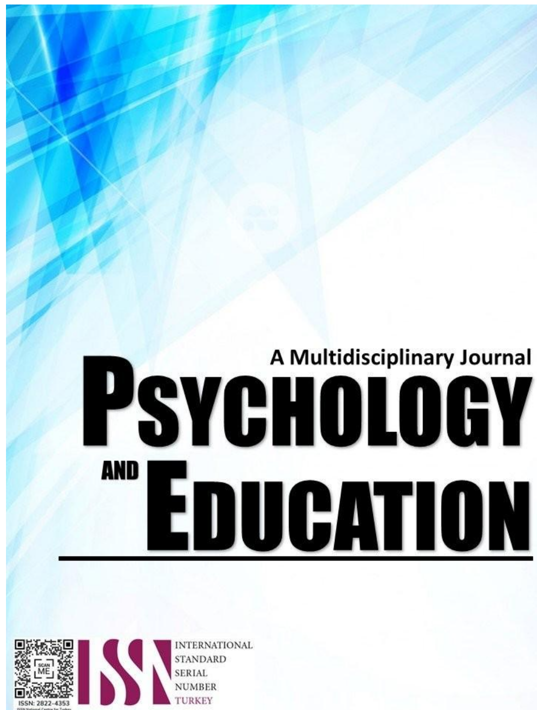
CHEMSKETCH IN IMPROVING STUDENT PERFORMANCE IN HYDROCARBONS



PSYCHOLOGY AND EDUCATION: A MULTIDISCIPLINARY JOURNAL

Volume: 47
Issue 8
Pages: 967-973
Document ID: 2025PEMJ9610
DOI: 10.70838/pemj.470804
Manuscript Accepted: 08-31-2025

Psych Educ, 2025, **47**(8): 967-973, Document ID:2025PEMJ4610, doi:10.70838/pemj.470804, ISSN 2822-4353
Research Article

Chemsketch in Improving Student Performance in Hydrocarbons

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Abstract

This study investigates the effectiveness of Chemsketch as an instructional tool to enhance the performance of Grade 11 STEM students in the topic of Hydrocarbons within the General Chemistry curriculum at the University of Luzon. Despite the relevance of Chemistry in industrial applications, many students perceive it as an abstract and challenging subject. Consequently, traditional teaching methods often fail to engage students effectively. Utilizing computer visualization tools like Chemsketch, this research aims to bridge the gap between theoretical concepts and practical understanding. The experimental design involved thirty students in an experimental group utilizing Chemsketch, compared to thirty students in a control group receiving traditional instruction. Data were gathered through pre-tests and post-tests, employing statistical analyses including the Independent T-Test and Paired T-Test to assess performance differences between the two groups. Results indicated that before the intervention, both groups scored below average, highlighting a need for effective instructional methods. However, post-test results showed significant improvements in the experimental group, underscoring the positive impact of Chemsketch on student comprehension and performance. This study emphasizes the importance of integrating innovative teaching tools in Chemistry education to enhance learning outcomes, ultimately aiming to improve students' performance in national assessments.

Keywords: *ChemSketch, instructional tool, Grade 11 STEM students, hydrocarbons, learning outcomes*

Introduction

Students often perceive chemistry as a challenging subject, despite its central role in explaining natural phenomena and its widespread relevance across various industries. This difficulty is often attributed to its abstract concepts, which many learners find disconnected from their everyday experiences (Brickhouse & Carter, 2014). Espinosa, Monterola, and Punzalan (2013) noted that students frequently view Chemistry as too abstract and mathematical, while Brickhouse and Carter (2014) emphasized that misunderstanding core concepts leads to further disengagement. As a result, many students struggle to appreciate the importance of Chemistry and to apply its principles in real-world contexts.

One major challenge in learning Chemistry is the inability of students to connect classroom lessons with real-life applications. When the subject is presented as purely theoretical, students often fail to see its relevance, especially in settings where teachers lack proper training or where resources and laboratory facilities are insufficient. In the Philippine context, this gap in instructional quality has been identified as a significant factor contributing to students' poor performance in science education (Cuyegkeng, 2012). Such limitations hinder the development of critical thinking and problem-solving skills, which are essential in mastering scientific concepts.

