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The influence of google sites digital media with a STEM approach on student learning outcomes in plant material

Nura Safrina^{1*}, Rita Novita¹, Sariakin¹

¹Bina Bangsa Getsempena University, Aceh, Indonesia

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ABSTRACT

This study aims to examine the effect of implementing Google Sites Digital Media with a STEM Approach as an Effort to Improve Student Learning Outcomes on Plant Material. This study used a pre-experimental design with a one-group model, namely pre-test and post-test, which was implemented in grade IV of SDN 48. Data were collected through a multiple-choice test of 25 questions that measured students' understanding of plant material. At the beginning of the study, students took a pre-test to determine their initial abilities. Furthermore, learning was carried out using Google Sites media that was designed interactively by integrating text, images, videos, simulations, and simple STEM-based project assignments. The learning process encouraged students to explore plant concepts scientifically, utilize digital technology, solve problems, and apply mathematical concepts in real contexts. After the treatment, students took a post-test to measure improvements in learning outcomes. The results showed a significant increase in the average post-test score compared to the pre-test, the average student score increased by 16.23 points, from 55.87 in the pre-test to 72.10 in the post-test. The magnitude of the effect of the increase was obtained by Cohen's d 2.21, which is included in the category of very large effects. This shows that the increase that occurred was not only statistically significant, but also had a large magnitude in practice. The Wilcoxon Signed Ranks test obtained a significance value of 0.000 which proves that interactive digital learning media based on Google Sites with a STEM approach is effective in improving conceptual understanding and student learning outcomes.



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Corresponding Author:

Nura Safrina,
Bina Bangsa Getsempena University
Email: nurasafriana@gmail.com

Introduction

Advances in information technology should be leveraged to improve the quality of learning through broad access to digital learning resources. Technology-based learning media is a crucial tool that requires teachers to innovate and adapt in the teaching process. Learning media assists teachers in delivering material, making the learning process more active and easier to understand. (Alsya Putri Nuh Graha, 2023). Learning media helps convey and clarify the meaning of the material, so that learning objectives can be achieved more optimally (Kustandi & Darmawan, 2020)

Natural Sciences (IPA) is a field of science that studies natural phenomena through scientific processes (Kusumawati, 2022). This learning emphasizes direct experience to hone critical thinking, curiosity,

responsibility, and learning abilities (Yusron Abda'u Ansya & Salsabilla, 2024). In addition, science learning is carried out systematically through scientific methods that provide concrete experiences to students, such as experimental activities, and focus on developing critical thinking and problem-solving skills (Triandika et al., 2023). This learning not only aims to convey concepts, but also to develop science process skills and attitudes to be able to link knowledge with phenomena that occur in the surrounding environment logically and systematically.

Technological developments require teachers to continue to innovate in the learning process, including in designing media that is integrated with technology (Salsabila & Aslam, 2022). In this context, the use of media that is only based on books is considered insufficient to meet students' learning needs in the digital era, so it needs to be supplemented with visual elements such as videos, animations, and interactive content so that the material is easier to understand and is highly relevant to the characteristics of science learning based on the scientific process.

A preliminary study conducted at SD Negeri 48 showed that although the school had implemented the Independent Curriculum and teachers had begun utilizing technology such as instructional videos, the learning process was still dominated by conventional, teacher-centered methods. Learning was generally limited to the use of textbooks without the support of interactive media or other aids. This condition made it difficult for students to understand the material, especially in science subjects, which are abstract and require visualization and direct experience. As a result, student learning outcomes were suboptimal, with 13 out of 30 fourth-grade students achieving scores below the Minimum Completion Criteria (KKM). The lack of supporting media and the lack of engaging learning activities quickly led to students becoming bored and losing motivation, necessitating learning innovations that could provide a more interactive, enjoyable, and relevant learning experience to increase learning effectiveness.

One solution to improve learning effectiveness is the use of digital platforms such as Google Sites, which enable integrated and interactive presentation of materials. When combined with a STEM approach, this medium not only enriches visual displays but also encourages students to think critically and creatively. Research at Bali Mandara State High School showed that Google Sites and STEM-based media were highly valid and practical, with a validity score of 4.67 and teacher and student practicality scores of 91.76% and 86.44%, respectively. (Sembung et al., 2022).

