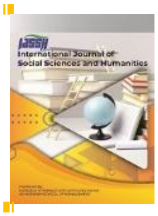

International Journal of Social Sciences and Humanities
Vol. 4 No. 2, Juni 2026, pages: 258-268
e-ISSN: 2985-6469
https://ejournal.45mataram.ac.id/index.php/ijssh

Google Sites-Based Science Learning and Higher-Order Thinking Skills in Vocational High School Students

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Article History

Manuscript submitted:
12 April 2026
Manuscript revised:
05 Mei 2026
Accepted for publication:
15 Juni 2026

Keywords

Google Sites;
Higher-Order Thinking Skills;
Science Learning;
Vocational Education;
Digital Learning.

Abstract

This study examined whether Google Sites-based science learning improved higher-order thinking skills (HOTS) among tenth-grade vocational high school students. A quasi-experimental nonequivalent control group design was used with 60 students of SMK Negeri 1 Langowan, divided equally into an experimental class and a control class. The experimental class learned science through a structured Google Sites environment, while the control class received conventional instruction. Data were collected through HOTS-oriented pretest and posttest instruments, student response questionnaires, classroom observation sheets, and documentation. The findings showed a clear difference between groups. The mean posttest score of the experimental class reached 78.93, whereas the control class obtained 54.50. The experimental group also recorded a moderate N-gain of 0.59, compared with 0.18 in the control group. The independent-samples t-test indicated a significant difference ($p < 0.001$), confirming that the intervention contributed to higher HOTS achievement. Students also responded positively to the platform, as reflected in a questionnaire percentage of 91.08% and an activity observation score of 88.67%. Overall, Google Sites supported a more interactive, motivating, and cognitively demanding science learning process.

Contents

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Introduction

Education in the digital era increasingly requires students to do more than remember information. They are expected to analyse evidence, evaluate alternatives, and generate solutions for unfamiliar problems. These higher-order thinking skills (HOTS) have become a central indicator of educational quality because they are closely linked to scientific reasoning, creativity, and adaptive problem solving in the twenty-first century (Ichsan et al., 2019; N. O. Mangelep et al., 2024; OECD, 2023, 2024b, 2024). Science learning is one of the most relevant contexts for HOTS development because it requires students to interpret phenomena, test explanations, and connect concepts with evidence. However, classroom practice often remains dominated by teacher explanation and textbook transmission, leaving few opportunities for students to question, compare, and justify scientific ideas. HOTS-oriented assessment and feedback are also still unevenly implemented in science classes (Khoiriah et al., 2020; Wibowo et al., 2022).

Digital platforms offer an alternative learning environment in which students can explore content independently, revisit materials, access multimedia, and participate more actively during lessons. Google Sites is especially attractive for school use because teachers can organise videos, readings, worksheets, quizzes, and discussion prompts in one web-based space without advanced programming skills. Previous studies reported that Google Sites-supported learning can strengthen concept mastery, science process skills, digital literacy, and creativity across different educational levels (Agustina et al., 2023; Ernest & Putra M, 2023; Ernest & Suyanta, 2024; Hidayat et al., 2023; N. Mangelep et al., 2020; Nurwita et al., 2024). A growing number of studies also suggest that Google Sites can improve critical thinking, engagement, collaboration, motivation, and learning outcomes when combined with active learning designs such as problem-based learning, inquiry, interactive e-modules, or structured web resources (Arrahma et al., 2025; Faiz et al., 2025; Johdi et al., 2025; Marantika et al., 2025; Ningsih & Haryanto, 2025; Ratnawati et al., 2024; Salsabilah & Sukarmin, 2025; Thomas et al., 2022; Wahyuni et al., 2024).

Even so, empirical evidence focusing on vocational high school science learning is still limited. Many recent studies have concentrated on media development, feasibility, or general learning outcomes rather than directly testing HOTS gains in vocational contexts. This gap is important because vocational students need both conceptual understanding and applied reasoning that mirrors real-world problem solving. Therefore, this study investigated the effect of Google Sites-based science learning on the HOTS achievement of grade X students at SMK Negeri 1 Langowan. The study was also expected to provide evidence for teachers seeking practical digital media that can enrich classroom interaction and improve learning performance (Jamaludin et al., 2025; Nasution & Astuti, 2024; Ningrum & Jumadi, 2024; Wahyunigtyas & Triwahyuni, 2025).

