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Research article

Inquiry-based learning and students' self-efficacy in Chemistry among secondary schools in Kenya

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A R T I C L E I N F O

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A B S T R A C T

Inquiry-Based Learning (IBL) influences educational outcomes such as test scores, students' attitudes, and self-efficacy. Self-efficacy is a significant predictor of the academic performance of students and therefore it is an important construct for measuring attainment of learning objectives. This paper discusses how inquiry-based learning in Chemistry practical lessons enhances students' self-efficacy in Chemistry. A total of 21 Chemistry teachers and 357 Form three Chemistry students were randomly selected from the 21 classrooms that these teachers taught. A concurrent triangulation mixed-methods research design was employed. Data was gathered using an adapted teachers' self-reported IBL instrument and a lesson observation schedule was used to rate the teachers' IBL use in Chemistry practical lessons. Besides, a 26 item instrument was also adapted from existing literature to measure students' self-efficacy in Chemistry. Exploratory Factor Analysis (EFA), and Principal Component Analysis (PCA) were used to determine the suitability of measuring tools. Means and percentages were used to examine IBL use and students' self-efficacy while Pearson Correlation coefficient and regression analysis were used to examine the influence of IBL on learners' self-efficacy. Results revealed that teachers used inquiry-based learning once a week (overall mean = 3.89). Also, students' rating of their self-efficacy in Chemistry was high (Mean = 3.929). Finally, the results from correlation and regression analysis revealed a strong positive correlation between inquiry-based learning and students' self-efficacy in Chemistry ($r = 0.903$, $p < 0.05$, $R^2 = 0.8155$).

1. Introduction

In science education, determining the effectiveness of various teaching methodologies is still a major concern given the continued emphasis on inquiry teaching. If inquiry-based learning is as effective as it's touted to be, then determining its impact on major educational outcomes would be a worthwhile endeavor [1]. According to Bernido, inquiry teaching has been backed up by research and is encouraged in the teaching of sciences. However, majority of the supporting empirical evidence has been coming from studies that focus on research contexts rather than in regular classroom settings [2].

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Inquiry-based learning has several definitions, but accurate definitions in the literature are difficult to come across. Inquiry is related to several different teaching methodologies, including many of the pedagogies used in modern classrooms [3]. [1] defines inquiry as a teaching strategy where the student is the active participant in the learning environment and the teacher avoids direct lecturing. According to Ref. [2]; inquiry-based learning has been used to represent a wide range of instructional methods, all of which involve some level of student decision-making. The [4] defines inquiry as:

A multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires the identification of assumptions, the use of critical and logical thinking, and consideration of alternative explanations. (p. 23).

In general, inquiry-based learning is a teaching and learning technique where students are actively involved in the learning process and the teacher facilitates the learning process. The most important qualities of IBL are learner-centered activities, there is solving problems, discovery activities, scientific applications, and the instructor as a facilitator rather than a knowledge source [1,3].

What makes up inquiry-based learning is what takes place in practical lessons. Practical work refers to activities that engage learners in the process of making observations, experimenting, and deducing explanations and conclusions based on the findings. Experimental work helps learners understand the theoretical Chemistry concepts, acquire problem-solving skills, and supports students' self-efficacy in sciences [5–7]. Besides, practical lessons provide the best opportunities for an inquiry learning approach due to the experimental nature of the strategy [8].

Chemistry in Kenya is taught through a combination of two approaches, theoretical and practical approaches. The subject is examined through three papers, paper 1 and 2 examine the theoretical aspect of Chemistry while paper 3 focuses on the practical aspect of Chemistry. Paper 1 tests content from forms 1, 2, 3 and 4 and each question carries a maximum of 3 marks. Paper 2 examines deep understanding of the concepts studied where a question carries a minimum of 10 marks and a maximum of 14 marks. Paper 2 tests content from specific topics from forms 1, 2, 3 and 4. Paper 3 tests from quantitative and qualitative practical skills attained by students from forms 1, 2, 3 and 4 [9]. The practical paper is marked out of 40 marks and therefore it accounts for 40% of the students' performance in Chemistry and the remaining percentage comes from the other papers. Practical exams i.e. paper 3 typically have qualitative and quantitative experiments (Kenya National Examination Council (KNEC), 2018) usually at structured and confirmatory levels of inquiry learning.

