	17	3
7. Time related constraints	11	9
8. Scheduling difficulty	17	3
9. Large class size	16	4
10. Lack of appropriate equipment's	12	8
11. Lack of professional trained expert	19	1
(Annual and daily plan, assessment checklist and laboratory report)		
12. Presentation/explanation/lecture	20	-
13. Demonstration of teaching aid (chart, model, real life aid)	8	12
14. Question and answer	20	-
15. Observation, field visit	3	17
16. Laboratory experiment and report	5	15
17.Test, exam, class work	14	6

As shown in the above table, questions in the first part focused on the availability of laboratory technician and necessary equipment, fixed time table, teacher's laboratory annual, laboratory plan and the conduciveness of the laboratory set up to apply practical science in the schools.

During observation, the researcher observed that there was a laboratory with a laboratory technician, but among the observed twenty laboratory technicians, sixteen of them are science teachers with double duty, and only four of them are trained and recruited as laboratory experts. In addition, in the observed laboratories, there are no fixed time schedule, sufficient facilities and equipment, except the six school laboratories.

Likewise, in the observed laboratories, science teachers did not plan the practical activities as one strategy during the delivery of the lesson, and except six schools, were not appropriately arranged and the laboratory set up did not get adequate. Items related to safety, time, scheduling, large class size, lack of appropriate equipment, lack of trained expert in the observed school laboratories were also indicated as hindering factors in the implementation of practical activities in science subjects.

Moreover, from the observed documents, including general science subjects’ annual and weekly plan, laboratory plan, students report and assessment checklists, the researcher observed that teachers did not include methods that are typically used to teach practical activities in science classes. They rather focused on the one way methods, such as explanation, lecturing, writing summarized notes on the blackboard, giving tests or quizzes and class works or home works, but they did not give assessment mark. Consequently, this implies that there is a gap in consolidating and using laboratories in schools. This may affect the overall implementation of the science subjects.

4.6. Students’ Focus Group Discussion Results

To facilitate focus group discussion, the researcher prepared questions to understand students’ awareness of practical activities in general science education, what strategies their science teachers practiced in the schools, what practical activities they applied, availability of functional laboratories and what problems they faced during the teaching-learning practice of science subjects.

The participants were randomly selected from each section considering gender balance: three male and three female students. This was done first by separating the list of female and male students of each section and then randomly selecting three students from each sex category.

Therefore, one focus group discussion was conducted in each school and in each group, six students participated. A total of 132 students participated in the FGD and the discussion lasted from 20 minutes- 25minutes. The FGD was also audio recorded following the participants’ consent, and a note was taken during each session. The analysis was done in three thematic categories based on the focus group discussion guideline items and presented as follows.

4.6.1. Students awareness of inquiry-based learning trough practical activities in general science subjects

In each FGD session, students mentioned several specific activities that can be comprised in one of the following general lists of activities. They said there are activities, like asking oral questions, explanation, writing notes on the blackboard, correcting class works and home works, giving assignments, and sometimes laboratory activities.

As can be assumed from the above presented data, most of the students did not clearly distinguish practical activities from theoretical ones since most of the activities identified as practical activities are not practical ones.

Similarly, students were asked to list down some of their preferred practical activities they use or want to use while learning despite their teachers' interest. They said that they prefer to use writing homework, presentation, laboratory-oriented activities, copying notes from a textbook, and other writing assignments. However, most of the practical activities students listed as their preferred practical activities are not practical activities; they are the one way direction where all tasks are directed or conducted by the teacher.

This raises into doubt the students' understanding of practical activities related to science once more. With the exception of laboratory-based activities, no student brought up any other methods for teaching general science curriculum through the practical activities during the FGD. Some of these methods included modeling, field visits, observation, debate, reflection, Inquiry-based exploration, experience sharing, indigenous creativity and various types of practical demonstration.

Participants were also asked how their teachers motivate them to apply practical activities during science classes to get science teachers insight, and they forwarded several responses that may or may not be helpful. They said that their teachers motivate them to learn carefully, read books, answer questions, love sciences subjects, memorize the science concepts to get a high mark on tests and give different quizzes and tests. This indicates that teachers' effort in motivating students to learn practical activities effectively did not go beyond advising and assessing them. This can also indicate science teachers' failure in using practical activities regularly in their delivery of the science curriculum in the sample schools.

Participants were asked to show their preferences among practice focus methods and presentation or explanation, and they reflected if possible it is better when science lessons are delivered through practice focused approach.

Thus, one can conclude that there is a partial mismatch between the way teachers teach practical activities and the way students want to learn practical activities during science lessons.

4.6.2. Extent practicing the techniques of Inquiry-Based Learning through practical activities in classroom

Questions to see the extent of practicing inquiry-based practical activities in the schools were asked.

The participants depicted their classroom practices as mainly revolving around presentations, prompting students to listen and respond to raised questions, and encouraging participation in group work and note-taking activities. From this data, it can be deduced that teachers also did not relate practical activities with students' environment to guide students on enquiry-based practical science.

Likewise, during the focus group discussion, students reflected that those practical activities in the general science subjects were limited to taking notes and listening to the teachers' presentations. Furthermore, the participants were asked about the frequency of use of the laboratory focused activities and practical activities outside laboratories to support science lessons. In response, participants from all middle schools in the FGD mentioned due lack of adequate allocated time to practical activities. They went to the laboratories once or twice a semester and they did not go to laboratories every month. In addition, they reflected as they did not conduct any practice based activities outside laboratories.

This indicates that teachers are not adequately encouraging their students to participate and exercise practical activities in their education inside as well as outside classroom, including laboratories or their environment. Practical activities differ considerably in what they ask students to do and what they teach.

If teachers are interested in the effectiveness of practical activities, they have to consider specific practical activities that they use or plan to use. According to Millar (2010), many science teachers believe that student practical work leads to better learning because we all understand and remember things better if we have done them ourselves. However, from the above data, the extent of applying practical activities in science subjects is not as planned in the syllabus.

4.6.3. Hindering factors faced during the teaching-learning practice of science subjects

During the focus group discussion, participants were asked if there is a laboratory in their schools, and they confirmed the existence of a laboratory room. However, most of the students from eighteen primary schools stated that the laboratories have insufficient equipment and facilities; as a result, they do not feel there is a laboratory and are not motivated to use it as they cannot get the material they want.

Participants from four schools reflected that the laboratories in the school are relatively better and have their own assigned laboratory technician. However, participants said that the interruption of electric power is one of the factors as it disturbed their classes when they rarely go to the laboratories. This indicated that students are not confident of their laboratories' quality, which affects their interest in engaging in science activities.

Similarly, the students who participated in the FGD indicated that teachers' reluctance to motivate and engage them in practical activities was the main factor for their poor engagement in practical activities. Students said that teachers are not interested in designing and delivering practical lessons. They doubted their teachers' ability to design and deliver practical activities by giving reasons for the lack of chemicals and equipment to teach them practically in the laboratories. Besides, in all cases, insufficient laboratory equipment, lack of facilities, lack of teachers' commitment, time, power supply, and lack of practical experience are the common barriers hindering the effective implementation of practical activities.

From these findings, one can conclude that laboratories are not giving the expected services for several reasons, and students are not getting practical experiences from laboratory focused practical activities set in the syllabus. Therefore, it can be said that several factors are affecting students' involvement in practical activities, and most of these factors are teacher-related.

4.7. Interview Results

In this study, twenty science department head teachers, eleven laboratory technicians and eleven academic school vice principals, who were selected randomly, were involved in the interview. The interview of science department head teachers, laboratory technicians and principals) were coded as (T 1, 2, 3, 20, LT 1, 2, 3, .11 and V.P1, 2, 3, .11) respectively and analyzed using thematic analysis technique. Then, data were jointly discussed by supporting scholars' views and research findings.

4.7.1. Science Department Head Teachers Interview Results

Twenty science department head teachers were interviewed to respond to six open ended questions to secure information about the extent, awareness of students, hindrance factors, preference and views of teachers on inquiry-based practical activities, and their replies are organized and analyzed as follows. Teachers were asked about the implementation of inquiry-based practical activities in the science curriculum in their schools, and they forwarded various means of implementing it.

The participants said that they use microscopes and local materials, including chart, diagram, and pictures, lecturing methods, writing notes, present how the laboratory activities are done, and employ questioning and answering as a means of practicing inquiry-based techniques in science. Evidently, these are methods of delivering science lessons, but all of them are one way or teacher directed, and teachers did not mention most of the approaches used to implement practical activities in science classes. This indicates that teachers are more concerned about theoretical knowledge and skills than their practical faces.

Likewise, in the interview, science department head teachers indicated that they give notes, and students copy the same from the blackboard and receive the information-theoretically.

Teachers were also asked to mention the method they prefer to deliver the science curriculum, and they mentioned a few commonly used theoretical methods to teach science. They stated that giving explanations of the subject related to the environment, lecturing, and questioning and answering are the methods they prefer to teach science classes in their schools. Moreover, teachers admitted that despite recognizing the importance of inquiry-based practical activities, they had not implemented them into their lessons.

One interviewee, T3, stated:

"Practical activities are important because students can imitate theoretical concepts in a laboratory setting with practical opportunity. Conversely, this remains a hypothetical or ideal rather than a tangible reality in our school due to the lack of suitable resources in the laboratory including teacher's skill to create and facilitate the strategies."

Teachers were asked to briefly indicate the method they think is simple to science lessons, and almost all of them said teaching students using materials and videos from the internet are the simplest ones. They said that downloading materials and videos makes life easy as it explains everything on it and does not require their effort. This view shows their disregard in teaching practical lessons and using methods that are used to deliver practical activities. This is one of the frustrating findings in this study since teachers are trying to devote less effort to teaching by simply providing their students with ready-made lessons. This constitutes a general disadvantage of technology on the process of teaching and learning.

Nevertheless, acknowledging the merits of inquiry-based learning, T2 expressed concern over the feasibility of catering to students' diverse learning needs in a resource-constrained environment.

He further said,

"In my classes, many students possess creative skills that could be fostered through practical tasks. However, how can this be achieved in a school that struggles to procure even a single dynamo or material to engage students?"

This shows teachers' constraint in implementing the general science lesson using variety of methods suitable to deliver practical activities; they are limited to using few methods that do not encourage the use of practical activities.

Furthermore, science department head teachers were asked about the methods they frequently consider during planning to teach practical activities in their classes. They mentioned that questioning and answering, lecture method, demonstration and writing notes on the blackboard are the methods they frequently plan to deliver their lessons. Teachers also stated that they employ these methods because they are easy to deliver and cover all the lessons. Similarly, T5 conveyed her preference for traditional teaching methods in the following way.

"I always choose for the lecture method since it allows me to hold my students' attention and complete the course content efficiently. It's a challenge for me to teach through practical activities as most students seem disinterested in this technique, with only a few eager to engage in practical tasks."

Similarly, teachers were asked to list down some of their strategies to implement practical activities. Among them, T12 said that, *"I provide the students with homework, classwork, group assignment, note provision, and prepare observation on technological materials from the internet in laboratory. This helps to the students by visualizing the materials they imagine how to implement practical activities for their future."*

This reflected that the practical activities are conducted in laboratory rooms through demonstrating only from the teacher side. Because most of the strategies the teachers mentioned are taken from the traditional teaching approach, they are not the strategies of practical activities, such as field visits, reflection, model preparation, demonstration, project works, discussion, sharing of experiences, laboratory practices, and peer teaching. However, the capacity for teachers to practice these techniques and motivate students to participate actively in their learning is crucial to ensure quality science education both inside and outside the classroom.

Likewise, science department head teachers were asked about their support to the teachers under their supervision relating to practice practical activities in their department.

In this regard, T17 said,

"*As a department head and coordinator of the teachers in my department, I try to support teachers during the preparation of annual, monthly and weekly plans by observing the plans and correcting the procedures that need improvement. In addition to this, I retain my signature by observing the plan every week; I help my teachers by monitoring whether the content given in the year is going according to the plan and monitoring the exam process."*

The data from the interview showed that the science department head teachers did not take any relevant training to implement science courses through inquiry-based practical activities. They tried on their own effort to explain/narrate science subjects to the students in class.

However, studies claiming the purpose of practical activities to help students develop their knowledge and understanding of the general world differ considerably in learning demand. The way teachers use practical activities aims at helping students develop their understanding of scientific inquiry. It often implies that practice makes perfect, and that students will get better at planning and conducting their investigations simply through practice (Millar, 2010).

Science department head teachers were asked about the inspiration of students to use a practice-focused or participatory teaching method; they answered that the method itself is the source of disturbance. For example, T20 stated, *"Most of the students found it to be an obstacle to using a participatory teaching method. This means that the students start disturbance and shouting even did not hear what they say to each other. Student's aspiration to learn through practice-focused or discussion is low. When I start to use such kind of method most of the students tried to get into shouting. During this school principals counted as the poor performance or low classroom management of the teacher. So I use the lecture method with full eye contact of the students."*

The participants reflected that common perception that students are less motivated to learn via practical tasks.

During the interview, questions related to factors affecting the implementation of Inquiry-based practical activities were forwarded to science department head teachers. They assured that several factors may hamper the practice.

Among them, T19 stated that,

"….the laboratories in their schools are not well prepared and need to be reexamined for they lack the necessary functional equipment, time arrangement problems, and lack of independent laboratory technicians."

Similarly, T2, T9, and T15 also mentioned that lack of teachers' commitment, lack of appropriate coordination from the school principals, facilities, professional training for teachers, and lack of interest from the students' side are the common problems hindering the effective implementation of practical activities. Here, it is worth emphasizing teacher-related factors than others as most of the gaps in the implementation are teacher originated or teacher supported cases raised.

4.7.2. Laboratory Technicians Interview Result

Eleven laboratory technicians were randomly selected for interview. Out of these laboratory technicians, six of them are science teachers with double duty acting as laboratory technician. Eight questions were asked to secure in-depth information on the implementation of practical activities from laboratory technicians and presented as follows.

Questions were asked to assess the preferred techniques of practical activity and frequency used by science teachers.

Among the interviewed laboratory technician, the first interviewee, LT1, forwarded the following.

"As everyone knows, students at this level are still at a level to introduce science education. Teachers, including me, occasionally invite students to the laboratory room and teach them by showing them instruments, such as charts that show the picture of body parts, microscopes, magnets, telescopes and lens instruments that are the basis of science lessons."

Moreover, they were asked about the frequency they facilitate activities per month and students eagerness to participate in the activities. LT3 and LT9 explained that two practical activities were facilitated in all three science subjects on average in a month. Based on their experience of facilitating the activity in laboratory, most of the students are simply listing the teacher demonstration, and when students get a chance by the teacher, they are eager to participate or present the lesson as the teacher does.

The other respondent, LT5, also reflected that,

"Due to different factors, such as electric power interaction, lack of availability of some materials for the requested activity and overlapping of schedule with my own class, I facilitated one laboratory activity per month. Related to students' activity, they simply follow the teacher's presentation and are not motivated to ask extra challenging questions."