Teaching strategies also play a key role in shaping students' perceptions of Chemistry. Traditional lecture-based approaches—often referred to as the "talk-and-chalk" method—remain prevalent; however, these approaches often limit student engagement and conceptual understanding (Nwosu, 2012; Johnson, 2013). Studies suggest that meaningful learning in Chemistry requires integrating hands-on activities and real-life applications that connect with students' experiences (Reyes, España, & Belecina, 2014; National Academy of Science, 2013). Without innovative pedagogical approaches, students continue to struggle with Chemistry, as reflected in their consistently low performance in national and international assessments such as the Program for International Student Assessment (PISA), where the Philippines ranked near the bottom in science and mathematics in 2019.

An essential aspect of mastering Chemistry is the ability to form mental models of molecular-scale processes, which students often find most difficult (Gilbert, 2011; Chittleborough & Treagust, 2011). To address this, researchers have highlighted the use of computer-based visualizations and animations to support conceptual understanding and spatial reasoning (Wu & Shah, 2009; Jones et al., 2011). Molecular visualization tools, when used effectively, help students bridge the gap between abstract concepts and observable phenomena, though they must be carefully implemented to avoid misconceptions (Tasker & Dalton, 2012). This highlights the importance of employing technology-enhanced learning tools that can transform complex chemical ideas into accessible and engaging representations.

One such tool is ChemSketch, a freeware application designed for drawing chemical structures and calculating molecular properties. With its features for creating 2D and 3D representations, naming structures, and generating professional outputs, ChemSketch provides both educational and professional applications. Students and educators have widely used it to simplify the learning of Chemistry concepts while offering skills transferable to the workforce. In this light, the University of Luzon recognizes the need to integrate ICT-based instructional tools such as ChemSketch into Senior High School Chemistry classes. This study, therefore, seeks to determine the effectiveness of ChemSketch as an instructional tool in teaching General Chemistry, aiming to offer an alternative to traditional approaches and ultimately improve student achievement in science.

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Methodology

Research Design

As the researcher determines the effectiveness of ChemSketch as a teaching tool in General Chemistry, this study employed an accurate experimental research method, observing a controlled and experimental group of participants.

According to Macin (2011), the experimental research designs used in this study compared two groups in one measure. This method is considered suitable because the study compared two groups: one utilizing the traditional method (chalk and board) and the other utilizing the proposed application, ChemSketch. The results of the pre-test and post-test for the two groups, comparing students who used the teaching tool (ChemSketch) with those who did not, were analyzed.

Respondents

The study's participants were the sixty students from the University of Luzon's first and second sections of Grade 11 Senior High School, specifically those in the Science, Technology, and Engineering (STEM) strand. The researcher identified two sections out of the three sections under the STEM strand, namely Stem A-Pythagoras and Stem B-Galileo. Each section had thirty students. The other section, STEM C-Archimedes, was subjected to test validation. Among the strands, they were the ones chosen since General Chemistry, which is one of their major subjects, was the basis for the application. Simple random sampling, specifically the fishbowl method, was employed in the study, ensuring that each member of the sample had an equal chance of being chosen for the study.

Instrument

A teacher-made test was used in this study. The test questions were constructed by the researcher and were validated by experts composed of (1) a holder of a doctorate degree in Science, and two college professors teaching Chemistry. The reliability of the instrument was assessed, involving one of the sections of STEM 11-C (Archimedes). The specific type of reliability used was Split-Half. Based on the correlation results, the test constructed was reliable, with a Pearson correlation coefficient of 0.73. Test questions were limited only to the topic Hydrocarbons: Its Properties and Bonding Patterns. The data generated from the pre-test and the post-test were used to determine the level of performance of the Grade 11 STEM students in General Chemistry. It served as the basis for ascertaining the use of the ChemSketch Application as a teaching tool to improve the performance of the target participants.

The entire experiment lasted for a whole week. The first day was allotted for the pre-test. Three more days were allotted for the discussion proper, while the last day was allotted for the post-test.

Procedure

To officially commence data gathering, the researcher sought permission from the Office of the Principal of the Senior High School Department at the University of Luzon for approval to conduct the research. Immediately after the permission was granted, the tests were administered to the study participants.

The researcher personally administered the pre-test and post-test. Each participant was asked to complete the instrument first by answering the 30 items in a pre-test, both for the control (traditional method) and experimental (using ChemSketch) groups. The two groups took the test on the same day, following their specific schedules in the subject involved.