The efficacy of inquiry-based instruction has been scientifically validated [10]. In science education, inquiry serves at least two purposes, both as a scientific discipline and as an instructional tool [2]. Inquiry takes four different forms; confirmation, structured, guided, and open inquiry. The freedom offered to the students in creating the inquiry is what differentiates the approaches [11]. The approaches begin with practically no students' flexibility but end with the students having total control in the learning process. In this study, these types of inquiry were not used because the focus of the study was on the phases of 5E model without classification of the different activities to the different types of inquiry.

Inquiry-based learning can be utilized in science lessons through the implementation of the 5E instructional paradigm, a lesson planning strategy that involves Engaging, Explaining, Exploring, Extending, and Evaluation (5Es) [12]. The occurrence of each of the 5E, and the frequency with which it occurs is a good measure of the extent to which IBL is being used. The engagement step takes into account the learner's past experience and knowledge and triggers the learner's preconceived ideas about the concept. In the exploration phase, learners are allowed to carry out investigations while the explanation phase is a teacher-directed step [13]. Learners are involved in further learning experiences that extend the concepts, processes, or skills in the elaboration phase. Finally, the evaluation step provides learners with an important opportunity to assess their learning by applying what they've learned [13].

Implementation of inquiry-based learning approach has been found to be useful in Chemistry. According to Ref. [14]; IBL is an effective method of facilitating and retaining students' conceptual understanding of Chemistry concepts such as chemical reaction rate. Also, IBL can lead to improvement of students' attitudes towards Chemistry as well as literacy skills in Chemistry concepts [15,16]. However, research has shown that IBL is not widely used. For example, in Hong Kong, IBL is used as a teaching aid by few teachers [17]. This could be attributed to some of the challenges that Chemistry teachers face in the implementation of this approach. They include large class sizes, lack of time, lack of effective instructional materials, and problems in guiding students to select a research topic and reformulate it into an investigation [17]. Besides, according to Ref. [18]; teachers who have poor attitudes towards IBL find it difficult to make use of IBL in science teaching. However, professional development workshops can enhance the understanding and practice of IBL in Chemistry teaching and learning [19].

Inquiry-based learning has been associated with enhanced efficacy beliefs of students in sciences. [20] defines self-efficacy as the judgments of individuals about themselves on how successfully they can deal with difficult situations. A study by Ref. [21] revealed that inquiry-based learning was more successful than scientific learning in increasing self-efficacy in science. Another study by Ref. [22] revealed that in physics, the use of a virtual laboratory with guided inquiry instruction was more effective for challenging concepts and scientific inquiry self-efficacy when compared to the physical laboratory. According to Ref. [23]; students who used the self-regulated learning technique to do inquiry enhanced their willingness to seek information as well as their self-efficacy. [24] discovered that students' efficacy beliefs in Chemistry increased after the problem-based laboratory experience. According to Ref. [25]; inquiry-based instruction, when compared to more didactic techniques, leads to greater gains in self-efficacy as students engage in problem-solving activities.

While self-efficacy beliefs of students are more accurate indicators of academic performance than objective assessments of their ability [20], performance in Chemistry has been poor, especially in Meru South Sub-County [26]. Besides, the efficacy beliefs of Kenyan students in Chemistry have been low [27]. Therefore, the goal of this study was to find out whether IBL is used in Chemistry teaching and how it relates to students' self-efficacy in Chemistry.