Rapid technological change has intensified the demand for higher-order thinking skills in school education. Contemporary curricula are expected to help students move beyond recalling isolated facts toward analysing situations, evaluating evidence, and producing reasoned solutions. International assessments have repeatedly shown that these abilities remain unevenly developed, particularly when classroom practice still emphasises routine exercises and teacher-dominated explanation. For this reason, the effort to cultivate HOTS has become closely connected with the search for digital learning environments that can support inquiry, reflection, and independent exploration (Eriyanti et al., 2022; OECD, 2023, 2024a).

In science education, HOTS is especially important because scientific understanding depends on reasoning with evidence rather than memorising definitions (Mudrika et al., 2024). Students are required to interpret observations, connect variables, infer causal relationships, and defend conclusions

e-ISSN : 2985-6469

based on data. When science instruction is reduced to formula reproduction or note copying, learners may perform basic recall tasks yet struggle to apply concepts in unfamiliar contexts. This challenge becomes more visible in vocational education, where students are also expected to relate scientific principles to practical work situations, technological tools, and problem solving in daily life.

The vocational school context deserves attention because its learners often face a dual demand. On the one hand, they must achieve general academic competencies such as critical and creative thinking; on the other hand, they are prepared for applied settings that require adaptive reasoning, collaboration, and digital literacy. As a result, effective instruction in vocational schools should not simply simplify academic content. It should instead bridge conceptual understanding and authentic application. A learning medium that provides flexible access to materials, visual explanation, guided tasks, and opportunities for self-paced review may therefore be highly relevant for this educational level.

Google Sites offers several pedagogical affordances that are compatible with such needs. Teachers can organise content into sequential pages, integrate text with images, videos, simulations, hyperlinks, and worksheets, and create a central online space that students can revisit inside and outside the classroom. Compared with fragmented messaging or slide-based delivery, a site-based environment can make learning pathways more coherent and easier to navigate. It can also increase student autonomy because learners are able to return to prior explanations, compare resources, and manage their own pace while still following the structure prepared by the teacher (Ernest & Putra M, 2023; Ernest & Suyanta, 2024).

Previous studies have reported positive outcomes from the use of Google Sites in science and related subjects. Research has linked the platform with stronger engagement, improved learning outcomes, better digital literacy, and growth in critical thinking when the site is integrated with student-centred strategies rather than used as a passive repository (Hidayat et al., 2023; Ratnawati et al., 2024; Wahyuni et al., 2024). Other studies have shown that Google Sites can support contextual science learning, socio-scientific issue discussion, and process-skill development by enabling multimedia presentation and structured task sequences (Jamaludin et al., 2025; Salsabilah & Sukarmin, 2025).

Even so, the evidence base still has several limitations. A considerable proportion of recent publications have focused on media development, validity testing, or implementation in elementary and junior high school settings. Fewer studies have examined the direct effect of Google Sites on HOTS in vocational high school science classes through comparative experimental designs. This gap is important because vocational students learn in environments that combine academic expectations with practical orientation, and the way they respond to web-based learning media may differ from students in general secondary schools.

Based on this background, the present study was designed to examine whether a Google Sites-based science learning model could significantly improve HOTS among grade X vocational high school students. The study compared the learning outcomes of an experimental group receiving Google Sites-supported instruction with those of a control group receiving conventional instruction. In addition to cognitive outcomes, the study also considered student responses and classroom activity in order to capture whether the digital environment influenced the quality of participation during learning. The working hypothesis stated that students who learned through Google Sites would demonstrate higher HOTS achievement than students who learned through conventional classroom practice.

Methods

This study employed a quantitative quasi-experimental approach using a nonequivalent control group design. The design was selected because the researcher worked with intact classes that had already been formed by the school. Both groups completed a pretest and posttest, but only the experimental class received Google Sites-based science learning. The research was conducted at SMK Negeri 1 Langowan, Minahasa, North Sulawesi, during the second semester of the 2025/2026 academic year. The sample consisted of 60 tenth-grade students selected purposively: 30 students from class X LKes served as the experimental group and 30 students from class X MP served as the control group. The intervention was implemented for approximately 4–6 weeks across 6–8 meetings on the topic of Earth and celestial objects.

The main instrument was a HOTS test constructed from the revised Bloom taxonomy, covering analysis (C4), evaluation (C5), and creation (C6) through multiple-choice and constructed-response items. Supporting data were gathered through a student response questionnaire, classroom observation sheets, and documentation. The instruments were reviewed through content validation, empirical testing, and reliability checking using Cronbach's alpha. Data analysis included the Shapiro–Wilk normality test, Levene's homogeneity test, N-gain analysis, and an independent-samples t-test.

