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The Effectiveness of Using Google Sites-based Learning Media on Learning Outcomes in Thermochemistry

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Abstract
Thermochemistry is one of the most challenging chemistry topics because it requires students to understand abstract concepts while solving mathematical problems. Conventional PowerPoint-based instruction often presents learning materials linearly, providing limited opportunities for students to review concepts independently. This study aimed to examine the effectiveness of Google Sites-based learning media on students' learning outcomes in thermochemistry. A quasi-experimental study employing a nonrandomized control group pretest–posttest design was conducted with 71 eleventh-grade students at SMAN 8 Pontianak, comprising 36 students in the experimental group and 35 students in the control group. Both groups were taught by the same teacher using the Discovery Learning model over four instructional meetings, with the only difference being the learning media used Google Sites in the experimental group and PowerPoint in the control group. Data were collected using a validated and reliable four-item essay test administered before and after the intervention and were analyzed using Analysis of Covariance (ANCOVA) with pretest scores as the covariate. After controlling for pretest scores, group membership had a significant effect on posttest scores ($F(1,68) = 106.794$, $p < 0.001$, partial $\eta^2 = 0.611$). The experimental group also achieved a higher mean posttest score (81.21) than the control group (63.30). These findings suggest that Google Sites-based learning media was associated with higher thermochemistry learning outcomes than conventional PowerPoint-based instruction. The observed effectiveness may be explained by the integration of multimedia representations, structured instructional resources, self-paced study opportunities, and interactive formative feedback that facilitate students' understanding of abstract thermochemistry concepts.

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INTRODUCTION

Thermochemistry is one of the most difficult chemistry topics for students to understand because it requires both grasping concepts and being able to do mathematical calculations (Pamungkasih et al., 2024). When learning this material, students are not only expected to distinguish between exothermic and endothermic reactions, but also to understand enthalpy changes through Hess's Law, standard enthalpy of formation, bond energy, enthalpy diagrams, and various calculations involving chemical equations. These difficulties arise because students have to connect different chemical representations at the same time, including macroscopic representations (observed phenomena), submicroscopic (particle interactions), symbolic (equations and chemical symbols), and mathematical (enthalpy calculations). The inability to make these four connections leads to misconceptions and low

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student achievement in thermochemistry (Rosyida & Widarti, 2025).

The low mastery of students in thermochemistry has been widely reported in various studies. Adisha & Rohaeti (2024) stated that thermochemistry is one of the chemistry topics that has a high level of difficulty and misconceptions, so students' learning outcomes are still in the low category. (Rahmi & Azra (2023) reported that as many as 83.69% of students at SMAN 13 Padang had not reached the Minimum Completeness Criteria (KKM) in thermochemistry. A diagnostic study by Yanti et al (2024) on 125 high school students in Palangka Raya showed that the difficulty level for students in determining reaction enthalpy changes reached 37.44%. In addition, Roghdah et al (2021) found that only 22% of students had a good conceptual understanding, while 39% had misconceptions, 26% did not understand the concept, and 13% gave incorrect answers. Those findings show that thermochemistry is still a topic that's hard to understand, both conceptually and in terms of calculations. These findings also suggest that meaningful learning of thermochemistry requires instructional media that facilitate conceptual visualization and active student engagement, particularly when abstract concepts and multiple representations must be integrated (Audia et al., 2021;Mutiara, Erna Retna Safitri, Makmum Raharjo, 2022)

The same problem was also found at SMAN 8 Pontianak. Based on an interview with the chemistry teacher on April 9, 2025, it was found that students' motivation and participation during thermochemistry lessons were still relatively low. Students tend to be passive, easily lose focus, and have difficulty solving enthalpy calculation problems. The teacher mentioned that the learning process is still dominated by lectures with the help of PowerPoint because it is considered more practical for delivering the material. Although using media like learning videos or occasional interactive activities can boost students' attention, their use has not yet been integrated into the learning process. This condition aligns with the research by Pratiwi & Sahputra (2021) conducted at the same school, which showed that most students feel bored following conventional chemistry lessons and hope for more variety in learning through visual media, educational games, or more interactive activities.

