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Implementation of inquiry-based practical activities in science classrooms in middle schools of Addis Ababa, Ethiopia

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Abstract

This study investigates the implementation of inquiry-based practical activities, and compares the execution of teaching strategies in science classrooms in middle schools among the sub-cities of Addis Ababa, Ethiopia. Using a survey-method and descriptive design, the research involved 120 science teachers, 1587 students, 22 randomly selected middle schools from the eleven sub-cities. A data collection methods questionnaire for teachers and students was used. Findings reveal that low or ineffective implementation of inquiry-based practical activities with a predominant reliance on lecture-based methods in the targeted middle schools in all sub-cities. Similarly, all respondents also agreed on the application of traditional-lecture method during teaching-learning science subjects with significance differences in their comprehension to implement the inquiry-based practical methods in all sub-cities. Thus, the study underscores the necessity of a strategic shift towards more interactive and student-cantered teaching methods to enhance science education in middle schools. Accordingly, the Addis Ababa city administration education bureau should focus on improving the teaching and learning process of science subjects in middle schools, particularly teachers' skills, by preparing professional training for teachers and raising awareness among students and stakeholders, such as parents, community members, and policymakers, regarding the significance of inquiry-based practical activities in science education.

Keywords: *implementation, inquiry-based practical activity, science education, middle school*

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1. Introduction

Increasing educational advancement is essential for community health, environmental preservation, collective learning, sustainable development, and engagement in democratic, social, and political processes. Learning is a dynamic process characterized by significant changes as learners engage in exploratory, investigative, and inquisitive activities. It is widely believed that presenting science topics within the context of the real world makes science education more appealing, relevant, and stimulating within the global educational framework (Vogelzang et al., 2019). As a result, science teachers are encouraged to use instructional strategies that contextualize learning and motivate students to actively participate, thereby fostering their development into productive societal contributors (Damopolii et al., 2018).

Scholars from different nations (Sandoval, 2005; Millar & Abrahams, 2009) have emphasized that teaching science entails conveying practical ideas to students through real-world applications or contexts. This educational approach includes actions such as asking questions, recognizing difficulties, examining and cooperating, defending results, proposing answers, and making joint decisions through inquiry (Sandoval, 2005). Educators and researchers alike argue that hands-on activities such as questioning, observation, laboratory practice, and fieldwork are essential for science education. This interactive approach helps students improve their science knowledge, appreciate evidence-based ideas, and acquire necessary hands-on skills (Millar & Abrahams, 2009).

To this end, Ethiopia has been striving to ensure access to quality education, placing emphasis on science and mathematics to enhance student performance in science subjects. Like several developing nations, Ethiopia has been implementing various reforms to enhance the quality of education (MoE, 2008). The reforms in science and mathematics education emphasize a shift from memorization to scientific reasoning and understanding real-world contexts. These changes necessitate that science teachers adopt student-centered and inquiry-based practical activities instead of a teacher-centered approach. In addition, the Ethiopian Federal Democratic Republic Ministry of Education has established efforts to enhance science and technology education in Ethiopia. This plan underlined that a country's long-term success is dependent on the availability and use of scientifically and technologically skilled individuals (MoE, 2009). In line with this, the current education road map document states that education is contributing to realizing the development goals of our country through application of science, technology and innovations (MoE, 2018). Currently, the natural science curriculum

predominantly utilizes inquiry-oriented instruction, which centers on teaching through hands-on activities. The worth of inquiry-based pedagogy is contingent upon the availability of high-quality professional support for teachers, including appropriate skills, facilities, and collaborative educational expertise. This support framework enables educators to facilitate activities that actively involve students in their own learning processes. In Ethiopia, the curriculum aims to develop competencies that integrate knowledge, skills, and attitudes applied in practical situations, fostering self-reliance, ethical behavior, and global competitiveness (MoE, 2020). Such real-world interactions and practical experiences are instrumental in developing students' knowledge, skills, and attitudes based on their observations, thereby enhancing critical thinking and problem-solving capabilities. Thus, implementing inquiry-based practical activities is vital for achieving the objectives of Ethiopian natural science curriculum. Therefore, assessing how inquiry-based practical activities are being implemented in middle schools is important and relevant.

The eminence of education, particularly in science, has long been a matter of argument in Ethiopia. However, the efforts to maintain educational standards have not generated encouraging outcomes, indicating a lack of collective knowledge and abilities regarding instructional strategies. Collaborative engagement of practitioners is indispensable to improve education quality. It is important to continually assess the implementation process from elementary to secondary schools in a contextualized manner and provide workable answers. There is broad agreement that inquiry-based practical activities are crucial to science education. Furthermore, it is acknowledged that inquiry-based practical activities are a powerful means of increasing students' motivation and expanding their comprehension of ideas related to the natural world.

