

## Review Article

# Inquiry-Based Learning in Science Education: A Content Analysis of Research Papers in Ethiopia (2010–2021)

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The development of learning theories, present societal needs, and the positive empirical findings in the relevant literature support the thesis that inquiry-based learning (IBL) is promising for teaching and learning, which deserves further development. Few studies have been conducted on content analysis of IBL in science education at the international level. However, the overall trends of IBL in science education research trends in Ethiopia are not well known. Therefore, this study aimed to investigate the nature and status of inquiry-based learning research in Ethiopia by employing a quantitative method. A total of 23 studies, including 14 theses, eight articles, and one dissertation were analyzed in terms of the methodological approaches used and the subjects studied. The most frequently investigated IBL science areas were biology (43.5%) and chemistry (34.75%). Guided inquiry (69.6%) (5E model = 65.2% and 7E model = 4.4%) studies were the most frequently investigated inquiry types. Teaching (47.8%) and learning (43.5%) were the most frequently focused subject matters of the studies reviewed, while cognitive elements (58.6%) were the most frequently used research elements in IBL studies, and quantitative studies with predominantly quasi-experimental methods (60.9%) were widely employed. The findings of this study indicated that IBL was found to be a new research area in Ethiopia where it has been practiced in science education at the primary level. This study is considered useful to develop an understanding of the nature and status of IBL research in Ethiopia and provide information on what could be done about IBL in the future.

## 1. Introduction

Inquiry refers to a learning and teaching process in which students undertake different activities, such as posing questions, identifying problems, investigating, collaborating, justifying decisions, coming up with solutions to the issues or answers to the questions, and communicating conclusions [1]. It has instilled interest among educational researchers and practitioners for a long time. It is also an encouraging teaching-learning method that makes learning more meaningful and conducive to higher-order thinking and active knowledge construction [2]. The theoretical foundations of inquiry-based learning emanated from the constructive theory, which asserts that learners build knowledge [3]. Inquiry learning is compatible with the constructivist approach, which emphasizes that knowledge

is actively developed by the student but not transmitted directly from the teacher to the student.

Several authors have developed different classifications of inquiry-based learning (IBL). According to Banchi and Bell [4], there are four levels of inquiry: confirmation, structured, guided, and open. In confirmation inquiry, students receive a question and a solution procedure to verify a previously learned concept or principle [5]. In structured inquiry that follows confirmation inquiry, the teacher provides problems, materials, and procedures for learning, in which the students are only required to investigate the issue. In structured inquiry, the teacher directs students to run an experiment and study a predetermined research question [6]. Guided inquiry is an approach where the teacher gives only problems and materials, and the students direct an investigation to solve the problem through

their procedures. In guided inquiry, students discover solutions to the given tasks via extensive research and group collaboration, while the role of the teacher is to facilitate the students' learning process [7]. Open inquiry is a student-centered approach that employs higher-order thinking levels. Here, the students generate problems, materials, and solutions by themselves.

There are different types of inquiry models designed for various purposes. However, the review of learning cycles in science inquiry education was limited to using the four models: the three phases (3E) [8], the five phases (5E) [9], the seven phases (7E) [10], and the nine phases (9E) [11]. Exploration, explanation, and elaboration make up the 3E learning cycle [8]. The 5E learning cycle, which was later enlarged to the 7E learning cycle, is the most widely used improved variant of the learning cycle. Engagement, exploration, explanation, elaboration, and evaluation are the five phases of the 5E instructional approach [7]. Eisenkraft [10] extended the 5E learning model into the 7E learning cycle model, with elicitation and extension at the beginning and the end, respectively. Elicitation, engagement, exploration, explanation, elaboration, evaluation, and extension are the seven successive stages of the 7E instructional approach [7]. Kaur and Gakhar [11] extended the 7E learning model into the 9E learning cycle model. Elicitation, engagement, exploration, explanation, echo, elaboration, evaluation, emend, and e-search are the phases of the 9E learning cycle [11].

Several studies reported the effects of IBL on students and teachers. Walan and Rundgren conducted studies on the effects of the IBL model on students and teachers [12]. Based on their findings, students were found to give better responses when IBL was used in the teaching and learning sessions. Research has also reported the positive effect of IBL on teachers [13–15] and teaching. IBL improved teachers' performance, understanding, science process skills, and inquiry. A case in point is that the experimental session conducted by teachers improved. Scholars have investigated the effectiveness of employing 3E, 5E, 7E, and 9E-guided inquiry models. The researchers reported that guided inquiry instructional models improved the learners' conceptual understanding, attitude, experience, and achievements more than traditional instructional methods [12, 16–19].