Similar to this, LT11 and LT6 showed that Inquiry-based practical activities are important, and they conducted in laboratory only. However, in the real situation of their schools with large number of class size, lack of trained laboratory technician, it is difficult to implement it. From this result, one can assume that the assigned laboratory technicians are science teachers without professional training on laboratory activities that affect the quality implementation of science subjects in the schools under study.

Interview with all laboratory technicians assured that the determinant factors, such as lack of materials, mainly equipment in the laboratories, uncomfortable school facility, teachers' load, lack of practical knowledge of teachers and school leaders, lack of sufficient budget, lack of teachers' interest due to low salary, lack of practical training, lack of both students and teachers' interest, in their schools are preventing them from applying Inquiry-based practical activities in their school. In addition to this, the laboratory technicians did not take professional training on laboratory skill, except two laboratory technicians who have received short term training and experience.

4.7.3. School Vice Principals Interview Result

Eleven academic school vice principals were involved in the interview. Questions were asked to assess the desired techniques of practical activity and frequency used by science teachers in their school. School academic vice principals were interviewed regarding the accomplishment of hands-on activities in their schools; they acknowledged prioritizing the completion of the academic syllabus over enhancing the holistic teaching-learning experience. They openly admitted their limited involvement in administration and aiding the instructional process.

For example, one of the interviewee, V.P4, said,

"Frankly speaking, I am not sure to say what the process of inquiry-based practical activities look like, and I simply check the plans of science teachers whether they fulfill the planning format. I check them by putting my stamp as a formality because I believe the teachers have appropriate knowhow of the subject matter better than me."

The data from the interview showed that teachers' preference of teaching methods and eagerness to implement the practical activities in the school reflects that most of the time, teachers use explanation and group discussion. In this case, V.P1 pointed out that,

"In my observation, teachers and students are always requesting us to fulfill different necessary electronics and chemicals to exercise practical creativity. They are also very interested to compute on the education and technology symposiums. However, our school budget is very limited. The teachers and students did not get sufficient time and budget to apply the practical activities, so they frequently used explanation."

The respondents also stated about their role to support students and teachers to implement inquiry-based practical activities. V. P8 explained that,

"School principals are expecting to control the entire academic and discipline aspects of students. As a result, I tried to check and control if all the teaching learning process should follow participatory approach, like this practical activity. However, due to a serious workload in handling administrative tasks, there is a gap on supporting teachers and students by preparing inspiring trainings related teaching activities in our school."

This implies that lack of involvement was attributed to multiple factors, including unfamiliarity with the strategies and techniques associated with practical activities and time constraints.

Likewise, principals reflected their view on the suitable facilities and hindering factors of the practical activities in the teaching learning process. The data showed that, at this level, students started the new division with new system of arrangement, but there is nothing new, except the common challenges. For instance, V.P11 explained that,

"As we know, in this level, students come from the Amharic version contents, and teachers should help students to aware and encourage introducing the science itself as well as the instructional media. To deliver this, first, the teachers should be trained on that way, but this is not proceeding in the middle schools. As a result, I believe that lack of appropriate training for us, teachers and students, lack of adequate resources and time scarcity are the main problems that prevent the quality delivery of science in our school".

The participants in the interview showed common agreement on issues related to the lack of conducive school environment, lack of teacher's exposure to practical activities, lack of principal's knowhow on the practical activities, lack of technical support to teachers on how to make science practical; as a result, teachers didn't support students on practical activities. For example. V. P2 stated that,

"Lack of emphasis on practical activities and science by the education experts and *lack of language skill on the instructional media are the reasons for the less quality implementation of science subjects. Because teachers didn't easily understand the concept of the science subjects, principals did not support the program. Consequently, teachers simply memorize the concept as it is and loss interest to find/research new things by relating with the real environment."*

Furthermore, they underlined that adjusting teachers training, inspiring students and fulfilling all necessary materials for schools should be mandatory to deliver the quality teaching science subjects.

4.8. Discussion of Results

In this part, the data gathered and analyzed above are discussed under three major teams in response to the basic research questions formulated in the introduction part of the study. These major teams are:

1. Investigate the current implementation of inquiry-based learning through practical activities in middle level schools of Addis Ababa;
2. Explore the perceptions and awareness regarding inquiry-based learning through practical activities in middle level schools of Addis Ababa;
3. Identify challenges hindering the implementation of inquiry-based learning through practical activities in middle level schools of Addis Ababa;

The discussions of the results were strengthened by supporting with reviews of literature which included research findings and views of scholars about inquiry-based practical activities.

4.8.1. Practice of Inquiry-Based Learning through practical activities in Science subjects in middle schools

This objective is designed to look at the current implementation of inquiry-based practical activities in science subjects in middle schools, and it would be divided into two sub-topics, and based on the results of the study, the discussion would be presented as follows.

A. Extent of science teachers apply the techniques of Inquiry-Based Learning through practical activities

Applying a variety of instructional strategies, such as inquiry-based practical or hands-on activities, fieldwork, guiding students to carry out practical activities individually or in groups permit to gain hands-on experiences and are involved in more than listening and reading (Grade 7 and 8 General Science Syllabus, 2021). Acquiring an understanding of skill to use evidence is imperative not only for science education but also for lifelong learning and for solving problems in daily life.

Concerning the existing state of inquiry-based practical activity implementation within the targeted schools, teachers were asked about their familiarity and engagement in inquiry-based practical activities in classroom and outside of classes. The response revealed that only 45.8% of the respondents confirmed their familiarity with the concept. Of those teachers who are familiar, only 38.2% of them integrate inquiry-based practical activities in their delivery of science subjects. However, the remaining 54.2% of science teachers showed a lack of knowledge or understanding of these activity types.

Exploring further into the implementation of inquiry-based practical activities within the classroom setting, the responses indicated a relatively low implementation rate. Even though some 20.8% of the respondents reflected that they incorporate the method; a significant majority of the teachers that accounted 79.2% stated not using practical activities at all in their science classes. This tells there is a beginning point, but the implementation of inquiry-based method is questioned.

Moving beyond the classroom, 85.8% of teachers revealed that they provide practical activity assignments for students outside of their class or school. However, among those who affirmed this practice, the majority that account 94.2% reported assigning such activities on a semester basis. This implies the implementation of inquiry-based practical activities in science subjects is not as planned in the curriculum as it expects every lesson is supported by practical activity related to students' everyday life. This result aligns with the study conducted in Hawassa University Technology Villages; sciences teachers rarely make students actively participate in inquiry-based learning and provide students with laboratory practices, projects, and assignments to improve their learning potential (Geeltu , 2024).

In general, the survey underscores a prevalent discrepancy between the familiarity with and actual implementation of inquiry-based practical activities in the target schools. Similarly, science teachers were asked to list down some of their strategies to implement practical activities. Among them T12 said that,

"I provide the students with homework, classwork, group assignment, note provision, and prepare observation on technological materials from the internet in laboratory. This helps the students by visualizing the materials they imagine how to implement practical activities for their future."

This reflected that the practical activities are conducted in laboratory rooms through demonstrating only from the teacher side. These results underscore the need for enhanced efforts toward promoting and integrating these experiential learning strategies within the classroom and beyond.

They also highlight the importance of making inquiry-based activities as a standard practice in science education to boost student engagement and motivation. In line with this, the Ethiopian general science syllabus for middle-level schools underscores the significance of practical activities in boosting students' overall academic performance. It emphasizes authentic engagements with real-world contexts within their environment (MoE, 2009).

The teachers were asked questions to gauge the frequency with which they implemented practical activities in their lessons to connect between lessons and real-life activities or environmental context and procure within the confines of a laboratory while instructing science in their respective schools. This takes into account not only the traditional classroom setting but also the laboratory environment at the schools to which the teachers incorporate practical, exploratory learning into their day to day pedagogy, contributing to an enriched learning experience for the students.

The findings reveal a significant gap between the advocated pedagogical methods and their actual implementation among science teachers. A substantial proportion of teachers, accounted 79.2% and 80.0% respectively, acknowledged that they did not connect their lessons to real-world activities, nor did they utilize hands-on exercises in their classrooms and conduct practical activities within a laboratory setting in their respective schools.

Only a small segment of the respondents that accounted 20.8% and 20% stated that they occasionally or rarely incorporate these features of practical activities while teaching science subjects respectively. This feedback starkly contrasts the emphasis placed on varied inquiry-based practical activities by the middle level school science curriculum and is mirrored in the students' textbooks.

When most teachers admit they do not use these teaching tactics, there is a clear discrepancy between the curriculum as written and how it is actually implemented in the classroom. Similar findings were found by Abza et al. (2022), who noted that science teachers used classroom instructional practices sparingly and displayed inadequacies in carrying out lesson plans and applying a diversity of participatory instructional techniques.

Similar to this, responses from students' questionnaire indicated significant majority of students that accounted 71.5% described it as low implemented and broad spectrum of perceptions regarding the integration of practical activity techniques by science teachers, with a considerable portion of students acknowledging a lower level of implementation. Data from observation, students' focus group discussion and interview with the teachers and principals also asserted that teachers focused on explaining science subjects theoretically to students rather than engaging them with different practical activities, and students were limited to taking notes and listening to the teachers' presentations.

This result is similar with a study conducted in Southern Nations Nationalities People's Region Wolaita Zone secondary schools on the practice and problems in science laboratory activities; the findings showed that science instruction is not supported adequately by laboratory or practical activities (Gogile and Alemayehu, 2016).

Contrary to existing learning techniques, studies have highlighted the necessity of ongoing practical activities to improve students' comprehension of the general world. Reliance on conventional teaching strategies and textbooks might hamper students' academic progress in science education, as noted by Hacieminoglu (2016) and Bell (2008). Students' interest in science is mostly sparked by concepts that are explored in authentic settings. Positive attitudes toward science are associated with greater test scores in students (Hacieminoglu, 2016). The value of practical labor in science has been recognized by educators and other stakeholders, and it is difficult to teach science without it (Bell, 2008).

Thus, based on the aforementioned results and discussions, there is a low level of application of practical activities in science subjects and a deviation from the syllabus and teacher-student interaction required by the science curriculum, which calls for practical inquiry. As a result, it is reasonable to draw the conclusion that the middle level schools in Addis Ababa City do not sufficiently implement the inquiry-based practical activities that are essential parts of the curriculum.

The result of the current study is consistent with the findings of other researchers, including research results conducted in South African physical science classrooms, in Diaspora secondary school at Bahirdar Ethiopia and in preparatory schools of Horo Guduru Wollega Zone, Ethiopia. The result of the research findings showed that the implementation of inquiry based practical activities or practical work is largely inadequate and at low level of implementation (Akuma and Callaghan, 2018); science teachers in Diaspora secondary school mostly use traditional teaching methods (Dagnew and Sitotaw, 2019), and the practical tasks related to practice based learning were not practiced in the preparatory schools in Horo Guduru, Wollega Zone, Ethiopia (Mosissa, 2017).

This can be an indication that teachers are more concerned about theoretical application of knowledge and skills than their practical appearances in authentic world. Teachers rarely conduct practical work, assuming the scarcity of resources in the laboratory, but they did not apply other practical strategies of the laboratory tasks. This gap points to a tangible need for reassessment and potential reform in the current approach to science education.

B. Common Strategies of Inquiry-Based Learning through Practical Activities used by teachers and students in the general science lessons delivery

Science teachers and students were requested to provide insights into their classroom teaching methodologies and techniques to see a clear overview of how teachers recognize and engage with inquiry-based activities, shedding light on the prevalence of different levels of implementation.

The analysis of teaching techniques among teachers reveals that “Lecture/Explanation” holds the top rank, attaining a mean score of 2.89 and a standard deviation of 0.31. This indicates that the method is widely practiced with a relatively high level of consistency among teachers. Similar to the findings of this study, Egne (2022) revealed that many Ethiopian teachers continue to commonly use traditional lecture techniques rather than implementing innovative strategies that inspire student participation and active learning, even in the face of educational changes meant to enhance pedagogical practices.

The second most frequently employed teaching activity is “Question and Answer,” with a mean score of 2.11 and a standard deviation of 0.46, suggesting a consistent usage pattern among teachers. Furthermore, the smaller standard deviations associated with both “Lecture/Explanation” and “Question and Answer” imply a more uniform application of these techniques by teachers. In the current study, students were asked to provide their standpoints on the same set of questions posed to their teachers. The data reveals a significant degree of alignment between the students and teachers’ views.

Students overwhelmingly corroborated their teachers’ assertions, stating that the “ Lecture/Explanation” is the top one or the primary teaching technique with a mean score of 3.96, followed by “ Question and Answer” with a mean score of 1.73, and “ Demonstration” with a mean score of 1.64 is also employed in their science classes. Concerning the constructs, “ Traditional/one way” , including Demonstration and Lecture/Explanation, “ Structured Inquiry” , including Question and Answer, Modeling, Written responses, are the top two implemented teaching techniques, with mean scores of 2.80 and 1.50 respectively. This result is aligned with a study by Bizuneh (2022); he pointed out that many teachers continue to use traditional, teacher-centered approaches in spite of reforms aimed at encouraging active learning and student engagement.

These findings highlight variations in perceptions between teachers and students regarding the utilization of different teaching techniques. The consistent preference for Traditional Teaching Method, as indicated by higher mean scores, underscores its perceived practice among teachers and students. A substantial portion of respondents primarily elucidates scientific concepts theoretically, bypassing the inquiry-based practical mechanisms that inquiry-based methods offer, and the use of inquiry-based practical activity strategies is unfortunately not a common practice in the examined middle schools. This concurrence underscores the dominance of traditional teaching methods, pointing to the under-utilization of inquiry-based practical activities in the science classrooms under consideration. Such insights call for an urgent need to reconsider pedagogical strategies, with a view to creating a more interactive, engaging, and practical learning environment for students. This consistency suggests that these methods are staples in the instructional practices of a significant majority of teachers, contributing to the stability and predictability of their implementation.

In addition, the examination of mean scores for the five teaching techniques categories across sub-cities offers nuanced insights into the diverse perceptions of instructional methods. “Traditional/one way”, including Demonstration and Lecture/Explanation and “Structured Inquiry”, including Question & Answer, Modeling, and Written Responses, emerge as consistently implemented methods across all sub-cities. Similarly, science teachers were asked to list down some of their strategies to implement practical activities. Among them, T12 reflected that,

“I provide the students with homework, classwork, group assignment, note provision, and prepare observation on technological materials from the internet in laboratory. This helps the students by visualizing the materials they imagine how to implement practical activities for their future.”

This revealed that the practical activities are conducted in laboratory rooms through demonstrating only from the teacher side that leads teacher-dominated strategies.

The above discussion indicated that they usually depend on traditional lecture methods and clearly underscored the fact that a considerable number of teachers rely heavily on traditional lecture-based pedagogy, with teacher demonstrations and question-and-answer sessions being frequently utilized, while written responses, group discussions, inquiry-based investigations and project work are significantly less commonly implemented techniques during the delivery of their science instruction. Additionally, teachers were asked about their preferred methods for delivering the science curriculum. Common responses included theoretical teaching through providing notes, homework, group projects, Power Point presentations, and demonstrations of materials. In this regard, a teacher, referred to as T5, expressed a preference for traditional lecture methods, by saying,

"I always opt for the lecture method since it allows me to hold my students' attention and complete the course content efficiently. It is a challenge for me to teach through practical activities as most students seem disinterested in this technique, with only limited interest to engage in practical tasks".

