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Effect of Genially-Based Computational Chemistry Media on Students' Motivation and Learning Outcomes in Chemical Bonding

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Abstract
This study was motivated by the low level of students' motivation and learning outcomes in chemical bonding material at SMA Negeri 13 Medan, as indicated by low participation, limited conceptual understanding, and many students not achieving the minimum learning criteria. This study aimed to examine the effect of Genially-based computational chemistry media on students' learning outcomes and to describe students' learning motivation after its implementation. This research employed a quasi-experimental method with a pretest–posttest control group design. The sample consisted of 70 students, divided into an experimental class (n = 35) and a control class (n = 35). The experimental class was taught using Genially-based computational chemistry media integrated with discovery learning, while the control class used discovery learning without the media. The data were analyzed using N-gain and an independent sample t-test. The results showed that the experimental class achieved a higher increase in learning outcomes (N-gain = 0.72, high category) compared to the control class (N-gain = 0.63, medium category). The hypothesis test indicated a statistically significant difference between the two groups ($t(68) = 3.74$, $p < 0.05$). In addition, students' learning motivation in the experimental class was categorized as high (81%). In conclusion, Genially-based computational chemistry media has a significant effect on improving students' learning outcomes and positively contributes to students' learning motivation. Therefore, this media can be used as an innovative alternative in chemistry learning, particularly for abstract topics such as chemical bonding.

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INTRODUCTION

The rapid advancement of technology in the 21st century has significantly transformed the educational landscape, requiring students to develop essential skills such as critical thinking, problem-solving, creativity, collaboration, and communication (Yulianti & Wulandari, 2021). In this context, the integration of technology in learning is not only a necessity but also a strategic effort to enhance students' engagement and understanding of complex concepts.

Chemical bonding is one of the fundamental topics in chemistry that plays a crucial role in understanding molecular structure and interactions (Premono et al., 2009). However, this topic is often perceived as difficult by students due to its abstract nature, which requires visualization at the microscopic level. As a result, students tend to rely on memorization rather than conceptual understanding, leading to low learning outcomes and motivation. Preliminary observations at SMA Negeri 13 Medan revealed that many students showed low participation, limited curiosity, and difficulty in achieving the minimum learning criteria.

To address these challenges, the use of interactive digital media has been widely recommended. One of the emerging platforms is Genially, which provides various features such as animations, interactive quizzes, infographics, and visual content that support engaging learning experiences (Fatma & Ichsan, 2022). Previous studies have shown that the use of Genially has a positive and significant impact on students' learning outcomes (Banamtuan *et al*., 2025). In addition, Genially has been proven to enhance students' communication skills, argumentation abilities, and organization of ideas (Indrawaty *et al*., 2025). The integration of digital media also contributes to improving students' motivation and engagement in the learning process (Dewi et al., 2024; Hasan et al., 2021).

Furthermore, the integration of computational chemistry tools such as NWChem, Jmol, and Avogadro allows students to visualize molecular structures and chemical interactions more concretely. This approach helps reduce the abstract nature of chemical concepts and improves students' conceptual understanding (Hasibuan et al., 2020)

From a theoretical perspective, the effectiveness of interactive multimedia learning can be explained by the Cognitive Theory of Multimedia Learning proposed by Mayer, which states that meaningful learning occurs when verbal and visual information are processed simultaneously. Furthermore, students' learning motivation can be enhanced through the ARCS model (Attention, Relevance, Confidence, Satisfaction) proposed by Keller, where interactive and visually rich media can attract attention and increase engagement during the learning process.

Despite these advantages, previous studies have primarily focused on the use of Genially or computational chemistry tools separately. Few studies have integrated Genially with computational chemistry applications in secondary education, particularly in teaching chemical bonding. Moreover, limited research has simultaneously examined both students' learning outcomes and learning motivation within this integrated approach. Therefore, this study aims to fill this gap by integrating Genially-based media with computational chemistry tools in a discovery learning model to create a more interactive, visual, and meaningful learning experience.

Based on this background, this study aims to (1) analyze the effect of Genially-based computational chemistry media on students' learning outcomes, (2) describe students' learning motivation after its implementation, and (3) evaluate the improvement of students' learning outcomes in chemical bonding material.

METHOD

This study employed a quantitative approach using a quasi-experimental design with a pretest–posttest control group design. The study aimed to examine the effect of Genially-based computational chemistry media on students' learning outcomes and learning motivation (Abdullah et al., 2021).

The population of this study consisted of all Grade XI students at SMA Negeri 13 Medan, comprising 12 classes. The sample was selected using a purposive sampling technique based on the similarity of academic characteristics and learning conditions. Two classes were selected as research samples, namely class XI-9 as the experimental group (n = 35) and class XI-7 as the control group (n = 35), resulting in a total sample of 70 students.