Table 1. Research design

Group	Pretest	Treatment	Posttest
Experimental	O1	X	O2
Control	O1	-	O2

The experimental class was taught through a Google Sites-based learning environment, while the control class learned through conventional classroom instruction. The decision rule for the hypothesis test was Sig. < 0.05, indicating a significant effect. The intervention was implemented through a sequence of classroom meetings in which the teacher used Google Sites as the main learning hub. At the beginning of each lesson, students were directed to a page containing learning objectives, key concepts, and an overview of the activity flow. During the core activity, the site provided short explanatory texts, visual illustrations, embedded videos, question prompts, and links to tasks that required students to analyse cases or answer HOTS-oriented questions. At the end of the lesson, students used the same site to revisit summaries and complete reflective or follow-up assignments. This structure was intended to reduce cognitive fragmentation and keep all learning resources in one accessible space.

Although the study focused on the comparison of outcomes, the learning design also emphasised active engagement. Students in the experimental class were not only asked to read materials from the site but also to discuss scientific problems, interpret examples, and formulate answers based on the information presented. The site functioned as a scaffold that supported classroom interaction rather than replacing the teacher. In contrast, the control class learned with a more conventional pattern characterised by verbal explanation, printed or board-based presentation, and routine question-and-answer activities without the support of a structured web platform. Before the main implementation, the research instruments were reviewed to ensure alignment with the intended HOTS indicators. The test blueprint was mapped to analysis, evaluation, and creation categories in the revised Bloom taxonomy so that each item measured reasoning rather than simple recall. The questionnaire items were designed to capture student perceptions of clarity, attractiveness, usefulness, motivation, and learning comfort, whereas the observation sheet focused on visible participation such as paying attention, responding to teacher prompts, engaging in discussion, analysing problems, and completing assigned tasks.

Student answers on the HOTS test were scored according to predetermined criteria and then converted into numerical values for analysis. To measure learning improvement, the study used descriptive statistics and the normalised gain index. The N-gain analysis was employed because it helps describe the extent of improvement from pretest to posttest relative to the students' initial position. Inferential analysis was conducted through normality and homogeneity testing before the independent-samples t-test was applied. This sequence ensured that the hypothesis test was based on appropriate statistical assumptions. In interpreting the supporting data, questionnaire scores were converted into percentages and classified using commonly applied response categories, while observation results were used to describe the quality of classroom engagement during implementation. The combination of achievement, response, and observation data made it possible to view the intervention not only as a score-producing treatment but also as a learning process. This is important in digital learning research because the effectiveness of a platform depends not merely on the technology itself but on how it shapes student interaction with content, teachers, and peers.

The study was carried out in the natural classroom context of the school, so the researcher worked with existing class groups rather than randomly assigning individual students. This condition is typical in educational field research and explains the choice of the quasi-experimental design. Even though intact classes were used, the inclusion of pretest data allowed the researcher to compare the starting point of both groups and to interpret posttest differences more carefully. All data collection was conducted during normal school activities with the cooperation of teachers and school administrators.

Results and Discussions

The pretest means indicated that the two groups started from a relatively similar level of HOTS achievement. The experimental group obtained a mean of 48.33, while the control group obtained 44.53. After the intervention, the difference between groups became much more visible. The experimental class reached a mean posttest score of 78.93, whereas the control class reached only 54.50. The mean N-gain for the experimental class was 0.59, which falls in the moderate category, while the control class obtained 0.18, which is low. These descriptive findings suggest that Google Sites-based learning provided more effective support for HOTS development than conventional teaching.

The assumption tests showed that parametric analysis was appropriate. The Shapiro–Wilk significance values for the four data sets were above 0.05, indicating normal distribution. The Levene test also showed homogeneity of variance (Sig. = 0.393). The independent-samples t-test further confirmed a statistically significant difference between the two groups, $t(58) = 11.328$, $p < 0.001$, with a mean difference of 24.433 points. In practical terms, the effect was very large, which means that the intervention influenced learning not only statistically but also educationally.

Table 2. Descriptive statistics of HOTS achievement

Group	N	Mean Pretest	Mean Posttest	Mean N-Gain
Experimental	30	48.33	78.93	0.59
Control	30	44.53	54.50	0.18

1. How Google Sites Supported HOTS Development

The positive result can be explained by the learning features embedded in Google Sites. The platform allowed teachers to present science content through organised pages, linked resources, and multimedia elements that students could revisit whenever needed. Such accessibility likely reduced dependence on teacher explanation and encouraged more active meaning making. Students were not limited to receiving information passively; instead, they could compare representations, read supporting texts, and respond to tasks that required interpretation and reasoning. This structure is consistent with previous studies showing that Google Sites and related web-based resources can improve concept mastery, digital literacy, and science process engagement (Ernest & Putra M, 2023; Ernest & Suyanta, 2024; Hidayat et al., 2023; Johdi et al., 2025).