Despite the positive effects of inquiry-based learning on students, IBL is not easy to adopt because it is different from the traditional learning method [20]. The type of inquiry required for the teaching and learning facilities available in schools has remained unclear among educators. Some teachers prefer structured or guided inquiry, whereas others prefer open. Research evidence indicated that structured inquiry was insufficient for developing critical and scientific thinking and appropriate dispositions and attitudes. Compared to the structured inquiry, the open inquiry could have a more positive effect on student learning outcomes and their perception toward the role of experiments in laboratory activities [21].

Guided inquiry is an intermediate level that can assist students in transitioning from structured to open inquiry. As students move progressively from structured to guided

inquiry and then to open inquiry, they develop both critical and scientific thinking, they show appropriate dispositions in attitudes, and they transform their data into much more complex and abstract forms [22]. A recent study has compared the influence of open versus guided inquiry learning approaches on inquiry performances among high school biology students. Sadeh and Zion [23] evaluated students from two groups concerning their ability to take on a theoretically structured inquiry biology assignment based on a list of basic inquiry skills [23]. The researchers found no significant differences in basic inquiry skills between the two groups in the structured inquiry assignment. In addition, the quantitative content analysis of the two groups using a dynamic inquiry performance index revealed that students in the open inquiry applied significantly higher levels of achievement in the criteria of changes during the inquiry and procedural understanding than students in the guided inquiry learning. However, the study indicated no significant differences between the two groups of students in learning as a process and affective domains of view [23].

With regard to engagement and motivation, research has asserted that students taught by IBL reported that open inquiry made them more involved in their project where they had a higher feeling of cooperation with others than students in the guided inquiry model [24]. This positive attitude demonstrates the benefits of the open inquiry, which derives from the opportunity to emphasize the dynamism and discoveries inherent in the systematic scientific study. [25, 26] Ethiopian researchers conducted few studies on the effects of IBL models on students' conceptual understanding, attitudes, experience, and achievement [25, 26]. Some of these studies indicated that students who learned with guided inquiry learning with the 5E learning model lesson design were better in their achievement, attitudes, and conceptual understanding of science topics than those who were taught by the conventional teaching method [16, 19]. In another study, the 7E instructional model had a significantly higher effect than the conventional teaching methods on enhancing conceptual understanding and minimizing misconceptions [17]. Furthermore, it was indicated that the majority of laboratory activities had a lower inquiry level of one and zero, and the dominant practical work identified was the demonstration-type activity [18]. Yilma [27] also found out that although many teachers were aware of IBL, they did not apply it in their classrooms.

In summary, the development of learning theories, the demands of current society, and the positive effects of IBL on learning reported from empirical findings in the relevant literature support the proposition that inquiry-based learning is essential for teaching and learning and worthy of considering IBL to improve science learning. Accordingly, the present study was devoted to analyzing the development of research on inquiry-based learning. Therefore, this study aimed to understand the nature and status of IBL research in Ethiopia and thereby shedding light on what to do about IBL in the future. The present study aimed to answer the following key research questions: what were the most frequent research topics, types of inquiry, and subject matters investigated in IBL research papers from 2010–2021? What

were the most frequent research elements, research designs/methods, data collection tools, samples and sample sizes, and data analysis methods used in IBL research papers?

## 2. Research Methodology

This study employed a descriptive quantitative method employing a systematically categorized content analysis. The authors subjected the research reports to content analysis based on the frequency of methodological approaches used and the subjects studied.

**2.1. Data Source and Search Strategies.** The data for this study were collected from published articles, theses, and dissertations conducted in Ethiopia from 2010 to 2021. The data sources were obtained by searching Google Scholar and DSpace Institution's institutional repository of theses and dissertations. Searching for the relevant literature included in this systematic review was conducted from July 2021 to September 2021. The main keywords used were "inquiry-based learning," "model of inquiry," "levels of inquiry," "learning cycles," "science education," and "Ethiopia." In addition, terms such as "chemistry," "biology," and "physics" were added. From the available electronic databases and/or national databases, we retrieved 31 research reports. After a careful examination of the abstracts and titles, only 23 research reports were selected, including 14 master's theses, eight articles, and one dissertation (Figure 1). Here, it is important to note that the other 8 research reports were excluded, for their focus was different from inquiry-based learning in science education.

