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Training Scientific Literacy Skills Through Inquiry Learning with Chemcollective's Virtual Laboratory on Chemical Equilibrium

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ABSTRACT

Objective: *This study uses ChemCollective's virtual laboratory to apply inquiry learning and seeks to describe the application of inquiry learning models, student activities, scientific literacy skills, and student responses.* ***Method:*** *This study uses a one-group pretest-posttest pre-experimental approach. The study tools included student response questionnaires, student activity observation sheets, learning implementation observation sheets, and literacy test instruments.* ***Results:*** *The study's findings were as follows: (1) the inquiry learning model was implemented at 83% of the first meeting and 93% of the second meeting; (2) the average percentage of student activity that is relevant to inquiry learning was 90.24% at the first meeting and 93.60% at the second meeting; (3) the results of the scientific literacy test improved, with an N-Gain Score of 0.76 in the high category and the results of the paired sample t-test revealed a significance value of 0.000; and (4) With very favorable criteria, 98% of students respond on average to inquiry learning when using the ChemCollective virtual laboratory. These findings suggest that, during the odd semesters of the 2022–2023 academic year, first-semester Science Education Study Program students at UIN Sunan Ampel Surabaya can train their scientific literacy through inquiry learning supported by ChemCollective's virtual laboratory.*

INTRODUCTION

Advances in science and technology that are increasingly fast and complex provide benefits to people's lives, such as improving the quality of health, the economy, and education. This progress also causes adverse effects such as global warming, energy crisis, natural destruction, and other negative impacts. To overcome these obstacles, people must comprehend scientific principles and the interrelationships between science, technology, and culture (Rahayu, 2017). The ability to reflect on the relationship between scientific issues and ideas by exploring prior knowledge is known as scientific literacy (Suryati et al., 2018).

Scientific literacy is understanding science, communicating knowledge, and applying scientific skills in solving problems (Allchin, 2014; Yuliati, 2017; Valladares, 2021). The Organization for Economic Cooperation and Development supports this definition, stating that scientific literacy is the capacity to engage with issues relating to scientific knowledge and ideas, including the capacity to evaluate and design scientific discoveries as well as interpret and prove data scientifically (OECD, 2019).

According to the World Economic Forum, one of the sixteen abilities required to meet the challenges of the twenty-first century is scientific literacy. Therefore, promoting scientific literacy among the general public should be a top concern when learning science. (Pratiwi et al., 2019). Learning that is based on scientific literacy encourages students to develop their own skills and creativity based on the scientific knowledge that is applicable to daily living (Adnan et al., 2021).

An indicator of a nation's foreign competitiveness and the caliber of its national education can be found in its capacity for scientific literacy (Zhang et al., 2018). PISA is one worldwide test that evaluates scientific literacy abilities. (Program for International Student Assessment). PISA is an evaluation system run by the Organization for Economic Cooperation and Development (OECD) every three years with a sample of 15-year-old pupils from 72 countries. With an average score of 396 in the 2018 PISA results for the scientific literacy category, Indonesia is placed 70 out of 78 countries, which is still quite low compared to the OECD average standard of 489 (Schleicher, 2019). These findings give cause for worry regarding Indonesian students' future scientific competitiveness on a global scale.

Low scientific literacy can be found not only in elementary and secondary schools but also in tertiary institutions. This is corroborated by a number of studies on student scientific literacy, such as one by T.R. Putri et al. (2022), which demonstrates the need for chemistry education students to have a better level of scientific literacy in order to explain scientific phenomena and use scientific evidence. According to research findings by Shofiyah (2015), the majority of science education students still need to improve their initial levels of scientific literacy because they are unable to explain their answers in terms of science and may even have misconceptions. Novitasari's (2018) study, which demonstrates that aspiring biology teachers' students need to become more acquainted with activities that focus on research and analysis of research findings, which are components of scientific literacy competency, supports this as well.

It is crucial for students to be trained in scientific literacy to familiarize them with applying science concepts meaningfully, being able to think critically, and making balanced and adequate decisions on issues contextual to student life (Rahayu, 2017). Training scientific literacy for students of the Science Education Study Program is essential to equip them with competence as prospective science teachers because teachers are the leading agents in training scientific literacy for students with various learning methods so that the students they teach understand the scientific phenomena around them, through learning experiences (El Islami & Nuangchalerm, 2020). The inquiry learning model is one of the instructional strategies that can be used to develop pupils' scientific literacy (Nurfadhilah, 2016; Sumarti et al., 2017; Zuhro & Nawangati, 2017).

The inquiry learning model, which has learning steps that can make students active and capable of discovering the ideas learned for themselves, is considered suitable for enhancing students' literacy abilities (Shellawati & Sunarti, 2018). Students have opportunities to observe and explain phenomena, recognize research variables, carry out evaluations, plan scientific investigations, and evaluate scientific investigation findings through inquiry learning (Fatmawati, 2016). The entire procedure promotes the development of scientific literacy incompetence.