2. Method

2.1. Research design

This research adopted a concurrent triangulation mixed methods research design. The design allows the collection of both quantitative and qualitative data to ensure a good understanding of a phenomenon [28]. In this study, Classroom observations were made, which is a qualitative method of data collection and the data from the observations was coded quantitatively [29]. This made it possible for the qualitative data to be analyzed quantitatively making it easy for deductions to be made from the comparison of the two sets of data. To establish the use of IBL in practical lessons, teachers' survey and lesson observations were used. A students' survey was employed to find out students' self-efficacy in Chemistry. The information obtained from the teachers was cross-checked with observations to determine the accuracy of the information.

2.2. Sample and sampling procedures

Purposive sampling was used to select the sub-county where this research was conducted. To select the number of secondary schools, both stratified and purposive sampling were used. The 21 teachers were selected purposively. The learners who participated in the study were chosen using simple random sampling. Using the Yamane formula, a sample of 357 Form three students was selected from the total population of 3,321 students [30]. This allowed a reasonable sample of 17 students from the classes of the 21 selected teachers. Since some students may not respond to the questionnaires, the researcher used a larger sample size to reduce the errors associated with sampling [31].

2.3. Instruments

The instruments for measuring teachers' utilization of inquiry-based learning consisted of 10 items each which were derived from the 5 E instructional model [13] and the existing literature [2,32]. The items were rated on a 5-point Likert scale as follows; 5 = Very Frequently (VF), 4 = Frequently (F), 3 = Sometimes (SM), 2 = Rarely (R), and 1 = Never (N). However, since it would not be clear to the teachers how to rate themselves, the scale was quantified where frequency indicated the occurrence of an event in lessons over a fixed time. Therefore, very frequently was modified to Every Lesson (EL), frequently to Once a Week (OW), sometimes represented Once a Month (OM), and rarely represented Once a Term (OT). The Cronbach reliability coefficient of the scale was 0.802. To obtain valid items for the lesson observation schedule, a peer check was done to determine the items to be included in the observation schedule. The interrater reliability between two authors was 0.925, and therefore the items were considered good enough to measure IBL use. The lesson observation was used to record the frequency with which the items would occur in the lesson in 10 minutes interval. Cronbach's reliability coefficient of the observation schedule was found to be 0.891. The instruments were scored as follows; a mean of 1–1.4 represents no IBL at all, 1.5–2.4 means IBL is used once a term (rarely), 2.5–3.4 means IBL is used once a month (sometimes), 3.5–4.4 means IBL is used once a week (frequently) then 4.5–5.0 means IBL is used in every lesson (very frequently).

For students' self-efficacy, the instrument was adapted from Ref. [33]; and [34]. The modified scale had a total of 26 positively worded items which were rated on a 5-point Likert scale as follows; 5 = Strongly Agree, 4 = Agree, 3 = Not Sure, 2 = Disagree, and 1 = Strongly Disagree. A score of 1–2.4 would be regarded as low self-efficacy, 2.5–3.4 would be neutral, and 3.5–5.0 would be regarded as high self-efficacy. The items were piloted with 90 Form three Chemistry students from two randomly selected County secondary schools in Embu County. The Cronbach alpha reliability coefficient for the self-efficacy scales was 0.784. Since the instrument was adapted and modifications were made, the data was subjected to EFA and PCA [35]. [36] describe a sample size of 300 people as adequate for factor analysis. Therefore, EFA was used to determine the structure of the scale. Results from the EFA revealed that the scale assessed three sub-constructs of self-efficacy; Confidence in Value of Chemistry, Confidence in Knowledge of Chemistry, and Confidence in doing practical work with Cronbach reliability coefficients of 0.867, 0.843, and 0.738 respectively. Again, the results from the EFA led to the removal of one of the items which had low factor loading, and therefore the resulting scale had 25 items.

2.4. Ethical considerations

The researcher received approvals to conduct the research from the Board of Postgraduate Studies, University of Embu, and the National Commission for Science Technology and Innovation (NACOSTI). In order to get access to the schools, the researcher sought permission from the County Director of Education, Tharaka Nithi County, the Sub-County Director of Education in Meru South Sub-county, and the school principals. Before data collection, the researcher visited the sampled schools to plan for lesson observations with the Chemistry teachers and explain to the respondents the purpose of the research. Respondents were assured of the confidentiality of their information and consent was sought from them to take part in the research.