**2.2. Data Collection Instrument.** The study employed the paper classification form (PCF) as a data collection tool as shown by Sozbilir et al. [28]. The PCF contains nine aspects of research papers, descriptive information, topics, level of inquiry, research elements, subject matters, research design/methods, data collection tools, sample and sample size, and data analysis methods.

**2.3. Data Analysis.** To ensure validity and reliability, all the research articles collected were subjected to double classification. To improve the validity and reliability of the analysis procedure, two colleagues who were currently attending Doctor of Education (DEd) in Biology assisted us in the initial classification of the papers. Then, the authors reviewed and exported the data into the excel grid for descriptive statistical calculations. The results are presented in descriptive statistics including frequency, percentage tables, and charts.

## 3. Results

**3.1. Descriptive Information of the Papers Reviewed.** Table 1 indicates research reports on inquiry-based learning (articles, theses, and dissertations conducted by Ethiopian researchers) from 2010 to 2021. Until 2014, inferring from the table, it was evident that Ethiopian science educators had

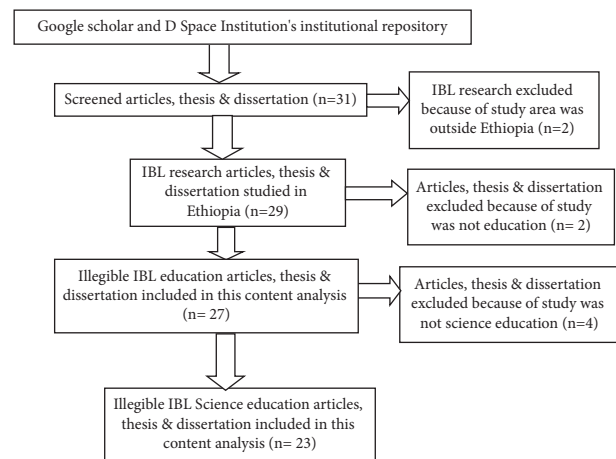


FIGURE 1: Flowchart of articles, theses, and dissertations selected for content analysis in Ethiopia.

little interest in IBL. The research trend reached its peak in 2019 and then slowed down in 2020 after which IBL research achieved a tipping point in 2021. Although the number of papers published in international journals was relatively minimal, the research trend on IBL has been growing steadily.

**3.2. Descriptive Statistics Related to IBL Studies in Ethiopia.** Table 2 indicates the descriptive data of IBL studies in Ethiopia. The reviewed papers were conducted by Ethiopian researchers (100%), in English language (100%), theses (60.9%), articles (34.8%), and dissertations (4.3%).

**3.3. Frequently Investigated Science Topics in IBL Papers (2010 to 2021).** As indicated in Table 3, the frequently explored science subjects in the reviewed IBL studies were biology (43.5%), followed by chemistry (34.75%), and physics (13.05%). Mixed science types were the lowest researched subjects (8.7%). The most commonly studied topics in the collected IBL studies in descending order were the structure and function of plants (21.8%), human biology (13%), and chemistry practical laboratory work (13%). The remaining publications were on acids and bases (8.7%), biology laboratory practical work (8.7%), electricity (8.7%), and other mixed science topics that focused on teaching and learning (8.7%).

**3.4. Frequently Investigated Types of IBL Studies (2010 to 2021).** As it is summarized in Table 4, the number of research reports dealing with guided inquiries was (69.6%) (5E model = 65.2% and 7E model = 4.4%). On the other hand, the authors researched confirmatory inquiry, guided inquiry, structured inquiry, and open inquiry levels. Mixed levels of inquiry accounted for 30.4% of all inquiry studies conducted in science laboratories. The representation of these inquiry levels was imbalanced in mixed-type research. Confirmation and structured inquiry levels were well represented, whereas guided inquiry kinds were few but non-existent in open inquiry.

TABLE 1: The number of research reports related to IBL in Ethiopia from 2010–2021.

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
National	1	1	0	0	1	0	1	0	0	5	0	6	15
International	0	0	1	0	1	0	0	0	1	1	2	2	8
<b>Total</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>6</b>	<b>2</b>	<b>8</b>	<b>23</b>

The total number of research reports in each year (2010-2021).

TABLE 2: Descriptive statistics for the reviewed studies related to IBL in Ethiopia.

Descriptive information of papers	<i>f</i>	%
Language of studies		
Amharic/other local	0	0
English	23	100
<b>Total</b>	<b>23</b>	<b>100</b>
Types of study		
Theses	14	60.9
Dissertations	1	4.3
Articles	8	34.8
<b>Total</b>	<b>23</b>	<b>100</b>

The total frequency and percentage of the types of studies under consideration.