This preference suggests a concerning trend; teachers may be opting for less labor-intensive methods by providing students with pre-made lessons, potentially compromising the quality of education. Likewise, during the classroom observation, the practical activities expected from teachers and students were not implemented in all of the observed classrooms, except rare classrooms where students reacted to the questions raised by teachers. Although the approach was in the form of one-way communication which means questions raised by the teacher and answer may be forwarded from few students or not, and teachers did not guide or give extra assessment/activities in most classes or did not collect any project work or report from the previous lessons.

The same holds true during the focus group discussion with students, and interview with the science teachers and school principals also assured due to the easiest way of delivering the content and always apply explanation or lecturing and describing of the science concepts to students. This result is consistent with research result obtained by (Alemu et al., 2019 and Mosissa, 2017); the studies showed that lecture dominating teaching is still prominent in the Ethiopian educational system to attain content factual knowledge at all levels (Alemu et al., 2019), and the most popular and reliable teaching strategies in preparatory schools are lecturing and interactive lectures; on the other hand, teachers have never assigned reading or practical assignments, such group projects, peer presentations, practical exercises, or group discussions (Mosissa, 2017).

The above analysis presents a comprehensive summary of the teaching methods and techniques adopted by the science teachers and students in their respective subject areas. However, the data still underscores the relative underutilization of such participatory methods. This corroborates the view that both teachers' preference for inquiry-based practical activities and students' active engagement in science learning is notably low within the surveyed schools. This result is also supported by other research results; there is a significant gap in the engagement and effectiveness of classroom instruction through participatory strategies (Abdulbasit et al, 2024).

In today's educational landscape, it is imperative for teachers to effectively employ inquiry-based practical teaching techniques, both inside and outside the classroom, to make scientific concepts more accessible and engaging for students. However, a research review on practical work implementation in general science subjects at secondary schools relay that the implementation process of practical exertion in science education is still limited in Ethiopian schools and students perform poorly in science subjects (Abebe, 2019).

Similarly, a substantial portion of teachers primarily elucidates scientific concepts theoretically, bypassing the inquiry-based practical mechanisms that inquiry-based methods offer, and the use of inquiry-based practical activity strategies is unfortunately not a common practice in the examined middle schools. Correspondingly, there are quiet crisis narratives in curriculum implementation or student learning, according to data from extensive studies of Ethiopian primary schools (Hoddinott et al., 2019).

This indicates a vital area for improvement as the inclusion of these strategies can profoundly enhance the educational experience, fostering a deeper understanding of scientific principles among students.

4.8.2. Perception of General Science Teachers & awareness of Students on the Inquiry-Based Learning through practical activities

Regarding the application of inquiry-based practical activities in their instruction in particular, teachers' views are a crucial psychological component that is strongly intertwined with their pedagogical activities. In line with this view, the perception and awareness of teachers and students assessed through different questions in the questionnaire and interview. The secured data and the discussion would be presented as follows.

A. Science Teachers' awareness and perception about the importance of practicing Inquiry-Based Learning through practical activities in science lessons

In line with this view, the Perception/awareness of teachers assessed through twenty different questions related to the principles of inquiry-based practical activities' positive and negative impacts. Accordingly, concerning with the teachers' perception or awareness on the importance of Inquiry-based practical activities in science lesson delivery, the mean scores for each statement range from 3.25 to 4.23, suggesting that overall, teachers view on inquiry-based practical activity (IBPA) is positively perceived. The highest agreement is for the statement "The role of the teacher is facilitating the learning process rather than controlling", with a mean of 4.23, highlighting a strong endorsement of facilitative teaching roles in Inquiry-based settings. The lowest mean score of 3.25 is associated with the statement regarding the preference for practical over theoretical learning. This reflects some reservations about fully prioritizing practical learning over traditional methods. Similar to this, during the interview, teachers acknowledged the value of Inquiry-based practical activities but reported not to incorporate them into their lessons.

The next significant majority that accounts 72.5% agreed that IBPAs are easy to implement and help learners solve their problems, and this indicates a positive view of the practicality and effectiveness of the inquiry-based practical activities (IBPA). Most teachers that account 89.2% acknowledged that IBPA helps learners understand science concepts within their environment or context better. Statements regarding the development of self-confidence and independent learning for both teachers and learners with mean score above 3.5 on average, signifying a strong belief in the personal development benefits of IBPA. Teachers also largely agreed that IBPA prepares learners to address real-world problems, reinforcing the practical value of this teaching approach. There is a nearly unanimous agreement that the role of a teacher should be more about facilitating rather than controlling, which underscores a paradigm shift in teaching perspectives among the respondents. Most of the responses show that teachers believe IBPA contributes to the development of self-learning abilities and interpersonal skills among students (See table, 4.9). This result complements with the study by Twizeyimana et al (2022) in Rwanda, the teachers' perception toward the inquiry-based learning approach; a considerable number of respondents agreed or strongly agreed that inquiry-based learning enhances learners' understanding in physics (Twizeyimana et al., 2022).

Generally, this analysis highlights a strong endorsement of inquiry-based practical activities within the educational process, emphasizing its significance in fostering a practical, interactive, and learner-centered educational environment. In addition, these results underscore a positive alignment of teachers with the principles of inquiry-based practical learning, focusing on its potential to foster independent learning, build self-confidence and improve conceptual understanding. This result aligns with the studies conducted by Geeltu (2024) and Ramnarain & Hlatswayo (2018). Here, the teachers have a positive perception of the use of inquiry-based methods in teaching general science subjects (Geeltu, 2024) and a positive attitude towards inquiry in the teaching and learning of Physical Sciences and diagnose the profits of inquiry, such as addressing learner motivation and supporting learners in the thoughtful of abstract science perceptions (Ramnarain and Hlatswayo, 2018).

Conversely, teachers were probed regarding the drawbacks or difficulties associated with the inquiry-based methodology. A mean score of 2.61 and a standard deviation of 1.23 indicate general disagreement with the total negative feeling concerning the practicality of inquiry-based practical activities (IBPA) in educational settings. Particularly, 64.2% of respondents do not consider that inquiry-based practical activities are practicable in their teaching environments, indicating significant variability in opinions. The grand mean, which is roughly 2.59 generally, indicates disagreement with the statements.

This advocates that teachers commonly have a positive opinion on inquiry-based practical activities (IBPA) or at slightest do not strongly agree with the statements' negative views. More than 60% of educators acknowledged the advantages of inquiry-based instruction, but there are discrepancies in how well they can put this knowledge into practice. A significant portion of teachers that accounted 20.9% viewed the lecture method as beneficial for transmitting knowledge efficiently, and when it comes to teaching science in middle schools, they frequently prefer teacher-dominated methodologies because they believe these methodologies are easier to execute(See table, 4.8). This shows a reluctance to fully utilize inquiry-based practical activities.

A common view in the teacher-centric role during such activities is indicated by the perception of teachers and also expressed a positive outlook on their role in the inquiry-based approach by disagreeing with Mean values of 2.58 with the idea that teachers should primarily be sources of knowledge rather than facilitators. However, there is notable doubt concerning the effectiveness of inquiry-based practical activities (IBPA) in promoting practical over theoretical learning, with a mean score of 3.18, reflecting agreement on its perceived ineffectiveness. This doubt extends to the applicability of inquiry-based practical activities (IBPA), which is often misunderstood as being confined to laboratory settings. In addition, teachers admitted that despite recognizing the importance of inquiry-based practical activities, they had not implemented them into their lessons. One interviewee, T3, stated that,

"Practical activities are significant because students can get the opportunity to imitate theoretical concepts in a laboratory setting with practical opportunity. Conversely, this remains a hypothetical or ideal rather than a tangible reality in our school due to the lack of suitable resources in the laboratory, including teacher's skill to create and facilitate the strategies."

To sum up, the findings from the teachers' result analysis about the positive and negative sentences associated with inquiry-based practical activities indicated that while most teachers agreed on the advantages of practice-based teaching, there were differences in their comprehension of how to implement practice-based instruction. Teachers with foundational and higher qualifications (Diploma and BSc+PGDT) and younger-career experience demonstrate relatively positive attitudes, underscoring the importance of advanced education and balanced professional growth. However, the consistently low aggregate means across all demographic groups, relative to the grand mean, emphasize systemic issues, such as resource constraints, lack of targeted training, and institutional support. In addition to acknowledging the merits of Inquiry-Based learning, T2 expressed concern on the feasibility of catering to students' diverse learning needs in a resource-constrained environment. He said that,

"In my classes, many students possess creative skills that could be fostered through practical tasks. However, how can this be achieved in a school that struggles to procure even a single dynamo or material to engage students?"

This indicates that while teachers acknowledge the worth and advantages of Inquiry-based practical activities, they still think that teacher-oriented education is superior since it is easier to execute. Similarly, this result complements research results conducted by Mosissa in preparatory schools at Horo Guduru Wollega Zone, Ethiopia and by Hussen et al., 2022 in secondary school chemistry classrooms in North Wollo Zone, Ethiopia. In theory, teachers have a good attitude towards practical learning, but they have not put it into practice in the authentic teaching-learning setting. This advocates that teachers are aware of the value of practice-focused learning. However, practically, they did not incorporate practical exercises into their lesson plans or evaluation strategies (Mosissa, 2017 and Hussen et al., 2022).

Supporting this challenge, scholars and investigations say when teachers are unfamiliar with inquiry-based instruction; they may mistakenly view it as unstructured, which could lead to a lack of appropriate scaffolding, assessment, and redirection as tasks progress. Investigations on inquiry-based learning have identified the hazards and repercussions that arise when students are not exposed to this methodology beforehand or receive inadequate guidance and modeling from teachers (Barron and Hammond, 2008). Gholam provided support for this by saying that we must keep in mind that our children are 21st century learners and that we cannot instruct them in the same way that we taught our students yesterday. The learning process requires the participation of our learners. They must ask their own questions, guide their own education, take ownership of it, and be accountable for it by themselves. Teachers must have a growth attitude and a strong belief that all students today can be trusted to take charge of their own learning if they want this to happen (Gholam, 2019).

In order to create a blameless change and implementation of inquiry-based practical activities in general science subjects, teachers must change the traditional teaching method and move in a new and modern teaching technique. Therefore, significant practitioners need to have a good understanding of the scientific implication and its process.

Consequently, it is crucial to give teachers the subject-matter expertise that corresponds with their pedagogical content knowledge, as well as the technological pedagogical content knowledge and the necessary abilities to implement the science curriculum in the specified environment. Additionally, science teachers should be prepared with 21st-century soft skill competencies like learning skills, literacy skills, and life skills in order to experience professional knowledge, professional practice, and professional engagement; understand the idea of inquiry-based practical activities; and foster their capacity to learn from and teach in a real-world setting.

Thus, it is critical to develop the positive perception by resolving the awareness gap in practice-focused education through creating the necessary awareness creation and training to teachers and other implementing bodies. Supporting this, Ethiopian curriculum framework also stated that aligning the curriculum with the teacher education curriculum is essential for its successful implementation. For the purpose of equipping teachers with the necessary skills to effectively apply the curriculum that is based on the planned framework, training and preparation must be provided in accordance with its guidelines in both pre-service and in-service modalities (MOE, 2020).

Similarly, during the interview, teachers were asked to briefly describe the technique they think is modest for science lessons that help learners to study science subjects. The majority of teachers stated that the simplest method is to instruct learners using materials and videos from the internet through explanations. They said that downloading documents and movies makes life easier because they are simple to understand and do not demands extra work. Given that, it implies that teachers are attempting to teach with less effort by providing their students with ready-made lessons.

In line with this finding, a study conducted by Awelani and Ramodungoane (2014) on teachers' classroom practices by focusing on how they conduct practical work in science classrooms showed that teachers conducted practical work tasks within the explanation model because of their clear view and understanding of the teaching strategies. This has been found that teaching science without practical activities affects students' interest in science disciplines, resulting in less student enrollment in science class.

Under this study, teachers were also listing the techniques they use to conduct practical learning activities. They assist their learners by providing notes, homework, group projects, Power Point, and demonstration of materials. Most of the tactics taught by the teachers are derived from the traditional teaching approach. Based on the teachers' assumption, they also continued to think that practical activities could only be done in laboratory settings.

This is due to the fact that they failed to employ tactics associated with practical activities, such as field visits, reflection, model preparation, demonstration, project works, and various forms of discussion, sharing of experiences, laboratory practices, and peer teaching. During the focus group discussion, students also argued similar points with their teachers.

From the above discussion, one can conclude that teachers in these schools have low level of awareness about how to perform practical activities using scientific inquiry's practical methodologies. The current study result is consistent with research studies by Gunta and Ousman (2015), Dessie et al., (2017) and Abebe, (2019). A study conducted in Southern Ethiopia Secondary and Preparatory Schools confirmed that due to lack of physics teachers' interest and lack of equipment in the laboratory, laboratory was not used for practical work to teach Physics (Gunta and Ousman, 2015).

Furthermore, a study conducted on influences of selected factors on students' performance level in Physics at secondary schools of Bale Zone, South East Ethiopia, and a research review by Abebe revealed that practical work is not implemented in most schools in Ethiopia due to teachers and students' lack of motivation and interest, lack of equipment and other laboratory facilities (Dessie et al., 2017). Nevertheless, in some schools, lack of teachers' motivation and lack of support of school principals hindered the implementation of practical work and negatively impacted students' academic achievement in science education (Abebe, 2019).

It suggests that these approaches, which fall under the umbrella of active teaching methods, are generally overlooked by science teachers who exhibit a preference for more conventional teaching styles. This implies an alarming lack of exposure to and implementation of Inquiry-based practical activity strategies among teachers in the surveyed schools.

B. Students' awareness on Inquiry-Based Learning through practical activities in science lessons

To see the implementation process, it is important to know the degree of the know-how of practitioners on the issue. Students were asked four questions about their awareness on Inquiry-based practical activities. The result showed that a significant majority of students that accounted 89.7%, 91.8%, 92.8% and 97.1% reported to have awareness, a preference, a higher quality over traditional lecturing methods, and its contribution to develop students' self-learning abilities and skills about inquiry-based practical activities respectively (See table, 4.13).

This survey finding indicates a vigorous awareness and positive insight of inquiry-based practical activities among the students. Such a great level of student positivity advocates that these methods not only align with students' learning preferences but also contribute positively to their educational experiences. Supporting this result, a study conducted by Dagnew and Sitotaw (2019) revealed a positive correlation between students' attitudes and achievements in Biology courses, and another study by Mosissa, (2017) showed that the students are well aware of the importance of practical-based learning the students are well aware of the importance of practical-based learning and interested in practical-based instruction. Modern teaching strategies recognize the importance of encouraging students to critically think about what they are learning (MOE, 2009).

Even though, the awe-inspiring confirmation from the students' body highlights a favorable acceptance and enthusiasm for inquiry-based practical activities; the result from teacher's questionnaire reflects the reverse.