This finding is in line with the results of a study at SDN Tunge 2 which indicated that the use of Google Sites in science learning significantly increased students' motivation and understanding (Ririn Puji Utami, 2023). In addition, meta-analysis of literature on the use of digital media such as Google Sites is able to support creative digital-based learning, as well as stimulate students' critical thinking skills which are modalities in the science subject on plant material. (Susmitasari et al., 2025).

The STEM approach makes material delivery more engaging and encourages students to think actively, creatively, and be prepared to face challenges. Research in fifth-grade elementary school students shows that this approach significantly improves students' critical thinking skills. (Abdullah, 2025). A study at SD Negeri 32 Muaro Putuih showed that STEM learning significantly improved students' 4C skills. A similar finding was found at SMPN 1 Cigombong, where STEM integration into science improved students' creativity, problem-solving, collaboration, and communication skills (Eva Mulida Hazana, 2024).

Although the use of technology in education has been widely discussed, its implementation at the elementary school level, particularly in STEM-based science learning, still faces various challenges. A preliminary study at SD Negeri 48 showed that the learning process was still dominated by conventional methods and minimal interactive media, even though technology was readily available. Students struggled to grasp abstract science material, such as the topic of plants, which requires visualization and active engagement. This was reflected in low learning outcomes. Several previous studies have evaluated the use of Google Sites or the STEM approach, but these were generally conducted at higher levels (such as junior high or high school) or focused solely on media development without directly examining its impact on student learning outcomes in the elementary school context. Few studies have explicitly integrated Google Sites and the STEM approach simultaneously in the context of elementary school science learning. Therefore, this study fills this gap by offering a new contribution: examining how the integration of Google Sites and the STEM approach can improve student learning outcomes in the topic of plants, directly addressing the need for applicable, science-based interactive digital media in elementary schools.

This study aims to determine the effect of using Google Sites media with a STEM approach on student learning outcomes in plant material.

Method

The design used in this study was a pre-experimental one-group model: pre-test and post-test. According to Sugiyono (2019), this pre-experimental design is often used to determine the effect of a treatment, although it cannot fully control for external variables that influence the research results. This design is suitable for use in situations where researchers do not have the flexibility to determine a control group or conduct randomization.

In this design, there was only one class that became the research subject, namely the fourth-grade students of SD Negeri 48, totaling 30 students. Data was collected through a test on plant material in the form of multiple choice consisting of 25 valid and reliable questions taken from the textbook. At the beginning of the study, students were given a pre-test to determine their initial abilities. Next, students were given learning using Google Sites media designed with a STEM approach. This media contains interactive material about plants in the form of text, images, videos, simulations, and simple project-based tasks that combine STEM elements. During the learning, students were invited to explore the concept of plants through a scientific approach, the use of digital technology, problem solving, and the application of mathematical concepts in a contextual manner. After the experimental process was completed, a test was conducted at the end of the stage to determine student learning outcomes after the treatment. After the data was obtained, it was then analyzed using the Wilcoxon Matched-Pairs Test to test whether there was a difference in the average between the pretest and posttest scores.

Results and Discussions

Based on the results of the research that has been conducted, the following research results were obtained.

Table 1. Descriptive Statistics Results

	Pretest	Post-test
Mean	55.87	72.10
Median	56.00	75.50
Mode	56	76
Std. Deviation	5.406	8.680
Minimum	44	56
Maximum	64	84
Sum	1676	2163

The average score for participants increased from 55.87 in the pretest to 72.10 in the post test, indicating improved performance after the intervention or learning provided. The median score also increased from 56.00 to 75.50, indicating that most participants obtained higher scores after the post test. The mode, or most frequently occurring score, also changed from 56 to 76. In addition, the standard deviation increased from 5.406 in the pretest to 8.680 in the post test, indicating a more varied distribution of scores in the post test. The minimum and maximum scores also showed an upward shift, from a range of 44–64 in the pretest to 56–84 in the post test. The total score for participants also increased from 1,676 to 2,163.

While the increase in mean scores and the shift in the distribution of scores toward higher scores indicate a positive impact of the intervention, it is important to examine more closely the increase in the standard deviation from 5.406 to 8.680, indicating increased variability in learning outcomes across participants. This suggests that the intervention may not have had a uniform impact, with some students experiencing significant benefits while others experienced little or even stagnation. This disparity is a concern, as the effectiveness of an intervention should be measured not only by the increase in mean scores but also by how the intervention reaches students at different ability levels. Overall, these data demonstrate that there was a significant increase in learning outcomes following the implementation of a specific learning or treatment.