TABLE 3: Frequently investigated topics in the reviewed IBL papers (2010 to 2021).

Subject	Topics	<i>f</i>	%
Biology (43.5%)	Structure and function of plants	5	21.8
	Human biology	3	13
	Biology laboratory practical work	2	8.7
Chemistry (34.75%)	Physical and chemical changes	1	4.35
	Acids and bases	2	8.7
	Water	1	4.35
	Substances	1	4.35
	Chemistry practical laboratory work	3	13
Physics (13.05%)	Electricity	2	8.7
	Atmospheric pressure	1	4.35
Mixed (8.7%)	Unspecified topics	2	8.7
<b>Total</b>		<b>23</b>	<b>100</b>

The total frequency and percentage of the study topics of the studies under consideration.

TABLE 4: Frequently studied inquiry types in the collected IBL papers in Ethiopia (2010 to 2021).

Types of inquiry	Level of inquiry/models	<i>f</i>	%
Confirmatory inquiry	0	0	0
Structured inquiry	1	0	0
Guided inquiry	2 (5E)	15	65.2
	2 (7E)	1	4.4
Open inquiry	3	0	0
Mixed	Level 0,1,2,3	7	30.4
<b>Total</b>		<b>23</b>	<b>100</b>

The total frequency and percentage of the types of inquiry in the studies under consideration.

3.5. *The Most Frequently Investigated Subject Matters in IBL Papers (2010 to 2021).* Table 5 indicates the most frequently investigated subjects in descending order. Teaching (47.8%), learning (43.5%), and attitude/perception studies (8.7%) were the top three subject matters that received considerable

TABLE 5: General subject areas in the IBL studies in Ethiopia (2010 to 2021).

Subject matters	<i>f</i>	%	
Teaching (47.8%)	Method comparing (Comparative study)	3	13
	Effect of teaching on attitude	0	0
	Effect of teaching on achievement	3	13
Learning (43.5%)	Effect of teaching on scientific process skills	5	21.7
	Misconceptions	1	4.35
	Learning styles	1	4.35
Attitude/perception studies (8.7%)	Determining achievement/knowledge	8	34.8
	Others	0	0
<b>Total</b>	<b>23</b>	<b>100</b>	

attention in all the studies. The majority of the studies that investigated IBL in Ethiopia focused on the teaching although there were some differences in percentages. The effect of teaching on scientific process skills was the most frequently studied (21.7%), followed by the comparison of teaching methods, and the effect of teaching on achievement (13% each). On the other hand, research on learning accounted for 43.5%, of which determining achievement/knowledge accounted for 34.8% and research on learning styles and studies related to misconceptions (4.35% each). No study was found examining other subject areas such as computer-aided instruction, general education problems, the nature of science, test/scale development or translation, environmental issues, and research method studies.

3.6. *The Most Frequently Used Research Elements in IBL Papers (2010 to 2021).* Figure 2 summarizes the reviewed results of elements related to IBL research in Ethiopia from 2010–2021. The findings indicated that the researchers in biology, physics, and chemistry favored the cognitive research element (58.6%) over psychomotor (31.1%) and affective (10.3%). However, little or no research was conducted to examine affective factors such as motivation, spirituality, and other research elements. Some researchers were found to include more than one research element in their studies.

3.7. *Frequently Used Research Design/Methods in IBL Papers (2010 to 2021).* Table 6 summarizes the frequently used research methods in IBL studies in Ethiopia from 2010–2021. The most frequent research methods used were quantitative (78.3%) and mixed (21.7% each), but no qualitative research was detected. The most frequently used research methods were quasi-experimental (60.9%), which was followed by a

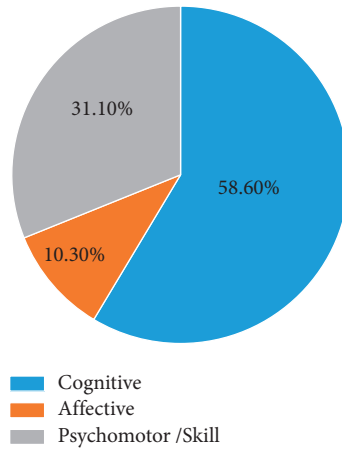


FIGURE 2: The most frequently used research elements in IBL studies in Ethiopia (2010 to 2021).

TABLE 6: Frequently used research design/methods in IBL studies in Ethiopia (2010 to 2021).

