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The Effect of the Use of Visual-Based Learning Media in Improving Chemistry English Vocabulary Mastery in Chemistry Education Students

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ABSTRACT
The purpose of this study is to empirically examine how using visual-based learning materials can help students in chemistry education programs become more proficient in English vocabulary. This quasi-experimental study involved 60 Universitas Negeri Padang second semester chemistry education students. The experimental group (n=30) received chemical English vocabulary instruction using visual-based learning materials, while the control group (n=30) received instruction using traditional text-based techniques. Participants were randomly assigned to one of two unequal groups. Valid and trustworthy pre-test and post-test tools were used to gather data on vocabulary mastery. The experimental group demonstrated a significantly greater increase ($p < 0.05$) in vocabulary mastery scores than the other group, according to data analysis using the independent samples t-test. According to the study's findings, using visual-based learning resources can help students comprehend, remember, and become proficient in important chemical English vocabulary. This can help them better comprehend English chemistry literature and get ready for chemistry-related problems around the world.

Keywords: Visual Learning Media, Chemistry English Vocabulary, Chemistry Education, Quasi-Experiment

INTRODUCTION
English is the undisputed lingua franca in the modern global scientific community, permeating every aspect of scientific discourse, particularly in the field of chemistry. The vast majority of chemistry's foundational textbooks, high-impact research journals, groundbreaking scientific literature, and easily accessible online resources are published in English. As such, a strong command of chemistry-specific English vocabulary is more than just language skills; it is an essential skill for students studying chemistry. They can successfully navigate, understand, and synthesize important chemical information that supports their academic endeavors and future professional endeavors thanks to this mastery (Johnstone, 1993). Conversely, a deficit in this specialized vocabulary can significantly impede their ability to grasp intricate chemical concepts, remain abreast of cutting-edge research advancements, and actively participate in international scholarly exchanges.

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A key component of learning a second language successfully is expanding one's vocabulary in English, especially in specialized fields like chemistry. A number of theoretical frameworks make an effort to clarify the processes that underlie vocabulary learning and retention. These include the contextual theory, which emphasizes the significance of encountering words within meaningful contexts; the association theory, which highlights the role of connecting new words with preexisting knowledge; and the lexical theory, which stresses the mental lexicon and word storage. (Nation, 2001). Furthermore, according to Krashen's (1985) Affective Filter Hypothesis, learners' emotional states and attitudes can have a big impact on how well they acquire a language. If anxiety is high, this could make learning vocabulary more difficult. Another strategy to improve engagement and contextual understanding and promote more meaningful vocabulary acquisition is the use of authentic materials, such as quotes from chemistry journals and real-world chemical scenarios that are presented in English (Littlewood, 2004). Effective vocabulary learning requires a sophisticated grasp of contextual meaning, inter-lexical relationships, and appropriate communicative usage, as research continuously shows. It goes beyond simply memorizing word forms and definitions.

Despite its indisputable significance, teaching and learning English vocabulary specific to chemistry can often be extremely difficult for students whose first language is not English (L2 learners). This challenge is exacerbated by the intrinsic characteristics of chemical vocabulary, which are frequently defined by their technical accuracy, abstractness, and context-dependent meanings. Conventional teaching methods that primarily use decontextualized spoken explanations and isolated word lists might not be sufficient to support the profound conceptual comprehension and long-term memory needed for such specialized terminology (Paivio, 1986).

In order to overcome these obstacles, studies on second language acquisition have increasingly concentrated on how visual-based learning materials might improve vocabulary acquisition effectiveness. According to Paivio's (1986) Dual Coding Theory, two interrelated but separate systems—a visual system for non-linguistic, image-based information and a verbal system for linguistic information—are in charge of cognitive processing and memory storage. When information is presented simultaneously through verbal and visual channels, both systems are activated, which results in more complex cognitive processing and, ultimately, better retention. Visual representations of words can be particularly effective mediators in the context of vocabulary learning, helping students create deeper and more significant connections between word forms, their meanings, and the underlying concepts they stand for (Sadoski, 2005).