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The characteristics of chemical equilibrium material are abstract, involve mathematical calculations, and are concrete. In the discussion of chemical equilibrium, abstract concepts such as reversible reactions, the concept of chemical equilibrium, and shifting of equilibrium; besides that, the discussion of chemical equilibrium involves mathematical calculations, such as calculating the value of the equilibrium constant and comparison between Qc and Kc values in predicting the reaction direction and calculating equilibrium concentrations. Shifting the equilibrium can also involve substantial experience in explaining the phenomenon of shifting the equilibrium, such as observing changes in color and the formation of precipitates.

The inquiry-based learning approach is one of the best models for teaching information about chemical equilibrium. Through cooperative discussions and lab practicums, inquiry learning can help students discover and compile concepts independently, fostering the growth of higher-order thinking abilities, science process skills, and an understanding of chemical equilibrium (Fitriah, 2017).

The hallmark of inquiry learning is that students' investigations into a problem lead to questions, ideas, and conclusions that form the basis of the learning experience. Media is required for investigative tasks on abstract material in order to aid students in connecting learning activities to practical issues (Prabowo et al., 2020). A virtual laboratory is one tool that can be used to support the inquiry-based learning process (Fatimah et al., 2020; Hermansyah et al., 2017; Saputra et al., 2017).

A computer-based tool called the virtual laboratory can be used to replace the constraints of laboratory work and serve as a medium for text, images, music, and video that can be used to maximize knowledge transfer and their scientific nature (Manurung et al., 2020). ChemCollective Virtual Laboratory is one of the virtual laboratory tools that can be utilised in chemistry education (Bukar et al., 2020). In contrast to most textbooks, the ChemCollective Virtual Laboratory is a digital library with basic chemistry online practicum exercises that engage students in real-world problem-solving situations. In order to simulate real-world activities that complement fundamental chemistry lectures, students can select from hundreds of standard reagents and tools in the ChemCollective Virtual Laboratory (Yaron et al., 2010). The ChemCollective Virtual Laboratory is intended to support the syntax of inquiry learning by providing problem-solving activities that link abstract concepts through digital experiments. By utilizing the virtual laboratory provided by ChemCollective, this research seeks to describe the application of inquiry learning models, student activities, scientific literacy skills, and student responses.

RESEARCH METHOD

This research uses a one-group pretest-posttest methodology with randomly chosen classes as its sample population. The chosen class will receive treatment in the form of a pre-test (O_1) to ascertain the students' degree of scientific literacy in the material related to chemical equilibrium. Furthermore, the ChemCollective virtual laboratory were used to deliver lectures using an inquiry model of treatment (X). Students received therapy to improve their scientific literacy skills, and after treatment, they took a post-test (O_2) to ascertain their final level of proficiency (Leedy & Ormrod, 2021).

Research Sample

33 students who were enrolled in the Science Education Study Program's odd semester during the 2022–2023 school year at UIN Sunan Ampel Surabaya made up the study's sample—using a random sampling method to choose the sample.

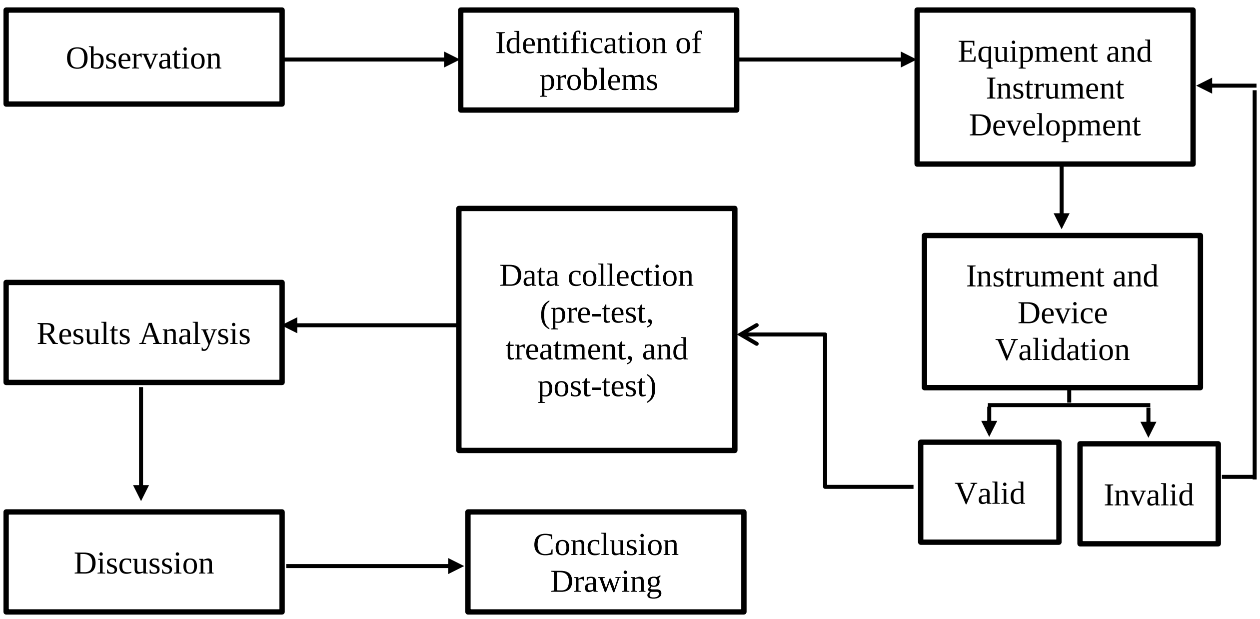

Figure 1. Research Flow

Research Instruments and Procedures

The study tools included student response questionnaires, student activity observation sheets, learning implementation observation sheets, and literacy test instruments. The student activity observation sheet contains observer statements regarding student activities both individually and in groups in lectures carried out with the assisted inquiry model ChemCollective virtual laboratory media, a student response sheet, and the learning implementation observation sheet contains observer statements regarding the implementation of lecture stages carried out by lecturers using the inquiry model with the help of the ChemCollective virtual laboratory media. The research flowchart is shown in Figure 1.

