Indonesian Journal of Educational Development (IJED)
Volume 7, Issue 1, 2026, pp. 395-409
ISSN: 2722-1059 (Online); ISSN: 2722-3671 (Print)
DOI: https://doi.org/10.59672/ijed.v7i1.6026

The effect of NHT Google sites on critical thinking and motivational learning on stoichiometry material

Rr Tasya Noor Nabila*)1, Nurfina Aznam2
1Universitas Negeri Yogyakarta, Yogyakarta, Indonesia; tasyanoor8@gmail.com
2Universitas Negeri Yogyakarta, Yogyakarta, Indonesia; nurfina_aznam@uny.ac.id
*)Corresponding author: Rr Tasya Noor Nabila; E-mail addresses: tasyanoor8@gmail.com

Article Info

Article history:
Received January 09, 2026
Revised February 16, 2026
Accepted March 25, 2026
Available online May 20, 2026

Keywords: Critical thinking, Google sites, NHT, Motivation, Stoichiometry

Abstract. Many students exhibit low levels of critical thinking and motivation for learning, indicating the need for innovative instructional approaches. This study aims to examine the impact of Numbered Heads Together (NHT) learning using Google Sites on students' critical thinking and motivation to learn. This research was conducted in two high schools in Yogyakarta. This study employed a quantitative quasi-experimental design, involving students from 11th-grade science classes. The experimental group learned NHT on Google Sites, whereas the control group received instruction using a scientific approach. The sampling technique uses a cluster random sampling. The research instrument uses a test and a questionnaire, and data are collected through pretest and posttest measures. Furthermore, the data were analyzed using MANOVA. The results from hypothesis tests showed significant differences in students' critical thinking and motivational learning, both simultaneously and separately, between students who were given NHT-Google Sites and those who were given a scientific approach, with a simultaneous effective contribution of 31.4%, which is categorized as large. and separately, 26,2% for critical thinking skills and 14,8% for student learning motivation, each of which was in a large category. Overall, students' critical thinking and motivation to learn in NHT using Google Sites were higher than those of students who received instruction using a scientific approach. These findings suggest that the Numbered Heads Together learning model, when implemented with Google Sites, can be an effective instructional strategy for enhancing students' critical thinking skills and motivation to learn.

Introduction

21st-century education is a key to student success in the current era. This is because education equips students to face challenges and seize opportunities in the 21st century. Through 21st-century learning, various 21st-century skills are taught, including critical thinking skills (Partnership for 21st Century Skills, 2015). Critical thinking is the ability to analyze, evaluate, and make logical, wise decisions when dealing with various situations (Ennis, 1987). The development of critical thinking skills helps students analyze and identify problems and find the right solutions (Facione, 2011). In addition, the ability to think critically enables students to make better decisions, avoid being easily influenced by misleading information, and communicate well in daily life (Halpern, 2014; Kahneman, 2011; Paul & Elder, 2006). Thus, it is important for students to think critically. However, students' critical thinking skills in Indonesia remain relatively low, especially in science. This is evident from the results of the 2022 PISA report: Indonesia ranks 69th out of 81 participating countries, with an average score in science of 383, below the OECD average of 491

(OECD, 2023). Furthermore, baseline data collected at the beginning of this study revealed that the average pretest critical thinking scores were relatively low. Therefore, there needs to be an effort to improve critical thinking (Evi Yupani & Widana, 2023).

Improving students' critical thinking skills can be achieved through innovative learning models, including cooperative learning strategies (Ibrahim et al., 2023). Cooperative learning is a pedagogical model that engages students in small-group collaboration, allowing them to work together to maximize individual and group learning (Johnson & Johnson, 2009). Cooperative learning has several stages of implementation, including organizing students into study groups and guiding work and learning groups (Hayati, 2017). Cooperative learning has several types of models, such as TGT, STAD, TAI, and NHT. However, each type of cooperative learning has its own advantages and disadvantages, so its application must consider time efficiency and the effectiveness in achieving the expected learning objectives.

Based on various considerations, the Numbered Head Together type was chosen in this study. The numbered heads together learning strategy is a variation of group discussion activities that consists of four steps: numbering, questioning, thinking together, and answering (Yuliani et al., 2021). Through the numbered heads together strategy, students exchange ideas, discuss, and solve problems together (Slavin, 2011). This can improve students' critical thinking skills by giving them the opportunity to actively participate in group discussions, synthesize information, and evaluate solutions, as they are responsible for their learning (Garcha & Kumar, 2015; Aprianto et al., 2025). In addition, students' active participation can help them understand chemistry concepts (Mukama & Byukusenge, 2023). Therefore, numbered heads together learning is considered appropriate for chemistry learning (Shaukat & Tanveer Afzal, 2025).

Chemistry learning encompasses a variety of materials that require conceptual understanding and high-level thinking skills, such as stoichiometric material. Stoichiometry is a branch of science that studies the quantitative relationships between reactants and products in chemical reactions (Hussain et al., 2023). Stoichiometric material consists of the calculation of moles, molarity, volume, molar mass of compounds or elements (Mr/Ar), percentage of substance content, empirical formulas and molecular formulas, percent of results, and limiting reagents (Chang, 2019) Stoichiometric material is important for students to learn, because it makes it easier for students to calculate chemistry, understand basic laws, and is useful for learning other materials in the future (Salsabila et al., 2023). In addition, stoichiometric material is also a bridge to understand all subsequent chemical concepts, because stoichiometry is the core material that underlies other materials such as thermochemical materials, chemical equilibrium, and acid-bases (Anekwe et al., 2024) However, the large number of calculation formulas in stoichiometrics sometimes makes it difficult for students to learn the material, such as applying the mole concept in multi-step calculations, causing students to be confused and leading to be less interested in learning chemistry (Priliyanti et al., 2021; Salame et al., 2026). This case has been strengthened by the preliminary study, as some students admitted the difficulty in understanding the stoichiometric material delivered by the teacher. In addition, students reported that learning classroom chemistry often feels boring. Meanwhile, the results of the teacher interview show that the teacher has implemented a scientific approach as an instructional approach, and that motivation for learning among students appears to have decreased at times. This condition is contrary to the ideal that teaching should improve material understanding and learning motivation.

