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Implementation of the Community Science Technology (CST) Learning Model Using Flipbook Media to Improve HOTS-Based Chemical Literacy on Hydrocarbons and Petroleum

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Abstract

Chemical literacy involves using chemical knowledge to interpret phenomena, evaluate information, and respond to issues connected with everyday life. This study investigated students' HOTS-based chemical literacy after instruction using the Community Science Technology (CST) learning model supported by Flipbook media. A quasi-experimental pretest–posttest control-group design was conducted at SMA Negeri 11 Medan during the 2025/2026 academic year. Class XI-6 was the experimental group and Class XI-8 was the control group. The experimental group learned through CST supported by Flipbook media, whereas the control group received conventional instruction. Students' chemical literacy was assessed using a multiple-choice test; 20 of the 30 developed items were retained as valid. The experimental group's mean score increased from 41.29 on the pretest to 86.14 on the posttest, while the control group's mean increased from 40.86 to 75.29. The N-Gain was 0.8427 (high) in the experimental group and 0.6342 (medium) in the control group. An independent-samples t-test produced t = 5.870 and a one-tailed p-value below 0.001, indicating a statistically significant difference in improvement between the groups. The experimental group also recorded higher N-Gain percentages for C4 + Reasoning (77.0%), C5 + Reasoning (79.5%), and C6 + Reasoning (71.2%). The results suggest that the combined CST and Flipbook approach can support the development of higher-order chemical literacy in the topic of hydrocarbons and petroleum.

Keywords: Community Science Technology; Flipbook media; higher-order thinking skills; chemical literacy; hydrocarbons and petroleum

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1. Introduction

Chemistry education is expected to equip students with more than the ability to recall definitions, formulas, and fundamental concepts. Students also need to interpret scientific information, assess evidence, and use chemical knowledge to respond to problems encountered in everyday life. These competencies are closely associated with higher-order thinking skills (HOTS), particularly the abilities to analyze information, evaluate alternatives, and develop reasoned responses. Such skills are important in chemistry learning because many chemical ideas are abstract and become more accessible when students relate them to observable phenomena and familiar contexts.

Chemical literacy refers to the use of chemical knowledge to make sense of phenomena and to respond to issues involving science, technology, and daily life. It includes dimensions of content, context, and competence. Learning experiences that connect chemical concepts with meaningful situations can help students interpret scientific information and apply chemical reasoning when considering chemistry-related issues (Fahmina et al., 2019).

Initial observations of Grade XI MIPA students at SMA Negeri 11 Medan suggested that chemistry lessons were still commonly delivered through teacher-centered instruction and made limited use of interactive learning media. As a result, students had relatively few opportunities to take an active role in learning, while classroom assessments tended to place greater emphasis on lower-order cognitive processes. This pattern may restrict students' practice in analysis, evaluation, and problem-solving. Hydrocarbons and petroleum provide a relevant context for addressing these skills because the topic is connected with fuel consumption, combustion, pollution, and industrial processes.

The Community Science Technology (CST) learning model offers an approach for relating scientific ideas to technological applications and issues in society. Learning may be organized around a problem that is relevant to students, followed by activities in which they gather information, examine evidence, discuss possible interpretations, communicate ideas, and consider potential solutions. Through this process, students are encouraged to use chemistry to understand contextual issues instead of depending only on memorization (Amali et al., 2019; Ayuningtyas et al., 2020).

Digital Flipbook media can be used alongside this learning approach to provide information in several forms, including written explanations, illustrations, videos, animations, and interactive features. These representations may assist students in exploring chemical structures and processes that are not readily observable. For hydrocarbons and petroleum, visual materials can support connections between molecular ideas, chemical processes, fuel use, combustion, and environmental effects (Amanullah, 2020; Sari & Ahmad, 2021).