One of the limitations of learning with PowerPoint is that the material is presented in a linear way, so students have to follow the teacher's explanation step by step. When students don't understand a concept, they have limited opportunities to review the material on their own. In addition, practice questions, learning videos, and assessments are usually presented separately, making the learning process less integrated. As a result, PowerPoint ends up being more of a presentation tool rather than a learning tool that can facilitate independent learning, provide immediate feedback, and help students gradually build their understanding of concepts.

One potential alternative to tackle this problem is the use of web-based learning media through Google Sites. Google Sites allows various learning resources, such as text, images, videos, animations, hyperlinks, and interactive exercises to be integrated into a single platform that can be accessed anytime and anywhere (Basori & Jufri, 2024 ; Reskiyati et al., 2023). Its ease of use, free access, and compatibility with other Google services also make it practical for classroom implementation (Suryanto, 2018). In this study, Google Sites was not only used as a material storage medium but was developed as a learning package integrated with the Discovery Learning model. This media includes nonlinear navigation, animated videos explaining abstract thermochemistry concepts, interactive exercises based on Wordwall and Quizizz, as well as materials interconnected through hyperlinks so that students can learn the material according to their needs and learning pace.

The selection of these features is based on the theory of learning. Previous studies have also suggested that interactive learning media can improve conceptual understanding and student engagement when multimedia elements are integrated into instructional activities (Nurlaela et al., 2025). According to Mayer's Cognitive Theory of Multimedia Learning, presenting information through a combination of text and visuals helps students select, organize, and integrate information more effectively, making it easier to understand abstract concepts. Animated videos on Google Sites are expected to help students visualize the submicroscopic representations that

underlie changes in enthalpy, while images, diagrams, and chemical equations help link macroscopic, symbolic, and mathematical representations. Meanwhile, Sweller's Cognitive Load Theory explains that learning is more effective when irrelevant cognitive load can be minimized. Hyperlink features allow students to review material they haven't understood without having to follow the learning sequence rigidly, thus reducing unnecessary cognitive load. In addition, interactive exercises through Wordwall and Quizizz provide immediate feedback as well as opportunities to practice repeatedly (retrieval practice), while step-by-step assessment rubrics help students monitor their thinking process when solving thermochemistry calculation problems, supporting their metacognitive skills.

Various previous studies have shown that Google Sites contributes positively to students' learning outcomes. Japrizal & Irfan (2021) reported an effect size of 1.26, which falls into the very high category. Purba et al (2022) also found a significant improvement in mathematics learning outcomes after implementing Google Sites, while Jusriati et al (2021) reported improved learning outcomes in English learning based on Google Sites. In chemistry education, Google Sites has also been developed for topics such as redox reactions, buffer solutions, acid–base titrations, and thermochemistry.

However, most previous studies have primarily focused on media development and feasibility testing. Empirical evidence regarding the effectiveness of a Google Sites-based learning media integrated with the Discovery Learning model through a quasi-experimental design, comparing learning outcomes with PowerPoint-based instruction while controlling students' initial achievement, remains limited.

The novelty of this research lies not only in the use of Google Sites, but also in the design of the learning package developed. The learning package integrates a Discovery Learning model with nonlinear navigation, multimedia representations, interactive exercises using Wordwall and Quizizz, as well as learning scaffolding designed to help students gradually understand thermochemistry concepts and calculations. This design is expected to help students connect macroscopic, submicroscopic, symbolic, and mathematical representations, thereby improving their conceptual understanding and learning outcomes in thermochemistry.

Based on the description, this study aims to find out whether there is a significant difference in post-test thermochemistry learning outcomes between students who learn using a Google Sites-based learning media and students who learn using PowerPoint media after controlling for students' initial abilities.

METHOD

This study employed a quantitative approach using a quasi-experimental method with a Nonrandomized Control Group Pretest–Posttest Design. This design was chosen because the researcher couldn't randomly assign subjects to the experimental and control groups. Therefore, the existing classes were used as the research groups, and the students' initial abilities were measured through a pretest before the treatment was given.