Data analysis

According to the type of data generated, the data obtained for this research were examined. The information gathered for this research comes in the form of observational data on the application of learning, data from observations of student activity, data from tests of students' scientific literacy, and data on students' reactions to learning. Observation data on the implementation of lectures is expressed in the form of a score with an assessment scale according to Table 1.

Table 1. Lecture Implementation Assessment Score

Lecture Implementation Score	Category
4	Excellent
3	Good
2	Not good
1	Very less
0	Not Implemented

The average percentage of implementation of the ensuing lectures is determined from the views of two observers, and is then used to evaluate the implementation of lectures both descriptively and qualitatively.

$$\% \text{ implementation of lectures} = \frac{\text{The average score of the two observers}}{\text{Maximum score}} x\ 100\%$$

the percentage number of lecture implementation is then converted using the criteria for the level of lecture implementation in Table 2.

Table 2. Criteria for Level of Lecture Implementation

Average Class Implementation (%)	Eligibility criteria
0-20	Not Implemented
21-40	Not Well Done
41-60	Well Done
61-80	Well Done
81-100	Very Well Done

(Riduwan, 2012)

Observational data on student activities were analyzed descriptively and qualitatively by calculating the percentage of student activity observed by two observers using the following formula.

$$\% \text{ student activity} = \frac{\textit{Number of student activities}}{\textit{Total frequency of student activity}} \; 100\%$$

It is said that student activities are effective if there are% more pertinent to learning student activities that employ the inquiry model and the ChemCollective virtual laboratory media than% of irrelevant activities. Pre-test and post-test information on the outcomes of the science skills test. Following is a conversion of the percentage findings to the category of scientific literacy mastery in Table 3.

Table 3. Criteria for Mastery of Science Literacy

Value Intervals	Eligibility criteria
0-20	Very Poor
21-40	Less
41-60	Enough
61-80	Good
81-100	Excellent

(Riduwan, 2012)

The findings of the pre-test and post-test data analysis revealed an improvement in student scientific literacy, which was then confirmed by performing a normalized gain test. Test for normalized gain using the following equation:

$$G = \frac{S_{post} - S_{pre}}{100 - S_{pre}}$$

Information:

G : increase in learning outcomes

Spost : post-test mean scores

Spre : pre-test mean scores

The N Gain score obtained is then categorized based on the following Table 4.

Table 4. N Gain Score Criteria

Average score	N Gain Score Criteria
G < 0.3	Low
0 0.3 <G<0.7	Medium
G>0.7	High

Adapted from Hake (1999).

The paired t-test was also used to examine the data from the pre-test and post-test. The scores from the students' pre-test and post-test results for scientific literacy were compared using the paired t-test to see if there was a difference in the means of the two paired samples. Because there are fewer than 50 research samples, the Shapiro-Wilk test is typically used to distribute the pre-test and post-test data (Sababalat et al., 2021). This is one of the requirements for the paired sample t-test. The homogeneity test also reveals that the pre-test and post-test data are homogeneous. No statistically significant difference exists between the pre-test and post-test scores, according to the paired t-test's statistical hypothesis. (H_0). The results of the pre-test and post-test show a significant difference. (H_1). With a 95% confidence interval and a significant level (α) of 0.05, the paired sample t-test for this study was conducted using the SPPS 24 program. The test for the hypothesis' acceptability is based on the following criteria: if $p > \alpha$, H_0 is accepted, and H_1 is rejected; if $p < \alpha$, H_0 is rejected, and H_1 is accepted. The following equation is used to analyze information from student answers to a questionnaire that asked them about their views on how inquiry learning should be applied while using the ChemCollective virtual laboratory resources.

$$P = \frac{\sum R}{\sum N} x\ 100\ \%$$

Information:

P : presentation of student responses

$\sum R$: the number of positive responses from students

$\sum N$: the number of positive responses from students

Following are the categories to which the student answer percentage is converted in Table 5.

Table 5. Student Response Criteria

Score Interval (%)	Student Response Criteria
0-20	Not Positive
21-40	Less Positive
41-60	Enough Positive
61-80	Positive
81-100	Very Positive

(Riduwan, 2012)

If students' responses demonstrate a favorable response to the implementation of learning in terms of the percentage of student scores of at least 61%, learning is considered successful.

RESULTS AND DISCUSSION

In order to train science education students' scientific literacy in introductory chemistry lectures with chemical equilibrium study materials, this project used learning tools created based on inquiry learning with the assistance of the ChemCollective virtual laboratory: the Science Literacy Test Questions, Lesson Plans, and Student Worksheets. Two postgraduate lecturers have validated the learning tools used, with the findings in Table 6.