Research Design	Research method	F	%	
Quantitative (78.3%)	Experimental	True-experimental	1	4.35
		Quasi-experimental	14	60.9
		Pre-experimental	0	0
		Single subject	0	0
	Nonexperimental	Descriptive	0	0
		Comparative	0	0
		Correlational	0	0
		Survey	3	13
		Ex post facto	0	0
		Secondary data analysis	0	0
Mixed (21.7%)	Mixed Designs	Explanatory	2	8.7
		Exploratory	1	4.35
		Triangulation	2	8.7

survey (13%). The two least utilized research methods were exploratory and true-experimental research methods (4.35% each). Most of the studies were empirical research, whereas the researchers did not use both interactive and noninteractive qualitative study designs.

3.8. *Frequently Used Data Collection Tools in IBL Papers (2010 to 2021).* Table 7 indicates that the two most frequently used data collection tools were achievement tests (28%) and observation (28%), which were followed by interviews (14.7%) and questionnaires (13.3%). One of the striking points in the table is that multiple choice was the most commonly used type of the achievement test, whereas the Likert scales were most commonly applied in questionnaire items. In the studies, the proficiency of students was measured by tests where multiple choice (22.1%) and open-ended (4.4%) were the most commonly used types of achievement tests. It was also indicated that the researchers' most commonly used interview was the semistructured type (5.9%). Apart from using questionnaires, tests, interviews, documents, and other data collection tools were not used as data collection tools in the studies. The findings also asserted that more than one data collection tool was used by the researchers in the study. For instance, both the multiple-

choice test and the open-ended test could be used together. Furthermore, the use of three or more, two, and one data collection instruments accounted for 65.2%, 26.1%, and 8.7%, respectively.

3.9. *Frequently Used Samples.* Table 8 displays the sample groups chosen for the research subjects. The majority of the sample groups were primarily second-cycle primary school students (41.9%) and teachers (29%), which were followed by undergraduate students (9.7%) and others (9.7%). It is noticeable from the following table that no IBL study in Ethiopia collected data from preschool students, first-cycle primary students, postgraduates, and parents.

3.10. *Frequently used Sample Sizes.* Figure 3 indicates the frequently used sample size for thesis, dissertation, and published research articles. As inferred from the findings of the reviewed studies (Figure 3), the most frequently used sampling sizes used in the IBL research papers ranged from 1 to 300 samples in the studies where the two most commonly used sample sizes were 31–100 samples (56.5%), followed by 101–300 samples (34.8%), whereas few studies used 11–30 samples (4.35%) and 1–10 samples (4.35%). The data also

TABLE 7: Types of data collection tools in IBL studies in Ethiopia (2010 to 2021).

Tools	<i>f</i>	%
Achievement tests	19	28
Multiple choice	15	22.1
Open-ended	3	4.4
Others	1	1.5
Questionnaires	9	13.3
Likert type	5	7.4
Open-ended	4	5.9
Aptitude, attitude, perception, personality, etc., tests	0	0
Interviews	10	14.7
Structured	3	4.4
Semistructured	4	5.9
Unstructured	0	0
Focus group	3	4.4
Not reported	0	0
Alternative assessment tools/informal assessment	6	8.8
Documents/content analysis	5	7.4
Observations	19	28
No of data collection tools		
One	2	8.7
Two	6	26.1
≥Three	15	65.2

TABLE 8: Frequently used samplings in IBL studies in Ethiopia (2010 to 2021).

Samples	<i>f</i>	%
Preschool	0	0
Primary (1–4)	0	0
Primary (5–8)	13	41.9
Secondary (9–12)	2	6.5
Undergraduate	3	9.7
Postgraduate	0	0
In-service teachers	9	29
Administrators	1	3.2
Parents	0	0
Others	3	9.7
<b>Total</b>	<b>31</b>	<b>100</b>

The total frequency and percentage of the sample types of the studies under consideration.

revealed that although the sample size of each study was specified, there was no study with large sample sizes.

