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The Effectiveness of Scientific Literacy-Based Student Worksheets in Improving Student Learning Outcomes in Colloid Chemistry Learning

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Abstract

Low student learning outcomes are a significant issue in high school colloid chemistry learning. Correspondingly, this research aimed to determine the effectiveness of scientific literacy-based student worksheets (LKPD) in colloid chemistry learning. A quasi-experimental approach, specifically the pretest-posttest control group design, was employed in this study. The experimental class, XI IPA-2, consisted of 15 students, while the control class, XI IPA-1, also included 15 students, with total sampling techniques used to select the sample. Test instruments were developed to collect student learning outcome data through pretest and posttest techniques. The effectiveness of student worksheets was analyzed using the N-gain test, independent sample t-test, and effect size tests. The N-gain results exhibited an average score of 0.7319, which was a high category for the experimental class, while the control class obtained a score of 0.5308, which was categorized as moderate. The independent sample t-test results indicated a 2-taliled significance score of 0.002 (< 0.05), demonstrating a significant difference between the learning outcomes of the experimental and control classes. Based on these findings, it can be concluded that scientific literacy-based student worksheets effectively improved student learning outcomes in colloid chemistry learning at the senior high school level.

Keywords: colloid; effectiveness; learning outcomes; scientific literacy; worksheets

Abstrak

Rendahnya hasil belajar siswa merupakan permasalahan yang signifikan dalam pembelajaran kimia koloid SMA. Sejalan dengan itu, penelitian ini bertujuan untuk mengetahui efektivitas Lembar Kerja Siswa (LKPD) berbasis literasi sains dalam pembelajaran kimia koloid. Pendekatan kuasi-eksperimental, khususnya desain kelompok kontrol pretest-posttest, digunakan dalam penelitian ini. Kelas eksperimen XI IPA-2 berjumlah 15 siswa, sedangkan kelas kontrol XI IPA-1 juga berjumlah 15 siswa, dengan teknik total sampling digunakan untuk memilih sampel. Instrumen tes dikembangkan untuk mengumpulkan data hasil belajar siswa melalui teknik pretest dan posttest. Keefektifan LKS dianalisis menggunakan uji N-gain, uji Independent Sample t-test, dan uji effect size. Hasil N-gain diperoleh skor rata-rata sebesar 0,7319 yang termasuk dalam kategori tinggi untuk kelas eksperimen, sedangkan kelas kontrol memperoleh skor sebesar 0,5308 yang termasuk dalam kategori sedang. Hasil uji Independent Sample T-test menunjukkan skor signifikansi 2-taled sebesar 0,002 (< 0,05) yang menunjukkan adanya perbedaan yang signifikan antara hasil belajar kelas eksperimen dan kelas kontrol. Berdasarkan temuan tersebut maka dapat disimpulkan bahwa LKS berbasis literasi sains efektif meningkatkan hasil belajar siswa pada pembelajaran kimia koloid tingkat sekolah menengah atas.

Keywords: efektifitas; hasil pembelajaran; koloid; literasi sains; lembar kerja

Introduction

Education is a means of acquiring the skills necessary for an individual to compete in the global era. It serves as a tool to develop abilities and shape the behavior and personality of students, making them believers with noble morals, skilled, and reasonable. Likewise, the educational process in schools aims to shape attitudes, develop intellectual intelligence, and enhance students' skills according to their needs.

Based on the 2013 curriculum, to promote active and scientific learning, teachers need to guide students in chemistry lessons that are motivating, inspiring, interactive, and challenging. Additionally, they must present engaging chemistry lessons to encourage students to seek information actively, helping them understand the importance of science and technology in everyday life (Ain & Mitarlis, 2020).

Effective chemistry education should impart a meaningful understanding of scientific processes to students. Therefore, teachers need to integrate these elements into their teaching methods to enable students to connect chemistry concepts with everyday life, encouraging them to construct their understanding of the material they have studied (Izzatunnisa et al., 2019).

As both contextual and theoretical, chemistry requires students to possess scientific literacy skills to grasp its concepts (Yael et al., 2022). One such contextual chemical topic is colloid chemistry matter (Novilia et al., 2019), which embodies concepts that can be applied in everyday live (Usman et al., 2017; Wati et al., 2019).

Given the importance of scientific literacy in chemistry education, the primary objective of the learning process is to equip students with scientific literacy skills, which involve understanding scientific processes and acquiring important information that can be applied in everyday life, enabling students to make decisions and solve problems (Izzatunnisa et al., 2019).

Scientific literacy can be integrated into chemistry learning through the use of appropriate teaching materials. These materials provide a learning substance that presents competencies that students must fully understand (Prastowo, 2020).

