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# Development of STEAM-based Teaching Materials using Google Sites to Improve HOTS of Fifth Grade Elementary School Students

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**ABSTRACT**

**Purpose**: In response to the low ability of Higher Order Thinking Skills (HOTS) caused by teacher-centered learning and the lack of digital teaching materials that support analytical, evaluative, and creative thinking processes, this study aims to develop Science, Technology, Engineering, Arts, and Mathematics (STEAM) based teaching materials using Google Sites to improve the HOTS abilities of fifth grade elementary school students. **Methods**: This study used the Research and Development (R&D) method with the ADDIE model, which includes the stages of analysis, design, development, implementation, and evaluation. The study was conducted at SDN 26 Kayu Pasak, Padang City, West Sumatra, with 21 fifth-grade students and their homeroom teachers as subjects. Data collection techniques were carried out through observation, interviews, questionnaires, and tests. Data analysis used expert validity tests, practicality tests, and effectiveness tests using N-Gain. **Findings**: Based on the research results, the STEAM-based learning materials created were very practical with a student response rate of 97% and a teacher response rate of 95%, included in the very valid category with a score above 90%, and successfully improved high-level thinking skills with an N-Gain value of 0.84 (high category). **Research Implications:** This study shows how STEAM-based teaching resources can be utilized as a substitute for creative learning to enhance students' HOTS and improve teaching standards in elementary schools. **Originality:** This study focuses on the creation of STEAM teaching resources that are specifically designed and proven to have an impact on improving the higher-order thinking skills of fifth-grade elementary school students through a systematic, reliable, useful, and successful methodology.

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## INTRODUCTION

The rapid advancement of science, technology, and information in the 21st century has had a profound impact on many aspects of human life, including education. These changes not only impact the way people interact and work but also demand changes in the education system to meet the demands of the times. In Indonesia, these changes require teachers to be able to integrate technology and learning innovations to make the learning process more meaningful and in line with the demands of the 21st century. In addition to impacting the way people interact and work, these developments also require changes in the education system to meet the demands of the modern world. The existing education system is no longer sufficient to focus solely on mastering conceptual knowledge; it must also equip students with the skills necessary to face increasingly complex and dynamic global situations. In Indonesia, these changes also require educators to be able to integrate technology and innovative teaching methods to make learning more relevant and in line with the demands of the 21st century (Daryanto & Karim, 2022).

The Four Cs communication, teamwork, critical thinking, and creativity are essential skills for the 21st century (Partnership for 21st Century Learning/P21, 2019; Trilling & Fadel, 2009). These four skills serve as an essential foundation for learning because they motivate students to actively process, evaluate, and apply knowledge in various real-world situations, rather than passively receiving information. Sani (2021) emphasized that 21st-century education in Indonesia must focus on improving literacy, competence, and character through learning exercises that require

students to be engaged, cooperative, and introspective. Higher-Order Thinking Skills (HOTS) are one of the key competencies that complement the 4Cs. Higher-order thinking skills, including analysis, evaluation, and creativity, are included in HOTS (Brookhart, 2010). The Independent Curriculum, which prioritizes problem-based and reasoning-based learning, has made HOTS a top priority in Indonesia (Kemendikbudristek, 2022). Helmawati (2022) emphasized that HOTS is very important to teach students how to think critically, creatively, and make judgments in practical situations.

However, findings from several international assessments indicate that Indonesian students' higher-order thinking skills remain relatively low. The Programme for International Student Assessment (PISA), one of the metrics used, revealed that Indonesian students' literacy levels in reading, numeracy, and science are still below the OECD average (OECD, 2023). Abidin's (2021) statement that learning that still primarily focuses on memorization and does not provide much space for higher-order thinking processes is the cause of low higher-order thinking skills in children further supports this situation.

The learning process, which is still driven by a teacher-centered learning style, is one of the reasons contributing to low HOTS capacity. Wena (2022) stated that learning in many schools in Indonesia still heavily emphasizes one-way information transmission, which discourages students from engaging in inquiry and problem-solving. Furthermore, the numerous routine and procedural questions in the training materials do not fully support HOTS development.

This issue highlights a stark gap between the learning methods used in schools, which still prioritize memorization and procedural questions, and the requirements of the 21st-century curriculum, which emphasizes HOTS (Higher Order Thinking Skills). Furthermore, although numerous studies have created digital learning materials, most still focus on improving general cognitive learning outcomes and have not explicitly incorporated the STEAM approach using Google Sites to improve elementary school students' HOTS, particularly in ecosystem content. These limitations indicate that there is still room for developing learning materials that are not only useful and valid but also effective in improving students' higher-order thinking skills.

Due to this gap, innovation in education is needed through the creation of interactive technology-based teaching materials. Arsyad (2021) states that technology-based learning media can improve learning effectiveness by presenting content in a more engaging, interactive, and easy-to-understand manner. Mayer (2021) also highlights that well-designed multimedia learning can enhance student comprehension through the effective integration of text, images, and video. Arsyad (2021) states that technology-based learning resources can improve learning outcomes by presenting content in a more engaging, interactive, and easy-to-understand manner. Mayer (2021) also highlights how well-designed multimedia instruction can enhance student comprehension by skillfully combining text, images, and video. Using Google Sites as a web-based learning platform is an important way to leverage technology. Google Sites enables the creation of dynamic, adaptive, and easily accessible learning materials. Daryanto (2021) states that because web-based media is not limited by time or location, it can facilitate independent learning and improve the quality of the learning process.