Motivational factors play an important role in determining students' engagement and academic achievement (Kong, 2021). Learning motivation refers to the internal and external forces that encourage students to initiate, direct, and sustain learning activities to achieve educational goals (Ramalingam & Jiar, 2022). Internal factors include interest in the material, its perceived value, and attitude toward the subject. In contrast, external factors influencing motivation include social support for learning from teachers, parents, and peers, as well as perceptions of the formal learning context (Wallace & Leong, 2020). Students who possess high learning motivation tend to demonstrate persistence, curiosity, and active participation in solving learning problems. In contrast, low motivation may lead to passive learning and poor academic performance (Owens et al., 2020). Therefore, innovation in learning strategies is needed to increase students' motivation to learn.

Innovations that can increase students' motivation to learn include the use of technology in learning, such as website media (Karyati, 2023). One website platform that is easy to create and can be used to promote learning quality is Google Sites. Google Sites is one of Google's website-hosting services that makes it easier for Google users to create websites or blogs (Huda et al., 2022). There are various features in Google Sites, such as the Upload file and insert feature to upload material files, Rich in content, which can load a lot of content on the page, and to Work together and share to set visitor permissions (Google, 2023). Through Google Sites, teachers can easily create learning materials/information that students can access quickly and for free (West & Malatji, 2021). In addition, teachers, students, and parents can collaborate effectively to achieve learning goals using Google Sites' features (Fahri, 2020). Thus, Google Sites can be considered an interactive learning medium that can increase students' motivation and understanding (Culajara & Catalina, 2022; Khasanah & Muflihah, 2021).

Several studies have examined the development and use of Google Sites in chemistry education, including a study by Jeyarajaguru (2023). However, previous research has not comprehensively explored its integration within cooperative learning models. Moreover, empirical studies on the combined use of Numbered Heads Together and Google Sites in chemistry learning are limited. On the other hand, previous studies on the implementation of NHT in chemistry learning have generally examined either critical thinking skills or learning motivation separately. Studies investigating the simultaneous effects of NHT integrated with web-based learning media, such as Google Sites, remain limited. Meanwhile, in contemporary education, developing students' critical thinking skills and motivation to learn has become a global priority, particularly in the era of digital learning environments. Therefore, this study seeks to investigate this issue in greater depth.

This study aims to examine the effect of the Numbered Heads Together learning model, when integrated with Google Sites, on students' critical thinking skills and motivation to learn. Specifically, this study addresses the following research questions: (1) Is there a significant difference in students' critical thinking skills and learning motivation simultaneously and separately between students taught using the Numbered Heads Together model assisted by Google Sites and those taught using a scientific approach? and (2) How much does NHT-Google Sites learning affect students' critical thinking skills and motivation to learn? Based on these questions, the hypotheses propose that students who learn through the Numbered Heads Together model using Google Sites will demonstrate higher critical-thinking skills and greater motivation to learn than those who receive regular instruction. Thus, this research offers a novel contribution to the broader discourse on technology-based cooperative learning in chemistry education.

Method

Research Method and Design

This study employed a quantitative, quasi-experimental design. The selection of this method was based on practical considerations, particularly time constraints and limited access to research participants; therefore, intact classes were utilized. The research design is a pretest–posttest nonequivalent control group design to examine the effect of the treatment by comparing outcomes between the experimental and control groups, while controlling for potential external variables to enhance the validity and credibility of the findings.

Research activities were organized into three stages: pretest, treatment, and posttest. Each class participated in five meetings: one for the pretest, three for the instructional treatment, and one for the posttest. Each session lasted 90 minutes. The treatment was conducted over three instructional sessions. This duration was considered appropriate for examining short-term changes in students' critical thinking skills and learning motivation, as prior studies suggest that structured short-term instructional interventions may yield measurable cognitive and motivational gains (Ennis, 1985; Facione, 2011). The nonequivalent control group research design is illustrated in Table 1.

Table 1. Nonequivalent control group design

Group	Pretest	Treatment	Posttest
Experiment	CT, M	I1	CT, M
Control	CT, M	I2	CT, M

Information:
CT =Critical thinking test
M = Motivation learning questionnaire
I1 = Numbered Heads Together Learning with Google Sites
I2 = Scientific Approach (regular instruction)

Participant and Sampling Techniques

The Populations in this study are eleventh-grade students at a public school in Yogyakarta City who possess the same skills as those of students at High School V Yogyakarta and High School IX Yogyakarta. From this population, cluster random sampling was used for all eleventh-grade science classes at High Schools V and IX in Yogyakarta, with two classes selected at random in each school. It presents results for the experimental group (Classes XI-2 and XI-A; 64 students) and the control group (Classes XI-4 and XI-B; 62 students). All groups have the same skills at initiation. Data collection was restricted to two schools, and therefore, the results should be interpreted within this context.

Research Setting and Timeline

This research was conducted in two public schools in Yogyakarta: High School V and High School IX. These schools were chosen for several characteristics: Curriculum independence, school accreditation "A", internet access, cell phones allowed, and research approval. The research was conducted from July to August 2025 and involved all science students from four classes in those schools. All classes in both schools have the same conditions and the same number of students. All students were treated as research subjects, and the researcher administered the treatment in those classes, as the teacher would.

Research Procedures

The research procedures include three steps: preparation, implementation, and final. The preparation steps consist of approval research, preliminary study, development of the research instrument, media preparation, and instrument validity. The research was conducted in accordance with ethical standards. Approval was obtained from the principal of High School IX and High School V Yogyakarta, and informed consent was secured from the participating students and their teacher before the study began. In addition, the student data obtained is anonymized.

Next, the implementation steps consist of five learning meetings in each class. The first meeting is administered a pretest; three meetings are for learning; and the last meeting is administered a posttest. The final stage includes data processing, data analysis, and reporting.