The integration of scientific literacy in colloid chemistry material was investigated by Rahmi et al. (2023), who found that a scientific literacy-based *LKPD* (student worksheets) was highly valid, with a validity score of 86.12% and highly practical, with a practicality percentage of 91.66%. In addition, the use of student worksheets as teaching material has been proven to improve students' scientific literacy effectively. Hidayat and Hidayati (2024) reported a 42% increase in students' scientific literacy, with 42% in the moderate category and 58% in the high category, achieved through worksheets on socio-scientific issues. Similarly, the application of PBL-based student worksheets significantly improved students' scientific literacy, with average ability percentages of 72.28% for content, 76.41% for process, and 67.98% for context aspects (Vebrianto et al., 2019).

Observations and interviews with students and teachers of Class XI MIPA at State Senior High School 1 KutaLong revealed that the teachers had not used student worksheets in the learning process, resulting in poor student learning outcomes. Moreover, students relied on limited learning resources from the school library. Consequently, 63.4% of students had not met the *KKM* (Passing Grade), set at 75, for colloid chemistry material. This situation indicated that most students struggled to master colloid material. The average scientific literacy of students in the colloid chemistry system was limited to recognizing some basic phenomena. They could not communicate and connect these abilities to various science-related aspects, resulting in a failure to explain scientific phenomena, evaluate and design scientific research, interpret data, and understand scientific evidence. Besides, they could not apply abstract and complex chemistry concepts (Rahmi et al., 2023; Wibowo & Ariyatun, 2024; Yolanda et al., 2024).

Low student learning outcomes can be improved through the use of student

worksheets as teaching material (Nuwa et al., 2024; Herawati et al., 2024, Vebrianto et al., 2019; Ardhiantari et al., 2015). Based on this background, effective teaching materials are needed to enhance student learning outcomes. Hence, the present research proposed a solution by utilizing scientific literacy-based student worksheets in colloid chemistry learning.

Method

This research employed a quantitative approach by applying a quasi-experimental design (Sugiyono, 2018). The study was conducted at SMA 1 Kutapanjang utilizing a pretest–posttest control group design with two groups: the experimental class and the control class. The experimental class received colloid chemistry learning treatment using scientific literacy-based student worksheets, while the control class used conventional student worksheets.

The population of this study consisted of 30 students of the XI IPA Class, with each of the two classes containing 15 students. The research samples were selected using a total sampling technique involving all 30 students. Subsequently, the student learning outcomes on colloid chemistry learning were assessed using a test instrument comprising 20 multiple-choice questions.

Student learning outcomes data was analyzed to determine improvements in student performance before and after the learning intervention. The data were then analyzed using the N-gain score formula.

The N-gain scores obtained were calculated to acquire an average score and then interpreted according to the categories in Table 1.

Table 1
The N-gain Score Criteria (Wardani & Mitarlis, 2019)

No.	N-gain Score	Category
1	$g < 0.3$	Low
2	$0.7 > g \geq 0.3$	Moderate
3	$g \geq 0.7$	High

The effectiveness of scientific literacy-based student worksheets was measured using influence measurement analysis (effect size). This analysis involved the normality, homogeneity, and two-average difference tests. Normality and homogeneity tests are prerequisites before conducting hypothetical analyses in experimental research.

Finally, the effect size score obtained was interpreted based on the criteria in Table 2.

Table 2
The Effect Size Criteria (Riyanto & Andhita, 2020)

No.	Criteria	Influence
1	< 0.15	Ineffective
2	0.15 – 0.40	Slightly effective
3	0.40 – 0.75	Moderately effective
4	0.75 – 1.10	Effective
5	> 1.10	Highly effective

Results and Discussion

This research gathered data on pretest and posttest scores in both experimental and control classes. The initial average pretest score for both classes was 28.6. After learning using scientific literacy-

based student worksheets, the experimental class achieved an average posttest score of 80. In contrast, the control class used conventional student worksheets and achieved an average posttest score of 66. This indicates that the experimental class obtained a higher average posttest score than the control class.

By comparing the average scores of the pretest and posttest, it is evident that both experimental and control classes experienced improved learning outcomes. Further analysis of students' learning gains was conducted using the N-gain score, which measured the improvement based on pretest and posttest scores in both class groups. The N-gain score test results analyzed utilizing the SPSS software version 25.0 are presented in Table 3.

Table 3
The N-gain Score from Experimental and Control Classes

No.	Class	N-gain Score	Category
1	Experiment	0.7319	High
2	Control	0.5308	Moderate

Table 3 displays that the control class obtained an N-gain score of 0.5308, categorized as moderate. Meanwhile, the experimental class obtained an N-gain score of 0.7319, categorized as high. This suggests that the use of scientific literacy-based student worksheets significantly improved student learning outcomes in colloid chemistry learning. This result is supported by Sholihah and Mitarlis (2020), who found that the use of scientific literacy-based student worksheets in chemistry learning resulted in an N-gain score of 0.83, categorized as high, on salt hydrolysis material.