The subject teacher handling the General Chemistry subject of the target participants then proceeded to demonstrate the lesson to both the traditional and experimental groups. The chalkboard method was used in the traditional group, while the ChemSketch Application was employed in the experimental group. The topics discussed were the same for both groups.

A post-test was administered to both the control and experimental groups after the lesson demonstration to assess the students' level of achievement, understanding, and performance. Afterward, the researcher classified and tallied the responses by section. The responses were then tabulated, analyzed, and interpreted. Additionally, documentary evidence regarding the action research and other learning materials was also documented.

After these documents are completed, the evidence and gathered data are collated, sorted, and analyzed by the researcher for proper appreciation, analysis, and interpretation.

Data Analysis

In this study, the researcher employed the following statistical tools to analyze the data for each sub-problem.

With reference to problem no. 1, frequency count and percentage were used. An independent t-test was also used to compare the pre- and post-test results of the two groups. Central tendency, including the mean, median, and mode, was also utilized, along with the skewness, kurtosis, and covariance of the two groups. Furthermore, a paired t-test was also used to compare the pre- and post-tests of a specific group, which served as the basis for measuring the effectiveness of the method in terms of performance.

Consistent with problem no. 2, which identified a significant difference in the performance of the groups (both controlled and experimental) between the pre-test and post-test, a z-test was used at the .01 level of significance.

Results and Discussion

This section presents the analysis and interpretation of the accumulated data that significantly contributed to the formulation of the study's output. It also includes the level of performance of the control and experimental groups.

Table 1. *Performance of the Two Groups in the Pre-Test*

Scores	*Controlled Group f*	*Controlled Group %*	*Experimental Group f*	*Experimental Group %*
1–5	3	10	3	10
6–10	22	73.33	20	20
11–15	5	16.67	7	70
16–20	0	0	0	0
21–25	0	0	0	0
26–30	0	0	0	0
Total	30	100	30	100

***Legend**: f – Frequency; % – Percentage*

Table 1 presents the performance of the controlled group using the traditional method, specifically the chalkboard method, and the experimental group, which observed the integration of the Chemsketch Application. For the controlled group, the frequency of students with scores ranging from 1 to 5 is 3, with a percentage of 10; 6 to 10 is 22, with a percentage of 73.33; 11 to 15 is 5, with a percentage of 16.67; and none of the students got scores ranging from 16 to 30.

Based on the results, all students received scores below average, as the average score is 15, corresponding to a 50 percent rate of success. Hence, in relation to the related studies conducted by Shia, based on the pre-test results, it can be concluded that students indeed exhibited malperformance. However, regarding the experimental group, the frequency of students with scores ranging from 1 to 5 is 3 with a percentage of 10, 6 to 10 is 20 with a percentage of 20, 11 to 15 is 7 with a percentage of 70, and none of the students got scores ranging from 16 to 30.

In summary, all the students received scores below average, as 15 is the average score. Just as with the other groups, the students in the experimental group manifested underachievement. This may reflect the challenging nature of the subject, as noted in Nakleh's work.

Overall, the results concur with the findings of Johnstone (2009), Nakhleh (2008), and Gabel (2009), indicating that students have difficulty understanding Chemistry, particularly concepts, theories, and principles underlying microscopic-level phenomena that explain observations at the macroscopic level. Schools must have visualization tools, such as ChemSketch, to help them improve their performance.

Table 2. *Performance of the Two Groups in the Post Test*

Scores	*Controlled Group f*	*Controlled Group %*	*Experimental Group f*	*Experimental Group %*
1–5	0	0	0	0
6–10	3	10	0	0
11–15	9	30	2	6.67
16–20	13	43.33	18	60
21–25	5	16.67	10	33.33
26–30	0	0	0	0
Total	30	100	30	100

***Legend**: f – Frequency; % – Percentage*

Table 2 presents the performance of the two controlled groups of students in the post-test, following the introduction of the Chemsketch Application to the experimental group. As regards to controlled group, none of the students got the scores ranging 1 to 5, for the bracket of 6 to 10, 3 students, equivalent to 10 percent; 30 percent or 9 student for 11 to 15, 5 students got got scores ranging from 21 to 25 or 16.67 percent and none of the students got the scores ranging 26 to 30. In summary, twelve students received scores below average, and eighteen students received scores above average. On the other hand, relative to the experimental group, none of the students got the scores ranging from 1 to 5 and 6 to 10; 2 students (6.67%) for 11-15; 18 students (60%) for 16-20; 10 students (33.33%) for 21 to 25; and no students got scores within the range of 26 to 30. Therefore, two students got scores below average, while twenty-eight students got scores above average.