Table 2. Frequency Distribution of Pretest Scores

Test scores	Frequency	Percent
44	1	3.3
48	4	13.3
52	5	16.7
56	9	30
60	7	23.3
64	4	13.3
	30	100

The frequency distribution of pre-test scores shows that the score most frequently obtained by participants was 56 with a frequency of 9 people (30%). Pretest scores were spread from the lowest score of 44 to the highest score of 64. A score of 60 was the second most frequent with 7 participants (23.3%), followed by a score of 52 with 5 participants (16.7%). Meanwhile, scores of 48 and 64 were each obtained by 4 participants (13.3%), and only 1 participant (3.3%) obtained a score of 44. This distribution shows that most participants were in the lower to middle score category, which reinforces the picture that the participants' initial abilities before the intervention still needed to be improved.

However, the distribution of pretest scores, which tended to be concentrated in the lower-middle category, not only reflects students' low initial abilities but also indicates initial disparities in material mastery, which could influence students' responses to the intervention. Most students scored close to each other, which could reinforce the assumption that prior instruction had not effectively reached all students. This is noteworthy because, in a one-group pretest-posttest design, the absence of a control group makes it difficult to determine whether post-intervention improvements are truly the result of the treatment or simply the result of initial ability gaps that provide greater room for improvement (a low ceiling effect).

Table 3. Frequency Distribution of Posttest Scores

Test scores	Frequency	Percent
56	3	10
60	1	3.3
64	4	13.3
68	4	13.3
72	2	6.7
75	1	3.3
76	7	23.3
80	4	13.3
84	4	13.3
Total	30	100

Based on Table 3 regarding the frequency distribution of posttest scores, it can be seen that participants' scores after the learning process shifted towards higher scores compared to the pretest scores. The most frequently occurring score was 76, with a frequency of 7 participants, or 23.3% of the total 30 participants. This was followed by scores of 64, 68, 80, and 84, each obtained by 4 participants (13.3%). A score of 56 still appeared in 3 participants (10%), while other lower scores, such as 60 and 75, were only obtained by 1 participant (3.3%) each. Conversely, a score of 72 was achieved by 2 participants (6.7%). This distribution indicates a general improvement in performance, as most participants scored above 68, with a more even distribution of scores in the middle to upper categories. This indicates that the learning process had a positive impact on participants' understanding and achievement of learning outcomes.

Tabel 4 Wilcoxon Signed Ranks Test

	Posttest - Pretest
Z	-4.818 ^b
Asymp. Sig. (2-tailed)	.000

The results of the Wilcoxon Signed Ranks test show a Z value of -4.818 and an Asymp. sign. (2-tailed) of 0.000. This significance value is much smaller than the significance limit of 0.05, so it can be concluded that there is a significant difference between the pretest and posttest scores. In other words, the increase in participants' learning outcomes after the learning process is not a mere coincidence, but rather a real impact of the treatment or intervention provided. These results reinforce the findings in the previous tables, which showed an increase in scores descriptively, and have now been statistically confirmed through the non-parametric Wilcoxon test.

The results of the descriptive statistical analysis show that there was a significant increase in student learning outcomes after learning using Google Sites media with a STEM approach was implemented. The average student score increased from 55.87 in the pretest to 72.10 in the posttest. The median score also increased from 56.00 to 75.50, while the mode changed from 56 to 76. These data indicate that the designed learning was able to optimize student understanding of the material, marked by a shift in scores towards a higher overall.

The frequency distribution of pretest scores shows that most students scored in the lower to mid-range, with 56 being the most common score (30%). After the learning process, the distribution of posttest scores shifted to the upper to mid-range, with the highest score being 76 (23.3%). The maximum score also increased from 64 to

84. This shift indicates that students experienced not only individual improvement, but also collective improvement in concept mastery. The more even distribution of scores in the high category after the intervention indicates the effectiveness of the learning media used. This medium allows for interactive, visual, and easily accessible presentation of materials, and can be used independently by students both inside and outside the classroom. The STEM approach applied in learning also strengthens interdisciplinary integration and encourages students to think critically and creatively. Previously abstract plant material becomes more concrete through project-based activities and problem-solving relevant to real life. Collaboration between digital media and the STEM approach is key to achieving optimal learning outcomes. The improvement in student scores after learning is not random, but rather a tangible result of the media and learning approaches used. This test provides strong statistical evidence that technology- and STEM-based learning strategies have a positive impact on student learning outcomes.