2. Student Response and Classroom Activity

The supporting questionnaire and observation data strengthened this interpretation. Student responses reached 91.08%, classified as very good, while observed classroom activity reached 88.67%, also in the very good category. Students reported that the platform was easy to use, more interesting than routine instruction, and helpful for understanding science concepts. Observation data likewise showed stronger participation, collaboration, questioning behaviour, and simple problem analysis during the lessons. These results echo earlier findings that Google Sites can improve motivation, critical thinking, engagement, and achievement when integrated with active pedagogies (Faiz et al., 2025; Marantika et al., 2025; Ratnawati et al., 2024; Thomas et al., 2022; Wahyuni et al., 2024). For vocational schools, this is especially important because students benefit from learning environments that connect scientific content with independent exploration and task-oriented reasoning.

3. Pedagogical Implications and Comparison with Previous Studies

Viewed from a learning progression perspective, the descriptive statistics suggest that the treatment did not merely raise scores in a superficial way. The experimental class started from a moderate baseline like that of the control class, yet it reached a notably higher posttest mean after the intervention. This pattern indicates that students benefited from the learning process during implementation rather than entering the study with an unfair advantage. The moderate N-gain in the experimental class is also educationally meaningful because HOTS improvement typically requires sustained engagement with reasoning tasks, not simple exposure to information.

A practical interpretation of the score difference is that the Google Sites environment likely helped students spend more instructional time on cognitively productive activities. Because the materials, examples, and task directions were organized in one place, less time was lost on searching for resources or waiting for repeated teacher explanation. Students could revisit content immediately when they encountered difficulty, which is an important support for analytical thinking. In conventional settings, such revisiting often depends on notes that are incomplete or on verbal repetition that may not address each learner's difficulty now it occurs.

Another important point is that the platform supported multimodal representation. Scientific ideas are often easier to understand when students can move between textual explanation, visual representation, contextual examples, and guided questions. When these elements are integrated in a coherent page structure, learners can compare information sources and build stronger conceptual links. This likely contributed to the higher posttest performance of the experimental group because HOTS tasks require students to manipulate and connect ideas rather than remember them in isolation.

The result is consistent with recent studies showing that Google Sites can strengthen science learning when used as part of an intentional instructional design. Studies by Hidayat et al., (2023) Nasution & Astuti (2024) and Ningsih & Haryanto (2025) similarly reported that site-based learning environments can improve concept mastery and achievement by providing accessible and attractive resources. In addition, findings from Ratnawati et al., (2024), Wahyuni et al., (2024) and Wahyunigtyas & Triwahyuni (2025) suggest that the benefit extends beyond basic outcomes toward critical-thinking engagement and more active participation, which aligns with the present study's focus on HOTS.

The positive effect can also be interpreted through the lens of student autonomy. A web-based platform such as Google Sites changes the flow of information in the classroom. Instead of depending entirely on teacher talk, students can navigate resources, reread explanations, and verify their own understanding before responding. This supports self-regulated learning, especially for students who need more time to process scientific information. In vocational schools, where student academic backgrounds may vary considerably, such flexibility is valuable because it allows the classroom to accommodate different rates of comprehension without disrupting the collective lesson flow.

The student response percentage of 91.08% provides further support for this interpretation. High questionnaire scores indicate that students did not perceive the platform as an additional burden; rather, they experienced it as helpful, attractive, and motivating. Positive response matters because motivation influences the quality of cognitive effort students invest in demanding tasks. Learners are more likely to persist in analysis and problem solving when the learning environment feels navigable and relevant. Thus, the attitudinal data complement the achievement data by showing that the treatment was both effective and acceptable from the student perspective.

Similarly, the classroom activity result of 88.67% demonstrates that Google Sites did not lead to passive screen-based learning. On the contrary, the observation data indicate that students remained involved in discussion, task completion, and problem analysis during the lessons. This is a crucial finding because digital media are sometimes criticised for increasing distraction or reducing teacher–student interaction. In this study, the platform appears to have functioned as a shared reference point that facilitated participation. Students could engage with the material individually while still discussing it collectively in class, thereby combining personal exploration with social learning.