Overall, the results are consistent with the study of Raiyn and Rayan (2015), which found that through the integration of modeling tools such as CHEMDRAW Software in chemistry education, the average score from 5.7 (prior ChemDraw incorporation) increased to 7.3 (post ChemDraw incorporation), indicating the effectiveness of the said instructional tool. Hence, the integration of the said tool is indeed helpful.

Table 3. *Descriptive Statistics of the Two Groups in Pre-Test*

	Mean	*Median*	*Mode*	*Std Deviation*	*Skewness*	*Kurtosis*	*Covariance*
Controlled Group	8.3	8.5	10	2.15198	-0.218	-1.006	0.009
Experimental Group	9.2	9	10	3.33362	0.44	0.344	

As shown in Table 3, in the Pre-Test, the control group has a mean of 8.3, a median of 8.5, and a mode of 10. Furthermore, the standard deviation is 2.15198, and its skewness is -0.218 (moderately skewed), and its kurtosis is -1.006. Whereas the mean of the experimental group is 9.2, the median is 9, and the mode is also 10. Additionally, its standard deviation is 3.33362, its skewness is 0.44, and its kurtosis of 0.344, with a covariance of 0.009. Based on the results, the experimental group registered a slightly higher mean value of 9.2 compared to the control group, with a mean value of 8.3. The scores of the controlled group, on the other hand, are more clustered than those of the other group, which implies that the latter is considered homogeneous. Furthermore, the skewness of both groups is near zero, hence almost all scores are normally distributed.

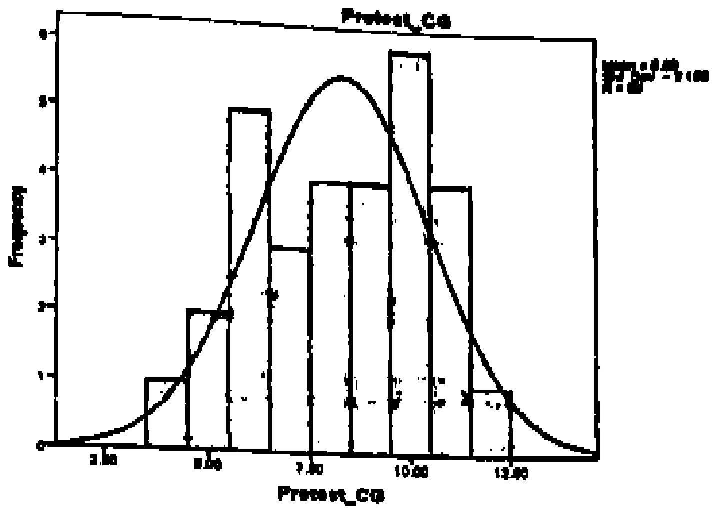

Figure 1. *Skewness of the Controlled Group in their Pre-Test*

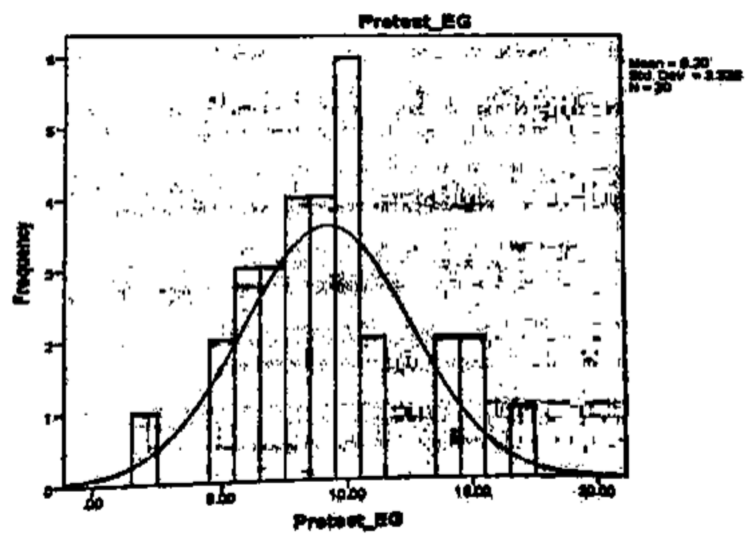

Figure 2. *Skewness of the Experimental Group in their Pre-Test*

Table 4. *Descriptive Statistics of the Two Groups in their Post-Test*

	Mean	*Median*	*Mode*	*Std Deviation*	*Skewness*	*Skewness*	*Kurtosis*
Controlled Group	16.2	17	19	4.01205	-0.092	-1.111	16.2
Experimental Group	19.1	19	16	3.4074	-0.038	0.055	19.1