Even though inquiry-based practical activities are widely accepted, research has shown that theory and practice are not always aligned. Studies by Trna et al. (2012), and Cakmakci et al. (2011) showed a global decline in students' interest in science and technology, highlighting a growing gap between how science is taught and societal views on science and technology. Similarly, local studies (Tolessa & Mohammed, 2016; Abza et al., 2023) revealed the minimal use of hands-on practical learning in Ethiopian schools, leading to low secondary school science test scores. Problems with attitudes, approaches, teachers' capacity, and resources contribute to poor performance in science education. Researches in Ethiopian secondary

schools are also found to have poor quality practical activities and ineffective practice-based instruction (Abraham, 2009; Ashebir & Bereket, 2016; Dagnew & Sitotaw, 2019).

Thus, this study seeks to scrutinize the implementation of inquiry-based practical activities in Addis Ababa's middle schools. To the researchers' knowledge, no studies have assessed the extent of implementing inquiry-based practical activities in middle level schools in Ethiopia, particularly in Addis Ababa. Therefore, the objective of this study is to examine the implementation of inquiry-based practical activities in science classes in middle-level schools of Addis Ababa. Specifically, the study aims to: a) assess the implementation of inquiry-based practical activities, and b) compare the execution of teaching strategies of inquiry-based practical activities in science classes among sub-cities. This study significantly contributes to the state of the art in science education, with an emphasis on inquiry-based practical activities, and gives unique insights or future directions that improve the implementation of quality science education.

2. Literature Review

2.1. Significance of Inquiry-Based Practical Activities 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-oriented practical technique. National education standards, significant educational theories, and technological developments have all influenced this approach. According to research, exposing students to science through inquiry-based practical activities helps them understand how science works, clarify ideas of the scientific method, encourages teamwork, guarantees reproducible results, and supports equitable testing (Watts, 2013). Additionally, by helping students understand the context of their surroundings, it enhances their overall performance and helps them increase their understanding of scientific concepts, theories, and models (Abraham & Millar, 2008). Inquiry-based practical activities in science education not only enhance students' motivation but also expand their knowledge regarding theories and insights about the natural world. Many students prefer hands-on activities to other learning methods. Supporting this preference, a study conducted by Dagnew and Sitotaw (2019) revealed a positive correlation between students' attitudes and achievements in Biology courses. To captivate students' interest and motivate them to participate in learning activities, systematic and hands-on instructional preparation is essential (Sofna et al., 2023). As a result, students become active learners who participate in

investigation, observation and real-world application inside or outside the classroom. Supporting this the Ethiopian General Education Curriculum Framework (2020) explicitly states that educators should employ a range of inquiry-based practical activities and learning strategies to provide students with opportunities to challenge, research, validate, and apply their learning. Likewise, science education specialists advocate the myriad benefits of implementing practical, inquiry-based activities for both teachers and students. These advantages include enhancing student motivation, curiosity, bridging theory and practice, growth of cognitive and logical processes, and fostering a broad spectrum of critical skills (SCORE, 2008). Thus, using inquiry-based practical activities is essential to achieving the objectives of the science curriculum.

2.2. Implementation Barriers

Ethiopia's Science curriculum structure encourages instructional methods that make learning entertaining. To convert passive knowledge into active discovery, the framework emphasizes student-centered, interactive methods that encourage students to conduct inquiry, explore, and create (MoE, 2020). Even though 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). Similar to this, Ethiopia has 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, and inadequate teacher preparation (UNESCO, 2022; Girma, 2022).The difficulties that scientific education faces both internationally and particularly in Ethiopia point to the critical requirement for innovative and reformative teaching strategies. These issues underscore the urgent need for tailored solutions that address the specific problems of the Ethiopian 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 bar for science education by demonstrating the significance of integrating inquiry-based practical activities to meet science education goals.

3. Materials and Methods

3.1. Research Design

The quantitative study employed a cross-sectional design. A cross-sectional approach compares the attitudes, opinions, and practices of two or more other groups in educational and school settings (Creswell, 2012). To accomplish the study's objectives and answer the research questions, a survey research method that combined explanatory and descriptive research was used. This technique helps to understand what happened inside delimited systems, such as individual teachers, classrooms, or schools (Gay, 2012).

3.2. Participants of the Study

The study's population comprised middle school students in grades 7 and 8, and science teachers. This population specifically included students attending their education in the 2023/2024 academic year, along with teachers from the selected middle schools in Addis Ababa. Two governmental middle-level schools were randomly selected from each sub-city in Addis Ababa City Administration. The 22-government middle-level schools can be considered representative samples since there is homogeneity among all the schools with regard to human and material resources, demographic background, pedagogical approach, and administrative procedures.