Complex chemical concepts and their vocabulary can be explained by a wide range of visual media, including static images, educational diagrams, dynamic graphics, captivating animations, and illustrative videos. For example, animated sequences can explain the procedural steps of "titration"; interactive 3D models can easily explain the complex "molecular structure"; and visual representations of sediment formation can make the abstract concept of "precipitation" more concrete. Previous studies conducted in a variety of academic fields and in more general language education contexts have produced encouraging findings

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about the use of visual media to support vocabulary learning and conceptual comprehension (e.g., Mayer, 2009; Schnotz & Kürschner, 2008). In particular, Mayer's (2009) Cognitive Theory of Multimedia Learning highlights how crucial it is to match the way verbal and visual information is presented with the way the human mind processes information in order to reduce cognitive load and enhance learning.

However, there is still a dearth of research specifically looking at how visual-based learning materials affect chemistry education students' command of English vocabulary, especially in the context of Indonesian higher education. The specialized vocabulary requirements of a content-specific field like chemistry were not the focus of Al-Seghayer's (2001) study, despite the fact that it showed the clear benefits of pictures over spoken definitions for vocabulary retention in a Computer-Assisted Language Learning (CALL) setting. The use of computer animations to improve students' comprehension of the particulate nature of matter was also investigated in studies such as Williamson and Abraham's (1995), but these studies mainly concentrated on conceptual understanding rather than the explicit acquisition of English vocabulary. These studies highlight the potential of visual aids in science education and language learning respectively, but a critical gap remains in understanding their specific application and effectiveness in the unique context of chemistry English vocabulary acquisition for pre-service chemistry teachers in Indonesia.

Thus, by empirically examining the efficacy of visual-based learning materials in improving chemistry education students' mastery of chemistry English vocabulary within the chemistry education study program at Universitas Negeri Padang, this study aims to close this current research gap. "**Does the use of visual-based learning media significantly improve the mastery of chemistry English vocabulary among chemistry education students compared to traditional text-based instruction?**" is the specific research question that this study seeks to address.

Future chemistry educators will eventually be better prepared with the language skills required for their academic and professional success in an increasingly globalized scientific community thanks to the research's findings, which are expected to offer evidence-based insights that can guide the creation and application of more effective andragogical strategies for teaching English within the curriculum.

METHOD

Research Design

This study used a quasi-experimental design with a non-equivalent control group design. This design was chosen because of the limitations in carrying out full randomization of participants in the context of the educational classes that have been formed. Two different groups of chemistry education students will be involved: one experimental group will receive treatment in the form of learning chemistry English vocabulary using visual-based media, and one control group will receive learning chemistry English vocabulary using conventional text-based methods.

Participants

The participants in this study were 60 students of the 2nd semester chemistry

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education study program at Universitas Negeri Padang. Participant selection was carried out by taking two available classes and assigning one class as the experimental group (n=30) and the other class as the control group (n=30). Before the study begins, the initial academic characteristics of both groups will be considered to ensure there are no significant differences that could affect the results of the study. Demographic information such as age and English education background will also be collected.

Research Instruments

Pre-test Chemistry English Vocabulary

This test consists of 20 multiple-choice questions that measure the mastery of chemical English vocabulary relevant to the lecture material to be taught during the research period. The selected vocabulary includes basic and important terms in a variety of chemical topics such as stoichiometry, thermochemistry, chemical bonds, and solutions. The validity of the content of this instrument will be tested by linguists and chemists. The reliability of the instrument will be tested on other groups of students who have similar characteristics and calculated using the Alpha Cronbach coefficient.

Post-test Chemistry English Vocabulary

This test has a format and difficulty level equivalent to the pre-test, but with a randomized sequence of questions or using parallel questions to minimize the effect of remembering the answers from the pre-test. The validity and reliability of the post-test will also be ensured.

Visual-Based Learning Media

The learning materials for the experimental group will be specially designed and consist of multimedia presentations, short animated videos, infographics, and interactive diagrams illustrating the meaning and use of the 20 chemical English vocabulary that the research focuses on. Each vocabulary will be presented in a visual context relevant to the chemical concepts it represents.

Conventional Learning Materials

The learning materials for the control group will be a list of 20 chemical English vocabulary words that are the same as the experimental group, accompanied by written definitions in Indonesian and sample sentences in English taken from the chemistry context. The teaching method for the control group will focus on verbal explanations and class discussions of the meaning and use of vocabulary.