Previous work has addressed contextual science learning, chemical literacy, higher-order thinking, and digital learning media. However, the extent to which the CST learning model and Flipbook media, when implemented together, can support HOTS-based chemical literacy in the topic of hydrocarbons and petroleum still requires examination in the present research setting. This study

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therefore compared students' improvement in chemical literacy after learning with CST supported by Flipbook media and after conventional instruction. It also examined improvement in the C4 + Reasoning, C5 + Reasoning, and C6 + Reasoning aspects.

2. Methods

This research used a quantitative approach and a quasi-experimental pretest–posttest control-group design. Students in both groups completed a pretest before instruction and a posttest after the learning period. The study took place at SMA Negeri 11 Medan during the 2025/2026 academic year. Grade XI students constituted the research population. Class XI-6 was assigned as the experimental group, whereas Class XI-8 was the control group. The two classes were selected using simple random sampling.

The experimental class was taught through the Community Science Technology (CST) model with Flipbook media, while the control class received conventional instruction. The topic, length of instruction, and assessment instrument were maintained across the two groups to support a meaningful comparison of learning outcomes. The procedure involved three main steps: a pretest, the instructional treatment according to each group's assigned approach, and a posttest.

Students' HOTS-based chemical literacy on hydrocarbons and petroleum was measured with a multiple-choice test. The instrument initially contained 30 questions and was assessed by an expert validator from the Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan. It was subsequently tried out with 35 Grade XI students. Item validity was evaluated using the product-moment correlation technique. For $n = 35$, the r-table value was 0.334 at the 0.05 significance level. The analysis showed that 20 items were valid and 10 items were invalid.

The item analysis showed that 21 questions had moderate difficulty, four were classified as difficult, and five as easy. The discrimination analysis categorized two items as very good, 17 as good, six as sufficient, and five as poor. Reliability was assessed using the Kuder–Richardson Formula 21 (KR-21), which produced a coefficient of 0.741. On the basis of this coefficient, the instrument was treated as sufficiently reliable for assessing students' HOTS-based chemical literacy.

Descriptive statistics and normalized gain (N-Gain) were used to examine changes in student performance. The N-Gain categories were defined as high for $g > 0.70$, medium for $0.30 < g \leq 0.70$, and low for $g \leq 0.30$.

Prior to hypothesis testing, the N-Gain data were examined for normality using the Kolmogorov–Smirnov test and for homogeneity of variance using Levene's test. Since the reported assumption tests met the 0.05 criterion, an independent-samples t-test was applied to assess whether improvement differed significantly between the experimental and control groups. The significance level was set at 0.05. Improvement was also considered separately for C4 + Reasoning, C5 + Reasoning, and C6 + Reasoning.

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3. Results and Discussion

3.1. Instrument Analysis

The instrument evaluation retained 20 of the 30 questions for data collection. Most questions were classified as having moderate difficulty, and the largest group of items showed good discrimination. The KR-21 coefficient was 0.741, indicating that the test had an acceptable level of internal consistency for the purpose of this study. The item-analysis results are summarized in Table 1.

Table 1. Summary of instrument analysis

Indicator	Result
Items developed	30
Valid items	20
Invalid items	10
Difficulty: moderate	21 items
Difficulty: difficult	4 items
Difficulty: easy	5 items
Discrimination: very good	2 items
Discrimination: good	17 items
Discrimination: sufficient	6 items
Discrimination: poor	5 items
KR-21 reliability	0.741

3.2. Pretest, Posttest, and N-Gain

Table 2. Pretest, posttest, and N-Gain results

Class	Pretest Mean	Posttest Mean	Pretest SD	Posttest SD	N-Gain	Category
CST + Flipbook	41.29	86.14	11.071	6.761	0.8427	High
Conventional	40.86	75.29	12.156	8.901	0.6342	Medium

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Both classes achieved higher mean scores after the instructional period. In the experimental class, which received CST instruction supported by Flipbook media, the mean score rose from 41.29 on the pretest to 86.14 on the posttest. In the conventional class, the mean increased from 40.86 to 75.29. The mean-score changes show improvement in both groups, with a larger increase in the experimental class.