A total of 1587 students in grades 7 and 8 and 120 science teachers were involved in the study. The general science subjects were intentionally selected to assess the execution of inquiry-based practical activities, aligning with the researchers' educational background and teaching experience in the field of natural sciences. Teachers and students participate directly in the planning, execution, and practice of school activities, making them the vital individuals to detect issues on the teaching learning process.

3.3. Instrumentation and Data Gathering Process

Data was collected using questionnaire to get comprehensive information from teachers and students and detailed insights on the extent of executing practical activities in each sub-city. The questionnaire method was selected to acquire information on the extent to which teachers applied inquiry-based practical activities in science classrooms and to identify the dominant executed method in the sample schools. This approach, often used in educational research, allows for the collection of information about specific conditions, practices, opinions,

and attitudes (Creswell, 2009). The data collection tools were devised considering the study's objectives and existing literature. Following reviews by colleagues and subsequent modifications was made. Then the questionnaire was distributed to all (120) teachers' all of them returned back the questionnaire. Students' questionnaire also contains items which were designed to assess the extent to which different instructional techniques are implemented by teachers and students in sciences subjects. The questionnaire was distributed to randomly selected (1588) students' and 99.9% (which was 1587) was collected.

3.4. Data Analysis

Data obtained through the questionnaire were entered into SPSS version 25 and 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 statistical techniques were employed to examine the relationships among variables and the significance of the study's results. Specifically, Analysis of Variance (ANOVA) was utilized to compare the effectiveness of different teaching techniques. Additionally, ANOVA was used to assess the practice of each teaching technique across various sub-cities.

3.5. Research Ethics

Strict ethical guidelines were followed while performing this study in order to guarantee integrity of the research process and the safety of all participants. Prior to data collection, permissions or written consent were obtained from the respective schools, and all participants were informed about the study's goal, nature of their involvement, and the use of the collected data. Furthermore, the study's goal was fully explained to all participants, ensuring that their anonymity and confidentiality were preserved. Finally, data were obtained using self-administered questionnaires.

4. Results and Discussion

4.1. Inquiry-based Practical Strategies and Instructional Tactics: Self-reported by Science Teachers

As part of the study, science teachers were invited to provide insights into their classroom teaching methodologies and techniques. Table 1 shows the frequency distribution

of ratings for inquiry-based activity approaches and practices on a scale of 1 to 3 (1 = not at all, 2 = sometimes, 3 = always).

Table 1

Frequency distribution of teaching techniques practices among teachers

Teaching technique	Activity	Not at all		Sometimes		Always		Activity	
		F	%	F	%	F	%	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 illustrated in table 1, it provides a clear picture of how teachers view and participate in inquiry-based activities, as well as data on the prevalence of different degrees of implementation. The summary also includes statistics such as mean and standard deviation, which provide a quantitative assessment of the effectiveness and variability of the five teaching styles used: traditional, structured, confirmation, guided and open inquiry.

The analysis of teaching techniques among teachers reveals that the demonstration techniques is not frequently used, with 45.8% of teachers reporting they never use it, 38.3% using it sometimes, and only 15.8% always using it. The mean score is 1.70, indicating low usage and the SD of 0.73 shows moderate variability in its usage. Lecture/Explanation is the most consistently used technique, with no teachers reporting they never use it, 10.8% using it

sometimes, and a significant 89.2% always using it. The mean score is 2.89, showing high usage, with a low SD of 0.31, indicating consistent application across teachers.

Structured inquiry techniques include question and answer, somewhat frequently used, with 5.8% not using it, 77.5% using it sometimes, and 16.7% always using it. The mean score is 2.11, suggesting moderate usage, with a low SD of 0.46. Modeling is less frequently used, with 60.8% not using it, 34.2% using it sometimes, and only 5.0% always using it. The mean score is 1.44, indicating low usage, with an SD of 0.59, suggesting moderate variability. Written responses are less frequently used, with 60.0% not using it, 26.7% using it sometimes, and 13.3% always using it. The mean score is 1.53, with an SD of 0.72.

Confirmation inquiry techniques include group works, infrequently used, with 58.3% not using it, 30.0% using it sometimes, and 11.7% always using it. The mean score is 1.53, with an SD of 0.70. Observation has low usage, with 69.2% not using it, 21.7% using it sometimes, and 9.2% always using it. The mean score is 1.40, with an SD of 0.65. Laboratory-based activities are also less used, with 73.3% not using it, 14.2% using it sometimes, and 12.5% always using it. The mean score is 1.39, with an SD of 0.70. Reflecting findings is the least frequently used, with 83.3% not using it, 10.0% using it sometimes, and only 6.7% always using it. The mean score is 1.23, with an SD of 0.56. Individual/peer presentation is infrequently used, with 65.8% not using it, 20.0% using it sometimes, and 14.2% always using it. The mean score is 1.48, with an SD of 0.73.