The findings of this study indicate that the use of Google Sites equipped with a STEM approach has proven highly effective in improving the quality of learning, especially in biology materials (such as environmental pollution). This has significant implications for teachers to more optimally design learning that is engaging, interactive, and meaningful for students. Other research supports these findings. For example, the development of Google Sites learning media on ecosystems material for grade 10 high school students successfully obtained a very appropriate category, with assessments from material experts of 97.2%, media experts of 93.7%, and student responses reaching an average of 89%, indicating a very positive acceptance of this website-based interactive media (Kamilah et al., 2023).

Furthermore, a differentiated learning media approach using Google Sites has also been shown to improve student learning outcomes, with the average post-test score in the experimental group (85.11) higher than that of the control group (78.30) (Situmorang et al., 2023). These findings demonstrate that Google Sites is not only feasible and engaging but also academically effective in enhancing student understanding. This finding aligns with other STEM learning media development trends. For example, a STEM-based flipbook for environmental change demonstrated high validity and increased student scientific creativity, with a moderate N Gain score (Desylva Nikita Jasmine, Indri Yani, 2025). Several recent studies also underscore the urgency of integrating interactive digital media into learning. For example, surveys of students and teachers indicate that the use of technology-based media significantly improves conceptual understanding and student engagement, although many teachers still do not utilize it optimally (Putri et al., 2024). The synergy of the STEM approach and digital media such as Google Sites has the potential to bridge this gap.

The results of this study support the recommendation to implement a Google Sites-based digital solution with a STEM approach as an alternative strategy that not only improves the quality of learning but is also pedagogically and practically relevant. Similar applications are recommended for other science subjects or cross-theme subjects, as well as further research to evaluate the effects of this media on students' affective (interest, learning motivation) and psychomotor (practical skills, observation, and experimentation) aspects. These findings provide important implications for learning practices in schools, particularly in the context of biology learning. Teachers are advised to utilize interactive digital media such as Google Sites in designing engaging and meaningful learning activities. The STEM approach can also be a strategic alternative in improving the quality of learning, as it can develop students' higher-order thinking skills, collaborative skills, and digital literacy. This study recommends implementing similar methods for other subjects, as well as expanding the study to see its effects on students' affective and psychomotor aspects.

The results of this study have limitations. Although the Wilcoxon test results show a statistically significant difference between the pretest and posttest, it is important to remember that statistical significance does not necessarily imply universal practical effectiveness. This test only indicates that a change in scores occurred, but does not explain the extent or extent of the intervention's impact across participants. Without a control group, it is impossible to rule out the influence of external factors such as practice questions, repetition of material, or increased motivation that are not directly related to the use of Google Sites or the STEM approach. Furthermore, these significant results need to be interpreted with caution because the one-group pretest-posttest design is highly susceptible to internal biases, such as the testing effect, where scores increase due to participants' familiarity with the format of the posttest questions. The lack of data triangulation or qualitative analysis to capture student responses throughout the learning process also poses limitations that hinder a deeper understanding of how and why this tool is effective. Therefore, while the Wilcoxon test strengthens the quantitative evidence of score improvement, the design context and its limitations should be considered when drawing overall conclusions about effectiveness.

Conclusions

Based on the research results, it can be concluded that the use of Google Sites media with a STEM approach significantly improved student learning outcomes in plant material. This is evidenced by an increase in the average score from 55.87 to 72.10. The results of the Wilcoxon Signed Ranks Test statistically supported this finding, with a Z-value of -4.818 and a significance level of 0.000 (<0.05), indicating a significant difference between the pretest and posttest scores. However, the increase in the standard deviation from 5.406 to 8.680 indicates that the impact of the intervention was not evenly distributed across all students, with most students experiencing rapid progress, while others did not benefit equally. This indicates the importance of evaluating individual factors such as digital readiness, learning styles, or access to media. Another limitation is the one-group pretest-posttest design without a control group, which makes it difficult to isolate the intervention effect from external influences. Therefore, further research is recommended to use a quasi-experimental design with a control group, as well as expanding the evaluation focus to affective and psychomotor aspects, in order to obtain a comprehensive picture of the effectiveness of this learning media.

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