The normalized-gain results provide a further comparison of the two instructional approaches. The experimental group recorded an N-Gain of 0.8427, classified as high, whereas the control group recorded 0.6342, which falls in the medium category. Within the limits of this quasi-experimental design, the results indicate that students in the CST + Flipbook class made greater progress in HOTS-based chemical literacy than students in the conventional class.

3.3. Normality and Homogeneity Tests

Table 3. Kolmogorov–Smirnov normality test for N-Gain data

Class	K–S statistic	df	p-value	**Conclusion**
CST + Flipbook	0.124	35	0.191	Normally distributed
Conventional	0.126	35	0.173	Normally distributed

The Kolmogorov–Smirnov significance values were 0.191 for the CST + Flipbook group and 0.173 for the conventional group. Both values exceeded 0.05; therefore, the normality test did not provide evidence of a departure from a normal distribution for either group's N-Gain data.

Table 4. Levene's test of homogeneity of variance for N-Gain data

Levene Statistic	**df1**	**df2**	p-value	**Conclusion**
1.160	1	68	0.285	Homogeneous

Levene's test produced a significance value of 0.285, which is higher than the 0.05 threshold. Accordingly, the null hypothesis of equal variances was not rejected, and the variance of the two groups was treated as homogeneous for the subsequent analysis.

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3.4. Hypothesis-Test Result

Table 5. Independent-samples t-test results

Comparison	t-value	p-value (one-tailed)	Decision
Improvement in HOTS-based chemical literacy	5.870	<0.001	H_0 rejected

The independent-samples t-test was used to compare the improvement scores of the experimental and control groups. The analysis returned a t-value of 5.870 and a one-tailed p-value below 0.001.

Because the reported p-value was lower than the 0.05 significance level, the null hypothesis was rejected. The result indicates a statistically significant difference in the improvement of HOTS-based chemical literacy between students taught with CST supported by Flipbook media and those taught through conventional instruction.

3.5. Improvement in Cognitive Aspects

Table 6. N-Gain percentages for HOTS cognitive aspects

Class	C4 + Reasoning	C5 + Reasoning	C6 + Reasoning
CST + Flipbook	77.0%	79.5%	71.2%
Conventional	62.6%	49.7%	50.8%

The comparison of the three cognitive aspects showed that the experimental group achieved higher N-Gain percentages than the conventional group in C4 + Reasoning, C5 + Reasoning, and C6 + Reasoning. In the experimental group, the largest percentage was observed for C5 + Reasoning (79.5%), followed by C4 + Reasoning (77.0%) and C6 + Reasoning (71.2%).

The conventional group recorded 62.6% for C4 + Reasoning, 49.7% for C5 + Reasoning, and 50.8% for C6 + Reasoning. Thus, the experimental group showed higher gains in each of the three aspects. The difference was most pronounced for C5 + Reasoning, although the experimental group also recorded higher percentages for analysis and creation-related reasoning.

3.6. Discussion

The main finding of this study is that the experimental class achieved a higher improvement in HOTS-based chemical literacy than the control class. The N-Gain values were 0.8427 for the CST + Flipbook group and 0.6342 for the conventional group, while the independent-samples t-test

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indicated a statistically significant difference. One possible interpretation is that the CST approach gave students structured opportunities to work with chemistry-related issues rather than engage only with the recall of concepts. Identifying a problem, locating relevant information, examining evidence, discussing interpretations, and considering responses can require students to use chemical knowledge in analytical and evaluative ways.

This interpretation is relevant to the subject matter of hydrocarbons and petroleum. Issues such as fuel selection, combustion, air pollution, and industrial use allow students to connect chemical principles with situations outside the classroom. When students are asked to consider these issues, they need to identify which chemical concepts are relevant and use them to interpret information. The contextual orientation of CST may therefore help make chemical literacy more visible in classroom tasks. This is consistent with the emphasis on connecting science, technology, and societal contexts in science-technology-society learning discussed by Amali et al. (2019) and Ayuningtyas et al. (2020).