Data Collection Techniques and Research Instruments

The measurement of Critical Thinking skills used a two-tier multiple-choice test developed based on the critical thinking theories of Brookhart (2010), Ennis (1985), Facione (2011), and Paul & Elder (2006). The critical thinking measurement uses a 1-5 rubric for each question. Critical thinking was measured using pretest and posttest instruments with different question sets. The critical thinking instrument comprises five main aspects: explaining (2 questions), interpreting (2 questions), evaluating (2 questions), summarizing (3 questions), and analyzing (3 questions), for a total of 12 questions.

On the other hand, the measurement of learning motivation used a questionnaire developed based on the motivation theories of Atkinson (1964), Pintrich & Schunk (1995), Sardiman (2014), and Uno (2016). This instrument is a questionnaire with the following Likert scale: "Strongly agree" (4 points), "Agree" (3 points), "Disagree" (2 points), and "Strongly Disagree" (1 point). Motivational learning was assessed using pre- and post-tests. Motivational learning instrument consists of five main aspects: A) There is encouragement and need for learning, B) There is great interest and attention in learning, C) Ability to be firm in completing tasks, D) There are interesting activities in learning, E) a conducive learning environment. Aspect "A" (4 items), aspect "B" (4 items), aspect "C" (5 items), aspect "D" (5 items), and aspect "E" (3 items), totalling 24 items. The summary of the instrument and data collection techniques is in Table 2.

Table 2. Data Collection Techniques and Instrument

Data Type	Data Collection Techniques	Instrument	Data Subject
Preliminary Study	Unstructured Interview	General Interview Guideline	Teacher and Student
Critical Thinking (Pretest-Posttest)	Test	Two-tier multiple choice	Student
Learning Motivation (Pretest-Posttest)	Questionnaire	Questionnaire sheet	Student
Student Learning Activity	Documentation	Camera/Smartphone	Student

Next, all instruments and media have been theoretically validated by two experts. Expert judgment was employed to assess both content validity, ensuring that the items adequately represented the domain of interest, and construct validity, confirming that the items were theoretically consistent with the underlying concept. Next, the critical thinking test and motivational questionnaire have been empirically validated and tested for reliability before use in the study. Those instruments were tested by students who have studied stoichiometry. The empirical validity of the data was assessed using Pearson correlation coefficients to evaluate the feasibility of each question item, and Cronbach's Alpha was used to assess the reliability of each question item.

Based on theoretical validity, the instrument is valid. The empirical validity results indicated that each critical thinking pretest and posttest contained 12 valid questions, and the instrument had reliability coefficients of 0.791 for the pretest and 0.829 for the posttest. According to Cohen et al. (2011), the instrument is reliable. Meanwhile, the empirical validity motivation questionnaire includes 21 valid items out of 24, and the instrument has a reliability of 0.747, which is considered acceptable according to Cohen et al. (2011). The summary of the validity instrument results is in Table 3.

Table 3. The Result of the Validity Instrument

Instrument	Validity	Reliability Score	Result
Pretest Critical Thinking	all items valid	0.791	Valid. reliable
Posttest Critical Thinking	all items valid	0.829	Valid. reliable
Questionnaire Motivation (Pre-post)	21 valid. 3 invalid	0.747	Valid. reliable

Data Analysis Techniques and Criteria

The data analysis used a one-way MANOVA with a significance level of 0.05. Before proceeding with the MANOVA test, several requirements must be met, including that the data are normally distributed and homogeneous. So the normality and homogeneity tests are necessary to verify. Data normality was examined using the Shapiro–Wilk test in SPSS. A p-value of 0.05 or higher indicates that the data are normally distributed, whereas a p-value below 0.05 suggests that the data do not meet the assumption of normality. In addition, data homogeneity was tested using Levene's test. A p-value of 0.05 or higher indicates homogeneous variance, whereas a p-value below 0.05 indicates non-homogeneous variance.

The research data were analyzed using a MANOVA to assess the significance of multivariate and univariate effects. The rules of statistical inference using the MANOVA test are as follows: a) If the calculated sig. < 0.05, the difference is significant; b) if the calculated sig value ≥ 0.05, it means that the difference is not significant. Students' critical thinking outcomes following the treatment were evaluated using the normalized gain (N-gain) test. The improvement was calculated as the average difference in scores between the pre- and post-test periods. In addition, a descriptive analysis was conducted to illustrate improvements in students' critical thinking skills and motivation to learn.

Results and Discussion

Results

Pretest and posttest data were analyzed to examine changes in students' critical thinking skills and learning motivation before and after the learning model was implemented. The pretest assessed students' initial critical-thinking levels, whereas the posttest measured their critical-thinking performance after completing the stoichiometry topic. The results are presented in Table 2.

Table 4. Critical Thinking Scores on Pre-test and Post-test for Stoichiometry Material in NHT-Google Sites and Scientific Approach

Description	NHT-Google Sites		Scientific Approach	
	Pre-test	Post-test	Pre-test	Post-test
N	64	64	62	62
Mean	35.83	87.68	33.79	79.22
Standard Deviation	9.621	6.990	10.782	7.336
Minimum	16.67	70.00	11.67	65.00
Maximum	65.00	100.00	60.00	95.00

Table 4. The average pre-test score for NHT-Google Sites and Scientific Approach is 35.83 and 33.79, respectively. Meanwhile, the average of posttest scores for both groups is 87.68 and 79.22. These scores indicate an improvement in critical thinking skills related to stoichiometry.

In addition, the results of students' learning motivation from the pretest and posttest are presented in Table 3.

Table 5. Learning Motivation Scores on Pre-test and Post-test between NHT-Google Sites and Scientific Approach

Description	NHT-Google Sites		Scientific Approach	
	Pre-test	Post-test	Pre-test	Post-test
N	64	64	62	62
Mean	69.90	80.27	70.31	76.31
Standard Deviation	4.521	4.255	4.608	5.110
Minimum	59.52	70.24	59.52	66.67
Maximum	78.57	88.10	78.57	86.90

Table 5 summarizes the average pre-test scores for the NHT-Google Sites and the Scientific approach, which are 69.90 and 70.31. Meanwhile, the average of posttest scores for both groups is 80.27 and 76.31. These scores indicate changes in learning motivation in both groups.