When gauging student motivation and awareness of applying practical activities in the school context during practical activities, the results were diverse. A significant 81.7% and 82.5% of the teachers supposed that students have poor awareness and motivation to actively participate in the hands-on activities integrated into their learning process respectively. Only 18.3% and 17.5% teachers perceived that students have an average level of awareness and motivation respectively.

The observations and witnesses of these teachers, therefore, paint a rather grim picture of student engagement and enthusiasm within the middle schools of Addis Ababa City. Their shared perception reveals a prevalent issue; the students are insufficiently motivated and aware of the practical activity to learn via practical exercises. Due to such problems, science department head teachers were asked about the inspiration of students to use a practice-focused or participatory teaching method, they answered as the method itself is the source of disturbance.

For example, T20 stated that,

"Most of the students found it to be an obstacle to using a participatory teaching method. This means that the students start disturbing and shouting and even did not hear what they say to each other. Student's aspiration to learn through practice-focused or discussion is low. When I start to use such kind of method, most of the students try to get into shouting. During this, school principals counted it as the poor performance or low classroom management of the teacher so I use the lecture method with full eye contact of the students."

This challenges the conventional notion that hands-on learning typically engages students more deeply. As the teachers' feedback overwhelmingly indicates the majority of students lack the requisite drive to probe into practical activities and a critical component of their learning journey. In a similar way, students' reflections during the Focus Group Discussion (FGD) included asking questions orally, providing explanations, taking notes on the blackboard, giving class works and home works, assignments, and occasionally using laboratory exercises as the main practical activities employed by their science teachers. The majority of students did not properly differentiate between theoretical and practical activity techniques, as can be inferred from the study above, given that the majority of the activities classified as practical still do not qualify as such.

A study result in preparatory schools of Horo Guduru Wollega Zone, Ethiopia revealed similar result; the students are interested in learning through hands-on experience, but they had no place to engage in hands-on activities in their authentic environment and their understanding of practical learning implementation is blurred (Mosissa, 2017).

Thus, these disparities between the students and teachers' result indicated gaps in the application of inquiry-based practical activities in science curriculum at schools. Even though students and teachers have the positive outlook on the importance of inquiry-based practical activities, the awareness of teachers and students in these schools regarding the application of practical activities through the practical strategies of scientific inquiry is deprived. This study's result is consistent with a study conducted by Boka, (2022) in West Arsi Zone of Oromia Region, Ethiopia; the majority of school principals, chemistry teachers and student respondents had a positive attitude and perception toward conducting experiments, but they had no experience doing so.

4.8.3 Factors that hinder the implementation of Inquiry-Based Learning through practical activities

The successful delivery of quality education depends on multiple decisive factors, such as the availability of essential resources, a conducive learning environment, and well-trained human resources within the school. During the implementation of any program, it is obvious that problems may occur. Hence, the exceeding results displayed that practical activities are not implemented in primary schools. Thus, it is crucial to contemplate that practical activities may be affected by various factors and shortcomings during their implementation in the actual classroom situation or outside the classroom.

Therefore, teachers and students were encouraged to provide their perspectives on the elements influencing the implementation of inquiry-based practical activities in their educational settings. As their responses indicated, the enactment of these activities in their schools leaves much to be desired. In order to assess the obstacles during the implementation of inquiry-based practical activities in the science curriculum, the researcher posed questions in each data collection instrument. The secured data and the discussion would be presented as follows.

A. Teacher and student related factors affecting the implementation of Inquiry-Based learning through practical activities in general science instruction

Teachers and principals are among the human resource inputs considered as front-line participants in the curriculum implementation process. Inquiry-Based instruction is among the learning modalities that include key components of deep learning. This approach allows for a high degree of critical thinking following the process of learning science skills. The main and most important aspect of this approach is that teachers' effectiveness and efficiency are dependent on their ability to communicate a range of skills to students in meaningful, understandable, creative, and innovative scientific exchanges. According to the research, there is substantial skepticism regarding the successful execution of the practical activities conducted, as well as an ongoing lack of clarity on the goals of practical scientific teaching (SCORE, 2008).

Three questions were asked to secure information from teachers and students about the teacher and student related factors hindering the implementation of inquiry-based practical activities. The result depicted that a significant proportion of teachers that accounted 85.0%, 88.3%, and 76.7% believed that the exposure to traditional lecture method, lack of additional training on inquiry-based practical activities and teachers' lack of interest have affected the practices of inquiry-based practical activities in schools under study. Similarly, students' result also showed that 92.8%, 94.7% and 89.0% of students respectively reflected that their teachers' tendency towards the traditional lecture method, lack of necessary additional trainings on inquiry-based techniques and their lack of interest in such approaches adversely hamper the incorporation of practical activities in science classes.

This result is similar with the research findings in South African schools; in spite of this positive opinion of inquiry-based learning, teachers are less likely to include it into their classes. Teachers affirm that there are many obstacles to executing inquiry-based learning, including the availability of lab space, instructional resources, curriculum completion time, and large class sizes, which make them reluctant to do so (Ramnarain & Hlatswayo, 2018). However, scholar's advice that rather than depending solely on conventional teacher-centered approaches, teachers should incorporate inquiry-based learning strategies into their lessons as science education continues to improve. Through using inquiry-based methodologies, students gain the skills they need to address real-world issues in society and involve in many of the equivalent activities and processes that scientists use to generate new knowledge (Husni, 2020; and Twizeyimana et al., 2022).

Furthermore, as the main facilitators of curriculum content, teachers can assist students in enlightening this kind of appreciation through inquiry-based teaching and learning activities, and in order to communicate the body of science process skills to students from diverse cultural backgrounds, teachers must adhere to the rules, principles, and norms of science (Li and Schoenfeld, 2019; Twizeyimana et al., 2024).

Effective implementation of curriculum intentions is contingent upon the provision of appropriate and timely teacher training. Without this crucial component, meaningful curriculum realization remains highly improbable. In this regard, the overwhelming majority of science teachers and students surveyed expressed a clear need for fulfilling further specialized training and awareness creation in Inquiry-based practical activities, a component they deemed vital for effective science instruction. In addition, the study showed that there are factors related to teachers' tendency to traditional approach, teachers' commitment and initiation to implement practical activities and mismatch of teachers and students' interest, lack of professional training for teachers, lack of motivation and guiding of students learning. Teachers also stated that they employ these methods because they are easy to deliver and cover all the lessons. Similarly, T5 conveyed her preference for traditional teaching methods,

"I always choose for the lecture method since it allows me to hold my students' attention and complete the course content efficiently. It is a challenge for me to teach through practical activities as most students seem disinterested in this technique, with only a few eager to engage in practical tasks."

Likewise, students brought up a number of barriers that kept them from actively participating in practical, hands-on learning experiences at their schools during focus group discussion sessions. Among these, one common complaint was that their science teachers would frequently tell learners to memorize, transcribe small notes from textbooks, and teachers lacked the know-how or initiative to lead them through hands-on activities or to actively include them in hands-on learning. Furthermore, the focus group discussion and interview with the teachers and principals disclosed that serious issues impeding the successful application of real-world tasks, such as teachers lack of language proficiency, lack of commitment, lack of coordination and lack of students' interest or low motivation as teacher and student related factors to its successful disposition.

This result is consistent with the findings of other researchers, including Oli, (2014) and Dessie et al., (2017). According to the research findings, here are the main causes of the low implementation of practical activities. Ethiopian schools do not seem to be succeeding in improving science teaching and student achievement because of the attitudes of students toward science and science learning strategies, teachers' ability, and ineffective teaching methods (Oli, 2014), and teachers' lack of excitement, competency in their subject and method of teaching, lack of interest and motivation to be engaged in their profession, as well as their inadequacy in both subject matter, pedagogy and students' low motivations and interest in learning (Dessie et al., 2017).

B. Other factors affecting the implementation of Inquiry-Based Learning through practical activities

Other than the teacher and student related factors, there are different barriers which affect the practice of Inquiry-based practical activities. The data gathered from teachers and students' questionnaire, observation, focus group discussion and interviews would be discussed below.

A significant majority of teachers reported several factors adversely impacting the implementation of Inquiry-based practical activities. For instance, 88.3%, 85.8%, and 89.2% of the teachers respectively reported that the lack of sufficient and suitable materials, time constraints, and financial limitations that hindered the implementation of actual practices of Inquiry-based practical activities or such pedagogical approaches. Supporting this, laboratory technicians reflected lack of resources affecting the implementation of Inquiry-based practical activities in their schools, and LT5 reflected as,

"Due to different factors, such as electric power interaction, lack of availability of some materials for the requested activity and overlapping of schedule with my own class, I facilitated one laboratory activity per month. Related to students' activity, they simply follow the teacher's presentation and are not motivated to ask extra challenging questions."

Similarly, a majority of students reported several factors unfavorably hindering the utilization of Inquiry-based practical activities. For example, 96.1% and 93.1% of students respectively reported lack of sufficient and suitable materials and combined influence of time constraints and financial limitations on the implementation of Inquiry-based practical activities.

Likewise, the findings suggest a potential gap in support mechanisms as only 14.2% of teachers and 8.8% students feel that their schools initiate them to develop team spirit in practical activities and foster collaborative learning environments. Similarly, school principals pointed out regarding the accomplishment of hands-on activities in their schools; they acknowledged prioritizing the completion of the academic syllabus over enhancing the holistic teaching-learning experience. They openly admitted their limited involvement in administration and aiding the instructional process. For example, as one of the interviewee, P4, said,

"Frankly speaking, I am not sure to say what the process of Inquiry-based practical activities look like, and I simply check the plans of science teachers whether they fulfill the planning format. I check them by putting my stamp as a formality because I believe the teachers have the appropriate knowhow of the subject matter better than me."

Therefore, one can conclude that school principals' facilitating role in implementing practice focused science lessons is missed. This result indicated that addressing these hindering factors would be instrumental in overcoming barriers and enhancing the successful integration of practical activities in science education within the surveyed schools. In addition, during the interview with science department head teachers, laboratory technicians and school principals, they highlighted a number of shared challenges to carrying out practical activities.

Among the common challenges raised, lack professional training on how to apply practical activities for teachers, laboratory technicians and principals, lack of experience and ability, time limitations, a predominance of lecture-based methods, a general reluctance to use inquiry-based practical activities, a lack of adequate and relevant resources, and a lack of support and follow-up from school administration are the major hindering factors.

During observation, it was witnessed that there was a laboratory in the schools, but it did not seem to give function; most the laboratory technicians are with double duty, and the facilities and equipment were not adequate or misplaced here and there. The laboratories did not inspire teachers and students as they were not appropriately arranged and did not get enough materials. Similarly, barriers related to safety protected materials, time, scheduling, large class size, lack of appropriate equipment, lack of trained expert in the observed school laboratories also considered as hindering factors in the implementation practical activities in science subjects.

In addition, this result aligns with research conducted in middle-level schools in Eastern Ethiopia; the different problems, like inadequate funding, inadequate training for teachers and large class sizes, frequently impede the effective use of classroom instruction and make challenging for educators to fully implement the goals of the science curriculum (Abdulbasit & Seyoum, 2021; Abdulbasit et al., 2024). In addition, lack of sufficient and conducive materials, shortage of time and finance, the absence of trained laboratory technicians, lack of materials and facilities, lack of the school authorities' commitment are found to be major factors affecting the implementation of inquiry based practical activities. The results of the current study mainly coincided with similar findings by Muleta et al. (2016) and Shitaw (2017).

The mentioned studies showed that the significant factors affecting the implementation of practical activities in Ethiopian schools are lack of laboratory rooms, inadequate supply of lab equipment, reagents and facilities, absence of trained laboratory technicians/teachers, lack of commitment and teachers' interest, lack of regular schedule for laboratory activities, poor management, monitoring and evaluations of laboratory activities, absence of a system for grading and assessment of laboratory examinations.

Similarly, a research review conducted by Abebe (2019) to identify factors and practice on the implementation of practical work in general science education revealed that the dominant factors hindering the implementation of practical activities in secondary schools of developing countries are related to school resource, such as lab equipment and supply, laboratory manuals, laboratory rooms, class size, teachers, and laboratory technicians. The implementation process of practical work in science education is still limited in Ethiopian schools, and students perform poorly in science subjects (Abebe, 2019). This substantiates the findings of the current study as they coincide with findings of similar studies.

Generally, all of these things together seriously weaken the science curriculum's actual application in practice. Therefore, addressing these hindering factors, including resource limitations, time constraints, financial support and the need for training and motivation, is crucial for fostering effective and widespread adoption of Inquiry-based pedagogical approaches in the sampled schools.

CHAPTER FIVE

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This study provides an in-depth investigation of the opportunities and challenges related to implementing inquiry-based learning through practical activities in General Science curriculum and general classes in middle-level schools in Addis Ababa City Administration. The research endeavors to address the significant gaps and structural impediments that prevent effective science education by combining the most important findings, coming to conclusions supported by rich data and documented evidences, and making practical suggestions. While the conclusions highlights the transformative potential of inquiry-based practical activities in fostering critical thinking, scientific literacy, and student engagement, the summary recaps the key findings from a thorough analysis of the data.

Additionally, the recommendations made are thoughtfully created to improve teacher preparation programs, inform educational policy, and maximize resource allocation all of which support the overarching objective of raising the standard of science education. This study not only emphasizes the urgent need for reform but also emphasizes the ethical and pedagogical imperatives to empower students through equitable, hands-on, and minds-on learning experiences that prepare them for the complexities of the modern world.

5.1. Summary

As the Ethiopian General Education Curriculum Framework (EGECF) underlined, teachers should incorporate different teaching strategies include group discussions, role plays, projects, presentations, debates, independent work, drill and practice, and inquiry to support students' learning both inside and outside of the classroom. Encourage and guide students to participate in activities that are meaningful, pertinent, inquiry-provoking, action-oriented, reflective, enjoyable, and encourages learners to connect what they currently know with new evidence through intellectually practical tasks in their context is very crucial (MOE, 2020).

Thus, the purposes of this study were to investigate the implementation of inquiry-based learning through practical activities, explore the perception of science teachers & awareness of students on the inquiry-based learning through practical activities, and identify problems that hinder the implementation of inquiry-based learning through practical activities in general science education specifically general science subjects in Addis Ababa middle-level schools. In order to address the basic questions, data were gathered from students, teachers and principals, using questionnaire, Focus group discussion, interview and classroom and laboratory observation.

In the selection of respondents, the researcher made use simple random sampling to select student respondents and availability sampling for teachers, the questionnaire were piloted and revised before the actual administration. The quantitative data obtained through questionnaire were analyzed using both descriptive and inferential statistical methods while the qualitative data obtained through the document review, classroom observation, interview, and focus group discussion were qualitatively analyzed using thematic analysis techniques was jointly discussed and narrated by supporting the view of scholars and research findings. Based on the analysis of the data, the following findings were obtained from the study.