Guided inquiry techniques include inquiry-based investigation, rarely used, with 85.8% not using it, 10.0% using it sometimes, and only 4.2% always using it. The mean score is 1.18, with an SD of 0.48. Generate Findings is also rarely used, with 86.7% not using it, 10.0% using it sometimes, and 3.3% always using it. The mean score is 1.17, with an SD of 0.46.

Open inquiry techniques include project works, infrequently used, with 72.5% not using it, 14.2% using it sometimes, and 13.3% always using it. The mean score is 1.41, with an SD of 0.72. Field visits are rarely used, with 85.0% not using it, 13.3% using it sometimes, and only 1.7% always using it. The mean score is 1.17, with an SD of 0.42. Reflection is also rarely used, with 81.7% not using it, 15.0% using it sometimes, and 3.3% always using it. The mean score is 1.22, with an SD of 0.49. Discussion with classmates is less frequently used, with 60.0% not using it, 25.0% using it sometimes, and 15.0% always using it. The mean score is 1.55, with an SD of 0.74 displays moderate inconsistency in its practice.

Table 2

Distribution of practices of teaching techniques among teachers

Teaching technique	Teaching Activity	Activity		Aggregate	
		Mean	SD	Mean	SD
Traditional/one way	Demonstration	1.70	0.73	2.30	0.39
	Lecture/Explanation	2.89	0.31		
Structured Inquiry	Question & Answer	2.11	0.46	1.69	0.38
	Modeling	1.44	0.59		
	Written responses	1.53	0.72		
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		
Guided Inquiry	Inquiry- based investigation	1.18	0.48	1.18	0.32
	Generate findings	1.17	0.46		
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		

Table 2 displays the distribution of practices in terms of aggregate methods. The study highlights that traditional/one way (demonstration and lecture/explanation) and structured inquiry (question & answer, modeling, and written responses) emerge as the two most predominant practiced methods among teachers in all Sub-City middle schools Addis Ababa.

Table 3 shows the teachers' ratings and extensive comparisons of various teaching methods. Analyzing the mean scores for the five teaching styles among sub-cities might provide valuable insights into the diverse viewpoints on instructional approaches.

Traditional/one-way teaching technique: Bole (2.50) has the highest mean score, indicating a higher preference or utilization of traditional teaching methods. Addis Ketema (2.10) has the lowest mean score, indicating a lower preference or utilization of traditional teaching methods. Lideta (0.47) has the highest SD, indicating a wider variability in the use of traditional teaching methods among teachers. Addis Ketema (0.21) has the lowest SD, indicating more consistency in the use of traditional teaching methods among teachers.

Table 3

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
Arada	2.30	0.35	1.77	0.39	1.44	0.26	1.15	0.24	1.33	0.41
Gulelie	2.15	0.43	1.72	0.33	1.26	0.25	1.04	0.14	1.33	0.39
Addis Ketema	2.10	0.21	1.70	0.25	1.28	0.29	1.00	0.00	1.43	0.35
Bole	2.50	0.38	1.58	0.30	1.30	0.21	1.06	0.18	1.22	0.21
Kirkos	2.25	0.46	1.79	0.43	1.55	0.40	1.19	0.37	1.44	0.42
Kolfie Keraniyo	2.43	0.32	1.42	0.27	1.24	0.19	1.07	0.18	1.18	0.18
Lideta	2.23	0.47	1.88	0.45	1.64	0.36	1.27	0.34	1.36	0.44
Yeka	2.25	0.46	2.04	0.42	1.68	0.43	1.50	0.46	1.56	0.48
Nefas Silk Lafto	2.25	0.34	1.75	0.41	1.48	0.28	1.42	0.42	1.33	0.27
Lemi Kura	2.38	0.39	1.42	0.29	1.25	0.23	1.06	0.17	1.23	0.31
Akaki Kaliti	2.39	0.42	1.93	0.22	1.64	0.31	1.33	0.43	1.47	0.29

Structured inquiry teaching technique: Yeka (2.04) has the highest mean score, indicating a higher preference or utilization of structured inquiry methods. Kolfe Keraniyo (1.42) and Lemi Kura (1.42) have the lowest mean scores, indicating a lower preference or utilization of structured inquiry methods. Lideta (0.45) has the highest SD, indicating a wider variability in the use of structured inquiry methods among teachers. Akaki Kaliti (0.22) has the lowest SD, indicating more consistency in the use of structured inquiry methods among teachers.

Confirmation inquiry teaching technique: Yeka (1.68) has the highest mean score, indicating a higher preference or utilization of confirmation inquiry methods. Gulelie (1.26) has the lowest mean score, indicating a lower preference or utilization of confirmation inquiry methods. The standard deviations are not provided for this category, which limits the analysis of variability.