The vocational school setting gives additional significance to these findings. Science subjects in vocational education are often perceived by students as distant from their chosen field, which can reduce engagement when instruction is abstract or overly textbook-centred. A Google Sites-based environment can help address this issue by presenting concepts through clearer structure, examples, and multimedia resources that make content feel more concrete. When students understand why a concept matters and can access explanations in more than one format, they are better positioned to interpret evidence and apply reasoning. This helps science learning contribute not only to academic success but also to transferable workplace-relevant thinking skills.

However, the findings should not be interpreted as evidence that technology alone automatically produces HOTS. The educational value of Google Sites depends on the quality of the learning tasks embedded in the site. If the platform were used only to upload notes or provide drill-type questions, the cognitive benefit would likely be limited. The present result was probably influenced by the combination of structured digital access and HOTS-oriented learning activities. This observation is consistent with broader literature on digital pedagogy, which emphasises that meaningful improvement occurs when technology is aligned with inquiry, problem solving, and reflective learning design rather than mere content delivery (OECD, 2024b).

From a pedagogical standpoint, the study suggests several implications for teachers. First, Google Sites can serve as a practical and relatively low-cost platform for organising science learning resources in a way that supports HOTS. Teachers do not need highly complex software to create a more inquiry-friendly environment; they need a platform that allows clear sequencing, multimedia integration, and easy access. Second, the platform can be especially useful for preparing pre-class orientation, in-class exploration, and post-class reinforcement within one connected space. This continuity can help students see learning as a process rather than a series of disconnected activities.

Third, teachers should consider the role of prompt design when building Google Sites pages. Questions that ask students to compare data, justify conclusions, evaluate alternatives, or propose solutions are more likely to activate HOTS than prompts focused on recalling definitions. Therefore, the success of the platform depends on the cognitive quality of the embedded tasks. Integrating short cases, real-world examples, or socio-scientific issues may further increase the relevance of science learning and encourage deeper reasoning, as suggested by studies that link Google Sites with contextual and issue-based learning models (Jamaludin et al., 2025; Salsabilah & Sukarmin, 2025).

4. Limitations and Directions for Further Research

At the same time, several limitations need to be acknowledged. The sample was restricted to one school and two intact classes, which limits the generalisability of the findings. The duration of the intervention was also bounded by the school schedule, meaning that the study captured short-term change rather than long-term retention. In addition, the effectiveness observed here may partly reflect teacher preparation and classroom management, not solely the digital platform. These factors should be considered when interpreting the results and when transferring the model to other settings.

Future research can extend the present findings in several ways. Studies with larger samples from multiple vocational schools would help determine whether the positive effect remains consistent across different student backgrounds and subject topics. Longer interventions would also be useful for examining whether HOTS gains are sustained over time and whether students become more independent in using web-based learning resources. Researchers may further compare different instructional models embedded within Google Sites, such as problem-based learning, inquiry learning, or project-based learning, to identify which pedagogical combinations produce the strongest improvement.

Overall, the discussion indicates that Google Sites contributed to HOTS development by improving access, structure, engagement, and the quality of students' interaction with science content. The platform offered a flexible digital environment, but its success was closely tied to the way the teacher designed learning tasks and classroom activities. In this sense, Google Sites should be understood not as a substitute for pedagogy but as a medium that can strengthen pedagogy when used intentionally. For vocational high school science learning, such intentional use appears promising because it connects digital accessibility with higher-level reasoning demands.

Conclusion

This study concludes that Google Sites-based science learning had a significant positive effect on the higher-order thinking skills of grade X vocational high school students. Compared with conventional instruction, the intervention produced higher posttest achievement, a stronger N-gain score, and a statistically significant difference between groups.

The findings also show that the value of Google Sites was not limited to test scores. The platform supported student motivation, learning participation, and classroom interaction, all of which are essential for HOTS development. Therefore, Google Sites can be recommended as a practical digital medium for science teachers, particularly in vocational settings where flexible access, contextual learning resources, and problem-oriented activities are needed.

In sum, the results reinforce the argument that digital platforms are most valuable when they are used to organise meaningful learning experiences rather than to merely digitise conventional teaching. In the present study, Google Sites helped create a science learning environment that was more structured, engaging, and supportive of analysis, evaluation, and problem solving. These characteristics are closely related to the development of HOTS, which remains a central educational goal in vocational schools. The study therefore supports the practical use of Google Sites as an accessible instructional medium for teachers who seek to improve both learning process quality and higher-level cognitive outcomes.

Acknowledgments

The authors express gratitude to SMK Negeri 1 Langowan, the participating students, and the science teachers who supported the implementation of this study.

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