5.2 Major Findings of the Study

First, regarding the current extent of implementing inquiry-based learning through practical activities in general science curriculum (biology, chemistry and physics), the majority of teachers (79.2%) reported not utilizing any practical activities at all, while the majority of students (71.5%) said that practical activities were not well-implemented in their science classes. Furthermore, a significant number of teachers (79.2% and 80.0%, respectively) acknowledged that they failed to incorporate hands-on exercises, link their lessons to real-world activities, or carry out practical activities in a laboratory environment at their respective schools. Similarly, almost all of teachers and students reflected about the teaching strategies used in their schools as, “Lecture/Explanation” and “Question & Answer” imply a more uniform application of these techniques across all the surveyed teachers and students.

The majority of teachers focused on explaining general science subjects theoretically to students rather than engaging them with different practical activities and students were limited to taking notes and listening to the teachers’ presentations. Second, concerning with the teachers’ and students perception and or awareness on the importance of inquiry-based practical activities in science lesson delivery, most (above 60%) of teachers agreed on the principles/advantages of inquiry-based practical teaching theoretically, but there were differences in their comprehension of how to implement inquiry-based learning through practical activities practical instruction. Though teachers acknowledge the worth and advantages of inquiry-based learning through practical activities, they still think that teacher-oriented education is superior since it is easier to execute in the middle schools.

Third, regarding to students' awareness on inquiry-based learning through practical activities in general science teaching, a significant majority (above 90%) of students indicates a vigorous awareness and positive insight of inquiry-based learning through practical activities. However, students' during the FGD reflects the practical activity strategies as asking questions orally, providing explanations, taking notes on the blackboard, giving class works and home works, assignments, and occasionally using laboratory exercises as the main practical activities employed by their science teachers. This indicates majority of students did not properly differentiate between theoretical and practical activity techniques. In addition, a significant (above 81%) of teachers' supposed that students have poor awareness and motivation to actively participate in the hands-on activities integrated into their learning process.

Likewise, the teaching learning strategies correlations provide insights into the alignment or divergence of perceptions between teachers and students for each teaching technique. This suggests that there is a lack of consensus or understanding on the significance of inquiry-based learning through practical activities that support teachers and students in teaching general science subjects in the classrooms of all sub-cities in Addis Ababa Middle schools under the study. Even though, students and teachers are with the positive outlook on the importance of inquiry-based learning through practical activities, the awareness of teachers and students in these schools regarding the application of practical activities through the practical strategies of scientific inquiry is deprived.

As to the major factors which are accountable to the low implementation of inquiry-based learning through practical activities in middle-level schools, a significant proportion (85.0%, 88.3%, and 76.7%) of teachers and (92.8%, 94.7% and 89.0%) of students reflects that the teachers exposure to traditional lecture method, lack of additional training on inquiry-based learning through practical activities and teachers' and students lack of interest has affected the practices of inquiry-based learning through practical activities in schools under study. Other than, the teachers and students related factors significant majority (88.3%, 85.8%, and 89.2) of the teachers and (96.1% and 93.1%) of students respectively reported that the lack of sufficient and suitable materials, time constraints, and financial limitations hindered the implementation of actual practices of inquiry-based learning through practical activities or such pedagogical approaches. In addition to this, a potential gap in support mechanisms, as only 14.2% of teachers and 8.8% students feel that their schools initiate them to develop team spirit in practical activities and foster collaborative learning environments. Yet, 85.8% of teachers and 91.2% of students reflected that the school administrative principals does not initiate them to develop team spirit in practical activities and fostering collaborative learning environments in their school context and the school principals facilitating role in implementing practice focused science lessons is missed.

In general it was witnessed that there was a laboratory in the schools but they did not seem functioned, most the laboratory technicians are with double duty, the facilities and equipment were not adequate or misplaced here and there. Science department head teachers, laboratory technicians and school vice principals' reported common challenges raised are lack professional training on how to apply practical activities for teachers, trained laboratory technicians and principals, lack of experience and ability, time limitations, a predominance of lecture-based methods, a general reluctance to use inquiry-based learning through practical activities, a lack of adequate and relevant resources, and a lack of support and follow-up from school administration are the major hindering factors.

5.3. Conclusions

The Ministry of Education underlined the importance of the general science curriculum chiefly based on inquiry-oriented instruction, which is about teaching science education through practical activities. Inquiry-oriented pedagogy can be effective if science teachers are supported with adequate laboratory facilities, science equipment, and high-quality teachers to support students technically (MOE, 2018). Through applying this approach, students should become more active participants in their learning by exploring, observing, experimenting, and practicing in teaching and learning methodologies and enable them to participate in various appropriate activities to enhance students' participation in their own learning. Based on the analysis of the data, the following conclusions are derived:

A. Regarding implementing the inquiry-based learning through practical activities in the general science (Biology, chemistry & physics) curriculum in the observed schools is not adequately implemented. They implement the curriculum by showing microscopes and images of local materials in the students' textbooks. Lecturing methods, writing notes, and question and answer are powerful strategies teachers apply. However, these methods of delivering general science commonly used to implement practical activities in science classes do not typically engage students in practical activities. This can indicate that teachers are more concerned about theoretical knowledge and skills than their practical expressions in an authentic world. In addition, the traditional teaching method, predominantly lecture-based and supplemented with copying notes from textbooks, coupled with question-and-answer sessions, remains the primary strategy for teaching general science subjects in the target schools.

In general, the findings revealed a strong dependence on traditional teaching techniques among science teachers in Addis Ababa. Although there are efforts in some areas, particularly Yeka and Akaki Kaliti, to integrate inquiry-based approaches, their application remains limited and slanted toward structured or confirmation inquiry, with very minimal adoption of guided and open inquiry methods. This pattern specifies a slow and irregular shift toward modern, participatory student focused pedagogies in general science instruction.

B. The other issue addressed in this study was the teachers' perception and students' awareness of the implementation of inquiry-based learning through practical activities in the general science curriculum in the middle schools, most of teachers and students agreed on the advantages of inquiry-based practical activities while teaching general science subjects, but there were differences in their comprehension of how to implement inquiry-based learning through practical activities. This indicates that while teachers acknowledge the worth and advantages of inquiry-based learning through practical activities, they still think that teacher-oriented education is superior since it is easier to execute.

Teachers were also listing the techniques they use to conduct inquiry-based learning through practical activities. They asserted also assist their learners by providing notes, homework, group projects, power point explanation, and demonstration of materials. Most of the tactics taught by the teachers are derived from the traditional teaching approach. As they assumed about it, they also continued to think that practical activities could only be done in laboratory settings. Teachers in these schools are with low level of awareness about how to execute practical activities using scientific inquiry's practical methodologies. Scholars support this, when a teacher applies inquiry-based learning through practical activities improperly in science instruction may not produce the expected constructive results and the disappointed teacher return to a traditional teaching approach (Darling-Hammond, 2008).

Therefore, it is imperative that teachers obtain professional competency to implement inquiry-based practical activities, which involves a set of different capabilities to be effective during the delivery of general science lessons. Additionally, science teachers must determine which inquiry-based activities level is acceptable to use as well as what information and skills their students should acquire, at what level, and in what order (Trna et al., 2012) is very crucial in science curriculum delivery.

Students also reflected their positive outlook to the importance of inquiry-based learning through practical activities. However students reflect the practical activity strategies included asking questions orally, providing explanations, taking notes on the blackboard, giving class works and home works, assignments, and occasionally using laboratory exercises as the main practical activities employed by their science teachers during the general science lesson deliveries. The majority of students did not properly differentiate between theoretical and practical activity techniques, as can be inferred from the study above, given that the majority of the activities classified as practical still do not qualify as such. Consequently, there is a lack of awareness among teachers and learners in these schools concerning how to apply general science lessons using inquiry-based learning through practical activities in their real context.

C. The research revealed that the middle schools have a low level of implementation of inquiry-based learning through practical activities during general science lesson delivery. The main factors responsible for this low level of implementation include teachers' exposure to traditional lecture method, lack of additional training on inquiry-based learning through practical activities and teachers' and students lack of interest has affected the practices of inquiry-based learning through practical activities in schools under study. It also, highlights issues related to teachers' lack of willingness and initiation to carry out practical activities, a mismatch of interests between teachers and students, a lack of professional training for teachers and lack of students awareness, the absence of trained laboratory technicians, scarcity of materials and facilities, a lack of motivation and guidance for student learning, and a lack of commitment from school authorities.

In contrast, Ethiopia still faces several challenges in delivering quality science education, including limited access to laboratory facilities, shortage of qualified science teachers, lack of financial support, and technological advances that do not align educational content with industry needs etc.…(UNESCO, 2022).

These elements significantly affected the implementation of inquiry-based learning through practical activities and the practice of hands-on activities in general science education remains limited in the middle schools of Addis Ababa, leading to poor performance in science subjects by students. Therefore, providing support by developing assistant policies and guidelines, enough resources and infrastructure, as well as encouraging teacher training and cooperation, is a chance to improve the science education delivery.

5.4. Recommendations

The current educational policy in Ethiopia underscores the importance of a general science curriculum, focusing primarily on inquiry-oriented instruction. This approach entails imparting science education through practical activities. Implementing inquiry-based learning pedagogy across all levels can effectively enhance science education in schools. This approach fosters active student participation in their learning by allowing them to engage or observe, explore, explain, experiment, and practice, thereby encouraging involvement in various practical activities to boost their learning. However, implementing inquiry-based learning through practical activities in the science curriculum requires adequate human resources, suitable, and sufficient materials, among other prerequisites. Attempting to carry out the curriculum without meeting these essential elements poses significant challenges. Therefore, based on the evidence from this study, the following recommendations have been forwarded:

A. Teachers in the target schools are primarily reliant on lecture-based methods for teaching science subjects. Teachers are still using the explanation or lecture method, simple explanation of the content theoretically. And they convey scientific content hypothetically and tend to believe that practical activity in science education is confined solely to laboratory-based activities. This belief discourages them from attempting or guiding student activities outside the lab due to their perspective and challenges with lab facilities. Teachers should go beyond the dissemination of content, they are supposed to be teachers of how to teach, how to facilitate the contents, and they should serve as role models for their students.

Therefore, it is essential to provide teachers the subject-matter expertise that is in line with their pedagogical content knowledge, along with the technological pedagogical content knowledge and the skills they need to apply the science curriculum in the given setting. Additionally, in order to experience professional knowledge, professional practice, and professional engagement, as well as comprehend the concept of inquiry-based practical activities and develop their ability to learn from and teach in a real-world setting, science teachers should be equipped with 21st-century soft skill competencies like learning skills, literacy skills, and life skill. Thus, teacher-educators should prepare to model good practices for their students. They have to update themselves on appropriate pedagogies for teacher education and use them in their classrooms. Therefore, the education professionals should evaluate themselves and go to the actual context of the school environment to support teachers on how to teach the science curriculum as a facilitator and as coaches in inquiry-based practical learning.

B. The awareness of teachers and students on the practical activities in science education is limited to the laboratory-related activities and the rote memory learning techniques only when there are other various kinds of activities. Science teachers, on the other hand, are expected to go beyond content dissemination and implement inquiry-based practical activities, teach students how to interact science content with real-world contexts, assist students while engaged in practical tasks, and serve as role models for their students. This application should not be limited to lab activities and will facilitate the enhancement of their contextual knowledge, technical skills, critical thinking abilities, problem-solving skills, and other essential skills for the current century.

Accordingly, the Addis Ababa City Administration Education Bureau should prioritize improvements in science teaching especially in middle-level general science by strengthening teacher capacity through comprehensive professional development programs focused on inquiry-based practical activities. Support should also include promoting teacher collaboration, providing technical assistance, encouraging hands-on learning such as science clubs, and implementing strategies to increase student engagement in practical activities, guiding them during conducting practical activities, and promote practical experiences. Additionally, increase awareness among stakeholders, such as parents, community members, and policymakers, about the significance of inquiry-based learning through practical activities in science education. This will help in identifying gaps, tracking progress, and making required adjustments to improve effectiveness of different practical activities in science classes. Therefore, it is essential to help teachers know the different practical activities strategies vital to teaching science subjects by preparing professional training for teachers and awareness creation for students.

C. Without fulfilling the necessary human and material resources, the implementation of inquiry-based learning through practical activity is challenging to meet the intended goals of the science curriculum. Thus, giving priority to arranging and overcoming the shortcoming in the schools is very important to improve the education quality system/quality assurance in the schools. School leaders and other relevant authorities should strategize to resolve the deficiency of necessary human and other resources for implementing practical activities in middle level schools, where students are expected to acquire fundamental science skills. Such steps are crucial to nurturing students' areas of interest and improving the quality of science education. Therefore, the following recommendations aim to bridge the implementation and quality gaps are forwarded:

- ✓ Professional Development**:** there is a clear need for ongoing professional development programs that equip teachers with the skills and confidence to implement IBPA effectively. Therefore, implement continuous comprehensive professional development programs focused on inquiry-based practical activities include workshops, continuous training sessions, and certification courses to equip teachers and school principals with the necessary skills and knowledge is important and timely.
- ✓ Improvement of Resource Allocation: schools must be better equipped with the necessary materials and facilities to conduct practical activities. This involves not only physical resources but also access to updated curriculum guides and teaching materials such as well-equipped laboratories, adequate supplies, and up-to-date technological tools and professionally trained laboratory technicians, school principals to facilitate hands-on learning that support IBPA in middle schools is crucial.
- ✓ Foster a Supportive Learning Environment: create a school culture that values and supports inquiry-based practical activities. This involves encouraging collaboration among teachers, providing technical support, and fostering a positive attitude towards innovative teaching methods.
- ✓ Cultural Shift in Teaching Practices: efforts should be made to shift the prevailing educational culture towards a more student-centered approach that values and prioritizes hands-on learning. This cultural shift can be facilitated through leadership training, community engagement, and highlighting successful examples of inquiry-based learning through increasing students engagement strategies to actively involve students in practical activities. This could include project-based learning, guiding students during conducting practical activities, science clubs, and extracurricular activities that promote hands-on experiences. Policy and Curriculum Reform: educational policymakers should consider integrating inquiry-based methods more prominently within the national curriculum standards which includes providing clear guidelines and support for teachers on how to balance theoretical knowledge with

practical skills through promoting awareness and advocacy among stakeholders, including parents, community members, and policymakers, about the importance of inquiry-based learning through practical activity in science education; because advocacy efforts can help garner support and resources for the implementation of practical activities.

- ✓ Monitor and Evaluate Implementation: continued research is needed to evaluate the long-term impact of IBPA on student learning outcomes and to identify best practices. Such research can inform ongoing adjustments to teacher training programs and curriculum development and establish a system for regular monitoring and evaluation of the implementation of inquiry-based practical activities. This will help identify challenges, track progress, and make necessary adjustments to improve effectiveness of science education.

The Addis Ababa City Administration Education Bureau and similar education authorities must prioritize science-education reform by investing in teacher capacity building, ensuring adequate resources, and fostering community engagement. Specifically, they should implement comprehensive professional-development programs focused on inquiry-based practical activities, support teacher collaboration, deliver technical assistance, and encourage hands-on learning and student-centered practical activities. These actions will strengthen science teaching, boost students' critical thinking and problem-solving skills, and better prepare them to face the challenges of the modern world.