Table 6. Learning Device Validity Results

Learning Media	Validation Results
Syllabus	The developed syllabus is highly reliable and valid, with an average validator score of 90.0% and a degree of judgmental conformity between the two validators of 92.7%, respectively.
Lesson Plans	The lesson plans were created very validly, with an average validator score of 90.0%, and reliably, with a degree of conformity of the assessment of the two validators of 90.0%.
Student Worksheets	The Student Worksheets created have very high levels of validity and reliability, with an average validator score of 92.5% and a concordance level of the two validators' scores of 90.5%, respectively.
Science Literacy Test Questions	The Science Literacy Test questions were created, and they are reliable and valid, with an average validator score of 87.5% and a concordance level of assessment from the two validators of 87.2%, respectively.

The findings of this validity demonstrate that any learning tool based on inquiry learning can be used to develop scientific literacy skills with the aid of the ChemCollective virtual laboratory.

Implementation of Learning

Two observers observed two meetings, and the views shed light on how the inquiry-learning strategy was applied. The efficacy of the teaching and learning process is measured by how much the lecturer applies the inquiry model while delivering the lecture with the help of the ChemCollective virtual laboratory. A review of the learning execution is done to gauge the quality of the executed learning tasks. The results of observing how the lessons were put into practice are displayed in Figure 2.

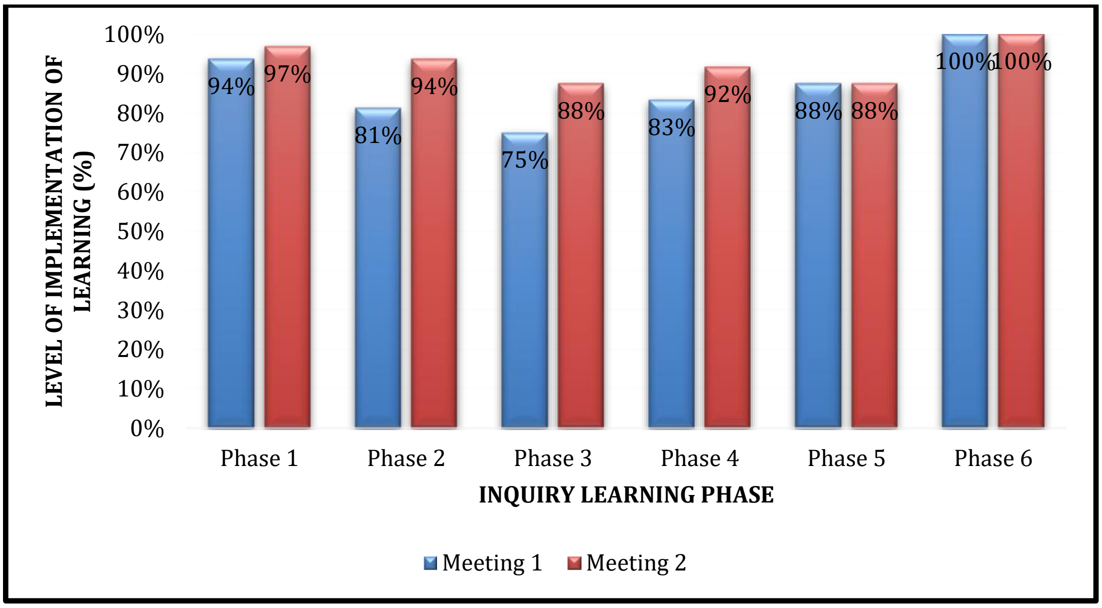

Figure 2. Graph of Observation Results of Learning Implementation

According to the findings of witnessing how the inquiry model of learning was applied in both meetings with the aid of the ChemCollective virtual laboratory media, each learning phase was completed in the good and very good categories in accordance with the criteria in table 2. The inquiry learning phase entails the following steps: (1) focusing on and outlining the inquiry process; (2) presenting the problem of inquiry or inappropriate cases; (3) formulating problems and hypotheses; (4) gathering data/information; (5) performing data analysis; and (6) making reflections and conclusions on the investigation's findings (Arends, 2015).

Inquiry-based learning uses the ChemCollective virtual laboratory during the data-gathering stage (phase four). An online tool called ChemCollective Virtual Laboratory can be used to run virtual chemistry labs. Data collection for testing inquiry learning theories can be done using the ChemCollective Virtual Laboratory. At the first and second meetings, the fourth learning phase's implementation level was 83% and 92%, respectively. This result demonstrates the effectiveness of the ChemCollective virtual laboratory during the data collection stage because it is furnished with hundreds of common reagents and tools that can be used to simulate real-world activities that support inquiry-based learning. According to Rusliati and Retnowati (2019), engaging in an inquiry-based learning process in a virtual laboratory requires students to solve issues during practicum actively. The average percentage of learning that was put into practice during the first meeting was 87%, and the average percentage during the second meeting was 93%, both with excellent ratings. This result demonstrates how inquiry learning consistently and accurately carries out learning. The existing components of scientific literacy and the learning stages of inquiry are closely related, as shown in Table 7.