Table 1. (Nonrandomized Control Group Pretest-Posttest Design)

Class	Pretest	Treatment	Posttest
Experimental	O_1	X	O_2
Control	O_3	–	O_4

(Arikunto, 2016)

Remark:
O_1: Pretest results of the experimental class
O_2: Posttest results of the experimental class
X: Treatment using a Google Sites-assisted learning media
—: Conventional instruction using PowerPoint
O_3: Pretest results of the control class
O_4: Posttest results of the control class

The research was carried out at SMAN 8 Pontianak during the even semester of the 2024/2025 academic year. The research subjects consisted of 71 eleventh-grade students, with 36 students from class XI Chemistry 2 as the experimental class and 35 students from class XI Chemistry 3 as the control class.

The sampling technique used was purposive sampling. The selection of the two classes was based on the consideration that both are taught by the same chemistry teacher, use the same curriculum, learning objectives, and schedule, and have relatively similar academic characteristics according to information from the subject teacher. Thus, the differences in learning

outcomes are expected to mainly come from the treatment given, namely the use of a Google Sites-assisted learning media.

The study was carried out over six meetings, which included one meeting for the pretest, four meetings for the learning process, and one meeting for the posttest. Each meeting lasted 2 × 45 minutes. During the four learning sessions, both classes studied the same thermochemistry material using the Discovery Learning model and were taught by the same teacher. The time allocation, learning outcomes, teaching materials, and assessment instruments were standardized in both classes to ensure equal treatment. The only difference in treatment was the learning media used, which was a Google Sites-assisted learning media in the experimental class and PowerPoint media in the control class. To minimize threats to internal validity, both groups were taught during the same academic semester following the same instructional schedule and curriculum to reduce history and maturation effects. The classes were taught separately to minimize treatment contamination, and students did not have access to the instructional materials used by the other group during the intervention.

In the experimental class, learning used a learning package assisted by Google Sites integrated with the Discovery Learning model. Google Sites was developed as a learning media that contains learning objectives, material in the form of text, images, presentations, animated videos, links (hyperlinks), interactive exercises based on Wordwall, formative evaluations using Quizizz, and learning resources that can be accessed again by students. All students accessed Google Sites using smartphones connected to the school's internet network or personal data packages. The hyperlink feature allows students to revisit the material according to their own needs and learning pace.

In the control class, learning also used the Discovery Learning model with the same teacher, learning time, material, and learning objectives. The difference was that the learning package relied solely on conventional PowerPoint presentations without integrating Google Sites, animated videos, Wordwall, or Quizizz. To ensure treatment fidelity, the implementation of learning in both classes was observed using a learning implementation observation sheet completed by one independent observer during each meeting.

The research instrument was in the form of a learning outcomes test given during the pretest and posttest, consisting of four essay questions arranged based on learning objectives and indicators of thermochemistry material. The instrument covers four main subtopics, namely the concept of exothermic and endothermic reactions, Hess's law, standard enthalpy of formation, and bond energy. The question indicators can be seen in the table 2.

Table 2. (Indicators of the Essay Test Items)

No.	Indicator	Cog. Level	Max. score
1	Students are able to analyze the relationship between changes in environmental temperature and the reaction characteristics (exothermic/endothermic) occurring in the system	C4	3
2	Students can apply Hess's law principle to calculate enthalpy in the given cycle diagram	C3	3
3	Students can use standard enthalpy of formation data to correctly calculate the enthalpy change of a reaction using the formula	C3	3
4	Students can calculate the total energy released when bonds are formed in the product.	C3	3

Most items were designed at the C3 level because thermochemistry learning outcomes in the curriculum emphasize the application of concepts and quantitative problem solving. One item was developed at the C4 level to assess students' ability to analyze thermochemical phenomena in real contexts.

An example of the essay item is: "Using the thermochemical equations below, determine the enthalpy change of the target reaction using Hess's Law and explain each calculation step."

Each essay item was scored using an analytic rubric on a scale of 0–3, resulting in a maximum raw score of 12. Scores of 0–3 represented incorrect responses, partially correct responses, mostly correct responses with minor errors, and completely correct responses, respectively. The

raw score ranged from 0 to 12 and was converted into a scale of 0–100 using the following formula. The final score was calculated using the following formula:

$$\text{Final Score} = \frac{\text{Raw Score Obtained}}{12} \times 100$$

All students' responses were scored by the same researcher using a standardized analytic scoring rubric to ensure scoring consistency. Because only one rater was involved, inter-rater reliability could not be assessed. This should be considered when interpreting the findings.