2.5. Data analysis

The data was coded and analysis was done using the R software and SPSS. Descriptive statistics were used to determine IBL use and students' self-efficacy while inferential statistics were used to determine the link between IBL and students' self-efficacy. Q-Q plot, residual vs fitted plot, and scatter plot were computed to check for various assumptions before regression analysis.

3. Results

3.1. Demographic characteristics of study participants

The descriptive statistics of the study participants are presented in Table 1.

3.2. Self-reported IBL use in chemistry practical lessons

This study examined the extent to which Chemistry teachers had used inquiry-based learning approach in Chemistry practical lessons. The self-reporting results from the teachers are presented in Table 2.

The results revealed that each and every lesson had hooking activities that lead students to engage with the lesson (mean = 4.76). Also, teachers evaluated the understanding of their learners in every lesson (mean = 4.50). From the results, the teachers provided explanations for experimental work and allowed learners to design and carry out experiments once a week (mean = 4.265 and 3.57 respectively). However, it is evident that teachers provided opportunities for learners to extend their knowledge once a month (mean = 3.215). The total mean was 4.062 out of the possible 5 points. It can therefore be stated that teachers used IBL once a week.

3.3. Observed use of IBL

Results from the lesson observations are presented in Table 3.

The mean for the observations was found to be consistently lower than the self-reporting mean. The total item mean for the lesson observations was 3.433. Due to the difference in means, a comparison was made between teachers' self-reporting results and the lesson observation results. The results are presented in Fig. 1.

Results from the comparison between teachers' ratings and lesson observation ratings on IBL revealed that teachers over-reported on the extent to which they have used IBL consistently and with a steady margin. Therefore, to determine the actual extent of IBL use results from lesson observation and teachers' ratings were triangulated. An over-reporting index was calculated. This index refers to the factor by which a compromise between observer bias and self-reported bias is established. The index was computed as shown below.

$$\text{Over reporting index} = \left(\frac{\text{Self} - \text{reported mean} - \text{Observed mean}}{\text{self} - \text{reported mean} + \text{Observed mean}}\right) \times 100 \left(\frac{4.062 - 3.433}{7.495}\right) \times 100 = 8.39\% \sim 0.0839$$

The over-reporting index was found to be 8.39%. This implies that the teachers' ratings on IBL use were higher by 8.39%. Since there is a possibility that the observer also underrated, the average of the over-reporting index was computed. Therefore, the self-reported mean was reduced by 4.195%. Also, the total mean of IBL use was reduced by the average index and therefore the final mean was computed to be 3.89. From this mean, it can be concluded that the extent of teachers' use of IBL in Chemistry practical lessons was once a week. Besides, it can be concluded that 77.8% of the lessons used IBL.

3.4. Students' self-efficacy in chemistry

The results for the students' self-efficacy are presented in Table 4. The highest scoring item "I am sure I can use equipment in the Chemistry laboratory" had a mean of 4.4622 while the lowest scoring item "I am sure I can come up with solutions to daily challenges by using Chemistry "had a mean of 3.2885.

The overall mean for students' self-efficacy in Chemistry was found to be 3.929. According to Ref. [37]; a mean above 3.0 indicates high self-efficacy while a mean below 3.0 indicates low self-efficacy. Also [38], opines that a general score that is beyond three on a Likert scale is considered high, and it indicates a positive attribute of the variable measured. Besides, small standard deviations occur where there is concurrence on the items among the students. Therefore, based on the results, students had high self-efficacy in Chemistry. The mean was approximately 4 with a small standard deviation (Std. Dev = 0.6703) indicating that most of the students agreed with the items.

Table 1
Descriptive statistics of participants.

	Gender	Frequency	Percentage
Teachers	Male	17	81%
	Female	4	19%
	Total	**21**	**100%**
Students	Male	159	44.5%
	Female	198	55.5%
	Total	**357**	**100%**

Table 2
Teachers' ratings on IBL use.