Table 7. The Linkage of Inquiry Learning with Aspects of Scientific Literacy

No	Inquiry Stages	Science Literacy Competence	Science Literacy Indicator
1	Describe the inquiry process	Explain phenomena scientifically	- Remember and apply appropriate scientific knowledge - Make the right hypothesis
2	Displays an inquiry problem		
3	Formulate problems and hypotheses.		
4	Collect data/information	Evaluate and design scientific investigations	- Evaluating the issues that can be investigated through scientific research - Propose a scientific way of exploring the questions given
5	Perform data analysis	Scientific interpretation of facts and evidence	- Converting data between different representations - Analyzing and interpreting data - Reaching the appropriate findings
6	Make reflections and conclusions on the results of the investigation		

(Arends, 2015; OECD, 2016)

The fact that there is a connection between inquiry learning and certain facets of scientific literacy suggests that inquiry learning that is effectively implemented in each phase will be able to develop students' scientific literacy as well. This is relevant to the study by Daniel (2020), which found that each stage of the inquiry learning process supports the development of student competencies for scientifically interpreting data and evidence, evaluating and designing scientific research, and explaining phenomena in terms of science. These competencies are a part of scientific literacy. In addition, a study by Saputra et al. (2017) demonstrates how successfully implementing virtual laboratory-based inquiry learning can enhance students' scientific literacy abilities.

Student Activity

Data on student activity was gathered from two observers' observations made during two meetings. Student activities are those that take place during lectures and use an inquiry paradigm with the help of the ChemCollective virtual laboratory resources. Observations were made throughout the entire lecture, starting at the beginning and ending when it was finished. The purpose of this observation is to ascertain the activities students engaged in accordance with the inquiry learning steps supported by the ChemCollective virtual laboratory media. Table 8 shows the findings from watching pupil behavior during the two meetings.

Table 8. Observation Results of Student Activities

	Student Activity	% Student Activity	
		Meeting 1	Meeting 2
1	Students pay attention to the problem orientation of the lecturer	10.94%	10.61%
2	Students compile and submit the formulation of the problem	8.25%	9.43%
3	Students develop and submit hypotheses	8.25%	9.43%
4	Students identify experimental variables	8.59%	9.76%
5	Students design an investigation using the ChemCollective Virtual Laboratory	10.77%	10.94%
6	Students collect data through experiments with the ChemCollective Virtual Laboratory	11.11%	11.11%
7	Students utilize other sources of information in solving problems	9.93%	10.10%
8	Students carry out an analysis of the results of the experiment	10.94%	10.94%
9	Students make conclusions on the results of experiments	10.77%	10.94%
10	Students discuss experimental results	10.61%	11.11%
Relevant Activity percentage		90.24%	93.60%
Irrelevant activity		9.76%	6.40%

According to the observer's observations of student activity, the first meeting's average percentage of student activity pertinent to inquiry learning was 90.24%, and the second meeting's average percentage was 93.60%. This demonstrates excellent student participation at both meetings and demonstrates that students are motivated to participate more actively in their learning, as evidenced by a rise in participation at the second meeting. This has a bearing on the study by Ristina et al. (2020), which found that guided inquiry-based virtual laboratory learning designs can boost pupil engagement. Due to the phases of inquiry learning that require students to develop hypotheses, conduct investigations, gather data, communicate findings, and draw conclusions, students are very active when using ChemCollective's virtual laboratory media (Sudiartha, 2022). Additionally, since virtual laboratories have a well-structured practicum flow, they turn students into engaged learning objects (Nugroho, 2021).

At the first and second meetings, the activities-collect data through experimentation with ChemCollective Virtual Laboratory had the highest percentage of student activity (11.11%). A virtual laboratory is an interactive computer-based medium that imitates laboratory practicum activities and offers a real-world setting. (Martoredjo, 2020; Muhajarah & Sulthon, 2020). With the topics Exploration of Equilibrium Constants in Biological Systems in the first meeting and Le Chatelier's Principles in Chemical Equilibrium Reactions in the second meeting, students engage in hands-on activities in the ChemCollective virtual laboratory. Figure 3 shows an illustration of how the

ChemCollective virtual laboratory is used. Due to the characteristics of the virtual laboratory, students use it with a high level of activity, which makes learning activities more enjoyable, motivates students more, and encourages them to participate more in order to better comprehend the concepts being taught. (Divine et al., 2022).