The content validity of the instrument was evaluated by one Chemistry Education lecturer and one chemistry teacher using the Gregory validity model. The calculation results showed a content validity coefficient of 0.95, which falls into the very high category, meaning all the items are considered to represent the learning indicators being measure. Each validator independently rated the relevance of every item using a dichotomous scale (relevant/not relevant). The Gregory coefficient was calculated from the agreement matrix between the two validators.

Before being used in the main study, the instrument was tested on 30 students from Chemistry class XI-1 who were not part of the research sample. The reliability of the instrument was analyzed using Cronbach's Alpha coefficient with the help of SPSS software version 29. The analysis results showed a Cronbach's Alpha value of 0.68, indicating that the instrument has an internally consistent reliability that is acceptable for use in the study (Anshari et al., 2024) . The moderate reliability coefficient may be attributed to the limited number of essay items included in the instrument.

Prior to its use in the main study, the instrument underwent item analysis, including empirical validity, item difficulty, and discrimination index. The results are presented in Table 3.

Table. 3 (Empirical Validity, Difficulty Index, and Discrimination Index of the Essay Test Items)

Item	Empirical Validity (r)	Criteria	Difficulty Index	Criteria	Discrimination Index	Criteria
1	0,470	Valid	0,633	Moderate	0,625	Good
2	0,371	Valid	0,533	Moderate	0,813	Very good
3	0,541	Valid	0,517	Moderate	0,688	Good
4	0,530	Valid	0,633	Moderate	0,688	Good

As shown in Table 3, all four items met the empirical validity criterion, had moderate difficulty levels, and demonstrated good to very good discrimination indices. Therefore, all items were considered suitable for use in this study.

Hypothesis testing was conducted using Analysis of Covariance (ANCOVA). ANCOVA was selected because this study employed a nonequivalent pretest–posttest control group design. By including the pretest score as a covariate, ANCOVA statistically controls for differences in students' initial abilities, allowing a more accurate estimation of the treatment effect on posttest scores.

Before hypothesis testing with ANCOVA, the data were first checked to meet the required assumptions, which include residual normality using the Shapiro–Wilk test, variance homogeneity using Levene's Test, linearity between the covariate and the dependent variable, and homogeneity of regression slopes. After all assumptions are met, hypothesis testing is done using ANCOVA with the posttest score as the dependent variable, the learning group as the independent variable, and the pretest score as a covariate at a significance level of $\alpha = 0.05$.

RESULTS AND DISCUSSION

Result

The treatment given to the experimental class involved learning using a Google Sites-based learning media on thermochemistry material. This learning media consists of several main features, namely: (1) a homepage that contains learning objectives and instructions for using the media; (2) learning materials presented in the form of text, images, and presentation slides that can be accessed nonlinearly; (3) learning videos explaining abstract concepts, such as enthalpy changes and Hess's Law; (4) interactive exercises based on Wordwall and Quizizz; and (5) hyperlink-based navigation that allows students to go back to the material they have studied.

Descriptive statistics of students' pretest and posttest scores in the experimental and control classes are presented in Table 4. The average pretest score in the experimental class was 36.86, while in the control class it was 39.71. After the

learning took place, the average posttest score in the experimental class became 81.21, while in the control class was 63.30. The comparison of pretest and posttest average scores in both groups is shown in Figure 6.