The results of the normality tests for all measured variables are summarized in Table 4.

Table 6. Normality Test Results for Critical Thinking and Learning Motivation in Both Groups

Group	Shapiro-Wilk	Sig.	Decision
NHT-Google Sites	Pre-test of Critical Thinking	0.104	Normal
	Post-test of Critical Thinking	0.169	Normal
	Pre-test of Learning Motivation	0.295	Normal
	Post-test of Learning Motivation	0.261	Normal
Scientific Approach	Pre-test of Critical Thinking	0.213	Normal
	Post-test of Critical Thinking	0.238	Normal
	Pre-test of Learning Motivation	0.195	Normal
	Post-test of Learning Motivation	0.216	Normal

As shown in Table 4, the pretest and posttest results for critical thinking skills and learning motivation in the stoichiometry material for both groups had p-values greater than 0.05, indicating that the data met the assumption of normality.

Next, the results of the homogeneity tests for the pretest and posttest scores of critical thinking skills and learning motivation are presented in Table 5.

Table 7. Homogeneity Test Results for Critical Thinking and Learning Motivation for Both Groups

Levene's Test	Sig.	Decision
Pre-test of Critical Thinking	0.432	Homogeneous
Posttest of Critical Thinking	0.556	Homogeneous
Pretest of Learning Motivation	0.431	Homogeneous
Posttest of Learning Motivation	0.093	Homogeneous

Based on Table 7, the data show that the pre-test and post-test scores for critical thinking and learning motivation for both groups are not statistically significant ($p > 0.05$), indicating homogeneity. Since the normality and homogeneity are met, data analysis can proceed using parametric statistics.

The research hypotheses were tested through multivariate analysis of variance (MANOVA) to assess the combined effect of the learning model on students' critical thinking skills and learning motivation. The findings of the multivariate and univariate analyses are reported in Tables 6 and 7.

Table 8. The Result of Multivariate Analysis

Effect	Value	F	Hypothesis df	Error df	Sig.	ηp^2
Hotelling's Trace	0.457	28.090	2.000	123.000	0.000	0.314

Table 9. The Result of Univariate Analysis

Dependent Variable	F	df	Sig.	ηp^2	Category Effect
Critical Thinking	43.958	1	0.000	0.262	Large
Motivational Learning	21.492	1	0.000	0.148	Large

Table 8 demonstrates that the learning model exerted a statistically significant multivariate influence on the combined dependent variables, as evidenced by Hotelling's Trace ($T = 0.457$, $F(2.123) = 28.090$, $p < 0.05$, partial $\eta^2 = 0.314$). These findings indicate that the learning model had a statistically significant effect on students' critical thinking skills and motivation to learn. Furthermore, the univariate analysis presented in

Table ***9*** shows that the learning model significantly influenced students' critical thinking skills ($F(1) = 43.958$, $p < 0.05$, partial $\eta^2 = 0.262$), indicating a large effect size. In addition, a significant effect was also found on students' learning motivation ($F(1) = 21.492$, $p < 0.05$, partial $\eta^2 = 0.148$), with a large effect size.

The improvements in critical thinking and motivational learning between the experiment and control classes are reflected in the increases in N-gain scores. The N-gain results for critical thinking and learning motivation are presented in Tables 8 and

Table *11*.

Table 10. N-Gain in Critical Thinking

Class	N	Average Pretest	Average Posttest	N-Gain	Category
Experiment	64	35.83	87.68	0.80	High
Control	62	33.79	79.22	0.69	Medium

Table 11. N-Gain in Learning Motivation

Class	N	Average pretest	Average posttest	N-Gain	Category
Experiment	62	69.86	80.27	0.34	Medium
Control	64	70.31	76.39	0.19	Low

Table 10 shows that the experimental class achieved an average N-gain score of 0.80 for critical thinking skills, which falls into the high category. In contrast, the control class obtained a lower average N-gain score of 0.69, categorized as medium.

Table ***11*** shows that the experimental and control groups differed in the improvement of learning motivation from pre- to post-questionnaire results. The experimental group, which applied the Numbered Heads Together strategy supported by Google Sites, demonstrated greater gains in learning motivation than the control group, which used a scientific approach. The average N-gain score of the experimental group was 0.34 (moderate), whereas the control group recorded 0.19 (low).

Moreover, the improvements in various aspects of students' critical thinking skills and learning motivation across the experimental and control groups are depicted in Images 1 and 2.