	EL	OW	OM	OT	N	Overall mean
Engagement	**83.4%**	**9.5%**	**7.1%**	**0%**	**0%**	**4.76**
I assess learners' prior knowledge	85.7%	9.5%	4.8%	0%	0%	4.81
I make connection between past and present learning experiences for effective learning	81%	9.5%	9.5%	0%	0%	4.71
Exploration	**19%**	**52.4%**	**9.5%**	**4.8%**	**14.3%**	**3.57**
I allow learners to design and carry out experiments in the laboratory	14.3%	57.1%	9.5%	4.8%	14.3%	3.52
I allow learners to discuss among themselves results from investigations	23.8%	47.6%	9.5%	4.8%	14.3%	3.62
Explanation	**59.5%**	**23.8%**	**7.2%**	**2.4%**	**7.1%**	**4.265**
I provide detailed explanations for investigations to be undertaken by students	61.9%	33.3%	0%	0%	4.8%	4.48
I ask learners to explain their understanding of the concepts under study	57.1%	14.3%	14.3%	4.8%	9.5%	4.05
Elaboration	**28.5%**	**16.7%**	**16.7%**	**23.8%**	**14.3%**	**3.215**
I provide instances for learners to extend their learned knowledge to get a deeper understanding	23.8%	19%	19%	23.8%	14.3%	3.14
I allow students to make connections between learned concepts and the world around them	33.3%	14.3%	14.3%	23.8%	14.3%	3.29
Evaluation	**61.9%**	**30.9%**	**2.4%**	**4.8%**	**0%**	**4.50**
I pose related questions to students to assess their knowledge and skills	66.7%	28.6%	0%	4.8%	0%	4.57
I give assignments to assess learners' understanding.	57.1%	33.3%	4.8%	4.8%	0%	4.43
Total mean						**4.062**

Table 3
Observed use of IBL.

	VF	F	SM	R	N	Overall mean
Engagement	**7.1%**	**64.3%**	**28.6%**	**0%**	**0%**	**3.786**
Teacher assesses learners' prior knowledge	9.5%	61.9%	28.6%	0%	0%	3.81
Teacher makes connection between past and present learning experiences for effective learning	4.8%	66.7%	28.6%	0%	0%	3.76
Exploration	**9.6%**	**35.7%**	**33.3%**	**19%**	**2.4%**	**3.310**
Learners are allowed to design and carry out experiments in the laboratory	4.8%	23.8%	47.6%	19%	4.8%	3.05
Learners are allowed to discuss among themselves results from investigations	14.3%	47.6%	19%	19%	0%	3.57
Explanation	**16.7%**	**33.4%**	**30.9%**	**19%**	**0%**	**3.476**
The teacher provides detailed explanations for investigations to be undertaken by students	28.6%	42.9%	14.3%	14.3%	0%	3.86
The teacher asks learners to explain their understanding of the concept under study.	4.8%	23.8%	47.6%	23.8%	0%	3.10
Elaboration	**4.8%**	**19%**	**52.4%**	**21.4%**	**2.4%**	**3.024**
The teacher provides instances for learners to extend their learned knowledge to get a deeper understanding.	4.8%	23.8%	52.4%	19%	0%	3.14
The teacher allows students to make connections between learned concepts and the world around them.	4.8%	14.3%	52.4%	23.8%	4.8%	2.90
Evaluation	**14.3%**	**45.2%**	**23.8%**	**16.7%**	**0%**	**3.571**
The teacher asks related questions to students to assess their knowledge and skills.	28.6%	57.1%	9.5%	4.8%	0%	4.10
Teacher gives class assignment	0%	33.3%	38.1%	28.6%	0%	3.05
Total mean						**3.433**

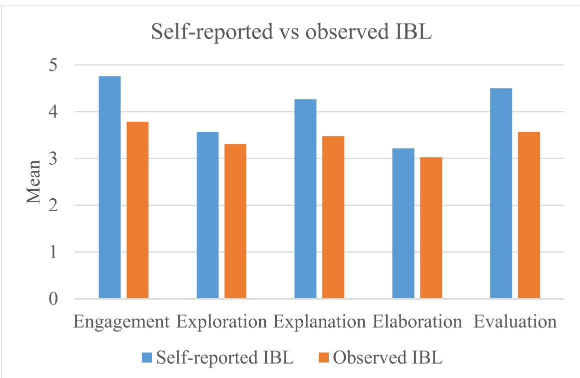

Fig. 1. Teachers' self-reported IBL vs observed IBL.