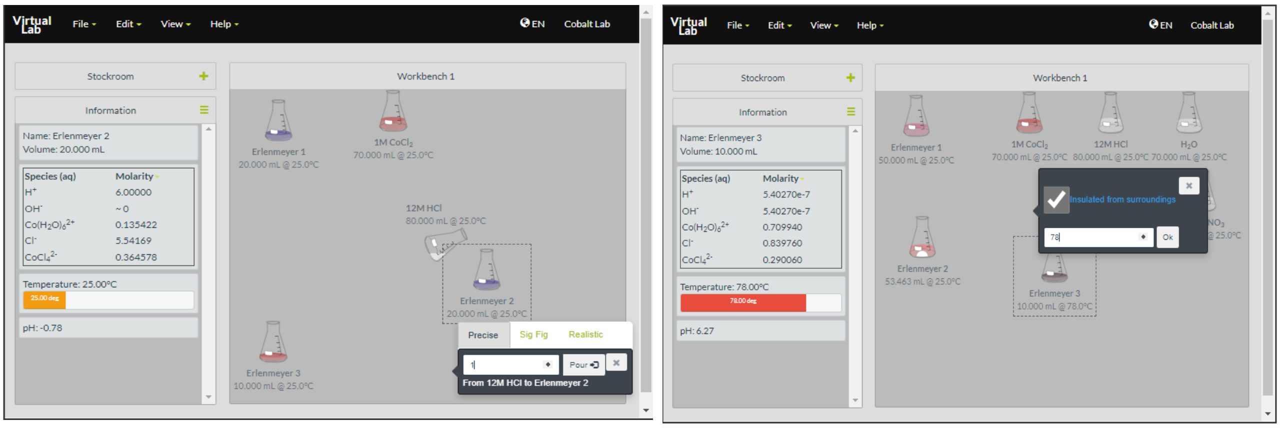

Figure 3. Le Chatelier Principles Practicum Activities in Chemical Equilibrium Reactions using the ChemCollective virtual laboratory

The student action with the lowest percentage was compiling-presenting problem formulations, with 8.25% for the first meeting and 9.43% for the second, and compiling-presenting hypotheses. The study's sample of first-semester students had minimal activity because they were not accustomed to formulating problems and hypotheses. The first stage in solving the issue is for the lecturer to offer scaffolding for creating problems and hypotheses. According to Vygotsky's theory of learning, scaffolding aids in problem-solving and learning in the beginning stages of learning before gradually reducing that assistance (Slavin, 2018). Providing support enables students to resolve issues on their own (Haidar et al., 2020).

Science Literacy Skills

Understanding science, communicating information, and using scientific techniques to solve problems are all components of scientific literacy. (Allchin, 2014; Valladares, 2021; Yuliati, 2017). The Organization for Economic Cooperation and Development supports this definition, stating that scientific literacy is the capacity to engage with issues relating to scientific knowledge and ideas, including the capacity to evaluate and design scientific discoveries as well as interpret and prove the data scientifically. (OECD, 2019). Results of the student's scientific literacy exams taken before and after they engaged in inquiry-based learning supported by ChemCollective virtual laboratory media (pre-test) provided information on the student's scientific literacy skills. (post-test). Figure 4 below shows the outcomes of the student exam on scientific literacy.

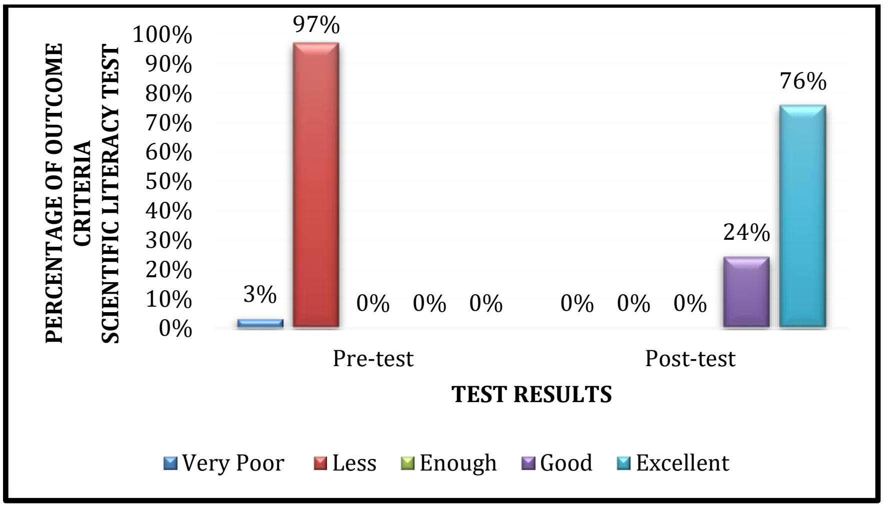

Figure 4. Graph of Student Science Literacy Test Results

Prior to learning, 97% of pupils had scientific literacy scores that met fewer criteria, and 3% had very low criteria. Prior to learning, the typical result for scientific literacy is 26.51. After learning, 76% of students achieved excellent scientific literacy scores, while 24% achieved good scores. After learning, the average scientific literacy result is 81.85. In order to ascertain whether there was an improvement in student scientific literacy, data from the pre-test and post-test findings were then analyzed with a normalized gain test. Figure 5 below shows the data from the N-Gain Score Test.