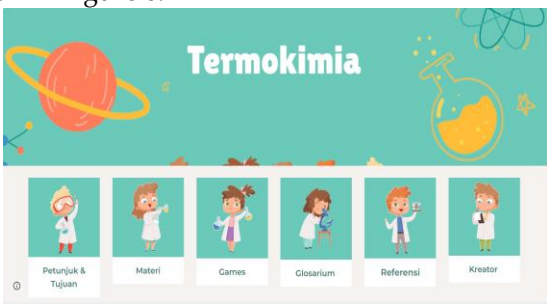


Figure 1. (Front Page View of Google Sites Thermochemistry Media)



Figure 2. (Material Page View)

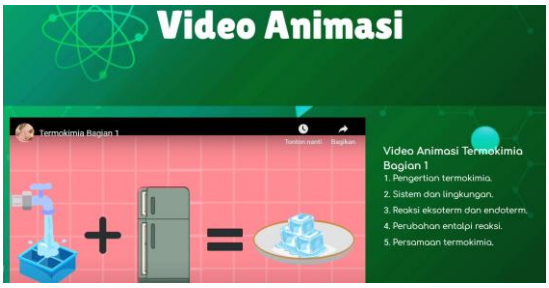


Figure 3. (Animation Video Page in Google Sites)



Figure 4. (Wordwall Activity Page)

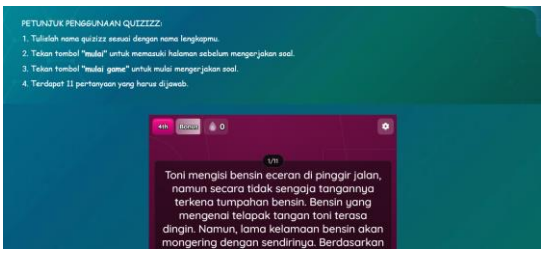


Figure 5. (Appears the Quizizz-Based Games Page)

Table 4. Descriptive Statistics of Pretest and Posttest Scores

Group	Statistical Test	n	Mean	SD	Median	IQR	Minimum	Maximum
Experimental	Pretest	36	36,86	17,068	37,15	32	8	65
xperimental	Posttest	36	81,21	13,273	83,30	17	42	100
Control	Pretest	35	39,71	17,045	41,60	25	17	67
Control	Postest	35	63,30	16,193	66,60	33	33	83

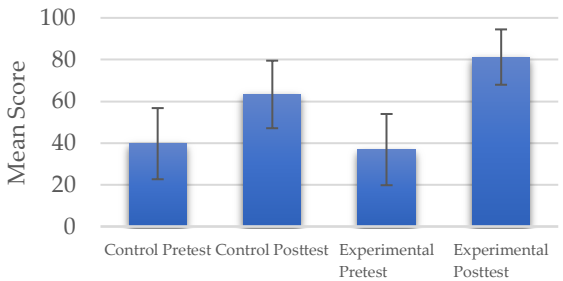


Figure 6. Mean Pretest and Posttest Scores of The Control and Experimental Groups (Mean ± SD)

ANCOVA Assumption Test

Before we conduct the analysis of covariance (ANCOVA), we'll check a few assumptions like residual normality, equal variances, linearity of the relationship between covariates and the dependent variable, and equality of regression slopes. You can see the assumption check results in Table 5. all the assumptions required for ANCOVA analysis have been met. The significance values for the tests of residual normality, variance homogeneity, linearity, and regression slope homogeneity are all greater than 0.05, so the ANCOVA analysis can proceed.

Table 5. (Summary of Assumption Tests for ANCOVA Analysis)

Assumption	Statistical Test	Sig.	Decision
Residual Normality	Shapiro–Wilk (Experimental)	0,711	Fulfilled
	Shapiro–Wilk (Control)	0,296	Fulfilled
Homogeneity	Levene's Test	0,418	Fulfilled
linearity between the covariate and the dependent variable	Experimental class	0,695	Fulfilled
	Control class	0,747	Fulfilled
Homogeneity of regression slopes	Interaction (Group × Pretest)	0,103	Fulfilled

ANCOVA Analysis Results

ANCOVA was conducted to find out the effect of using Google Sites-based learning media on students' learning outcomes while controlling for the influence of initial ability (pretest). The results of the analysis are presented in Table 6.

Table 6. (Results of the Analysis of Covariance (ANCOVA))

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	16,471.104	2	8,235.552	130.101	<0.001	0.793
Pretest (Covariate)	10,776.127	1	10,776.127	170.236	<0.001	0.715
Group	6,760.160	1	6,760.160	106.794	<0.001	0.611
Error	4,304.476	68	63.301	-	-	-

An analysis of covariance (ANCOVA) was conducted to examine the effect of Google Sites-based learning media on students' posttest scores while controlling for their pretest scores. The results are presented in Table 6.