3.11. *Frequently Used Data Analysis Methods in IBL Papers (2010 to 2021).* Table 9 displays the frequently used data analysis methods across the years (2010–2021). The data analysis methods that received more attention from the researchers were quantitative (72.6%) and qualitative (27.4%). Although descriptive and inferential statistics were the most frequently used data analysis methods, the percentage of use of descriptive statistics (54.6%) was greater than that of inferential statistics (18%) in both the national and international publications of the research reports. The authors used frequency and central tendency measures as data representing tools in descriptive studies. In addition, the *t*-test and ANOVA were the most commonly used

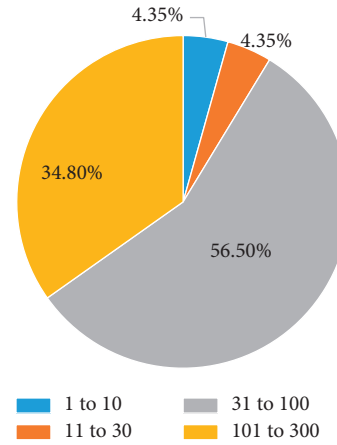


FIGURE 3: Frequently studied sample sizes in IBL studies in Ethiopia (2010 to 2021).

TABLE 9: Frequently used data analysis methods in IBL studies in Ethiopia (2010 to 2021).

Quantitative/qualitative	Types of statics	<i>F</i>	%
Descriptive statistics (54.6%)	<i>f</i> /% tables	23	27.4
	Central tendency measures	15	17.6
	Charts	8	9.6
	Others	0	0
Inferential statistics (18%)	<i>t</i> -test	14	16.8
	Correlation	0	0
	ANOVA/ANCOVA	1	1.2
Qualitative (27.4%)	Content analysis	5	6
	Descriptive analysis	18	21.4
	Others	0	0
No of data analysis methods	One	7	8.70
	Two	37	43.50
	≥Three	40	47.80

inferential statistical methods in the reviewed studies for this research. However, they did not use MANOVA/MANCOVA, factor analysis, regression, and nonparametric tests. Although the interest in qualitative analysis methods has slightly declined in recent years, the use of descriptive analysis (21.4%) was equivalent to quantitative inferential statistics. The findings indicate that the researchers used more than one data analysis method in a single study. The findings indicated that more than one data analysis method might be used in a study. For instance, both descriptive statistics and inferential statistics could be used together, so the total frequency may go over 23 in the columns. Three or more data analysis methods (47.8%) and two data analysis methods (43.5%) were extensively employed, whereas the use of one data analysis method (8.5%) had the lowest frequency.

#### 4. Discussion

Many of the research reports reviewed for the present study were theses. It might be because of the newly launched master-level education programs in different universities in

the country. Although the number of research papers published in international journals was still relatively small, it has been steadily increasing in recent years. In line with the study conducted by Sozibilir et al. [28] that reviewed over 1200 research articles, IBL studies in Ethiopia were found to be quite few, although there has been a steady increase since 2019. The main reason behind this could be the relative newness of the field among Ethiopian science educator scholars, indicating that more attention needs to be paid to science education research in Ethiopia.

The language of publication for all reviewed IBL research studies was English. This has made IBL research more visible in the eyes of the international research community. Hence, these studies will undoubtedly make it easier for academics everywhere to analyze and compare IBL studies with those studies conducted in their own countries.

Biology was the most often explored research subject in the IBL studies analyzed, which was followed by chemistry and physics. This finding was consistent with the results of Breslyn and McGinnis [29]. The most popular research topics in the studies reviewed for the present study were human biology, plant form and function, and chemistry practical laboratory work. In contrast, studies conducted worldwide have revealed that students, prospective teachers, or teaching staff still have limited knowledge, learning difficulties, misconceptions, negative attitudes, etc., on topics of animal form and function [30–32]. This result gives clear indication for future researchers to conduct further studies on these areas.

Guided inquiry with the 5E model studies was the most frequently investigated inquiry type. Compared to the study conducted by Bybee et al. [33] that reviewed over 97,000 posted and discrete examples of universities, 5E studies in Ethiopia are still fewer. Confirmatory inquiry, guided inquiry, structured inquiry, and open inquiry were frequently researched and combined with science laboratory investigations. Structured inquiry and confirmatory inquiry were more common in mixed-type study reports than in studies that dealt with guided inquiry. On the other hand, researchers did not prefer open inquiry (level 3). Educators have not reached a consensus regarding the types of inquiry that were more appropriate to the teaching and learning facilities provided in schools. Some teachers preferred using structured or guided inquiry, and others favored open inquiry. The main factors that hindered the implementation of inquiry learning were lack of motivation, students' inability to access investigative techniques, practical constraints on the learning context, students' background knowledge of inquiry-based learning, and problems related to managing and extending activities [2]. Furthermore, as science advances, it requires a more complex environment to learn effectively. As a result, the complexity of implementing inquiry-based learning might have been one of the reasons why researchers preferred using 5E models to lead the inquiry.