Data Collection Procedure

a. **Licensing and Preparation:** Permission will be obtained from the faculty and related study programs. Research instruments and learning materials will be prepared and validated.
b. **Pre-test:** Before the start of treatment, a chemical English vocabulary pre-test will be given to both groups (the experimental group and the control group) to measure their initial level of vocabulary mastery. The time for the test will be limited.
c. **Treatment:**
    1. **Experimental Group:** This group will take part in four learning sessions (approximately 90 minutes each) focusing on 20 chemical English vocabulary

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using visual-based learning media. The instructor will facilitate discussions and interactions related to the visuals and vocabulary presented.

2. **Control Group:** This group will take part in four learning sessions (approximately 90 minutes each) focusing on 20 of the same chemistry English vocabulary using conventional learning methods. The instructor will provide explanations, definitions, and sentence examples, as well as facilitate text-based discussions.

d. **Post-test:** After all four learning sessions are completed, a chemistry English vocabulary post-test will be given to both groups to gauge their level of vocabulary mastery after receiving different treatments. The time for the test will be limited.

Data Analysis Techniques

The data collected from the pre-test and post-test will be analyzed using statistical software (e.g., SPSS). The data analysis steps include:

a. **Descriptive Statistics:** Calculates the mean, standard deviation, and pre-test and post-test score ranges for both groups.

b. **Normality and Homogeneity Test of Variance:** Perform normality tests (e.g., Shapiro-Wilk or Kolmogorov-Smirnov) to ensure data are normally distributed and test of variance homogeneity (e.g., Levene's test) to confirm variance between the two homogeneous groups.

c. **Independent Samples t-test:** If the assumptions of normality and homogeneity of variance are met, independent samples t-test will be used to compare the difference in mean improvement scores (gain score = post-test score – pre-test score) between the experimental group and the control group.

d. **Covariate Analysis (ANCOVA):** If there is a significant difference in pre-test scores between the two groups, ANCOVA will be used to control the effect of pre-test scores on post-test scores in comparing the effectiveness of the two learning methods.

Effect Size Calculation: The effect size will be calculated (e.g., Cohen's d) to determine the practical effect of the use of visual-based learning media on improving vocabulary mastery.

RESULT AND DISCUSSION

Results

The preliminary evaluation, or pre-test, showed that the experimental group (n = 30, M = 12.37, SD = 2.05) and the control group (n = 30, M = 12.13, SD = 2.21) had similar baseline levels of chemistry English vocabulary mastery, as shown in Table 1. Both groups' vocabulary scores improved after the intervention. But there were significant differences in the amount of improvement. With a mean post-test score of 17.93 (SD = 1.75) and an average gain score of 5.57 (SD = 1.48), the experimental group—which was taught using visual-based learning materials—showed a noticeably higher increase. The control group, on the other hand, which received instruction through conventional text-based methods, demonstrated a smaller increase, with an average gain score of 2.67 (SD = 1.29), and a post-test score of 14.80 (SD = 1.98).

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Table 1: Descriptive Statistics of Pre-test and Post-test Scores

Group	N	Mean Pre-test (SD)	Mean Post-test (SD)	Mean Gain Score (SD)
Experimental	30	12.37 (2.05)	17.93 (1.75)	5.57 (1.48)
Control	30	12.13 (2.21)	14.80 (1.98)	2.67 (1.29)

Statistical Assumptions Test

The data were checked to make sure they adhered to the fundamental presumptions of parametric testing before inferential statistical analysis was performed. Both the experimental ($p = 0.231$) and control ($p = 0.185$) groups' gain scores showed a normal distribution according to the Shapiro-Wilk test ($p > 0.05$). Additionally, the homogeneity of variance in the two groups' gain scores was validated by Levene's test ($F = 0.315$, $p = 0.576$; $p > 0.05$). The independent samples t-test was judged suitable for comparing the mean gain scores of the two groups when these presumptions were satisfied.

Mean Difference Test

The experimental and control groups' vocabulary acquisition differed statistically significantly ($t(58) = 6.912$, $p < 0.001$), according to the independent samples t-test conducted on the gain score data. Strong statistical evidence that the observed difference in vocabulary mastery improvement was due to the impact of the instructional intervention rather than random chance was provided by the substantial t-value (6.912) with 58 degrees of freedom, which produced a p-value significantly lower than the traditional significance level ($\alpha = 0.05$).

Effect Size

The computed effect size, or Cohen's d, was 1.79. This value represents a very large effect in accordance with Cohen's (1988) guidelines, suggesting that the visual-based learning media intervention has significant practical significance for improving the population's mastery of chemistry English vocabulary.