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List of Publications

Publication 1: Implementation of Inquiry-based Practical Activities in General Science Education: With Specific Reference to Primary Schools in Addis Ababa City (DOI: 10.7176/RHSS/12-5-02)

Publication 2: Implementation of Inquiry-based practical activities in science classrooms in Middle schools of Addis Ababa, Ethiopia (DOI: https://doi.org/10.53378/ijemds.353161)

Appendices

Appendix A: Letter of Research Permission and Cooperation

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Addis Ababa University
College of Education
Department of Curriculum
and Instruction

☎ 251 11 123 97 16 ✉ 1176 Fax: 00251(11) 242719 e-mail: ctpd@aau.edu.org.et

Date: April 27, 2022

Ref. No. C&I/32/2022

To: Addis Ababa

Subject: **Cooperation**

Ms. Azebe Brhane is a PhD Student (ID.No. GSR/1977/10) at Addis Ababa University, College of Education and Behavioral Studies in the Department of Curriculum and Instruction. She is working on a research project titled "**Implementation of inquiry-based Practical Activities in Science Curriculum at Primary School of Addis Ababa**"

I would be most grateful if you extend to her all the necessary assistance regarding this matter.

Thank you for your kindness

Sincerely,

Teshome Tola (PhD)
Chairperson, Department of Curriculum and Instruction

አዲስ አበባ ዩኒቨርሲቲ
ሥነ ትምህርት ኮሌጅ
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Addis Ababa University
College of Education
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and Instruction

☎251 11 123 97 16 ✉1176 Fax: 00251(11) 242719 e-mail: ctpd@aau.edu.org.et

Date: April 27, 2022

Ref. No. C&I/32/2022

To: Arabsa primary & middle School
Addis Ababa

Subject: Cooperation

Ms. Azebe Brhane is a PhD Student (ID.No. GSR/1977/10) at Addis Ababa University, College of Education and Behavioral Studies in the Department of Curriculum and Instruction. She is working on a research project titled "**Implementation of inquiry-based Practical Activities in Science Curriculum at Primary School of Addis Ababa**"

I would be most grateful if you extend to her all the necessary assistance regarding this matter.

Thank you for your kindness

Sincerely,

Teshome Tola (PhD)
Chairperson, Department of Curriculum and Instruction

አዲስ አበባ ዩኒቨርሲቲ
ሥነ ትምህርት ኮሌጅ
የሥርዓተ ትምህርትና ማስተማር
ትምህርት ክፍል

Addis Ababa University
College of Education
Department of Curriculum
and Instruction

☎ 251 11 123 97 16 ✉ 1176 Fax: 00251(11) 242719 e-mail: ctpd@aau.edu.org.et

Date: April 27, 2022

Ref. No. C&I/32/2022

To: [illegible]
Addis Ababa

Subject: Cooperation

Ms. Azebe Brhane is a PhD Student (ID.No. GSR/1977/10) at Addis Ababa University, College of Education and Behavioral Studies in the Department of Curriculum and Instruction. She is working on a research project titled "**Implementation of inquiry-based Practical Activities in Science Curriculum at Primary School of Addis Ababa**"

I would be most grateful if you extend to her all the necessary assistance regarding this matter.

Thank you for your kindness

Sincerely,

Teshome Tola (PhD)
Chairperson, Department of Curriculum and Instruction

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Addis Ababa University
College of Education & Behavioral Studies
Department of Curriculum and Instruction

☎ 251 11 123 97 16 ✉ 1176 Fax: 00251(11) 242719 e-mail: ctpd@aau.edu.org.et

Date: October 26,2023
Ref. No. C&I/13/2023

TO:________________________________
Addis Ababa

Subject: Cooperation

Azeb Brhane is a PhD student in our Department of Curriculum & Instruction, Addis Ababa University. Currently he/she is working on his/her thesis titled **Implantation of inquiry-based Practical Activities in Science Curriculum at Primary School of Addis Ababa**

I would be most grateful if you extend to them all the necessary assistance regarding this matter.

Thank you for your kindness

Sincerely,

Abdulaziz Hussien (PhD)
Chairperson, Department of Curriculum and Instruction

አዲስ አበባ ዩኒቨርሲቲ
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Addis Ababa University
College of Education & Behavioral Studies
Department of Curriculum and Instruction

☎ 251 11 123 97 16 ✉ 1176 Fax: 00251(11) 242719 e-mail: ctpd@aau.edu.org.et

Date: October 26,2020
Ref. No. C&I/13/2020

TO: HIBRET FIREE K.G AND PRIMARY SCHOOL
Addis Ababa

Subject: Cooperation

Azeb Brhane is a PhD student in our Department of Curriculum & Instruction, Addis Ababa University. Currently he/she is working on his/her thesis titled **Implantation of inquiry-based Practical Activities in Science Curriculum at Primary School of Addis Ababa**

I would be most grateful if you extend to them all the necessary assistance regarding this matter.

Thank you for your kindness

Sincerely,

Abdulaziz Hussien (PhD)
Chairperson, Department of Curriculum and Instruction

Wudu Zerie Bayeh
Vice Director

Appendix B: Consent Forms

Addis Ababa University
School of Graduate Studies
College of Education and Language Studies
Department of Curriculum and Comparative Education

Title of the Research Project:

Implementation of Inquiry-based Practical Activities in General Science Education at Middle Schools of Addis Ababa, Ethiopia

Researcher: Azeb Brhane Gebru

Dear participants, I am a PhD. Student at Addis Ababa University, Department of Curriculum and comparative education. As part of the requirements for my doctoral study, I'm doing a research study on the title provided above. The study will be conducted based on the data given by school practitioners such as teachers, students and school principals etc... Nevertheless, your participation in this research is completely voluntary. I need to know whether you like to participate through providing the following information. Before that you are politely requested to participate in this study since you are the right sources of data I need for my study. Thus, it would be my desire if I get your consent. I would like to read the following consent statements and describe each loud to you, too. Again, I will answer any questions, or reflect on any of the worries or comments you may have about the study in general and each consent statements in particular. The information obtained will be used only to achieve the purpose of the study. I need to guarantee that no risks are put in a situation where you may be harmed physically or psychologically as a result of your participation. No information given in the interviews or discussion will be made public in any form that could identify you and your school, and pennames or codes will be used to protect your identity. Again, participation in the study is strictly voluntary and your confidentiality is assured. The answers, views or particular experiences obtained from you will be explained anonymously in that the results of the study will be reported without disclosing any identifying characteristics and information. However, the results of the study will be reported to the public honestly. Again, the information obtained in this study may be published in academic journals, used for further research works or it may be presented at scientific meetings or research conferences. Additionally, I will keep the data in a secure place such as protecting it in my personal computer. As research participants, your rights will be safeguarded and participation in the study will be totally voluntary. You have the right not to take part in the study at all. If you want to stop or withdraw during the interview or focus group discussion, you can do that at any time you wish without any negative consequence such as penalty. In addition, I may also need to conduct a follow-up interview (most likely with teachers and school principals by telephone) in order to check on any questions that may arise over the research period. My research is being conducted under the supervision of Dr. Solomon Areaya and Dr. Meseret Assefa (Addis Ababa University; emails:solomonaeayak@gmail.com). Thank you for considering my request!

Yours sincerely,

Azeb Brhane

PhD student at Addis Ababa University, Ethiopia

Telephone: +251912187729

Email: azebhane@gmail.com.

Participant consent form and information sheet

Addis Ababa University

School of Graduate Studies

College of Education and Language Studies

Department of Curriculum and Comparative Education

Title of the Research:

Implementation of Inquiry-based Practical Activities in General Science Education at Middle Schools of Addis Ababa, Ethiopia

Researcher's name and address: Azeb Brhane Gebru

Email: azebhane@gmail.com

Name of the participant of the research ________________________________, I consent and agreed to participate in this research voluntarily. I obtained the necessary information about my role in the research, the confidentiality of the data and the nature and objective of the research through reading the information sheet and the detailed orientation provided by the researcher. I also understand that I can withdraw from the research at any time based on my own interest and convenience. I also got the copy of the signed participant consent and information sheet. I agreed and gave permission to the researcher and the university to use and publish the data.

Name of the research participant ______________signature ________Date _______________

Name of witness ___________________Signature_____________Date ________________

Appendix C: Science Teachers Questionnaire

Addis Ababa University

School of Graduate Studies

College of Education and Language Studies

Department of Curriculum and Comparative Education

Questionnaires for Science Teachers

General direction to all respondents

Dear respondents the main aim of this study is to investigate the practices of Inquiry-based practical activities in general science teaching, how teachers & students perceive Inquiry-based practical activity and what challenges hinder the practice of science education to fill the teaching learning gaps by observing the implementation process of the practical activities in science education curriculum and to suggest the possible recommendations based on the major findings of this research. Therefore, I kindly requested you and your cooperation to provide genuine information for it highly determines the success of the study. Thus, it should be known that the information you give will be used for the academic purpose only and individual data will kept confidential. At last, the researcher wants to send her thanks in advance for your cooperation and devotion of time.

Thank you!

A QUESIONNAIRE TO BE FILLED BY GRADE 7 AND 8 SCIENCE TEACHERS

Part one: Demographic Information

Note

1. You are kindly requested not to write your name.
2. To those questions with alternative, indicate your response on the space provided by putting "√" or encircling the letter.
3. For any additional opinion and explanation, you are kindly requested to write briefly on the space provided.

Thank you in advance for your cooperation

Personal Information

1. School Name: ______________Department _________Sex: M ________ F _______

2. Qualification:

    a. Diploma

    b. B.E.D

    c. B.Sc. /MSc
    d. B.Sc. + PGDT
    e. Please specify if any

3. Total teaching experience:
    a. Less than 5 years
    b. 6-10 yrs
    c. 11-15 yrs
    d. 16-20 yrs
    e. 21 yrs & above

4. Have you taken a course of pedagogy in your undergraduate training?

    Pedagogical training during pre-service training

    a. Yes b. No

On job/in-service pedagogical training

A. Yes B. No

Part two: The current practices of Inquiry-based practical activities in science subjects

DIRECTION: Items related to your current practices of Inquiry-based practical activities are provided below. Please, give appropriate answers based on your experiences by putting a tick (√) mark in the box and fill the appropriate response in the blank space.

Inquiry-based practical activity is operationalized in this study as an investigative approach to teaching and learning science by provided students with opportunities to ask questions, investigate a problem, search for possible solutions, make observations, test out ideas, think creatively, use hands-on activities over several classes in their authentic situation to relate theoretical knowledge with practical activities done in the laboratory, classroom, field or elsewhere.

1. Are you familiar with the Inquiry-based activities?

   Yes ☐ No ☐

2. If your answer for question number 1 is 'yes', do you use Inquiry-based practical activities in your delivery of sciences subjects?

   Yes ☐ No ☐

3. How often do you use the practical activities in your science classes?

   Usually ☐ Sometimes ☐ rarely ☐ Not at all ☐

4. Do you give practical activity works for your students to conduct outside their class/school?

   Yes ☐ No ☐

5. If your response to the above question is 'YES' how often do you give?

   1times per a week ☐ 3times per a month ☐ 2 times per a semester ☐

6. To what extent are students motivated to conduct the practical activities while you give the

   activities? Very high ☐ High ☐ Average ☐ Low ☐

7. To what extent do you think that students are aware of applying practical activities in your school?

   Very well ☐ Well ☐ Poor ☐

8. How often do you relate your lesson with your life activities or environmental realities?

   Usually ☐ Sometimes ☐ rarely ☐ Not at all ☐

9. How often do you conduct practical activities in laboratory class in your school?

Always ☐ Sometimes ☐ rarely ☐ not at all ☐

10. How often do you use the teaching techniques in delivering science lessons in your school?

No	Teaching techniques	How often		
		always	**Some times**	**Not at all**
1	**Traditional/one way**			
	1.1. Teacher's demonstration			
	1.2. Lecture/Explanation			
2	**Structured Inquiry**			
	2.1. Question & answer			
	2.2 Modeling			
	2.3. Written responses			
3	**Confirmation inquiry**			
	3.1.Group works			
	3.2. Observation			
	3.4. Reflecting findings			
	3.5. Individual/peer presentation			
4	**Guided Inquiry**			
	4.1. inquiry- based Investigation			
	4.2. Generate findings			
5	**Open Inquiry**			
	5.1. Project works			
	5.2. Field visits			
	5.3. Reflection			
	5.4. Discussion with classmates			

PART TWO: Inquiry-based practical activities in science teaching

DIRECTION: Please, give appropriate answers based on your view by putting a tick (√) mark in the box and fill the appropriate response in the blank space. Please indicate your level of agreement or disagreement regarding the statement in the table.

Key: S. A- Strongly agree **A**- Agree **U**- Undecided **D**. A- Disagree **S. D**- Strongly disagree

A.

NO	**Basic concepts of Inquiry-based practical activities**	**S.A**	**A**	**U**	**D.A**	**S.D**
1	Inquiry-based practical activities enable learners to understand & solve their problems.					
2	Inquiry-based practical activities provide learners with better understanding science concepts in their environment/context.					
3	Inquiry-based practical activities help the learners to share experiences &learn from each other.					
4	Inquiry-based practical activities develop self-confidence & independent learning for the teacher.					
5	Inquiry-based practical activities develop self-confidence & independent learning for the learner.					
6	Inquiry-based practical activities prepare the learner to solve real problems in the society.					
7	The role of teacher is facilitating the learning process rather than controlling.					
8	Using Inquiry-based practical activities helps to develop students self-learning abilities and skill.					
9	Inquiry-based practical activity strategies promote the development of students' interpersonal skill.					
10	Inquiry-based practical activity strategies promote the students' to learn from practical world than the theoretical one.					

B.

NO	Basic concepts of Inquiry-based practical activities	S. D	D .A	U	A	S. A
1	It is too difficult to practice Inquiry-based practical activities in schools.					
2	Learning is occurring when learners are silent & passive receivers of information from the teacher.					
3	Inquiry-based practical activities takes time so, traditional methods are preferable to implement.					
4	Learning is effective when teachers have good subject matter knowledge to narrate rather than the knowledge of how to teach.					
5	Using lecture method is helpful because with in short time one can transmitting or fill the learners mind with a lot of knowledge.					
6	In Inquiry-based practical activities teachers are the sources of knowledge in the teaching & learning process.					
7	The strategies of Inquiry-based practical activity do not promote students' to learn from practical world than the theoretical one					
8	Inquiry-based practical activity strategies are conducted in laboratory class only					
9	An Inquiry-based practical activity doesn't contribute to prepare learner to solve real problems in the society.					
10	Inquiry-based practical activities make the science lessons difficult during delivery in schools.					

PART THREE: Factors May Hinder the practice of Inquiry-based practical activities in science teaching

DIRECTION 1**:** Please show what you feel right by using a tick (√) mark in the box and fill the right response in the space provided.