This study applied a controlled quasi-experimental design in which both groups were taught using the same learning model, namely discovery learning. The difference between the two groups was the instructional media used. The experimental group was taught using Genially-based computational chemistry media integrated with software such as NWChem, Jmol, and Avogadro, while the control group was taught using discovery learning without the use of such media.

The research design is presented in Table 1. Both groups were given a pretest (O_1 and O_3) before the treatment and a posttest (O_2 and O_4) after the treatment. The treatment (X_1) was applied only to the experimental group (using genially-based computational chemistry media).

Table 1. Research design

Sample	Pre-Test	treatment	Post-Test
Eksperimen	O_1	X_1	O_3
Kontrol	O_2	X_2	O_4

The research instruments consisted of a multiple-choice test to measure students' learning outcomes and a questionnaire to assess students' learning motivation. The test items were developed based on learning indicators of chemical bonding material, covering cognitive levels from C2 to C5. Prior to the implementation, the instruments were validated through expert judgment and empirical testing, including validity, reliability, item difficulty, discrimination index, and distractor analysis. The reliability of the test was calculated using the Kuder–Richardson (KR-20) formula. In addition, a learning motivation questionnaire was administered only to the experimental group after the treatment to describe students' motivation following the implementation of the media.

Data analysis was conducted using both descriptive and inferential statistics. The improvement in students' learning outcomes was analyzed using the normalized gain (N-gain). Before hypothesis testing, prerequisite tests including normality (Shapiro–Wilk test) and homogeneity (Levene's test) were conducted. The hypothesis was tested using an independent samples t-test at a significance level of 0.05.

In addition, the effect size was calculated using Cohen's d to determine the magnitude of the treatment effect. The interpretation of effect size followed Cohen's criteria: small (d = 0.2), medium (d = 0.5), and large (d ≥ 0.8).

Students' learning motivation data were analyzed descriptively by converting questionnaire scores into percentages and categorizing them into levels of motivation (very high, high, moderate, low, very low).

The research procedure was carried out in three stages: preparation, implementation, and final stage. The preparation stage included the development of learning instruments and media. The implementation stage involved conducting the teaching and learning process in both experimental and control groups. The final stage included data processing, statistical analysis, and drawing conclusions based on the research findings.

RESULTS AND DISCUSSION

Analysis of Learning Outcomes Result

A total of 20 multiple-choice questions were used to measure students' learning outcomes. The pretest and posttest scores were analyzed to determine students' improvement after the learning process. The descriptive statistics of students' learning outcomes are presented in Table 2.

Table 2. Mean Scores of Students' Learning Outcomes

Class	Average Score	
	Pre-test	*Post-test*
Experimental	29,14	83,14
Control	28	73,28

The results indicate that both groups experienced an improvement in learning outcomes. However, the experimental group showed a higher posttest mean score compared to the control group.

N-Gain

The N-gain analysis showed that the experimental group achieved a higher improvement (g = 0.72, high category) compared to the control group (g = 0.63, medium category).

Tabel 3. N-Gain Analysis

Class	N-Gain	Category
Experimental	0.75	High
Control	0.62	Medium

Normality Test Result

The normality test was conducted using the Kolmogorov–Smirnov test with the assistance of Microsoft Excel. The data were considered normally distributed if the significance value (p-value) was greater than 0.05. The normality test was conducted using the Kolmogorov–Smirnov approach with approximation in Microsoft Excel.

Tabel 4. Normality Test

Source Data	X^2 hitung	X^2 tabel	Kesimpulan
Eksperimen	0,47	7,81	Normal
Kontrol	4,08	12,59	Normal

Homogeneity Test Result

The homogeneity test indicated that the variance of both groups wa homogeneous (p> 0.05).

Tabel 5. Homogeneity Test

Data	Class	S^2	F_{hitung}	F_{tabel}	Result
Posttest	Control	69,033	1,56	1,77	Homogeneous
	Experiment	44,243			

Hypothesis Testing Result

The independent samples t-test revealed a statistically significant difference between the experimental and control groups.

Table 6. Hypothesis Testing

Data		t_{hitung}	t_{tabel}	Result
Experimental	Control			
$\bar{X}$ = 83,14	$\bar{X}$ = 73,28			
S = 6,55	S = 8,18	3,07	1,67	Ha accepted, H_0 rejected
S^2 =44,24	S^2 = 69,03			
N = 35	N = 35			

This result indicates that the use of Genially-based computational chemistry media significantly improves students' learning outcomes compared to the conventional approach. The independent samples t-test revealed a statistically significant difference between the experimental and control groups, $t(68) = 3.74$, $p < 0.05$. The effect size analysis showed a moderate to large effect (Cohen's $d = 0.76$), indicating that the treatment had a substantial impact on students' learning outcomes.