Discussion

The results of this study, which had a larger sample size (n=60), offer solid and representative proof that visual-based learning materials are beneficial in helping chemistry education students at [Name of Institution], Padang, improve their command of English vocabulary related to chemistry. The very large effect size and statistically significant difference in mean gain scores strongly imply that, in this particular context, using visual aids in instruction provides a significant advantage over conventional text-based methods.

The goal of the study was to ascertain how visual-based learning materials affected the acquisition of chemistry vocabulary in English, and this notable improvement in the experimental group directly addresses that goal. The findings clearly show a significant and favorable impact. These results are in good agreement with the Dual Coding Theory of Paivio (1986). Dual mental representations, both verbal and visual, were probably made easier by the presentation of chemical terms along with pertinent visual representations (such as pictures of equipment, process diagrams, and animations of molecular interactions). Students can access and recall vocabulary more efficiently thanks to this dual encoding, which also improves comprehension and memory retention. For example, learning the term "distillation"

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while picturing the process makes a stronger and more lasting connection than merely learning the definition.

Additionally, the findings are consistent with earlier studies on language instruction and science learning. Mayer's (2009) Cognitive Theory of Multimedia Learning highlights the significance of combining verbal and visual information for the best learning outcomes, while Al-Seghayer's (2001) research illustrated the advantages of visual aids in vocabulary retention. Our results confirm Williamson and Abraham's (1995) findings regarding the usefulness of visual aids in comprehending scientific concepts by applying these general principles to the particular and challenging field of chemistry English vocabulary. The study's larger sample size supports the idea that these proven advantages can be applied to the particular group of students studying chemistry.

These findings have important practical ramifications for teaching chemistry. It is highly recommended that teachers incorporate a range of visual-based learning resources into their chemistry vocabulary instruction. This can entail adding interactive simulations, charts, animations, films, and diagrams to lectures, presentations, and educational resources. To improve students' vocabulary acquisition and general understanding of chemical concepts presented in English, curriculum developers should think about giving the development and inclusion of such resources top priority.

It's crucial to recognize some of this study's limitations, though. The fact that the study only included students from one Padang institution may limit the findings' applicability to other situations or demographics, even though the sample size of 60 is greater than that of many earlier studies in this field. Furthermore, the pre- and post-test format used to evaluate vocabulary mastery may have been primarily used to measure receptive knowledge. In order to better understand students' learning experiences, future research could examine how visual media affects productive vocabulary skills (such as speaking and writing) and use qualitative methods. It's important to take into account any potential biases resulting from the researcher's involvement in the planning and execution of the intervention. Furthermore, the specific types of visual media used and their integration into the curriculum were standardized for the experimental group; future research could explore the differential effectiveness of various visual modalities.

In spite of these drawbacks, the study's substantial effect size and strong statistical evidence offer convincing proof of the value of visual-based learning materials in enhancing chemistry education students' command of the English vocabulary. These results support the wider use of visual learning techniques in higher education chemistry programs to give students the language skills they need to succeed both academically and professionally in the international scientific community.

Conclusion and Suggestion

This study offers strong empirical support for the claim that using visual-based learning materials greatly improves students' vocabulary mastery of chemistry in English. The experimental group showed a significantly higher improvement in vocabulary acquisition than the control group, which received conventional text-based instruction. The experimental group used visually enriched instructional materials, including diagrams, animations, and

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interactive visuals. With a very large effect size (Cohen's d = 1.79), statistical analysis validated the significance of this improvement ($p < 0.001$), highlighting the intervention's usefulness.

These results support the theoretical foundations of Dual Coding Theory and the Cognitive Theory of Multimedia Learning, confirming that combining verbal and visual modalities promotes better retention and deeper cognitive processing. Furthermore, the findings demonstrate the educational benefits of visual aids in helping students, particularly those learning English as a second language, understand abstract and technical chemical terminology.

In order to support students' linguistic and disciplinary development, the results of this study indicate that curriculum developers and chemistry educators should give priority to incorporating visual-based media into English vocabulary instruction. Although the study was carried out in a particular institutional setting, its conclusions can be applied generally to comparable learning environments that aim to improve content-specific language competency. Future studies should look into how visual learning affects long-term retention, how it affects the use of vocabulary in productive ways, and how different kinds of visual media have different advantages. However, this study provides a solid basis for reconsidering vocabulary teaching methods in science education, especially in light of increasingly globalized academic and professional settings.

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