1. Do you think that there are sufficient and suitable materials in your school to be used in practicing Inquiry-based practical activities? Yes ☐ No ☐

2. Do you think that shortage of time influence the actual practices of Inquiry-based practical activities in your school Yes ☐ No ☐

3. Do you think that lack of financial support influence the actual practices of Inquiry-based practical activities in your school? Yes ☐ No ☐

4. How is the school equipped with the necessary instructional materials to practice inquiry-based practical activities? Very high ☐ High ☐ Medium ☐ Low ☐ Very low ☐

5. Do you think that the traditional lecture method has affected the practices of inquiry-based practical activities in your science teaching? Yes ☐ No ☐

6. Teachers lack of interest has affected the practices of Inquiry-based practical activities in the school? Yes ☐ No ☐

7. Does the school assesses the problems of teachers in practicing practical activities and provides immediate solutions to the problems? Yes ☐ No ☐

8. Do you think that you need additional training on Inquiry-based practical activity?

Yes ☐ No ☐

9. If your answer for the above question is yes, on which area and why?

1.____

2. ____

3.____

10. Please list factors that you think are the main problems in practicing Inquiry-based practical activities in your sessions?

1. ____

2. ____

3.____

4. ____

11. What are your suggestions to solve the problems and to implement Inquiry-based practical activity strategies effectively in school?

1. ____

2. ____

3. ____

Appendix D: Students Questionnaire

Appendix (English Version)

Addis Ababa University

School of Graduate Studies

College of Education and Language Studies

Department of Curriculum and Comparative Education

Questionnaires for Grade 7& 8 students

General Direction

Dear respondents the main aim of this study is to investigate the practices of Inquiry-based practical activities in general science teaching, how teachers & students perceive Inquiry-based practical activity and what challenges hinder the practice of science education to fill the teaching learning gaps by observing the implementation process of the practical activities in science education curriculum and to suggest the possible recommendations based on the major findings of this research. And it is also aimed at suggesting the possible recommendations based on the major findings of this research. Therefore, I kindly requested you and your cooperation to provide genuine information for it highly determines the success of the study. Thus, it should be known that the information you give will be used for the academic purpose only and individual data will kept confidential. At last, the researcher wants to send her thanks in advance for your cooperation and devotion of time.

Thank you!

Part one: Awareness on Inquiry-based practical activities in science teaching

DIRECTION 1: Items related to your awareness on Inquiry-based practical activities are provided below. Please, give appropriate answers based on your experiences by putting a tick (√) mark in the box and fill the appropriate response in the blank space if necessary.

School Name:______________________________

1. Do you have any knowledge about inquiry- based practical activities?

   Yes ☐ No ☐

   If your answer for question number one is 'yes' answer questions 2-5

2. Do you think that an Inquiry-based practical activity is better than lecturing method?

   Yes ☐ No ☐

3. What is your outlook towards Inquiry-based practical activities?

   Positive ☐ Negative ☐

4. Do you think that Inquiry-based practical activities resulted in greater quality of teaching than traditional lecture method?

   Yes ☐ No ☐

5. Do you think that using Inquiry-based practical activities help to develop students self-learning abilities and skills?

   Yes ☐ No ☐

Part Two: Practices of Inquiry-based practical activities

DIRECTION 1: Items related to the different instructional techniques that your sciences teachers employ to deliver their subject matter are listed below. Please, show how often your teachers use these methods by putting a tick (√) mark in one of the boxes in the response scale.

1. Extent of using teaching techniques in science classes

No	Teaching techniques	How often			
		always	Some times	Rarely	Not at all
1	Traditional/one way				
	1.1.Teacher's demonstration				
	1.2. Lecture/Explanation				
2	Structured Inquiry				
	2.1. Question & answer				
	2.2. Modeling				
	2.3. Written responses				
3	Confirmation inquiry				
	3.1.Group works				
	3.2. Observation				
	3.3. Laboratory based activities				
	3.4. Reflecting findings				
	3.5. Individual/peer Presentation				
4	Guided Inquiry				
	4.1. inquiry- based Investigation				
	4.2. Generate findings				
5	Open Inquiry				
	5.1. Project works				
	5.2. Field visits				
	5.3. Reflection				
	5.4. Discussion with Classmates				

Part Three: Factors May Hinder the practices of Inquiry-based practical activities

DIRECTION: Items related with factors that hindering the implementation of Inquiry-based practical activities are listed below. Please show what you feel right by using a tick (√) mark in the box and fill the right response in the space provided.

1. Do you think that there are sufficient and suitable materials used in implementing practical activities in your school? Yes ☐ No ☐

2. Do you think that shortage of time and finance influence the actual practices of Inquiry-based practical activities in your school? Yes ☐ No ☐
3. How is the school equipped with the necessary instructional materials to implement practical activities learning strategies?

   Very high ☐ High ☐ Medium ☐ Low ☐ Very low ☐

4. To what extent do your science teachers implemented practical activity techniques while they teach science in your school?

   Very high ☐ High ☐ Average ☐ Low ☐

5. Do you think that your teachers' tendency to the traditional lecture method has affected the implementation of practical activity in science? Yes ☐ No ☐
6. Do you think that your teachers' lack of necessary training affected the full implementation of practical activities in science classes in your school? Yes ☐ No ☐
7. Teachers' lack of interest has affected the implementation of practical activities in the schools? Yes ☐ No ☐
8. Does the school initiate students to develop team sprit on practical activities in science?

   Yes ☐ No ☐

9. In your classroom you may face difficulties preventing you from involving on practical activities, please try to list factors that you think are the main problems in practicing inquiry-based practical activities in your classroom/ school?

   1. ____
   2. ____
   3. ____

10. What are your suggestions to solve the problems and to implement Inquiry-based practical activity strategies effectively?

    1. ____.
    2. ____.

Appendix (Amharic Version)

ቅፅ-ዲ

አዲስ አበባ ዩኒቨርሲቲ

የትምህርት እና የስነ-ባህርይ ሳይንስ ኮሌጅ

የስርዓተ ትምህርት እና መመሪያ ክፍል

የ7ኛ እና 8ኛ ክፍል ተማሪዎች መጠይቅ

አጠቃላይ አቅጣጫ

ውድ ተማሪዎች የዚህ ጥናት ዋና አላማ በተፈጥሮ ሳይንስ የትምህርት ዓይነቶች ተግባር ተኮር ትምህርት አሰጣጥ፣ የመምህራን እና የተማሪዎች ጥያቄን መሰረት ያደረጉ ተግባር ተኮር ዘዴዎች ግንዛቤ እና የሳይንስ ትምህርትን ተግባራዊ ለማድረግ የሚያጋጥሟቸው ተግዳሮቶችን በመለየት የመማር ማስተማር ክፍተቶችን ለመጠቆም ነው። እንዲሁም በአጠቃላይ የተፈጥሮ ሳይንስ ሥርዓተ-ትምህርት ውስጥ በተግባር የተደገፉ የትምህርት አተገባበር ሂደት በመመልከት፤ በዚህ ምርምር ዋና ዋና ግኝቶች ላይ በመመርኮዝ ሊሆኑ የሚችሉ ምክሮችን ለማቅረብ ያለመ ነው። ስለሆነም የጥናቱ ስኬት እርስዎ በሚሰጡኝ እውነተኛ መረጃ ላይ የተመሰረተ በመሆኑ አስፈላጊውን ትብብር እንዲያደርጉልን በአክብሮት እጠይቃለሁ። በተጨማሪ እርስዎ የሚሰጡት መረጃ ለትምህርታዊ ዓላማ ብቻ የሚውል መሆኑና የግለሰብ መረጃዎች በሚስጥር እንደሚጠበቁ ለማሳወቅ እወዳለሁ። በመጨረሻም ለሚደርጉት ትብብር እና ውድ ጊዜዎ በቅድሚያ አመሰግናለሁ።

አጥኟ

ክፍል አንድ፡ በሳይንስ ትምህርት ውስጥ በጥያቄ ላይ የተመሰረቱ ተግባር ተኮር ዘዴዎች ግንዛቤ

አቅጣጫ 1፡ በጥያቄ ላይ የተመሰረቱ ተግባር ተኮር የማስተማር ዘዴዎች ላይ ያለህ/ሽ ግንዛቤ ጋር የተያያዙ ጥያቄዎች ከዚህ በታች ቀርበዋል። እባክዎት በሳጥኑ ውስጥ ይህ (√) ምልክት በማድረግ ከተሞክሮዎ በመነሳት ተገቢውን መልስ ይስጡ እና አስፈላጊ ከሆነ ባዶ ቦታ ላይ ተገቢውን ምላሽ ይሙሉ።

1. በጥያቄ ላይ የተመሰረቱ ተግባራዊ የማስተማርያ ስነ-ዘዴዎች በተመለከተ ግንዛቤው አለህ/ሽ?

አዎ ☐ የለኝም ☐ የተለየ____

ለጥያቄ ቁጥር አንድ መልስዎ ‘አዎ’ ከሆነ ከ2-5 ጥያቄዎችን ይመልሱ።

2. በጥያቄ ላይ የተመሰረቱ ተግባር ተኮር የማስተማር ስነ-ዘዴ በገለፃ ከማስተማርያ ስነ-ዘዴ የተሻለ ነው ብለህ/ሽ ታስቢያለህ/ሽ?

አዎ ☐ አይደለም ☐ የተለየ ____

3. በጥያቄ ላይ የተመሰረቱ ተግባር ተኮር የማስተማርያ ዘዴዎች ላይ ያለህ/ሽ አመለካከት ምን ይመስላል?

አዎንታዊ ☐ አሉታዊ ☐ የተለየ __________________________________

3. ጥያቄን መሰረት ያደረጉ ተግባር ተኮር የማስተማርያ ስነ-ዘዴዎች ከ መምህር ተኮር ስነ-ዘዴዎች የበለጠ ውጤታማ የሚያደርግ ይመስላችኋል?

አዎ ☐ አይደለም ☐ የተለየ______________________________________

4. ጥያቄን መሰረት ያደረጉ በተግባር የተደገፉ የማስተማር ስነ-ዘዴዎችን መጠቀም የተማሪዎችን በራስ የመማር ችሎታ እና ክህሎት ለማዳበር የሚረዳ ይመስልሀል/ሻል?

አዎ ☐ አይደለም☐ የተለየ ____

ክፍል ሁለት፡- በጥያቄ ላይ የተመሰረቱ ተግባር ተኮር የማስተማርያ ዘዴዎች አጠቃቀም

አቅጣጫ 1፡ የአጠቃላይ ሳይንስ (የባዮሎጂ፣ ኬሚስትሪና ፊዚክስ) አስተማሪዎችዎ ከሚጠቀሙባቸው የተለያዩ የማስተማሪያ ዘዴዎች ጋር የተያያዙ ሀሳቦች ከዚህ በታች ተዘርዝረዋል። እባክዎን አስተማሪዎችዎ በምላሽ ሚዛን ውስጥ ካሉት ሳጥኖች ውስጥ በአንዱ ይህ (√) ምልክት በማድረግ እነዚህን ዘዴዎች ምን ያህል ጊዜ እንደሚጠቀሙ ያሳዩ።

No	Teaching techniques	How often/ድግግሞሽ			
		Always (ሁልጊዜ)	Some times (አንዳንድ ጊዜ)	Rarely (አልፎአልፎ)	Not at all (በጭራሽ)
9.1	Teacher's demonstration (በስዕል፣በቻርት ማሳየት)				
9.2	Lecture/Explanation (በገለፃ)				
9.3	Structured Inquiry				
	9.3.1 Question & answer(በጣያቄና መልስ)				
	9.3.2 Modeling (ማሳያ)				
	9.3.3 Written responses (በፅሁፍ መመለስ)				
9.4	Confirmation inquiry				
	9.4.1.Group works (የቡድን ውይይት)				
	9.4.2. Observation (ምልከታ)				
	9.4.3. Laboratory based Activities (የቤተ ሙከራ ተግባራት)				
	9.4.4. Reflecting findings				
	9.4.5. Individual/peer Presentation (በግ/አቻ አቀራረብ)				
9.5	Guided Inquiry				
	9.5.1. inquiry- based Investigation (ጥያቄ ላይ የተመሰረተ ምርምር)				
	9.5.2. Generate findings (የፈጠራ ስራዎች)				
9.6	Open Inquiry				
	9.6.1. Project works (ፕሮጀክት ሰራ)				
	9.6.2. Field visits (ጉብኝት)				
	9.6.3. Reflection (ፅብረቃ)				
	9.6.4. Discussion with Classmates (የቡድን ውይይት				

ክፍል ሶስት፡ በጥያቄ የተመሰረቱ የተግባር ተኮር የማስተማርያ ዘዴዎች ተግዳረቶች

አቅጣጫ፡- በዚህ መጠይቅ ላይ በጥያቄ የተመሰረቱ በተግባር የተደገፉ የማስተማርያ ስነ-ዘዴዎች ተግባራዊ ለማድረግ እንቅፋት ከሆኑ ምክንያቶች ጋር የተያያዙ ተግዳረቶች ከዚህ በታች ተዘርዝረዋል። እባክዎ ትክክል የሚሉትን ሀሳብ በሳጥኑ ውስጥ ይህ (√) ምልክት በማድረግ ያሳዩ። ተጨማሪ ሃሳብ ካለዎ በተዘጋጀው ቦታ ላይ ይፃፉ።

1. በትምህርት ቤትዎ ውስጥ በተግባር የተደገፈ ትምህርት ለመተግበር በቂ እና ተስማሚ ቁሳቁሶች አሉ ብለው ያስባሉ?

አዎ ☐ የሉም ☐ የተለየ ____

2. የጊዜ እና የፋይናንስ እጥረት በትምህርት ቤትዎ ውስጥ በተግባር ላይ የተመሰረቱ ዘዴዎች መተግበር ላይ ተጽዕኖ አሳድሯል ብለው ያስባሉ?

አዎ ☐ አይደለም ☐ የተለየ __________________________

3. የበጥያቄ ላይ የተመሰረቱ የተግባር ተኮር የማስተማርያ ስልቶችን ተግባራዊ ለማድረግ ትምህርት ቤቱ አስፈላጊውን ግብዓት በምን ያህል መጠን ያሟላ ይመስሎዎታል?

በጣም ከፍተኛ ☐ ከፍተኛ ☐ መካከለኛ ☐ ዝቅተኛ ☐ በጣም ዝቅተኛ ☐

4. የሳይንስ (የባዮሎጂ፣ ኬሚስትሪና ፊዚክስ) አስተማሪዎችዎ በጥያቄ የተመሰረቱ በተግባር የተደገፉ ዘዴዎችን በምን ያህል ደረጃ ተግባራዊ አድርገዋል?

በጣም ከፍተኛ ☐ ከፍተኛ ☐ አማካይ ☐ ዝቅተኛ ☐

5. የአጠቃላይ ሳይንስ አስተማሪዎችዎ ለመምህር ተኮር ዘዴ ባላቸው ዝንባሌ በበጥያቄ የተመሰረቱ አሳታፊ የትምህርት ዘዴዎች መተግበር ላይ ተጽዕኖ ያሳደረ ይመስልዎታል?