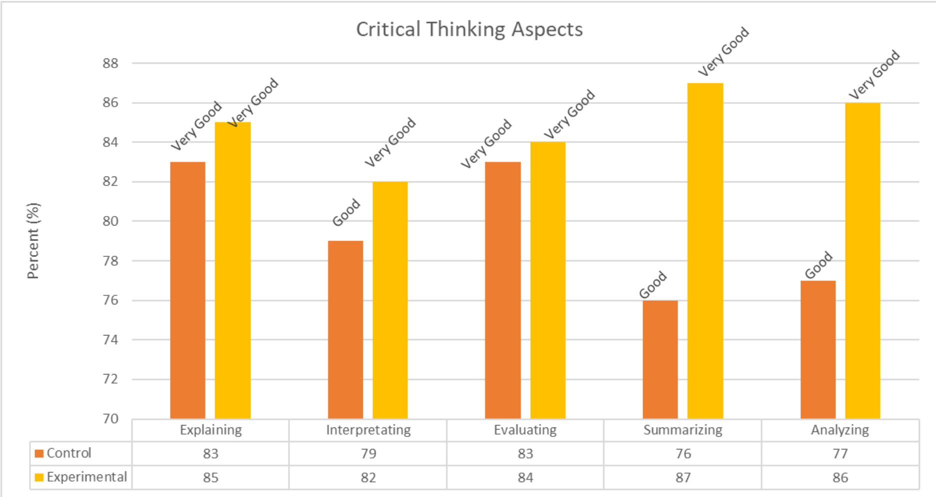

Image 1. The Percentage of Critical Thinking Aspects

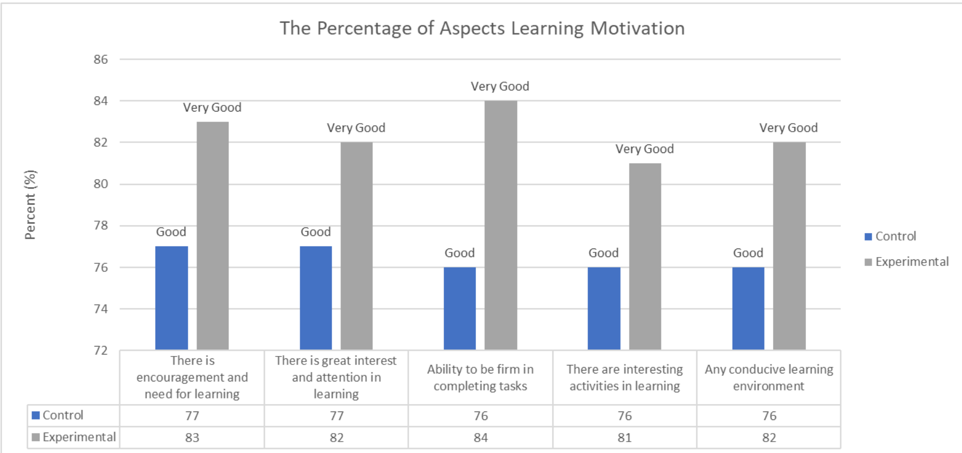

Image 2. The Percentage of Learning Motivation Aspects

Discussion

The research results contain substantial information that we can describe. Drawing on the results in Tables 2 and 8, the experimental group had a higher average posttest score in critical thinking than the control group, despite similar initial levels of critical thinking. Additionally, the magnitude of improvement in critical thinking was greater in the experimental group, as indicated by a high N-gain of 0.80. In contrast, the control group showed a moderate N-gain of 0.69. These findings suggest that the Numbered Heads Together strategy, supported by Google Sites, is more effective in improving students' critical thinking skills than instruction grounded in a scientific approach. The improvement in students' critical thinking skills may result from the NHT model's encouragement of active participation, discussion, and collaborative problem-solving among group members. This finding supports the results reported by Agustin et al. (2024), which indicate that NHT positively impacts the development of students' critical thinking skills through group discussion activities. Overall, the results highlight the influence of instructional methods on students' critical thinking development. In the Numbered Heads Together learning activity using Google Sites in the experiment class, selected students are required to communicate their answers, and other students are required to respond to or critique those answers. The method used in this experimental class sharpens students' critical-thinking skills in evaluating the correctness of their answers. Meanwhile, in the control class, Students are not required to present their answer results, so the session communicates the answer results only based on the students' initiative, without any in-depth evaluation from other students, which causes the increase in critical thinking skills in the control class to be lower than in the experimental class.

As shown in Table 5, the average learning motivation score for the experimental class (80.27) was higher than that for the control class (76.31). This finding indicates that students in the experimental group demonstrated greater posttest motivation to learn than those in the control group. Accordingly, the implementation of the Numbered Heads Together strategy, supported by Google Sites, can be considered to have a positive effect on students' motivation to learn. These results align with the findings of Sudewiputri & Dharma (2021), who reported significant differences in learning motivation between students taught using the Numbered Heads Together learning model and those taught using conventional methods, with higher motivation observed in the experimental group. This result is also consistent with the study by Nwuba et al. (2023), which found that the Numbered Heads Together strategy increases student motivation and active participation by fostering engagement and enthusiasm during group discussions. Furthermore, the N-gain analysis presented in Table 9 shows that the experimental group achieved a moderate average N-gain score of 0.34, whereas the control group recorded a lower average of 0.19. This is in line with research by Nafi & Sugiyarto (2024). The Numbered Heads Together learning provides increased learning motivation in the medium category.

Based on Table 8, as indicated by Hotelling's Trace ($T = 0.457$, $F(2.123) = 28.090$, $p < 0.05$, partial $\eta^2 = 0.314$). The results indicate that the learning model had a statistically significant and strong influence on students' critical thinking skills and motivation to learn. In addition, the univariate analysis shown in Table 7 demonstrates that the learning model significantly affected students' critical thinking skills ($F(1) = 43.958$, $p < 0.05$, partial $\eta^2 = 0.262$), indicating a large effect size. In addition, a significant effect was also found on students' learning motivation ($F(1) = 21.492$, $p < 0.05$, partial $\eta^2 = 0.148$), with a large effect size. The simultaneous improvement in critical thinking skills and learning motivation in experimental classes applying the NHT model can be attributed to its structured learning stages. The numbering stage facilitates the formation of student groups and encourages active participation in critical thinking processes. Next, during the questioning stage, students are presented with problems and collaboratively engage in critical thinking to develop solutions. This is in line with the findings of Reyes et al. (2024). Engaging students in learning improves their attention and focus, encourages them to develop higher-order critical-thinking abilities, and fosters meaningful learning experiences. Furthermore, in the answering stage of the Numbered Heads Together strategy, all students are given equal opportunities to present the outcomes of their group discussions, as determined by the teacher using a spin wheel. This approach increases students' motivation to learn, think critically, understand the material, and take responsibility for their group's work. Consequently, the Numbered Heads Together strategy is effective at simultaneously improving students' critical thinking skills and motivation to learn. In addition, the large effect size was influenced by the teacher's ability to organize groups, provide direction, and facilitate meaningful interactions. (Slavin, 2011). Another factor, the heterogeneity of group members in NHT learning, allows for peer tutoring and positive interdependence, in which students feel they need each other to achieve a better understanding (Johnson et al., 2014; Sujiati, 2021).