Table 4
Students' self-efficacy in Chemistry.

Sub-scale	No. of items	M	Std. Dev
Confidence in the knowledge of Chemistry	8	4.027	0.682
Confidence in the value of Chemistry	11	3.614	0.7085
Confidence in doing practical work	6	4.145	0.6205
Overall mean		3.929	0.6703

3.5. Correlation between inquiry-based learning and students' self-efficacy in chemistry

To find out the relationship between IBL use and students' self-efficacy, correlation and regression analysis were carried out. The teachers' practices of IBL use were matched with their students' self-efficacy in Chemistry. To systematically analyze the relationship between this kind of nested data, a multilevel approach would be appropriate. However, this could not be possible due to the limited number of classes participating in the study ($N_{classes} = 21$) which is below the recommendations for multilevel approaches [39]. Results from correlation analysis are presented in Table 5.

Based on Table 5, it can be deduced that there is a strong link between IBL and students' self-efficacy in Chemistry ($r = 0.903$, $p < 0.05$). The relationship is positive and statistically significant implying that the more a teacher practices inquiry-based learning in practical lessons the higher the students' self-efficacy.

Before linear regression analysis was carried out, statistical assumptions such as linearity, independence, homoscedasticity, and normality were checked. Fig. 2 demonstrates one of the statistical assumptions for a regression to be carried out, which states that there should be a linear relationship between the two variables. Based on the figure, it is clear that there exists a linear relationship between the utilization of inquiry-based learning and students' self-efficacy in Chemistry. The Kolmogorov-Smirnov test was computed for normality and the results were $p > 0.05$. Q-Q plot also revealed that the normality test was met (see Appendix 2). Durbin-Watson test value according to Table 7, is close to 2.0 implying that there is no autocorrelation and therefore independence assumption was met. A plot of fitted values vs residuals (Appendix 1) was carried out and the results revealed that the homoscedasticity principle was not violated.

Equation of the line is; $Y = 2.024623 + 0.045586\times$, $R^2 = 0.8155$.

Fig. 2 reveals that there is a positive linear correlation between inquiry-based learning and students' self-efficacy in Chemistry. The graphic shows that the majority of the points align along the line of best fit. In general, as the level of inquiry-based learning rises, so does the level of student self-efficacy.

Since all the statistical assumptions were met, linear regression was computed. Results from regression analysis revealed that there is a strong relationship between inquiry-based learning and students' self-efficacy in Chemistry, $t = 9.163$ $p < 0.05$ (see Table 6). Besides, up to 82% of the students' self-efficacy beliefs could be attributed to the use of inquiry-based learning while teaching, R Squared $= 0.8155$, $F(1,19) = 83.954$, $P = 0.000$ (see Tables 7 and 8). The remaining percentage could be attributed to factors such as vicarious experiences, verbal persuasion, and psychological states.

4. Discussion

The study's goal was to determine the extent to which inquiry-based learning was used in Chemistry practical lessons, as well as the relationship between IBL use and students' efficacy beliefs in Chemistry. The study followed a sound and rigorous methodology, giving robustness to the results. The study found that Chemistry teachers practice IBL in Chemistry practical lessons once a week. Besides, 77.8% of the lessons in Chemistry use IBL. The study results are consistent with previous research [38] who found more practice of IBL in Chemistry lessons compared to Physics and Biology lessons. However, this study differs from other studies [32,40] and this could be explained by the fact that Chemistry teachers in Kenya have had training on IBL and so they tend to use it more. Professional development helps teachers to perfect on their teaching methodologies. This has helped to transform the design of practical from traditional oriented laboratory work to IBL oriented laboratory work. To achieve the goals of teachers being facilitators of inquiry-based laboratories, teachers need to undergo continuous long term professional development aimed at enhancing their pedagogical content knowledge. Their training need to have assessment strategies that are similar to those of high school learners. These professional experiences have the potential of helping teachers develop their skills and confidence in working in student-centered learning environments [41].