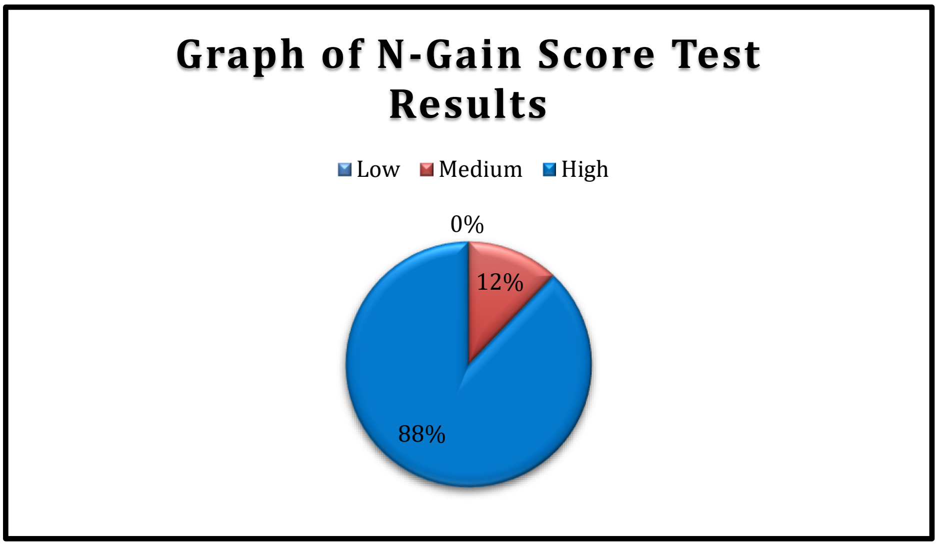

Figure 5. Graph of N-Gain Score Test Results

Figure 5 shows an average N-Gain Score of 0.76 was found in the high category by the N-Gain Score analysis results. This demonstrates an improvement in exam scores for scientific literacy following the introduction of inquiry learning supported by ChemCollective virtual laboratory media. Eighty-eight per cent of students improved their N-Gain Score in the high group, and twelve per cent of students improved it in the medium category. This demonstrates how inquiry-based learning, supported by the virtual laboratory resources provided by ChemCollective, can enhance students' scientific literacy. Through the use of statistical tests like the Paired Sample t Test, which first carried out prerequisite tests like the Normality Test (Shapiro Wilk) and Homogeneity Test, the results of pre-test and post-test data analysis also revealed an increase in students' scientific literacy. The findings of the statistical tests are shown in Table 9.

Table 9. Statistical Test Results for Science Literacy Test

Statistical Parameters	Score	
	Pre-test	Post-test
Means	25.61	81.85
Normality Test (Shapiro Wilk)	0.064	0.068
Homogeneity Test	0.710	
Paired Sample t Test	0.000	

The findings of the normality test revealed that the significance values obtained in the pre-test and post-test groups, respectively, were 0.064 and 0.068, respectively. The pre-test group's and post-test group's data both have significance values greater than 0.05, which suggests that they are regularly distributed. A significance value of 0.720 for the homogeneity test is displayed. Indicating that the data are homogeneous, this number is greater than 0.05. The results of the normality and homogeneity tests indicate that the paired sample t-test can be used with the results of the scientific literacy test. A significance value of 0.000 was displayed in the paired sample t-test findings. Since the pre-test and post-test values differ significantly (by a significant amount, that is, 0.005), it can be said that inquiry learning, supported by ChemCollective's virtual laboratory media, has an impact on the outcomes of student literacy tests.

According to Table 7, inquiry learning can exercise scientific literacy abilities because it includes stages that are pertinent to scientific literacy. Additionally, inquiry-based learning can assist instructors in connecting the material covered in class to the real-world experiences of their students. This helps students develop their science literacy skills and makes learning more engaging (Anggri Destrilia et al., 2021). Students are helped by the use of virtual labs in inquiry learning to explore and visualise abstract ideas so they can use them as sources for their investigations (Kusdiastuti et al., 2019; Sugiarto, 2023). Students will learn how to create experimental designs through investigative tasks in inquiry-based instruction (Mardianti et al., 2020). The results of the increased scientific literacy test show that inquiry learning, supported by the virtual laboratory media from ChemCollective, successfully develops students' scientific literacy. According to research by Kang (2022), inquiry-based learning that is supported by successful classroom management can significantly raise scientific literacy. The implementation of virtual practicum activities with inquiry-based learning results in an increase in scientific literacy, according to a study by Putri, et al. (2021), in part because the learning process emphasises scientific competence and focuses on how to behave like a scientist. The scientific explanation of phenomena, the evaluation and design of scientific discoveries, and the scientific interpretation of data and evidence all fall under the domain of scientific literacy that was trained in this study. Figure 6 below shows how well the students performed on each scientific literacy skill.