Using Google Sites in Numbered Heads Together learning can simultaneously increase students' critical-thinking skills and their motivation to learn. This is because the visually appealing design and completeness of features on Google Sites can arouse students' interest in learning. In addition, Google Sites can help students deepen and hone their understanding through learning videos,

materials, activities, and games. The availability of learning video resources facilitates improved understanding of the material among students who prefer auditory–visual learning styles. In addition, the games menu on Google Sites helps students hone their understanding and thinking skills. Other Google Sites menus, such as learning materials, contain materials, sample questions, and steps to work on, which can help students build their knowledge. In addition, the activity menu encourages students' critical thinking by including questions that require advanced reasoning and are grounded in real-life contexts. Thus, Google Sites media can facilitate students' learning and help them construct knowledge in accordance with the NHT-type cooperative learning model, grounded in constructivist learning theory. Here's what Google Sites looks like in
Image *3*.

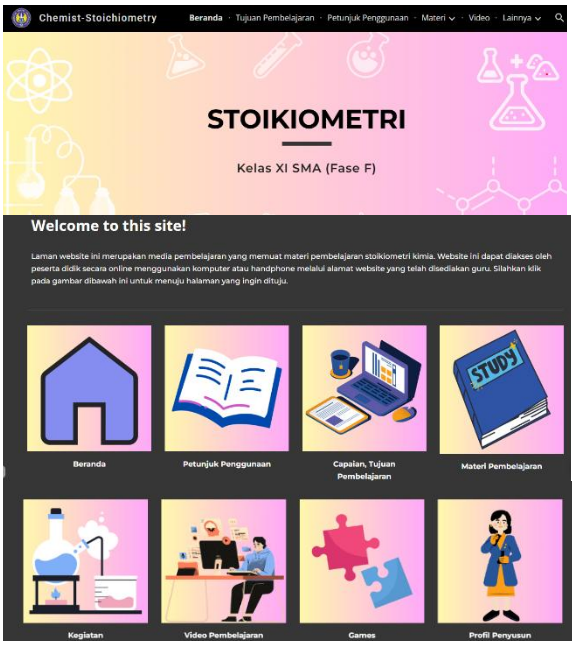

Image 3. Image of Google Sites

Based on Image 1, the explaining component in both the control and experimental groups was classified as very good, with scores of 83% and 85%, respectively. For the interpreting component, the control group achieved 79%, which falls into the good category, whereas the experimental group reached 82%, placing it in the very good category. The evaluation component showed similarly high performance in both groups, with the control group scoring 83% and the experimental group slightly higher at 84%, both categorized as very good. In the final component, the control group achieved 76% (good), while the experimental group achieved 87% (very good). A comparable pattern was observed in the analysis component, with the control group scored 77% (good), and the experimental group 86% (very good). On the other hand, these finding is align with a relevant study by Agustin et al. (2024). The critical thinking skills of students who meet the satisfactory criteria comprise three aspects: problem identification, conceptual understanding, and conclusion. Nevertheless, the results of the present study indicate that the percentage differences between the experimental and control groups for certain aspects of critical thinking were relatively modest (Adawiah et al., 2024). This is because the ability to think critically is not always evenly developed across all aspects, but is influenced by the complexity of the cognitive demands of each indicator, according to Facione's (2011) critical thinking theory. Overall, the inferential statistics indicate that Numbered Heads Together learning with Google Sites had a significant effect, as the MANOVA test showed a p-value < 0.05. ($0.000 < 0.05$). This is in accordance with statistical theory, where the significance of differences is determined through inferential statistical tests, considering p-values, sample size, and data variability, while percentages are used to describe achievements descriptively (Field, 2013; Gravetter & Wallnau, 2014).

According to
Image *2*, Aspects (the presence of encouragement and the need for learning) in the control group had a percentage of 77%, classified as good, while in the experimental group, it was 83%, classified as very good. Aspects (Presence of great interest and attention in learning) in the control group of 77% were categorized as good, while in the experimental group, 82% were classified as very good. The aspect (ability to be firm in completing tasks) in the control group had a percentage of 76%, classified as good, while in the experimental group it was 84%, classified as very good. The aspect (the presence of interesting activities in learning) in the control group had a percentage of 76%, classified as good, while in the experimental group it was 81%, classified as very good. The aspect (conducive learning environment) in the control group had a percentage of 76%, classified as good, while the experimental group had 82%, categorized as very good.

The improvement in both students' critical thinking skills and learning motivation in this study indicates that the learning environment created through the Numbered Heads Together model, supported by Google Sites, can support not only cognitive development but also students' motivational engagement. Critical thinking requires students to actively analyze information, evaluate arguments, and formulate logical conclusions, which are essential higher-order thinking processes. According to Ennis (1985), critical thinking involves reflective and reasonable thinking focused on determining what to believe or what action to take. Similarly, Facione (2011) and Widana (2018) explain that critical thinking consists of cognitive skills such as interpretation, analysis, evaluation, inference, explanation, and self-regulation. These thinking processes often emerge when students are actively involved in meaningful learning activities. At the same time, students' motivation is crucial in encouraging them to engage in such complex cognitive processes. As proposed by Atkinson (1964), motivation is influenced by individuals' expectations of success and the value they attach to learning tasks. Furthermore, the social cognitive perspective described by Pintrich & Schunk (1995) suggests that supportive learning environments, collaborative interaction, and meaningful tasks can enhance students' motivation and self-efficacy. In addition, educational perspectives from Sardiman (2014) and Uno (2016) emphasize that engaging learning activities and conducive learning environments can stimulate students' desire to learn and succeed. In the context of this study, the collaborative structure of the Numbered Heads Together model encourages students to discuss, exchange ideas, and justify their reasoning, while Google Sites provides accessible learning resources that support exploration of chemical concepts. These learning conditions not only stimulate students' analytical and evaluative thinking but also foster greater interest and motivation to participate actively in the learning process.