Guided inquiry teaching technique: Yeka (1.68) has the highest mean score, indicating a higher preference or utilization of guided inquiry methods. Gulelie (1.26) has the lowest mean score, 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 (2.50) but a lower preference for structured inquiry (1.58), suggesting a potential area for professional development to encourage more inquiry-based methods. Addis Ketema shows the lowest preference for traditional methods (2.10) and structured inquiry (1.70), indicating an overall lower use of both teaching techniques.

Lideta (0.45) shows high variability in structured inquiry, indicating differing levels of adoption among teachers, whereas Akaki Kaliti (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 (1.68) and guided inquiry (1.68), indicating a balanced approach to utilizing inquiry-based techniques. Gulelie has the lowest scores for both confirmation (1.26) and guided inquiry (1.26), suggesting a need for increased support in adopting these methods.

As the summary revealed, traditional/one way (demonstration and lecture/explanation) and structured inquiry (question & 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 while confirmation inquiry (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.

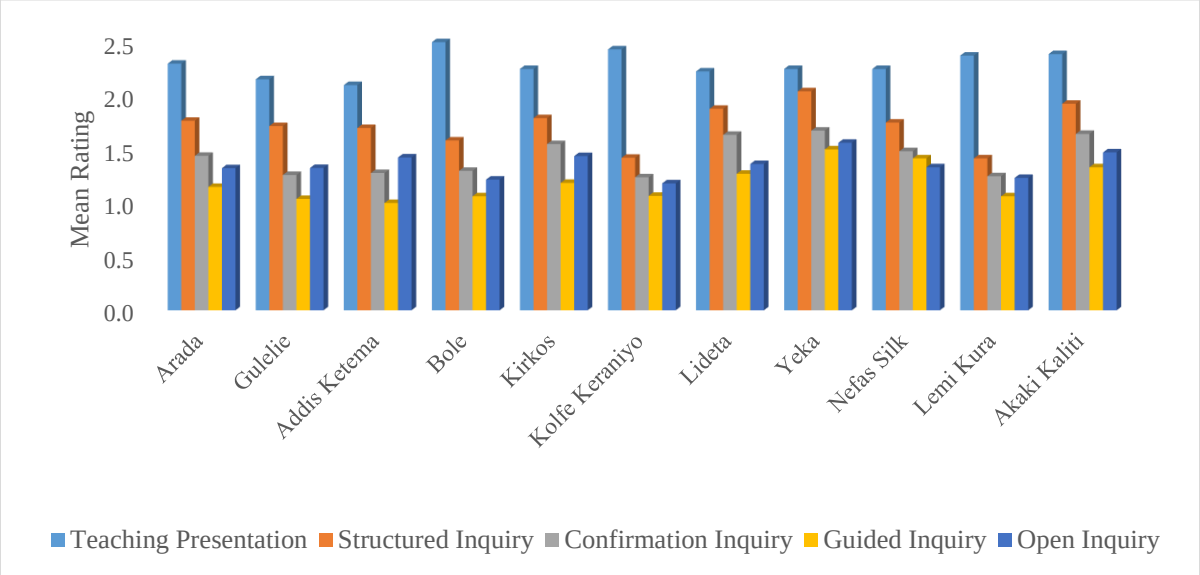
The data reveals varying preferences and consistencies in teaching techniques across different sub-cities. Sub-cities like Bole and Yeka show distinctive trends that could guide targeted professional development and support initiatives. The variability in standard deviations suggests differing levels of adoption and consistency, which could be addressed through more uniform training and resource allocation.

In addition to a thorough analysis of different methods of instruction, figure 1 offers visual representations of the teachers' ratings. Analyzing the mean ratings for the five teaching styles across sub-cities provides a variety of insights into the diverse viewpoints on instructional approaches. All sub-cities regularly employ the two methods known as traditional/one way (which involves demonstration and lecture/explanation) and structured inquiry (which includes question and answer, modeling, and written responses). Bole and Kolfe Keraniyo earned the highest mean scores for traditional/one way, indicating that this

strategy is generally well-liked and widely adopted among the sub-cities. In addition, structured inquiry has a higher mean score in Yeka sub-city.

Figure 1

Bar chart for comparison of teaching techniques among sub-cities based on the rating of teachers



4.2. Inquiry-based Practical Strategies and Instructional Practices: Self-reported by Students

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 teachers is summarized in table 4. Here, a 4-point rating is used (1 = not at all, 2 = sometimes, 3 = rarely, 4 = always).

Traditional/one-way techniques: Demonstration is reported to occur "not at all" by 50.7% of students, with a mean of 1.64 and an SD of 0.75. The high percentage of "not at all" responses and the relatively low mean suggest that demonstrations are infrequently used. Most students (96.2%) reported 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.