As shown in Table 6, the pretest score, included as a covariate, had a significant effect on students' posttest scores, $F(1, 68) = 170.236$, $p < 0.001$, partial $\eta^2 = 0.715$. After controlling for students' initial achievement, the learning group also had a significant effect on posttest scores, $F(1, 68) = 106.794$, $p < 0.001$, partial $\eta^2 = 0.611$. Furthermore, the overall ANCOVA model was statistically significant, $F(2, 68) = 130.101$, $p < 0.001$, explaining 79.3% of the variance in posttest scores ($R^2 = 0.793$, Adjusted $R^2 = 0.787$).

Besides showing a statistically significant difference, the analysis results also showed a partial η^2 value of 0.611, which falls into the large effect category. This indicates that after controlling for students' initial abilities, the learning media used has a strong impact on thermochemistry learning outcomes. Therefore, the differences in learning outcomes obtained not only have statistical meaning but also practical significance in the learning context.

Discussion

The results of this study show that, after taking into account the students' starting scores, learning with Google Sites significantly improved thermochemistry learning outcomes compared to using PowerPoint. The partial η^2 value we got (0.611) is considered a large effect according to Cohen (1988) which means the difference we saw is not only statistically significant but also meaningful in an educational sense. This can be explained by looking at the features of the learning media and the concepts involved in thermochemistry.

Thermochemistry involves abstract concepts that require students to integrate verbal explanations, symbolic representations, graphical information, and mathematical procedures simultaneously. Google Sites allows these learning resources to be organized within a single web-based environment through text, diagrams, videos, hyperlinks, and interactive exercises. From the perspective of the Cognitive Theory of Multimedia Learning (Mayer, 2021), presenting complementary verbal and visual representations may facilitate students in constructing meaningful mental representations when learning complex concepts. Likewise, Cognitive Load Theory (Sweller, 2019) provides a theoretical explanation that learning environments which organize information clearly and reduce unnecessary navigation demands may support students in processing instructional materials more efficiently. However, these interpretations should be viewed as theoretical explanations because cognitive load and long-term memory were not directly measured in this study.

Several features of Google Sites may explain why students in the experimental group achieved better learning outcomes. First, energy profile diagrams embedded in the learning materials enabled students to observe the relative energy levels of reactants and products together with activation energy, making it easier to distinguish exothermic and endothermic reactions. Instead of relying solely on verbal explanations, students could repeatedly relate graphical representations to changes in enthalpy. Second, hyperlinks connecting related subtopics allowed students to move easily between definitions, examples, and applications, helping them establish conceptual relationships among enthalpy change, energy diagrams, and reaction types.

Another important advantage concerns the learning of Hess's Law calculations. Solving Hess's Law problems requires students to follow several sequential steps, including identifying target equations, manipulating chemical

equations, adjusting enthalpy values, and summing the resulting reactions. Through Google Sites, worked examples, instructional videos, and supporting materials remained available throughout the learning process. Students were therefore able to revisit each calculation step whenever necessary, an opportunity that is generally more limited during teacher-centered PowerPoint presentations. This flexibility may have supported students in following multistep procedures at their own pace.

Google Sites also provided opportunities for self-paced learning. Students could review explanations, replay videos, and revisit learning materials outside classroom instruction without depending entirely on teacher explanations. Such flexibility may be particularly beneficial because students differ in their prior knowledge and learning speed. Rather than assuming that all students understand concepts after a single classroom explanation, the platform enabled repeated exposure to difficult topics according to individual learning needs.

In addition, the integration of interactive quizzes through platforms such as Quizizz and Wordwall provided immediate feedback on students' answers. Immediate feedback may help students recognize misconceptions shortly after completing learning activities and encourage them to review relevant concepts before proceeding to subsequent topics. Although this study did not specifically measure formative assessment processes, the availability of timely feedback provides a plausible theoretical explanation for the improved learning outcomes observed in the experimental group.