Pre-conditional normality and homogeneity tests were conducted to measure the effectiveness of scientific literacy-based student worksheets through hypothetical analysis. The results of the normality test are presented in Table 4.

Table 4
Normality Test Results

Class	Learning Outcomes	Sig.	Decision
Experiment	Pretest score	0.076	Normal
	Posttest score	0.153	Normal
Control	Pretest score	0.063	Normal
	Posttest score	0.091	Normal

Table 4 shows that the pretest score of the experimental class obtained a significant value of 0.076, while the posttest had a significant value of 0.153. Based on the test criteria, the data was considered to be normally distributed as the significant value was greater than 0.05. Therefore, the experimental class's pretest and posttest scores were normally distributed.

For the control class, the pretest score obtained a significant value of 0.063, and the posttest obtained a significant value of 0.091. Both values exceeded 0.05, indicating that the data were normally distributed. The homogeneity test results for the pretest and posttest scores in the experimental and control classes are presented in Table 5.

Table 5
Homogeneity Test Results

No.	Data	Sig.	Decision
1	Pretest	0.261	Homogeneous
2	Posttest	0.654	Homogeneous

Table 5 presents the homogeneity test results of the pretest and posttest data for the experimental and control classes utilizing the SPSS 25.0. The pretest scores for both classes obtained a significant value of 0.261, while the posttest scores had a significant value of 0.654, both greater than 0.05. Thus, the data in both classes had homogeneous variances.

Based on the normality and homogeneity tests, the data in this study were normally distributed and homogenous. This condition allows for the analysis of significant differences between the posttest scores of the experimental class, which used scientific literacy-based student worksheets, and the control class, which used conventional student worksheets in colloid chemistry learning. The result of the independent samples t-test are presented in Table 6.

Table 6
Independent Samples t-Test Results

No.	T	Df	Sig. (2-tailed)
1	3.500	28.000	0.002
2	3.500	27.858	0.002

Based on the independent samples t-test using the SPSS 25.0 software, as shown in Table 6, the tests obtained a sig. (2-tailed) value of 0.002, which is less than 0.05. The test criteria indicated that H0 was rejected while H1 was accepted. Thus, the independent samples t-test results indicated that the average student score in the experimental class was significantly higher than the average in the control class. This finding aligns with the study by Nahak and Bulu (2020), which discovered that the average scores of classes using science-based student worksheets were higher than those of the control class. Furthermore, the t-test obtained a significance value of 0.001, indicating a significant difference in learning outcomes between the two teaching methods.

To determine the effect of scientific literacy-based student worksheets on student learning outcomes in colloid chemistry material, the researchers conducted an effect size measure on the experimental class data. This test required a paired samples t-test; the results are presented in Table 7.

Table 7
Paired Samples t-Test Results

T	df	Sig. (2-tailed)
-31.067	14	0.000

Based on the paired samples t-test on learning outcomes of the experimental classes, as presented in Table 7, a sig. (2-tailed) value of 0.000 was obtained, which is less than 0.05. This result indicated a significant difference between the pretest and posttest scores in classes using scientific literacy-based student worksheets as teaching material. The effect size was then calculated based on the t-score obtained from the test.

The effect size test was carried out to determine the impact of scientific literacy-based student worksheets on student learning outcomes in colloid chemistry material. Thus, it can be concluded that scientific literacy-based student worksheets effectively improved student learning outcomes in colloid chemistry learning. This finding aligns with a study by Harahap (2020), which revealed that scientific literacy-based student worksheets could effectively improve student learning

outcomes by teaching them to use their scientific knowledge to solve questions, make fact-based decisions, and apply their knowledge in everyday life. The findings of this study are also consistent with an investigation by Rohmi (2021), suggesting that the use of student worksheets in learning could effectively enhance scientific literacy and student learning outcomes in global warming material. This study found an effect size score of 1.73, categorized as highly effective. Additionally, research by Putri and Rinaningsih (2021) also supports the findings of this study, demonstrating that student worksheets effectively improved students' scientific literacy skills in chemistry learning, with an effect size score of 3.1981, categorized as highly effective.

Conclusion

Based on the results of this study, it can be concluded that student learning outcomes were significantly improved when using scientific literacy-based *LKPD* (student worksheets) as teaching material in colloid chemistry learning. Hence, the scientific literacy-based student worksheets were deemed effective in enhancing student learning outcomes in colloid chemistry learning at the senior high school level.

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