Flipbook media may have supported this process by making learning content available through more than one form of representation. Written explanations, illustrations, and multimedia can provide additional ways to examine structures and processes that are difficult to observe directly. In this study, the media were used as support for the CST learning process; they should not be interpreted as a separate intervention whose individual effect was tested. This distinction is important because the research compared the combined CST + Flipbook approach with conventional instruction. The potential role of digital Flipbook resources in presenting instructional content is also addressed in Amanullah (2020) and Sari and Ahmad (2021).

Among the three cognitive aspects, C5 + Reasoning showed the highest N-Gain percentage in the experimental group (79.5%). This result may be related to the evaluative demands of contextual learning activities, in which students consider information, compare alternatives, and justify a decision. The finding is conceptually relevant to research examining the relationship between chemical literacy and higher-order thinking, such as Purba et al. (2022), and to work considering HOTS through project-based learning in relation to chemical literacy (Simamora, 2022). However, those studies address related constructs or instructional approaches rather than the exact CST + Flipbook combination examined here.

The experimental group's C4 + Reasoning gain was 77.0%, also higher than the 62.6% recorded in the conventional group. This pattern suggests that students in the experimental class improved in interpreting information and identifying relationships among chemistry concepts. The problem-based and contextual activities in CST may have provided repeated opportunities to select relevant information and connect it with appropriate chemical principles. The broader use of science-literacy instruction to support students' thinking skills has also been considered in studies such as Sutiani et al. (2021), although their instructional model differs from the one used in this research.

For C6 + Reasoning, the experimental group achieved 71.2%, compared with 50.8% in the conventional group. Although this was the lowest of the three percentages in the experimental class, it remained higher than the corresponding control-group result. One possible explanation is that

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creating or formulating a response places additional demands on students because they must combine information and concepts to develop a proposal or decision. The present data show improvement in this aspect, but they do not establish which particular classroom activity caused that improvement.

The assumption tests supported the use of the parametric comparison reported in this study: the Kolmogorov–Smirnov significance values were 0.191 and 0.173, and Levene's test yielded 0.285. The independent-samples t-test then produced t = 5.870 with a one-tailed p-value below 0.001. This inferential result is consistent with the descriptive comparison, in which the experimental class had the higher mean posttest score and N-Gain. Taken together, the statistical results support a difference in improvement between the two groups under the conditions of this study.

Overall, the findings suggest that the combined use of CST and Flipbook media can support students' development of HOTS-based chemical literacy in the topic of hydrocarbons and petroleum. CST provides a learning sequence that connects science with technology and societal issues, while the Flipbook offers additional representations of the subject matter. Because both components were implemented together, the study cannot determine the separate contribution of each component. Future research could examine the individual and combined effects of the learning model and the digital media, involve additional schools, and investigate how students' reasoning develops during specific learning activities.

4. Conclusion

Students who participated in the Community Science Technology (CST) learning process supported by Flipbook media showed greater improvement in HOTS-based chemical literacy than students who received conventional instruction. The experimental group achieved an N-Gain of 0.8427 (high), whereas the control group achieved 0.6342 (medium). The independent-samples t-test yielded t = 5.870 with a one-tailed p-value below 0.001, indicating a statistically significant difference in improvement between the groups.

The experimental group also recorded higher N-Gain percentages in all three cognitive aspects: 77.0% for C4 + Reasoning, 79.5% for C5 + Reasoning, and 71.2% for C6 + Reasoning. The highest percentage was found in C5 + Reasoning. These findings indicate that the combined CST and Flipbook approach was associated with stronger improvement in students' ability to analyze, evaluate, and formulate responses when learning about hydrocarbons and petroleum. Since the two components were implemented together, their individual effects cannot be separated based on this study.

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