One of the major objectives of this study was to identify the most frequently focused subject areas in IBL studies. With regard to this, the most frequently investigated subject areas were IBL effects on teaching, learning, and attitude/

perception studies. Among these few studies, the most common practice of IBL in science education was the investigation that focused on the effects of IBL on the achievement of science topics. The majority of the studies that investigated IBL in Ethiopia focused on teaching although the percentages were similar. The effect of teaching on scientific process skills got the highest frequency, whereas the compared method and the effect of teaching on achievement each had a low frequency. While research areas related to learning achievement were frequently researched, both learning style and misconception have still received little attention in science education. No study focused on how IBL could be integrated effectively into the teaching of science. The result revealed the scarcity of research on integrating IBL activities, which was more or less similar to the trends of other science education studies throughout the world [25,28,34,35]. In a similar vein, the findings indicated the lack of studies focusing on applied practical studies, curriculum studies, teacher training, concept analysis, test/scale development or translation, general educational problems, the nature of science, and research method studies. Thus, the paucity of research on such topics indicates that researchers still need to provide due attention to these research subjects.

The research elements traced in IBL research included cognitive, affective, and psychomotor. Cognitive and psychomotor factors were the most frequently used elements, whereas the affective factors got less attention. This finding was consistent with the research results of Haviz and Ridho [36] and Şeyda and Sözbilir [37]. The majority of the studies evaluated the effectiveness of students' conceptual knowledge by utilizing various inquiry-based learning strategies. Second, assessment of the state of practical skills of students and teachers was reported and, lastly, the reviewed analysis of studies also showed the attitudes of teachers and students toward inquiry learning. Therefore, there is a need to give attention to the affective factors that impede the effective implementation of IBL by science educators.

Recalling the analysis of the reviewed data, it was evident that quantitative research approaches were the most popular in Ethiopian IBL studies from 2010–2021. Among the quantitative research methodologies employed in the present study, the experimental research designs (15 studies) were preferred over nonexperimental designs (3 studies). The most popular experimental research method was quasi-experimental (14 studies). Indeed, the result of this study was in tandem with the findings of Kizilaslan et al. [25]. A quasi-experimental design entails manipulation of an instruction-related independent variable with a comparison/control group, but randomization is absent at all levels. This advantage of the quasi-experimental method might have induced researchers to prefer it to the true-experimental method. The reason for the frequent use of the quasi-experimental method by the researchers might be because most science educators were influenced by previous research.

Although the percentage was relatively lower compared to quantitative approaches, mixed-method designs (5 studies) gained slight attention in the IBL studies reviewed

for this study. This tendency is reminiscent of the findings of other studies. For instance, Schram [38] stated that more and more researchers in science education have been turning to the practice of combining qualitative and quantitative designs. This value supports the claim that IBL researchers really appreciated the importance of mixed methods in their studies. Because mixed method studies include two key methodologies: quantitative and qualitative, they have the potential to progress IBL research [39]. In the next years, this seems to be a developing trend in science education research. Mixed method research is a great way to look at a variety of interventions [39]. In contrast, no noninteractive or interactive qualitative research designs were used in the IBL studies reviewed for this study. This contradicts the findings of Sozbilir et al. [28]. This finding could be linked to the lack of science educators' understanding, skills, and attitudes toward qualitative research designs. To illustrate, although qualitative research is popular among researchers because it enables them to understand real-life problems, little or no research was conducted using qualitative methods in the studies reviewed for this study. Therefore, as such needs are crucial, it can be suggested that there is a need to develop the qualitative research skills of science educators.

Various data collection tools were used to gather both the quantitative and qualitative data. The most frequently used data collection tools in the research were achievement tests, observation, interviews, and questionnaires. This study revealed that most of the research papers utilized multiple-choice questions from achievement tests, Likert type and open-ended questionnaires, semistructured interviews, and documents. It was also revealed that most studies were conducted based on the data collected through two or more data collection tools. This was consistent with the research results of the authors of [25,28,37]. The use of one data collection tool has been decreasing but increasing gradually to two or three data collection tools. The reason for all these findings may be because the researchers might have preferred mixed research designs and methods. The use of the Likert-type questionnaires was the most common among the data collection tools used throughout the IBL studies analyzed for this study [28]. Especially, due to facilities in analyzing and applying the data, questionnaires might direct researchers to use them in their studies. Moreover, De Jong [40] stated that the use of these instruments was often quite fast and that much data could be collected easily. However, the data analysis could not provide much information about the argumentation that was used by the participants. This kind of information could be better collected by using different methods, such as multiple-choice questions that provide participants with an opportunity to explicate their answers and essay questions of an open or semistructured nature [40]. Similarly, open-ended questions can provide richer data [41]. However, documents and other data collection tools such as informal assessments were not widely used as data collection tools in the studies. This was most likely due to these types of tests being usually used in qualitative research, which was not observed in the IBL studies conducted from 2010–2021.