The results of this study strengthen existing evidence that integrating NHT and Google Sites positively affects critical thinking and learning motivation, with a large effect. The concurrent improvement in critical thinking skills and learning motivation indicates that integrating the Numbered Heads Together (NHT) model with Google Sites can support both cognitive and affective domains of learning. These findings complement previous studies that tended to examine these variables separately. In addition, this study provides empirical support for implementing accessible web-based platforms in secondary chemistry education. Given that Google Sites is relatively easy to implement and does not require advanced technical expertise, it may be a viable option for schools with limited technological infrastructure. Therefore, integrating structured cooperative learning with simple digital tools may be a practical alternative for teachers seeking to enhance instructional effectiveness in line with current educational demands.

Conclusion

According to this research, there are significant differences in students' critical thinking skills and learning motivation simultaneously and separately, between students taught using the Numbered Heads Together model assisted by Google Sites and those taught using a scientific approach. There is a significant effect of NHT-Google Sites on students' critical thinking skills and learning motivation, both simultaneously and separately. Overall, the results indicate that students who participated in the Numbered Heads Together (NHT) learning model, supported by Google Sites, demonstrated higher levels of critical thinking and learning motivation than those who learned through a scientific approach. These findings suggest that integrating the NHT learning model with Google Sites can be an effective instructional strategy for improving students' critical thinking skills and motivation to learn chemistry. Future research is recommended to explore additional variables beyond critical thinking and learning motivation to provide broader insights into chemistry education.

Bibliography

Adawiah, R., Ruchliyadi, D. A., & Halidi, W. (2024). A combination of the project-based learning model and value clarification technique in improving students' critical thinking skills. *Indonesian Journal of Educational Development (IJED)*, *5*(1), 68-78. https://doi.org/10.59672/ijed.v5i1.3728

Agustin, G. P., Afrizal, A., & Irwanto, I. (2024). Analysis of students' critical thinking abilities through the Numbered Heads Together (NHT) cooperative learning model on the topic of buffer solutions. *Journal of Research in Education and Pedagogy*, *1*(1), 1–10. https://doi.org/10.70232/zfd29e68

Anekwe, C., Opara, M., & Nnorom, N. (2024). Emotional intelligence and self-efficacy as predictors of chemistry students' achievement in stoichiometry. *IJEE International Journal of Education and Evaluation*, *10*(3), 377–386. https://doi.org/10.56201/ijee.v10.no3.2024.pg377.386

Aprianto, I., Sofyan, Rahmawati, S., & Sufyadi, S. (2025). Artificial intelligence and its effects on critical thinking and problem-solving abilities in higher education. *Indonesian Journal of Educational Development (IJED)*, *6*(3), 704–719. https://doi.org/10.59672/ijed.v6i3.5030

Atkinson, J. (1964). *An introduction to motivation*. Van Nostrand Reinhold.

Brookhart, S. M. (2010). How to assess higher-order thinking skills in your classroom. In *Ascd*. ASCD.

Chang, R. (2019). *Chemistry (9th ed.)*. McGraw-Hill.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education* (7th ed.). Routledge.

Culajara, C. J., & Catalina, S. (2022). Maximizing the use of google sites in delivering instruction in physical education classes. *Physical Education and Sports: Studies and Research*, *1*(2), 79–90. https://doi.org/10.56003/PESSR.V1I2.115

Ennis, R. H. (1985). A logical basis for measuring critical thinking skills. *Educational Leadership*, *43*(2), 44–48.

Evi Yupani & Widana, I. W. (2023). The impacts of the stem-based inquiry learning models on critical thinking and concept mastery. *Indonesian Research Journal in Education, 7*(1), 171-184. https://doi.org/10.22437/irje.v7i1.24227

Facione, P. A. (2011). *Critical thinking: What it is and why it counts*. Insight Assessment.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics (4th ed.)*. SAGE Publications.

Garcha, P. S., & Kumar, K. (2015). Effectiveness of cooperative learning on critical thinking dispositions of secondary school students. *Issues and Ideas in Education*, *3*(1), 55–62. https://doi.org/10.15415/IIE.2015.31005

Google. (2023). *Create & edit a site. Google Support.*

Gravetter, F. J., & Wallnau, L. B. (2014). *Statistics for the behavioral sciences (9th ed.)*. Cengage Learning.
Halpern, D. F. (2014). *Thought and knowledge: An introduction to critical thinking* (5th ed.). Psychology Press.
Hayati, S. (2017). *Belajar pembelajaran berbasis cooperative learning (Learning cooperative learning based learning)*. Graha Cendekia.
Huda, A. A. N., Tanal, A. F., Ermayda, R. Z., & Hayati, S. (2022). Pemanfaatan google sites sebagai media praktik pembelajaran administrasi perpajakan di SMK Kepanjen (Utilization of Google Sites as a medium for practical learning of tax administration at Kepanjen Vocational School). *Prosiding National Seminar on Accounting, Finance, and Economics (NSAFE)*.
Hussain, S., Khan, H., Khan, J. R., & Tariq, R. (2023). Chemistry for the life sciences. In *Chemistry for the Life Sciences*. ISRES Publishing. https://doi.org/10.1201/9781420069365
Ibrahim, I., Marwan, M., & Firmansyah, J. (2023). Enhancing critical thinking skills in biology subject with the legendary model of cooperative learning. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 2368–2373. https://doi.org/10.29303/jppipa.v9i5.2323
Jeyarajaguru, K. S. (2023). Effective creation and usage of simplified virtual curation lab using google sites: Implementation for principles of biochemistry laboratory course. *Journal of Educators Online*, *20*(1). https://doi.org/10.9743/JEO.2023.20.1.6
Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Sage Journals: Educational Researcher*, *38*(5), 365–379. https://doi.org/10.3102/0013189X09339057
Johnson, D. W., Johnson, R. T., & Smith, K. A. (2014). Cooperative learning: Improving university instruction by basing practice on validated theory. *Journal on Excellence in College Teaching*, *25*(3&4), 85–118.
Kahneman, D. (2011). *Thinking, fast and slow*. Farrar, Straus and Giroux.
Karyati, A. (2023). Efektivitas penggunaan website pembelajaran dalam meningkatkan motivasi belajar siswa (The effectiveness of using learning websites in increasing students' learning motivation). *AKSARA: Jurnal Ilmu Pendidikan Nonformal*, *09*(03), 1665–1674. https://doi.org/10.37905/AKSARA.9.3.1665-1674.2023
Khasanah, R., & Muflihah, S. M. (2021). Online learning management using google sites on relations and functions in pandemic conditions. *Journal of Education and Learning Mathematics Research (JELMaR), 2*(1), 68–76. https://doi.org/https://doi.org/10.37303/jelmar.v2i1.49
Kong, Y. (2021). The role of experiential learning on students' motivation and classroom engagement. *Frontiers in Psychology*, *12*(771272), 1–4. https://doi.org/10.3389/fpsyg.2021.771272
Mukama, E., & Byukusenge, P. (2023). Supporting student active engagement in chemistry learning with computer simulations. *Journal of Learning for Development*, *10*(3), 427–439.
Nafi, M. R., & Sugiyarto, K. H. (2024). The influence of the STAD and NHT learning models on students ' cognitive achievement and learning motivation on colloid material in Banyumas. *Jurnal Pendidikan Kimia Indonesia*, *8*(2), 96–104. https://doi.org/https://doi.org/10.23887/jpki.v8i2.79261
Nwuba, I., Egwu, S. O., Awosika, O. F., & Osuafor, A. M. (2023). Fostering secondary school students' interest in biology using numbered heads together cooperative instructional strategy. *The Universal Academic Research Journal*, *5*(2), 48–56. https://doi.org/10.55236/TUARA.1136342
OECD. (2023). *PISA 2022 Results (Volume I): The state of learning and equity in education*. https://www.oecd.org/en/publications/pisa-2022-results-volume-i_53f23881-en.html
Owens, D. C., Sadler, T. D., Barlow, A. T., & Smith-Walters, C. (2020). Student motivation from and resistance to active learning rooted in essential science practices. *Research in Science Education*, *50*(1), 253–277. https://doi.org/10.1007/s11165-017-9688-1
Partnership for 21st Century Skills. (2015). *Framework for 21st Century Learning*.
Paul, R. W., & Elder, L. (2006). Critical thinking: The nature of critical and creative thought. *Journal*