When asked for self-report on the extent to which they use IBL, Chemistry teachers give a steady but consistent overrating of about 4.195%. This is in agreement with [40] who argue that due to self-protection, relying on data gathered from teachers is insufficient in

Table 5
Correlation between IBL use and students' self-efficacy.

		Self-efficacy
Inquiry-based learning	Pearson Correlation	.903
	Sig. (2-tailed)	.000
	N	21

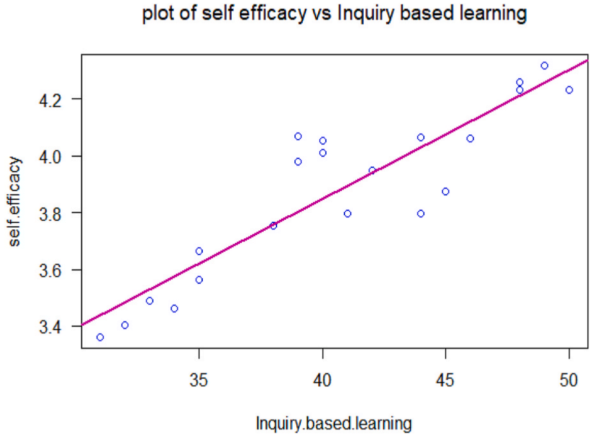

Fig. 2. A plot of self-efficacy vs inquiry-based learning.

Table 6
Regression model coefficients.

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.0246	.204076		9.921	.000		
	Inquiry-based learning	.0456	.004975	.903	9.163	.000	1.000	1.000

Table 7
Regression analysis results.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.903	.8155	.8057	.1302	2.190

Table 8
ANOVA.

Model	Sum of Squares	Df	Mean Square	F	Sig.
1 Regression	1.42339	1	1.42339	83.954	.000
Residual	.32213	19	.01695		
Total	1.746	20			

comprehending their practice.

Results from the study portrayed that students had enough confidence in their capability in Chemistry. Similar findings were revealed in the study by Ref. [42]. Also [43], found that students' efficacy beliefs were slightly above neutral with students displaying a favorable opinion of self-efficacy. The study results revealed that the use of IBL can account for 80% of the Students' self-efficacy. The study findings were consistent with previous research [3,6,21–24,44]. For example [6], found that argument-driven Inquiry instructional paradigm enhances the efficacy beliefs of students in Chemistry. Also [24], interviewed the study participants and found that following the PBL laboratory experience, students exhibited greater efficacy beliefs in Chemistry for carrying out practical activities than they had previously. Besides, results agree with the findings by Ref. [6] who found that inquiry learning enhances the efficacy beliefs of students in Chemistry.

According to Ref. [25]; inquiry-based instruction, when compared to more didactic techniques, leads to greater gains in self-efficacy as students engage in problem-solving activities. Madden (2011) found that after participating in demanding inquiry-based laboratories, freshman biology honors students felt more secure about understanding science. The use of an inquiry-based education strategy improves science teachers' perceptions of their efficacy beliefs in experimental work [44]. However, the results contradict the findings by Ref. [3] who found that IBL was negatively associated with students' learning outcome in terms of their performance.

The results of this study show that the practice of IBL in Chemistry teaching is associated with high self-efficacy beliefs of students in Chemistry. It has been established in previous studies that high self-efficacy beliefs are associated with good performance in sciences yet performance in Meru South is still poor [26]. One of the possible reasons that could have led to such finding is the false self-efficacy where teachers and students think that they know but they don't. Also, this study never looked at the relationship between self-efficacy and performance since it was not its aim and hence it would be interesting if another study focuses on these aspects to ascertain the assertion.