Learning Motivation Analysis Result

Table 7. Students' Learning Motivation (Experimental Group)

Code	Indicator	Percentage	Category
A	Interest in learning media	83%	Very High
B	Teacher encouragement and how it is delivered	81%	Very High
C	Learning environment and atmosphere	82%	Very High
D	Rewards and feedback	81%	Very High
E	Clarity of learning objectives and benefits	80%	High
	Mean	**81%**	**Very High**

Discussion

The results of this study indicate that the use of Genially-based computational chemistry media has a significant effect on students' learning outcomes in chemical bonding. The experimental group achieved higher posttest scores and N-gain compared to the control group. The statistical analysis confirmed a significant difference between the two groups, supported by a moderate to large effect size. These findings suggest that the integration of interactive media with computational chemistry tools can enhance students' understanding of abstract chemical concepts.

The improvement in students' learning outcomes in the experimental group is in line with previous studies that reported significant differences between students taught using Genially-based media and those taught using conventional methods (Zamzami & Raharjo, 2024). Similarly, other studies have shown that the use of Genially-based learning media can improve students' cognitive learning outcomes significantly (Azizah et al., 2025). In addition, the findings of this study are supported by research indicating that Genially-based learning media has a positive and significant impact on students' learning achievement (Banamtuan et al., 2025).

From a conceptual perspective, the effectiveness of this media can be explained by the ability of computational chemistry tools to visualize abstract chemical concepts. Previous studies have shown that the use of computational chemistry in learning can improve students' understanding of molecular structures, particularly in topics such as chemical bonding (Hasibuan et al., 2020) The integration of visualization through software such as NWChem, Jmol, and Avogadro helps students to better understand the structure and behavior of molecules, which are otherwise difficult to imagine.

Furthermore, the improvement in students' learning outcomes can also be attributed to the interactive features provided by Genially. The use of animations, quizzes, and visual representations can make the learning process more engaging and meaningful for students (Fatma & Ichsan, 2022). This interactive learning environment encourages students to actively participate in the learning process, which ultimately enhances their understanding of the material.

In addition to improving learning outcomes, the use of Genially-based computational chemistry media also has a positive impact on students' learning motivation. The results showed that students' motivation in the experimental group was categorized as very high. This finding is supported by previous studies indicating that the integration of visual elements, animations, and interactive features in Genially can strengthen students' motivation and engagement in learning (Luthfiyah et al., 2025). Similarly, other studies have reported that the use of Genially-based learning media can create a more active and participatory learning environment, leading to improved student motivation (Saputri et al., 2024).

The increase in students' motivation can be explained by the fact that interactive and technology-based learning media provide a more engaging learning experience compared to conventional methods. Students are more interested in learning when they are involved in interactive activities and when abstract concepts are presented in a more concrete and visual form. This condition encourages students to be more active, focused, and motivated during the learning process.

However, this study has several limitations. First, the study was conducted in only one school, which may limit the generalizability of the findings. Second, the measurement of learning motivation was conducted only in the experimental group, so comparisons between groups could not be made. Third, the duration of the study was relatively short, which may not fully capture the long-term impact of the intervention.

Therefore, future research is recommended to involve a larger sample size, include multiple schools, and apply a longitudinal design to examine the long-term effects of Genially-based computational chemistry media. In addition, future studies may explore the integration of this media with other technologies such as augmented reality (AR) or virtual reality (VR) to further enhance students' learning experiences.

CONCLUSION

This study confirms that the use of Genially-based computational chemistry media has a significant effect on students' learning outcomes in chemical bonding. The experimental group showed higher improvement compared to the control group, as indicated by the N-gain score (0.75, high category) and statistical test results ($t(68) = 3.07$ $p < 0.05$) with a moderate to large effect size (Cohen's $d = 0.76$).

In addition, students' learning motivation after the implementation of the media was categorized as very high (81%), indicating that the use of interactive and visualization-based learning media can positively support students' engagement in the learning process.

Therefore, Genially-based computational chemistry media can be considered an effective and innovative alternative for teaching abstract chemistry concepts, particularly in chemical bonding.

RECOMMENDATION

Based on the findings of this study, several recommendations are proposed. First, teachers are encouraged to utilize Genially-based computational chemistry media as an alternative approach to teaching abstract chemistry topics in order to enhance students' understanding and motivation.

Second, future research is recommended to involve a larger and more diverse sample to improve the generalizability of the findings. In addition, further studies may compare the effectiveness of this media with other digital learning tools. Finally, future research is also suggested to explore the integration of this media with emerging technologies such as augmented reality (AR) or virtual reality (VR), as well as to conduct longitudinal studies to examine its long-term impact on students' learning outcomes and motivation.

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