As shown in Table 4, the post-test results for the control group indicate a mean of 16.2, a median of 17, and a mode of 19. Furthermore, the standard deviation is 4.01205, its skewness is -0.092, and its kurtosis is -1.111. The experimental group, on the other hand, had a mean of 19.1, a median of 19, and a mode of 16. The standard deviation is 3.4074, the skewness is -0.038, and the kurtosis is 0.055

Based on the results, the experimental group performed relatively better, with a mean value of 19.1, compared to the control group, which had a mean value of 16.2. The scores of the controlled group, on the other hand, are more dispersed than those of the other group, which implies that the latter is heterogeneous. Furthermore, the skewness of both groups is close to zero, indicating that almost all scores are normally distributed.

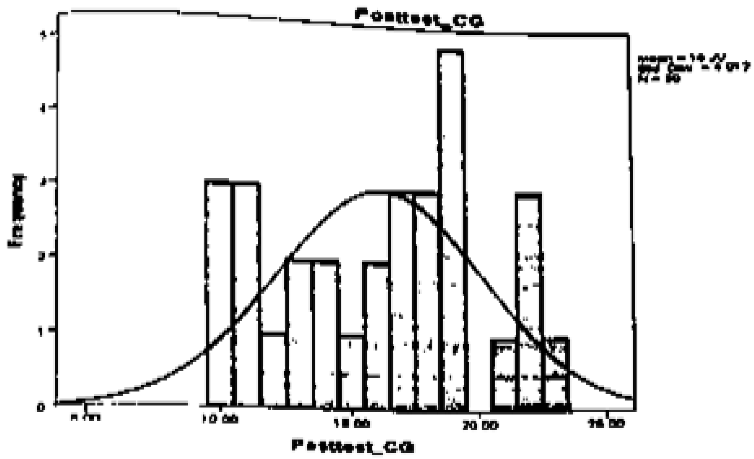

Figure 3. *Skewness of the Controlled Group in their Post-Test*

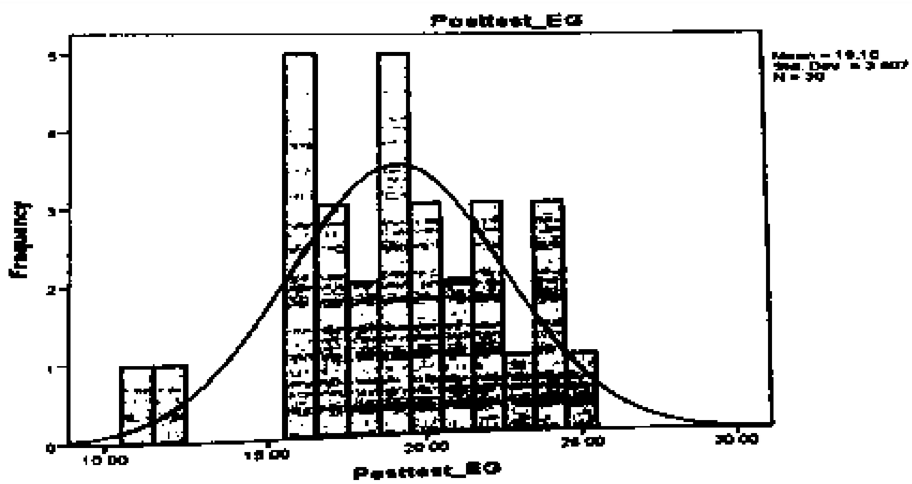

Figure 4. *Skewness of the Experimental Group in their Post Test*

Table 5. *Independent T-Test of the Two Groups in the Pre-Test and Post-Test*

	Levene's Test for Equality of Variances			*t-test for Equality of Means*			*95% Confidence Interval of the Difference*		
	F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	*Mean Difference*	*Std. Error Difference*	*Lower*	*Upper*
PRE_TEST Equal variances assumed	2.232	.141	-1.242	58	.219	-.900	.725	-2.351	.551
PRE_TEST Equal variances not assumed			-1.242	49.570	.220	-.900	.725	-2.358	.556
POST_TEST Equal variances assumed	1.911	.172	-3.018	58	.004	-2.900	.961	-4.824	-.976
POST_TEST Equal variances not assumed			-3.018	56.518	.004	-2.900	.961	-4.825	-.975