4.1. *Study limitations*

The study has certain limitations. One is that the study was aimed at establishing the relationship between IBL and student self-efficacy, but did not address the relationship with student performance. This relationship has been hypothesized and established by previous studies in other contexts [43,47]. Given that the Kenyan students have previously shown low levels of attainment in Chemistry, it would be interesting to explore in further studies whether the association identified by this study is also reflected on student performance. Another limitation was that only one Sub-County was involved. This may make it difficult to generalize the results to other contexts and hence future studies should increase the number of participants by increasing the number of Sub-Counties as well as the number of schools. Also, this study investigated the relationship between inquiry-based learning and students' self-efficacy in Chemistry but did not investigate the relationship between the different types of inquiry based learning and students' self-efficacy and therefore further studies can be done to examine the relationship between specific levels of inquiry-based learning and students' self-efficacy.

5. Conclusion

This study has found out that teachers use IBL in practical lessons once a week. Besides, the study affirms that when teachers are asked to rate their use of IBL, they tend to over report. On the other hand, students' self-efficacy in Chemistry was found to be high according to the study results. This research also discovered a link between IBL and students' efficacy beliefs in Chemistry. According to Pearson's correlation coefficient findings, there is a substantial positive association between inquiry-based learning and students' self-efficacy in Chemistry in secondary schools. Please note that the general self-efficacy of students can be influenced by so many things but this particular article is about self-efficacy in Chemistry. Self-efficacy can predict performance and therefore it's important that instructional strategies that boost students' self-efficacy are utilized. The correlation between the use of specific levels of IBL and students' self-efficacy in Chemistry in secondary schools was not examined in this study, so it is recommended that a study be conducted to investigate the relationship between specific levels of inquiry-based learning and students' self-efficacy in secondary schools.

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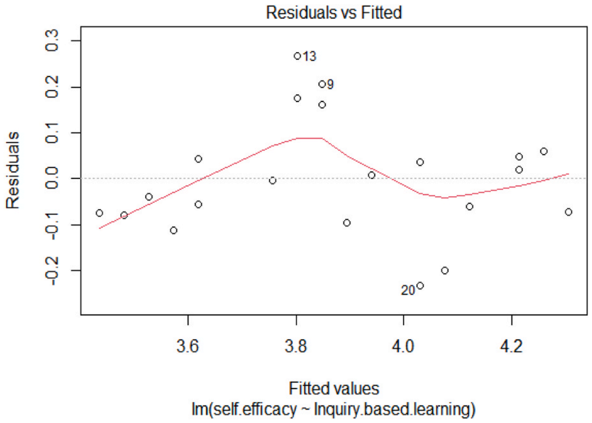
Appendix B. Supplementary data

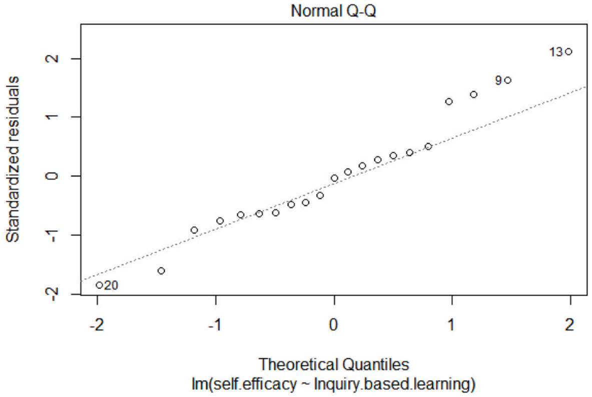
Supplementary data related to this article can be found at https://doi.org/10.1016/j.heliyon.2022.e12672.

Appendices.

Appendix 1: Residuals vs fitted values; self-efficacy and inquiry-based learning.



Appendix 2: Q-Q plot for self-efficacy vs inquiry-based learning.



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