Structured inquiry: Nearly half of the students (48.3%) reported that question and answer activity does not occur at all, with a mean of 1.73 and an SD of 0.88, indicating moderate variability in student experiences. A significant majority (86.6%) reported modelling activity "not at all," with a mean of 1.15 and an SD of 0.39, showing that modelling is rarely

utilized. Similarly, written responses has been reported by 49.1% of the respondent as “not at all," with a mean of 1.61 and an SD of 0.68, indicating low but somewhat variable use.

Table 4

Frequency distribution of inquiry-based practical activities within the view of students

Teaching technique	Activity	Not at all		Sometimes		Rarely		Always	
		n	**%**	***n***	**%**	***n***	**%**	***n***	**%**
Traditional/ one way	Demonstration	805	50.7	576	36.3	175	11.0	31	2.0
	Lecture/Explanation	1	0.1	8	0.5	51	3.2	1527	96.2
Structured Inquiry	Question & answer	766	48.3	605	38.1	94	5.9	122	7.7
	Modeling	1375	86.6	194	12.2	16	1.0	2	0.1
	Written responses	779	49.1	659	41.5	135	8.5	14	0.9
Confirmation Inquiry	Group works	876	55.2	610	38.4	97	6.1	4	0.3
	Observation	1299	81.9	259	16.3	27	1.7	2	0.1
	Laboratory based activities	1108	69.8	441	27.8	38	2.4	0	0.0
	Reflecting findings	1411	88.9	164	10.3	12	0.8	0	0.0
	Individual/peer presentation	816	51.4	606	38.2	161	10.1	4	0.3
Guided Inquiry	Inquiry- based investigation	1316	82.9	251	15.8	20	1.3	0	0.0
	Generate findings	1483	93.4	98	6.2	6	0.4	0	0.0
Open Inquiry	Project works	976	61.5	535	33.7	74	4.7	2	0.1
	Field visits	1445	91.1	133	8.4	9	0.6	0	0.0
	Reflection	1460	92.0	114	7.2	12	0.8	1	0.1
	Discussion with classmates	1045	65.8	453	28.5	88	5.5	1	0.1

Confirmation inquiry: Over half of the students (55.2%) reported group work activity as "not at all," with a mean of 1.51 and an SD of 0.62. Observation has been reported by a significant (81.9%) number of students "not at all," with a mean of 1.20 and an SD of 0.45, indicating very low usage. Laboratory-based activities, reported by 69.8% as "not at all," with a mean of 1.33 and an SD of 0.52, indicating infrequent occurrence and reflecting findings (88.9%) reported "not at all," with a mean of 1.12 and an SD of 0.35, showing very low engagement. Similarly, individual/peer presentation has been reported by 51.4% of students “not at all," with a mean of 1.59 and an SD of 0.68, showing some variability.

Guided inquiry: As reported by the students, 82.9% of respondents replied "not at all," with a mean of 1.18 and a standard deviation of 0.42, indicating very low usage. Generate findings was reported by 93.4% of respondents as "not at all," with a mean of 1.07 and an SD of 0.27, indicating a very rare occurrence.

Open Inquiry: Project works, field visits, reflection, and discussion with classmates are all reported as "not at all'' by most of the respondents. 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 student experiences: The standard deviations for most activities are relatively low, indicating consistent student 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 student 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.

The summary statistics (mean and standard deviation) of students' ratings of inquiry-based practical activities are presented in table 5.

Table 5

Summary statistics of students' ratings about inquiry-based practical activities

Teaching technique	Activity	Activity		Aggregate	
		Mean	SD	Mean	SD
Traditional/one way	Demonstration	1.64	0.75	2.80	0.40
	Lecture/Explanation	3.96	0.24		
Structured Inquiry	Question & Answer	1.73	0.88	1.50	0.45
	Modeling	1.15	0.39		
	Written responses	1.61	0.68		
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		
Guided Inquiry	Inquiry- based investigation	1.18	0.42	1.13	0.26
	Generate findings	1.07	0.27		
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		

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), structured inquiry (question and answer, modeling, written responses) are the top two implemented teaching techniques, with mean scores of 2.80 and 1.50, respectively.

The comparison of the various teaching methods throughout the sub-cities is displayed in the table 6.

Traditional/one-way teaching technique: This teaching method, characterized by a teacher-cantered approach, is rated highest in Arada (Mean = 3.25, SD = 0.34) and Lideta (Mean = 3.01, SD = 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 (Mean = 2.45, SD = 0.19), indicating a lesser preference for traditional methods. The standard deviations are relatively low across all sub-cities, suggesting a consistent perception among students regarding this method.

Table 6

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

Structured inquiry: Structured inquiry, which provides directed instructor guidance while enabling students to explore, had the highest mean in Lideta. This suggests that this strategy is well received in Lideta. In contrast, Addis Ketema (Mean = 1.11, SD = 0.22) and Yeka (Mean = 1.26, SD = 0.34) had lower means, indicating less effectiveness or a preference for organized inquiry in these regions. Student assessments vary moderately (SD), showing some perception disparities within each sub-city.