The findings of this study are consistent with previous empirical studies demonstrating the effectiveness of Google Sites in supporting learning. Adzkiya & Suryaman, (2021) found that integrating text, images, videos, and audio in Google Sites increased students' interest and facilitated learning, while Suryana et al., (2023) reported that Google Sites provides flexible access to learning resources. Similarly, (Pratama et al., 2023) highlighted that Google Sites supports interactive learning and helps visualize abstract concepts. These findings are also supported by Thomas et al., (2022) and Abdjul (2023) who reported that Google Sites enhances accessibility to learning resources, as well as Afifah et al (2021), Marini et al.,(2023), and Syah et al., (2024) , who showed that this platform can increase student engagement during learning. The present study extends these previous findings by providing quantitative evidence from a quasi-experimental design, demonstrating that Google Sites significantly improved thermochemistry learning outcomes with a large effect size (partial η^2 = 0.611).

Even so, the size of the improvement in learning outcomes reported in various studies isn't always the same. For example, Nurwita (2024) and Basori and Jufri (2024) reported more moderate increases. These differences are likely influenced by variations in education level, the material studied, intervention duration, the learning model used, assessment instruments, student characteristics, and research design. In addition, some previous studies used a one-group pretest–posttest design without a control group, whereas this study applied a quasi-experimental design with a control group, which provides a stronger basis for linking differences in learning outcomes to the treatment given.

Nevertheless, the findings should be interpreted cautiously because several potential confounding factors were not fully controlled. Differences in teacher implementation, students' digital literacy, availability of personal devices, internet connectivity, learning motivation, and learning environments outside the classroom may also have influenced students' learning outcomes. Although both classes followed the same curriculum and learning objectives, these contextual variables could contribute to variations in learning performance and therefore limit causal interpretation.

The generalizability of the findings is also limited. The study was conducted in only one senior high school with one experimental class and one control class. Learning outcomes were measured using only four essay questions administered immediately after a relatively short intervention, and no delayed posttest was conducted to examine long-term retention of conceptual understanding. Consequently, the effectiveness of Google Sites observed in this study should not be generalized directly to different educational contexts, chemistry topics, or longer instructional periods without further empirical evidence.

Future studies are therefore recommended to involve multiple schools, larger samples, longer intervention periods, more comprehensive assessment instruments, and follow-up retention tests. In addition, future research should examine variables such as learning motivation, engagement, digital literacy, and students' perceptions to provide a more comprehensive understanding of how Google Sites influences learning processes and outcomes.

Overall, the findings suggest that Google Sites-based learning media can effectively support thermochemistry learning by providing integrated visual representations, structured learning resources, opportunities for self-paced review, and immediate formative feedback. These characteristics provide plausible theoretical explanations for the improved learning outcomes observed in the experimental group compared with conventional PowerPoint-based instruction.

These findings show that Google Sites doesn't just work as a platform for delivering material, but also as a digital learning environment that can support visualizing abstract concepts, self-directed learning, and formative assessment. Because of this, this medium has the potential to be an effective alternative in chemistry learning, especially for material that is abstract like thermochemistry.

CONCLUSION

This study concludes that the use of Google Sites-based learning media was associated with significantly higher thermochemistry posttest learning outcomes than conventional Power-Point-based instruction after controlling for students' initial achievement. Students in the experimental group obtained higher posttest scores than those in the control group. The observed association may be theoretically explained by the integration of text, diagrams, videos, hyperlinks, and interactive quizzes within a single learning environment, which may facilitate visualization of abstract concepts, self-paced review, and immediate formative feedback. However, these explanations should be inter-preted cautiously because cognitive load, learning engagement, and long-term retention were not directly measured in this study. The findings provide empirical evidence supporting the potential of Google Sites as an alternative digital learning medium for teaching abstract chemistry concepts, particularly thermochemistry.

RECOMMENDATION

Teachers are encouraged to integrate Google Sites into chemistry instruction, particularly for abstract topics such as thermochemistry, because the platform enables students to revisit learning materials independently and receive immediate formative feedback. Future research should involve multiple schools, larger samples, longer intervention periods, and include variables such as motivation, engagement, cognitive load, and learning retention to provide a more comprehensive evaluation of Google Sites-based instruction.

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