አዎ ☐ አይደለም ☐ ሌሎች ____

6. በትምህርት ቤትዎ ውስጥ የአስተማሪዎች ሙያዊ ስልጠና ማነስ በሳይንስ ትምህርቶች በጥያቄ የተደገፉ ተግባራዊ ዘዴዎች አፈፃፀም ላይ ተጽዕኖ ያሳደረ ይመስልዎታል?

አዎ ☐ አይደለም የተለየ _________________________________.

7. የመምህራን የማስተማር ፍላጎት ማነስ በትምህርት ቤቶች ውስጥ በጥያቄ የተመሰረተ ተግባር ተኮር ዘዴ አተገባበር ላይ ተጽዕኖ አሳድሯል ብለው ያምናሉ?

አዎ ☐ አይደለም ☐ የተለየ ____________________________

8. የትምህርት ቤቱ አመራሮች በሳይንስ ትምህርቶች ላይ በጥያቄ የተደገፉ የተግባር ስራዎች ላይ በጋራ የመስራት ልምድ እንድታዳብሩ ያነሳሷቸዋል?

አዎ ☐ አያነሳሱንም ☐ የተለየ ____________________________

9. በክፍልዎ/በትምህርት ቤትዎ ውስጥ በጥያቄ ላይ የተመሰረቱ የተግባር ዘዴዎች ላይ እንዳትሳተፉ/እንዳትተገብሩ የሚገድቧቹ ችግሮች መካከል እባክዎ ዋና ዋና ናቸው ብለው የሚያስቧቸውን ምክንያቶች በመዘርዘር ይፃፉ?

1. ____.
2. ____.
3. ____.
4. ____.
5. ____.

10. ከላይ የተዘረዘሩት ችግሮች/ተግዳረቶችን ለመፍታት እና በጥያቄ የተመሰረተ የተግባር ስልቶችን በብቃት ለመተግበር ቢደረግ የሚሉት ሃሳብ ካለ ይጻፉ?

1. ____.
2. ____.
3. ____.
4. ____.
5. ____.

Appendix E: Classroom Observation Checklist

Addis Ababa University

School of Graduate Studies

College of Education and Language Studies

Department of Curriculum and Comparative Education

Classroom Observation Checklist

Department observed___________________

Date______________

Subject topic___________________________________

Number of students in the class______________________Male _______ Female _______

Duration of observation____________________________

Observed teacher: Male _____Female ______

Key: No= not observed, NI= needs improvement; SU=satisfactorily used; EU=effectively used

No	Instructional activities of teacher and students	NO	NI	SU	EU
1	Does the teacher bridge the previous lesson by inquiry questions/activities?				
2	Does the teacher give chance to students to answer questions?				
3	Does the teacher introduce the day's lesson by giving examples related with daily life activities?				
4	Does the teacher encourage students to ask and answer questions?				
5	Do students actively participate in asking and answering questions?				
6	Does the teacher facilitate and shape students' answer?				
7	Does the teacher present the lesson through participatory activities rather than explanation/lecture method?				
8	Are students passively listening to teacher's presentation?				
9	Do students actively participate in peer/group-discussion?				
10	Do students actively participate in group reflection?				
11	Does the teacher use teaching aids to support the lesson?				
12	Does the teacher give chances for the students to demonstrate it?				
13	Does the teacher give tasks, such as class work and homework, for students?				
14	Does the teacher give tasks, such as group works and assignments for students?				
15	Does the teacher plan laboratory activity in his/her annual& monthly plans as given in the syllabus?				
16	Does the teacher record individual or project works done by students?				
17	Does the teacher promote students to practice field works?				
18					

Other observed activities during the observation time ________________________________
____

Appendix F: Laboratory Observation & Document analysis checklist

Addis Ababa University

School of Graduate Studies

College of Education and Language Studies

Department of Curriculum and Comparative Education

Laboratory Observation & Document analysis checklist

Department observed____________________

Date_______________

Subject topic______________________________________

Part:1	Description	Yes	No
1	Is there a trained laboratory technician in the school?		
2	Does the teacher have laboratory (practical) period allocated in his/her weakly timetable?		
3	Is the lab equipped with adequate equipment's and materials?		
4	Does the teacher have planned the topic in his/her annual plan as practical activity in laboratory?		
5	Is the Lab-room arrangement is suitable to implement practical activities?		
Part:2	The major barriers:		
1	Safety concern challenges		
2	Time constraint		
3	Scheduling difficulty		
4	Large class size		
5	Lack of appropriate equipment's		
6	Lack of professional trained expert		
Part:3	Planned teaching strategies in (Annual and daily plan, assessment checklist and laboratory report		
1	Presentation/explanation/lecture		
2	Demonstration of teaching aid (chart, model, real life aid)		
3	Question and answer		
4	Observation, field visit		
5	Laboratory experiment and report		
6	Test, exam, class work		

Appendix G: FGD Questions for Students

Appendix G (English Version)

Addis Ababa University

School of Graduate Studies

College of Education and Language Studies

Department of Curriculum and Comparative Education

FGD Questions for Students

1. What major practical activities are your science teacher's uses during science lesson delivery?

    ____
    ____
    ____

2. List at least three practical activities which are conducted in the general science subjects?
    1. ____
    2. ____
    3. ____
    4. ____
    5. ____

3\. List three mechanisms your science teachers are motivate you to apply practical science?

____
____
____

3\. Do you think that practice focus methods are more effective than presentation or explanation in your school? How?

____
____

5\. Is there a science laboratory room in your school?

____
____

6\. How often do you conduct practical activities in a laboratory per month?

____
____

7\. How often do you conduct practice related activities out of laboratory activities?

____
____

8\. List factors that affect the implementation of practical activities in general science subjects?

Appendix G (Amharic Version)

ቅፅ-ጂ

አዲስ አበባ ዩኒቨርሲቲ

የትምህርት እና የስነ-ባህርይ ሳይንስ ኮሌጅ

የስርዓተ ትምህርት እና መመሪያ ክፍል

FGD ጥያቄዎች ለ7ኛ ና 8ኛ ክፍል ተማሪዎች

1. የአጠቃላይ ሳይንስ (የባዮሎጂ፣ ኬሚስትሪና ፊዚክስ) መምህራንዎ የሚጠቀሙባቸው ዋና ዋና በጥያቄ የተመሰረቱ ተግባር ተኮር የማስተማርያ ዘዴዎች ምን ምን ናቸው?

____________________፣__________________________፣______________________________

____________________፣__________________________፣______________________________

2. በአጠቃላይ ሳይንስ ትምህርቶች ውስጥ ከተዘረዘሩት ተግባር ተኮር የማስተማርያ ዘዴዎች መካከል በሳይንስ መምህራኖቻችሁ ከሚከናወኑት ውስጥ ቢያንስ አምስቱን ይዘርዝሩ?

   1. ____
   2. ____
   3. ____
   4. ____
   5. ____

3. የተፈጥሮ ሳይንስ አስተማሪዎችዎ በተግባር የተደገፉ ስራዎችን እንድታከናውኑ እንዴት ያነሳሷችኋል(ያበረታቷችኋል)?

____

____

4. በትምህርት ቤትዎ ውስጥ የተፈጥሮ ሳይንስ (ቤተ-ሙከራ) ላብራቶሪ ክፍል አለ?

____

____

5. በወር ምን ያህል ጊዜ በቤተ ሙከራ ውስጥ ተግባራዊ ትምህርት ትተገብራላችሁ?

____

6. ከ ቤተ-ሙከራ (ላቦራቶሪ) ውጭ የሆኑ በተግባር የተደገፉ ስራዎችን በወር ምን ያህል ጊዜ ታከናውናላችሁ?

____

7. በተፈጥሮ ሳይንስ ትምህርቶች ውስጥ በተግባር የታገዙ የማስተማር ዘዴዎች ለመተግበር የሚያዳግቷችሁ ችግሮች ዘርዝሩ?

1. ____
2. ____
3. ____
4. ____
5. ____

Appendix H: Interview Guide for Science Department Heads

Addis Ababa University

School of Graduate Studies

College of Education and Language Studies

Department of Curriculum and Comparative Education

Interview Guide for Science department heads

1. Would you please tell me what you know about the implementation of Inquiry-based practical activities in science instruction?

   ____

2. How do you guide the teachers under your supervision related to the Inquiry-based practical activities in science classes in your school?

   ____

3. What methods do you prefer to deliver the science lessons in your school? Why?

   ____

4. Are students eager to apply practical activities while you are teaching science lessons in your school?

   ____

   ____

5. As a department head are teachers consider the practical activity strategies during their planning? To what extent?

   ____

6. What are the major obstacles hinder the delivery of practical activities in your School?

____

____

Appendix I: Interview Guide for Laboratory Technicians

Addis Ababa University

School of Graduate Studies

College of Education and Language Studies

Department of Curriculum and Comparative Education

Interview Guide for Laboratory Technicians

1. From your experience what techniques do science teachers prefer to deliver the science lessons in your school and how often they use it?

   ____

2. How many practical activities do you facilitate in grade 7& 8 science subjects per month in your school?

   ____

3. From your observation are students eager to apply practical activities in laboratory during science teachers deliver the science lessons in the laboratory?

   ____

4. Are there sufficient equipment's and materials in the laboratory?

   ____

5. Do you think that the strategies of practical activities conducted in laboratory class only? Give justification for your answer?

   ____

6. What are the major obstacles affecting the delivery of practical activities at laboratory in your school?

   ____

7. Do you think science teachers' and laboratory technician's lack of practical/ technical skill, interest and lack of experience affect the delivery of science subjects?

   ____

8. Have you taken any kind of training related with school laboratory?

   ____

Appendix J: Interview Guide for School Vice Principals

Addis Ababa University

School of Graduate Studies

College of Education and Language Studies

Department of Curriculum and Comparative Education

Interview Guide for School Vice Principals

1. Do you think that science teachers implement the Inquiry-based practical activities in science subjects in your school?

    ____

2. What methods do science teachers prefer to deliver the science lessons in your school? Why?

    ____

3. From your observation to extent are teachers and students eager to apply practical activity strategies in science teaching in your school?

    ____

4. As a principal what is your support for science teachers to custom Inquiry-based practical activities in your school?

    ____

5. Are there sufficient equipment's and materials in the laboratory?

    ____

6. What are the major obstacles affecting the delivery of practical activities in your school?

    ____

7. Can you suggest possible solutions to solve the challenges in your school?

    ____

Thank you!

Appendix K: Sample Transcribed Data

1. Common strategies used by general science teachers
   - Explanation
   - Group work
   - Lecturing /presentation
   - Laboratory activities
   - Coping short notes from students text book
2. List the Inquiry-based practical activates used in all general science subjects.
   - Coping short notes from text book
   - Coping homework & classwork questions from students text book
   - Question and answer
   - Presentation
3. How your science teachers motivate you to apply Inquiry-based practical activities in general science subjects?
   - Teachers advise us to study hard
   - They recommend us to be a disciplined student
   - They warn students to write notes & to memorize it.
4. Is their laboratory room in your school?

   Yes 5 Yes but not functional 11 No 6 (except five schools the answer is no because most of the schools has laboratory room physically but not functioned).
5. How many times a month do you conduct practical lessons in the laboratory?

   3-4 times 3 middle schools 1-2times 9 middle schools 0 time 10 middle schools
6. How many times a month do you do hands-on activities outside of the laboratory?

   3-4 times 3 1-2times 7 0 time 12
7. Factors prevented from applying practical activities in the school
   - ✓ There is no laboratory room
   - ✓ There is no laboratory equipment's & materials
   - ✓ There is no laboratory technician
   - ✓ School directors did not give permission to do laboratory works
   - ✓ There is no water & light supply in the school
   - ✓ Our teachers told as there is not enough time to do practical activities
   - ✓ Lack of teachers capacity to help as they didn't give a right answer for our questions
   - ✓ The no of students is very high due to this problem we didn't get a chance to do practical activities
   - ✓ Teachers didn't help us on how to apply the practical activities.

Appendix L: Pilot Study

All the data gathering instruments were developed taking into account the basic questions, purposes of the study and the reviewed literature. Before using the instruments to the main study, they were reviewed by different colleagues and pilot tested. The pilot test was conducted at two randomly selected middle-level schools (Menelik II Middle-level School and Atsenaod Middle-level School), which were excluded from the main study.

1. **Reliability of the instruments**

Glance the validity and reliability of data collection tools is critical in ensuring that the data collected are accurate, consistent, and meaningful. Thus the responses from teachers and students questionnaire under the pilot studies allowed the researcher not only to check the simplicity of the questionnaire items, but also to adjust the sequence of the questions. Beyond familiarizing the researcher with administration of the instrument, this process also permitted to refine the final version of the questionnaire by rewriting some questions and excluding some others.

In addition, the researcher pointed out which questions were weak or inappropriate. In this line, the internal consistency of items, how closely related the set of items of the questionnaire, was computed using coefficient of reliability of Chronbach's Alpha. As both teachers and students questionnaire contains diversified questions to get an appropriate data based on the research question items was checked their internal consistency on each specific part to avoid a misleadingly low reliability score. Accordingly, the coefficient of reliability value of teachers' and students questionnaire based on the category of each items related with the inquiry-based practical activities in general science subjects the outset measure is stated in the following tables respectively:

Table 1: Teachers pilot study instruments reliability indexes'

Category	**No of items**	**Measure**	**Value**
Familiarity	9	Cronbach's Alpha	0.84
Practice	16	"	0.85
Perception on the importance	10	"	0.87
Perception on the practice	10	"	0.78
Hindering factors	9	"	0.92

Table 2: Students pilot study instruments reliability indexes'

Category	**No of items**	**Measure**	**Value**
Awareness	5	Cronbach's Alpha	0.728
Practice	16	"	0.86
Hindering factors	8	"	0.79

According to standard guidelines, a Cronbach's alpha of the above score falls into the "Good" category, indicating that the items have a high level of internal consistency and are possible measuring the same underlying construct. The scale appears to be a reliable measure of the construct it aims to assess the objectives of the study.

2. Validity of the Instruments

Content validity assesses whether the content of the tools adequately represents the construct being measured (Kombo and Tromp, 2006). Content validity in this study was established by seeking judgments from a panel of different judges competent in the area of study. These included advisors who assisted in developing and revising the research instruments as well as pedagogical experts from the colleges of education and language departments. The advisors provided feedback and their recommendations were incorporated in the final questionnaire. Particularly, the advisors read the draft instruments and made their recommendations on how the content and construct validities were to be ensured. Based on the suggestions of the advisors, the content validity is also checked by peer reviewers, experts with diverse backgrounds in educational research. Based on the pilot study and comments from reviewers, a necessary modification was made on the data collection tools, procedures and the researcher made the final instruments which were used in the final data collection. Teachers and students questionnaires were addressed by providing a brief introduction in the questionnaire and the researcher herself through giving explanation about how to respond the questions in the questionnaire as well as school directors also made a follow-up and assistance by request the respondents' related with questionnaire returns.

Their collective expertise ensures that the tools accurately capture the intended concepts and the internal consistency is also checked using Cronbach's alpha, which measures the correlation between different items in the tool with a high Cronbach's alpha value indicates strong internal consistency, reinforcing the reliability of the data collected.