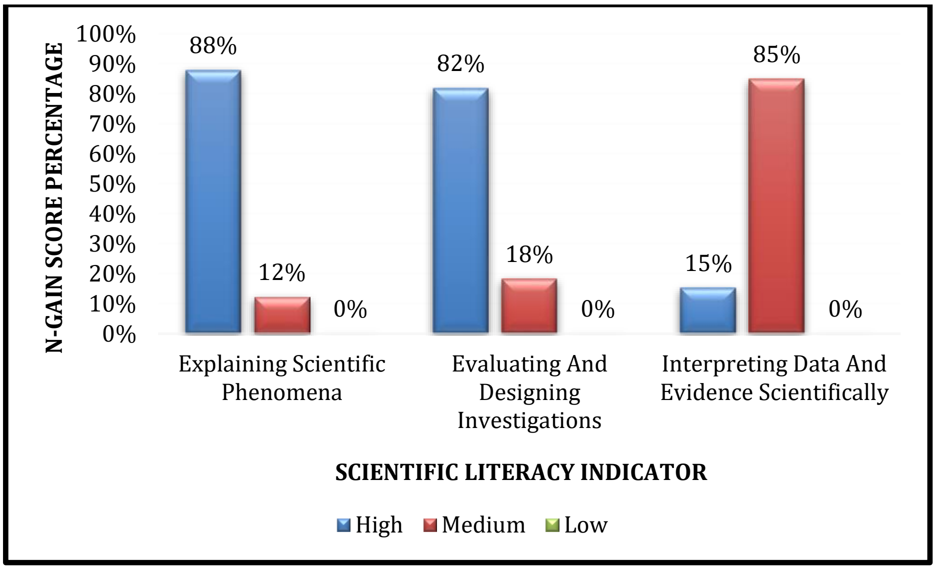

Figure 6. Graph of N-Gain Score Percentage on each competency aspect

Figure 6 shows N-Gain score percentage graph for each competency component, all facets of scientific literacy competence have improved. 88% of students saw a rise in the high category for explaining scientific phenomena, while 12% saw an increase in the medium category. In order to explain scientific events, students must grow curious about the issues presented (Hapsari et al., 2016). The phases of inquiry learning in which students observe problem phenomena, formulate problems, and develop hypotheses support the improvement of students' capacity to explain scientific phenomena. 82% of students saw an increase in the high category for evaluating and planning scientific studies, while 18% of students saw an increase in the medium category. Students must make suggestions for scientifically valid methods to investigate the given questions when evaluating and designing investigations (Setiawan, 2019). The stages of inquiry learning that students go through when designing investigations and gathering data through experiments with the ChemCollective Virtual Laboratory support the improvement of students' capacity to explain, evaluate, and design investigations. 15% of students saw an improvement in the high category for scientifically interpreting facts and evidence, and 85% saw an improvement in the medium category. Students must conduct quantitative data analysis, make predictions, and draw conclusions in order to interpret data and scientific proof (Sustainable & Siskandar, 2020). The phases of inquiry learning are supported by the activities of performing data analysis and making reflections and conclusions on the findings of investigations. This increases students' capacity to interpret data and evidence scientifically. Due to the need for students to become accustomed to transforming data from one representation to another, the majority of students see a rise in the moderate category. Overall, the improvement in all areas of scientific literacy competence demonstrates that attaining scientific literacy competence is supported by all literacy levels throughout all inquiry learning phases.

Student Response

Data about student reactions during the lecture were gathered from a questionnaire. In order to improve students' scientific literacy, this student answer seeks to learn what students think about inquiry learning supported by ChemCollective virtual laboratory media. Table 10 displays the findings of the student responses.

Table 10. Student Response Results

	Question	Percentage	Criteria
1.	I am happy while attending basic chemistry lectures on chemical equilibrium material	100%	Very Positive
2.	I can study independently (find out concepts from observations/experiments using the ChemCollective virtual laboratory)	91%	Very Positive
3.	Student Worksheets can train my ability to explain a scientific phenomenon related to chemical equilibrium material	100%	Very Positive
4.	I understand lecture material from reading books, doing lab work using the ChemCollective virtual laboratory, and working on student worksheets	94%	Very Positive
5.	Learning and the student worksheets that are distributed can train the ability to formulate problems	97%	Very Positive
6.	Learning and the student worksheets that are distributed can train the ability to formulate hypotheses	100%	Very Positive
7.	Through learning and the student worksheets that are distributed can train the ability to identify variables	100%	Very Positive
8.	Through learning and the student worksheets that are distributed can train the ability to analyze experimental data	100%	Very Positive
9.	Learning and the student worksheets that are distributed can train the ability to make conclusions	100%	Very Positive
10.	I feel that learning basic chemistry is different from everyday learning and more fun	94%	Very Positive

	Question	Percentage	Criteria
11.	With learning like this, it will be exciting and more accessible for students to learn introductory chemistry	97%	Very Positive
Average		**98%**	**Very Positive**

Table 11 shows the results of student responses reveal that students responded favorably to the development of their scientific literacy through inquiry learning with the aid of ChemCollective's virtual laboratory resources. Student comments have a 98% average percentage value on very positive criteria. The high average percentage suggests that ChemCollective's virtual laboratory media, used in conjunction with inquiry learning, effectively develops students' scientific literacy. This overwhelmingly positive reaction can be attributed to the fact that inquiry-based learning encourages students to take an active role in their education (Kuhlthau et al., 2010). Additionally, virtual labs, according to Wibawanto (2020), offer graphic visualizations that can help translate abstract representations into more tangible experiences to encourage students to actively engage in learning.

CONCLUSION

Students enrolled in the Science Education Study Program at UIN Sunan Ampel Surabaya's first semester in the odd semesters of the school year 2022–2023 can develop their scientific literacy through inquiry learning with the aid of ChemCollective's virtual laboratory resources. This study is restricted to chemical equilibrium topics and science literacy, with only competency-based evaluations. **Fundamental finding:** This is backed by the effective implementation of instruction and student activities as well as the improvement of scientific literacy abilities both before and after the use of the inquiry learning model supported by ChemCollective's online virtual laboratory resources. **Implication:** This study has consequences for how inquiry learning, supported by ChemCollective's virtual laboratory media, can be used as a substitute for traditional scientific training. **Limited:** This study only used one class without any comparison class. **Future Research:** a comparison class is needed to see comparisons with existing research.

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