The most frequently used samples in the IBL studies were taken primarily from second-cycle primary school students and in-service teachers, followed by undergraduate students. This finding was consistent with the findings of studies by [28,42]. A possible explanation for such a sampling trend could be because the researchers might have tended to conduct studies with easily accessible samples. To illustrate, science-based topics in primary schools and undergraduates are presented as more comprehensive and detailed, and hence, researchers have probably accessed these sample populations because they were most suited to the types of the inquiry to be conducted [42]. It is noticeable that no IBL study collected data from preschool students, first-cycle primary students, postgraduates, or parents in Ethiopia. This might be associated with the level of the research inquiry conducted.

The most commonly utilized sample sizes were determined to be 31–100, 101–300, and 11–30. According to McMillan and Schumacher [39], one probable reason for this finding is the impact of having a small sample size in research that shows no statistically significant differences or connections, especially when so many educational studies use small samples. However, when the sample size is limited, other factors, such as sampling bias or the presence of confounding variables, have a greater chance of influencing the results.

Another major result revealed that the IBL researchers favored quantitative data analysis methods. Quantitative data analysis methods were the most generally utilized data analysis tools. It is important to mention that in quantitative data analysis, descriptive and inferential statistics were used, whereas qualitative data analysis focused on descriptive and content analysis. The usage of descriptive statistics was the highest across the years, whereas qualitative data analysis approaches were second. Only a few researchers preferred to utilize only one data analysis method in their investigations, whereas the majority of IBL researchers used two or three data analysis methods. The foci of multiple data analysis methods used by IBL studies reported in this study are pivotal and consistent with the findings of Sozbilir et al. [28].

Researchers preferred diverse study designs and methods. Frequency/percentage tables, central tendency measures, and charts were the most commonly used or popular descriptive data analysis tools. A lot of the studies employed inferential analysis, among which, the *t*-tests and ANOVA/ANCOVA were the most commonly used types. However, the reports obtained from the reviewed IBL studies did not use the nonparametric tests; MANOVA/MANCOVA, factor analysis, and regression analysis. *t*-tests and ANOVA were more frequently used than the other techniques because these data analysis methods were amenable to the statistical computations given the use of relatively small sample sizes in the majority of the studies. It may be because the studied intervariable characteristics were designed in a low number, and thus, the researchers preferred to analyze using *t*-tests and ANOVA [44]. In addition, the reason why the researchers did not use advanced statistical methods such as MANOVA/MANCOVA tests,



factor analysis, and regression analysis may be attributed to the lack of research skills of the researchers.

## 5. Conclusion

The total number of IBL studies that compared the current science education with previous content analysis studies was limited. The majority of the research reports in this study were theses. The most frequently investigated research subjects were biology, followed by chemistry and physics. Research reports that focused on guided inquiry with the 5E model were the most frequently studied inquiry types. The most frequently investigated subject areas were teaching, learning, and attitude/perception. The research reports with cognitive features were the most frequently employed research elements, while quantitative research approaches were the most commonly employed research methodologies; the quasi-experimental was the most popular experimental research method used by IBL researchers in Ethiopia from 2010–2021. In general, the findings of this study indicated that inquiry-based learning has been a newly introduced research area in Ethiopia where it has been frequently practiced in science education at the primary level. This study may help researchers realize the practicability of inquiry-based learning in teaching science lessons and apply it to their disciplines.

## 6. Recommendations

Based on the findings of this investigation, IBL has not yet been a widely used teaching and learning strategy in Ethiopian science education. Thus, a new educational pedagogy that moves from traditional, primarily deductive teaching methods to more engaging, cognitively active learning techniques is required. IBL is an approach of choice for increasing students' interest in achievement and scientific literacy in science. Therefore, we suggest that Ethiopian science educators should pay considerable attention to IBL studies in Ethiopia, with a higher emphasis on using several methodologies rather than a single primary research model. For the next generation to be scientifically literate, we recommend that the effective implementation of IBL will be significantly essential.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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