Table 5 presents the independent t-test results comparing the two groups in their pre- and post-tests. In the pre-test results, the t-value of 1.242 is less than the critical value 2.6633 (two-tailed, 0.01 level of significance).

Ergo, there is no significant difference between the performance of the two groups in their pre-test; hence, the groups are homogeneous by nature. On the other hand, in the post-test, the t-value 3.018 is greater than the critical value 2.6633 (two-tailed, 0.01 level of significance).

Table 6. *Paired T-Test of the Controlled Group*

	Paired Differences			*95% Confidence Interval of the Difference*		*t*	*df*	*Sig. (2-tailed)*
	Mean	*Std. Deviation*	*Std. Error Mean*	*Lower*	*Upper*			
Pair 1 CONTROLLED_PRE_TEST - CONTROLLED_POST_TEST	-7.900	3.623	.662	-9.253	-6.547	-11.943	29	.000

Table 6 presents the paired t-test results for the controlled group, including its mean, standard deviation, level of confidence, and degrees of freedom. Based on the result, the t-value, which is 11.943, is greater than the critical value of 2.756; hence, there is a statistically significant difference between the pre-test and post-test scores of the said group, indicating an increase in student performance using the chalkboard method for instruction.

Table 7. *Paired T-Test of Experimental Group*

	Paired Differences			*95% Confidence Interval of the Difference*		*t*	*df*	*Sig. (2-tailed)*
	Mean	*Std. Deviation*	*Std. Error Mean*	*Lower*	*Upper*			
Pair 1 EXPERIMENTAL_PRE_TEST - EXPERIMENTAL_POST_TEST	-9.900	2.833	.517	-10.958	-8.842	-19.142	29	.000

Table 7 shows a t-value of 19.142, which is greater than the critical value of 2.756; hence, there is a statistically significant difference between the pre-test and post-test scores of the said group. This implies that there was an increase in student performance after the integration of the Chemsketch Application into instruction.

Table 8. *Difference between the Performance of the Controlled and Experimental Groups*

Teaching Method	*n*	$\bar{x}$	s^2	*z-value*	*Critical Value*
Controlled Group (Traditional Method)	30	16.20	16.09	-3.01	-1.96
Experimental Group (ChemSketch Application)	30	19.10	11.61		

Table 8 shows the sample size (n), mean ($\bar{x}$), variance (s^2), z-value, and the critical value for each teaching method. The controlled group using the traditional method of teaching with 30 participants has a computed mean of 16.20 and a variance of 16.09. In contrast, the experimental group using the ChemSketch Application with the same number of respondents has a mean of 19.10 and a variance of 11.61.

This finding is similar to the study conducted by Ghavifekr and Rosdy (2015), where a significant difference in the performance of the traditional group and the experimental group was clearly evident. Based on the study's results, technology-based teaching and learning, where visualization tools like ChemSketch are applied, is more effective than the traditional mode of teaching. This result is also in consonance with the research findings of Macho (2005), which state that using visualization tools would enhance students' learning.

Conclusions

The study's findings reveal that integrating ChemSketch into the teaching of Hydrocarbons under General Chemistry is effective in enhancing students' understanding of Chemistry concepts, particularly those related to molecular structures. The use of the application enabled students to visualize molecular arrangements more clearly, leading to improved comprehension and engagement. These promising outcomes highlight the potential of ChemSketch as a valuable instructional tool in making abstract concepts more concrete and accessible to learners.

In light of these findings, it is recommended that the use of ChemSketch be promoted in Science instruction as a supplemental teaching tool. Teacher training programs may also be designed to equip educators with the necessary skills to maximize the application's features. Furthermore, future research should explore the full integration of ChemSketch in Chemistry instruction across different topics and grade levels to validate its effectiveness and broaden its application in enhancing science education.

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