Confirmation inquiry: Confirmation inquiry, in which students confirm known concepts, is consistently ranked lower across all sub-cities than traditional structured inquiry approaches. Arada has the greatest mean (1.89, SD = 0.56), while Gulelie (1.39, SD = 0.35) and Addis Ketema (1.11, SD = 0.22) have the lowest. Arada has a greater standard deviation, indicating more diverse perspectives among students.

Guided inquiry: Encourage students to explore with direction is largely uniform throughout the sub-cities. Arada (mean = 1.58), Gulelie (mean = 1.29) and Addis Ketema (mean = 1.24) had the highest and lowest means, respectively. The means are close, indicating that this method's accomplishment is perceived quite consistently. The standard deviations are minimal, indicating fewer variations in student assessments.

Open inquiry: Open inquiry, which allows students to investigate individually, consistently produces lower means than other methods. Kolfe has the greatest mean (1.43), while Yeka has the lowest mean (1.21). The homogeneity in low means indicates open inquiry is perceived as less effective or preferred by students overall. Standard deviations are low, showing that the method's efficiency is widely accepted.

The data 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-cantered learning approaches in this sub-city.

Confirmation inquiry and open inquiry are generally rated lower, suggesting that these methods may not be as effective or preferred in the current educational context of Addis Ababa's middle schools. Similar to this result study by Abebe (2019), highlighted that both teachers and students frequently do not engage in practical activities, which impedes the effectiveness of science education. 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.

Figure 2

Bar chart for comparison of teaching techniques among sub-cities based on students' ratings

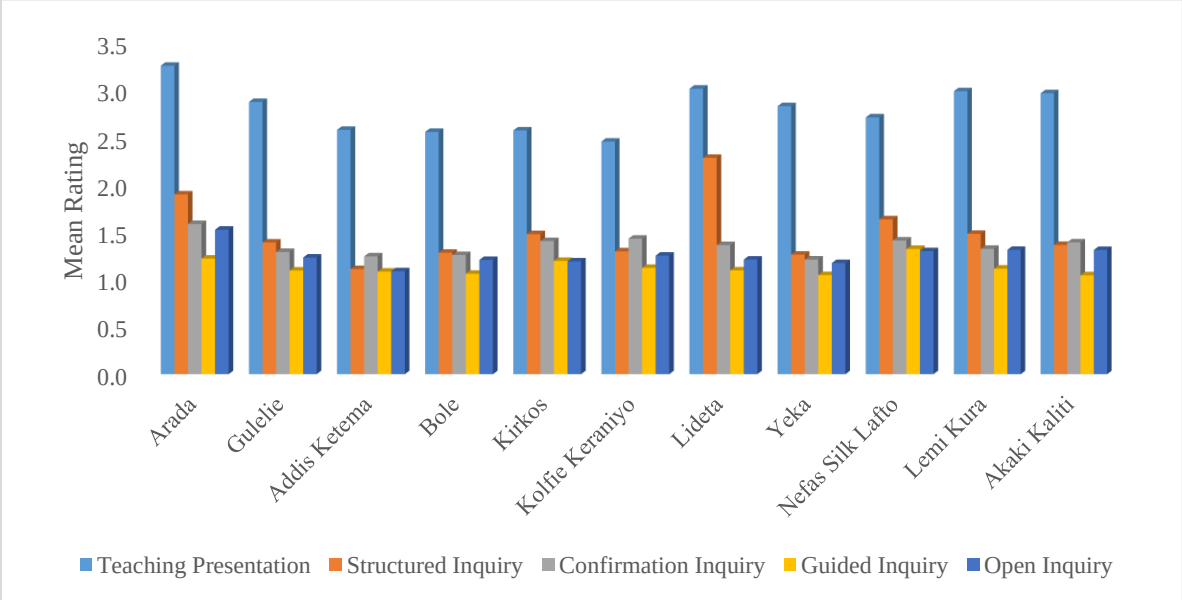


Figure 2 also provides a comprehensive overview of various teaching approaches, as well as graphic representations of students' ratings. Overall, student assessments indicate a preference for structured and traditional teaching techniques. This may indicate a need for teacher training and curriculum improvement to improve the effectiveness of inquiry-based methods, making them more interesting and well-received by students. Future treatments could combine old methods with innovative inquiry-based tactics to boost student engagement and learning results.

4.3. Practices of Teaching Techniques between Teachers and Students

Mean scores differed significantly between teachers and students in response to different teaching techniques (traditional method, structured inquiry, confirmation inquiry, open inquiry, and guided inquiry). An ANOVA was used to compare the mean differences between these teaching techniques for both teachers and students. Both groups showed statistically significant results ($p < 0.001$).