of Developmental Education.
Pintrich, P., & Schunk, D. (1995). *Motivation in education: Theory, research, and applications*.
Priliyanti, A., Muderawan, I. W., & Maryam, S. (2021). Analisis kesulitan belajar siswa dalam mempelajari kimia kelas xi (Analysis of students' learning difficulties in studying chemistry in grade xi). *Jurnal Pendidikan Kimia Undiksha*, *5*(1), 11–18. https://doi.org/10.23887/JJPK.V5I1.32402
Ramalingam, K., & Jiar, Y. K. (2022). Influence of intrinsic and extrinsic motivation in knowledge sharing behavior. *Central Asia And The Caucasus*, *23*(1), 1884–1893. https://doi.org/10.37178/ca-c.23.1.186
Reyes, M. S., Capuno, F. T., & Baluyos, G. R. (2024). Enhancing students' academic performance in science through the use of Numbered Heads Together (NHT) Learning Strategy. *United International Journal for Research & Technology*, *5*(11), 53–65.
Salame, I. I., Kanishka, H., & Ishak, A. (2026). Examining challenges and difficulties students face in learning about stoichiometry in general chemistry courses. *Interdisciplinary Journal of Environmental and Science Education*, *22*(1), 1–9. https://doi.org/10.29333/ijese/17701
Salsabila, F., Muslim, B., Amin, F., & Mulyanti, D. S. (2023). Efektivitas metode pembelajaran pada materi stoikiometri: Review literatur (Effectiveness of learning methods on stoichiometry material: Literature review). *Prosiding Seminar Nasional Orientasi Pendidik Dan Peneliti Sains Indonesia*, *1*, 131–135.
Sardiman. (2014). *Interaksi dan motivasi belajar mengajar (Interaction and motivation in teaching and learning)*. PT Raja Grafindo Persada.
Shaukat, H., & Tanveer Afzal, M. (2025). Original article effect of numbered heads together strategy on application level of achievement in chemistry for 9th grade students. *Journal of Social Horizons*, *2*(02), 334–341. https://doi.org/https://doi.org/10.5281/zenodo.16639320
Slavin, R. E. (2011). *Cooperative learning : Teori, riset, dan praktik*. Nusa Media.
Sudewiputri, P., & Dharma, I. A. (2021). Model pembelajaran Numbered Heads Together (NHT) terhadap motivasi dan hasil belajar ipa (The Numbered Heads Together (NHT) learning model on science learning motivation and outcomes). *Jurnal Pedagogi Dan Pembelajaran*, *4*(3), 427–433.
Sujiati, T. (2021). Meningkatkan hasil belajar fisika siswa menggunakan model pembelajaran kooperatif tipe NHT (Improving students' physics learning outcomes using the NHT type cooperative learning model). (2021). *Indonesian Journal of Educational Development*, *2*(2), 207-218. https://doi.org/10.5281/zenodo.5232392
Uno, B. H. (2016). *Teori motivasi dan pengukurannya analisis di bidang pendidikan (Motivation theory and its measurement analysis in the field of education)*. PT Bumi Aksara.
Wallace, M. P., & Leong, E. I. L. (2020). Exploring language learning motivation among primary efl learners. *Journal of Language Teaching and Research*, *11*(2), 221–230. https://doi.org/10.17507/jltr.1102.10
West, J., & Malatji, M. J. (2021). Technology integration in higher education: The use of website design pedagogy to promote quality teaching and learning. *Electronic Journal of E-Learning*, *19*(6), 629–641. www.ejel.org
Widana, I. W., et.al. (2018). Higher-order thinking skills assessment towards critical thinking in mathematics lessons. *International Journal of Social Sciences and Humanities*, *2*(1), 24-32. https://doi.org/10.29332/ijssh.v2n1.74
Yuliani, H., Andani, T., & Aulia, M. (2021). Advantages and disadvantages of applying the NHT type cooperative learning model physics learning in school. *Jurnal Ilmiah Pendidikan Fisika*, *5*(1), 55–61.