To elucidate specific differences, further analysis focused on pairwise comparisons within each group. The traditional teaching method received much higher marks than other techniques ($p < 0.001$). Structured inquiry performed much better than confirmation inquiry ($p < 0.001$). Finally, guided inquiry differed significantly from other teaching methods ($p < 0.001$).

Table 7

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				

Students, like teachers, preferred traditional teaching methods over others ($p < 0.001$). Structured inquiry had considerably higher evaluations than confirmation inquiry ($p < 0.001$). Open inquiry had significantly lower scores than traditional teaching method and structured inquiry ($p < 0.001$). Guided inquiry received the lowest rating from students, significantly lower than traditional teaching method and all other teaching styles ($p < 0.001$). 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 both 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.

These findings align with previous research by Negassa (2014) and Endalamaw et al. (2017), which indicated that Ethiopian schools struggle to improve science teaching due to ineffective teaching participatory methods and lack of motivation among both 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. This finding aligns with research by Alemu et al. (2019) and Adugna (2017), which indicates that lecture-dominated teaching remains prevalent in the Ethiopian educational system to impart factual knowledge at all levels.

Additionally, lectures and interactive lectures are the most popular and reliable teaching strategies in preparatory schools. Teachers rarely assign practical exercises, peer presentations, group projects, or debates in scientific classes. Comprehensive surveys conducted in Ethiopian primary schools have also revealed frozen crisis narratives in either curriculum implementation or student teaching (Hoddinott et al., 2019). These insights provide valuable guidance for teachers and curriculum developers in tailoring instructional approaches to better incorporate inquiry-based practices. The data underscores the relative underutilization of participatory methods, corroborating the view that both teachers' preference for inquiry-based practical activities and students' active engagement in science learning are notably low in the surveyed schools. However, science education experts such as SCORE (2008) and Girma (2022) stress that practical, inquiry-based, hands-on activities benefit both instructors and students by raising motivation, igniting curiosity, combining theory with practice, developing

critical skills, understanding native methods, and fostering critical skills like planning, investigating, evaluating, making precise observations, recording, explaining, managing information, making experiences tangible, and increasing interest in learning science (SCORE, 2008); and teachers and students must adapt to the changing requirements of the twenty-first century to implement the science curriculum effectively (Girma, 2022). 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.

5. Conclusion and Recommendations

Inquiry-oriented pedagogy can be effective if science teachers are supported with adequate laboratory facilities, science equipment, and high-quality teachers to support students' practically and technically (MoE, 2018). Using this approach, students should become more active participants in their learning by exploring, observing, experimenting, and practicing in teaching and learning methodologies, as well as participating in various appropriate activities to improve students' participation in their own learning. The study aimed to investigate the implementation of inquiry-based practical activities, and identify the dominant technique in science classes in the middle schools among the sub-cities of Addis Ababa. Based on the data analysis, the following conclusions are drawn: practical activities in the general science curriculum in the observed schools are not adequately implemented. Because the data continues to show that participatory methods are underutilized. This corroborates the idea that both teachers' preference for inquiry-based practical activities and students' active engagement in science learning is particularly low within the assessed middle schools. Similarly, teachers' and students' opinions on each approach to learning differ significantly across all sub-cities. However, there are no significant differences between traditional lecture methods.

Thus, the findings indicate a significant reliance on traditional lecture-based methods in science classrooms, with limited engagement in inquiry-based practical activities. In today's educational landscape, it is commanding 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. Furthermore, science teachers must determine what type of inquiry-based activities is appropriate to use, as well as what

knowledge and abilities their students should learn, at what level, and in what sequence (Trna et al., 2012).

The current educational policy in Ethiopia underscores the importance of a natural science curriculum, focusing primarily on inquiry-based instruction. Implementing inquiry-based pedagogy across all levels can effectively enhance science education in schools. This approach fosters active student participation in their learning through explore, observe, research, and practice, thereby encouraging involvement in various practical activities to boost their learning.

This study illustrates the disparity between the emphasis on inquiry-based practical activities in Ethiopian science education and their implementation in Addis Ababa middle schools. Based on the study's findings, the following recommendations are forwarded:

Teachers and students in the target middle schools rely heavily on lecture-based approaches to teach science subjects, and inquiry-based practical activity is underutilized in all sub-cities. 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. Therefore, it is imperative to equip teachers with the necessary technical skills and 21st-century competencies to help them comprehend the concept of inquiry-based learning and develop their skills to learn from and teach in a real-world environment.

Almost all teachers and students in the targeted schools agreed on using traditional lecture dominated techniques to teach science courses. Thus, the study underscores the necessity of a strategic shift towards more interactive and student-cantered teaching methods to enhance science education in middle schools. Accordingly, the Addis Ababa city administration education bureau should focus on improving the teaching and learning process of science subjects in middle schools, particularly teachers' skills by implementing comprehensive professional development programs focused on inquiry-based 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.

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