Furthermore, one successful strategy for creating HOTS is the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach. STEAM strongly emphasizes the integration of multiple disciplines through practical problem-solving. This aligns with the Independent Curriculum policy, which prioritizes project-based, contextual, and collaborative learning (Kemendikbudristek, 2022). According to Kurniawan (2023), STEAM can help elementary school students develop their critical and creative thinking skills through project-based learning.

However, field observations indicate that textbooks and student worksheets continue to dominate teaching in elementary schools, which is not yet the best way to support HOTS development. Teachers also revealed that students still struggle to respond to analytical, critical, and reasoning-based questions. This suggests there is still significant demand for innovation in educational media. Based on this description, creating STEAM-based learning resources with Google Sites is seen as a viable alternative to improving elementary school students' HOTS skills.

## METHOD

Reiser and Molenda's ADDIE model was used in this study's research and development (R&D) methodology. The five phases of the ADDIE paradigm are analysis, design, development, implementation, and evaluation. This model was chosen because it follows a systematic process and allows for changes at each stage of development, allowing the final product to be evaluated for feasibility, usability, and effectiveness.

This research was conducted at SDN 26 Kayu Pasak, Palembayan District, Agam Regency. Ten fifth-grade students were selected as research participants for a small-scale pilot phase based on differences in their learning capacities. Afterward, fifth-grade students from SDN 26 Kayu Pasak and SDN 25 Koto Alam participated in extensive

testing. The selection of research subjects was carried out purposively, taking into account the research objectives and the suitability of student characteristics for utilizing Google Sites-based learning materials with a STEAM approach.

Data collection techniques in this study included observation, interviews, documentation, and questionnaires. Observations were conducted to obtain a realistic picture of the learning environment at the school and the learning process in the classroom. Structured and semi-structured interviews were conducted with the principal, fifth-grade teachers, and students to explore learning needs, student characteristics, and obstacles encountered in the learning process. Documentation was used to collect supporting data in the form of photographs of learning activities, learning tools, and other documents relevant to the research. Meanwhile, a questionnaire was used to measure product validity, practicality of media use, and student interest and response to learning. The questionnaire instrument was constructed using a four-point Likert scale: strongly agree, agree, disagree, and strongly disagree. To ensure the quality of the research instrument, validity and reliability tests were conducted.

## RESULTS

This study created learning resources for fifth-grade elementary school students on ecology using a Google Sites-based STEAM approach. The five steps of the ADDIE model analysis, design, development, implementation, and evaluation were used in product development. The final product is a web-based learning platform consisting of e-modules, educational resources, learning videos, STEAM-based worksheets, Google Form-based assessments, and developer profiles.

In the analysis stage, the needs, student profiles, curriculum, and school facilities were all examined by the researcher. According to the findings of interviews conducted with instructors and fifth-grade students at SD Negeri 26 Kayu Pasak, the teaching of science and science on ecology content still uses a lecture and textbook approach, which makes students less engaged in the learning process and more likely to be passive. According to the instructor, to increase students' active involvement in the learning process, they need more interesting, interactive, and technology-based educational materials. Meanwhile, students said that the use of images, videos, animations, and interactive activities during learning makes the subject matter easier to understand. In addition, students want educational materials that are easily accessible through digital devices such as computers and smartphones.

Based on the findings of the student characteristics analysis, fifth-grade elementary school children are at the concrete operational stage, thus requiring the use of visual, contextual, and engaging learning materials. According to observational findings, students are more interested in technology-based learning and enjoy educational activities that combine images, films, animations, and interactive tests. Consequently, the creation of Google Sites-based learning materials is considered appropriate for the characteristics of students from the digital generation. The curriculum study revealed that the school implements the Independent Curriculum with materials created in accordance with the objectives of science learning regarding energy transformation, environmental balance, and the relationships between living things in the ecosystem. In addition, the results of the school facilities analysis indicate that the school has adequate facilities and infrastructure such as LCD projectors, speakers, a WiFi network, Chromebooks, and teacher laptops that can support the implementation of web-based learning media.

In the design phase, using several tools, including Canva, CapCut, and Google Forms, researchers created the appearance and content of Google Sites-based learning materials. The homepage, e-modules, learning materials, learning videos, STEAM-based worksheets, assessments, and developer profiles were the main components included in the media design. Furthermore, researchers created learning aids such as student interest surveys, practicality questionnaires, and expert validation sheets.

Development stage: Created using Google Sites to implement product design into web-based learning resources. The created materials are engaging, easily accessible, and interactive, thus suiting the characteristics of elementary school students. The media's main page attracts students' attention with its topic, "Harmony in Ecosystems," which is illustrated with images of nature. Students will find the content easier to understand because the designed e-module is methodically structured and uses simple language. In addition, the materials include STEAM-based worksheets, learning videos, and Google Form-based assessments that can provide direct feedback to students. Experts in related fields, media experts, and language experts validated the product after it was fully developed. This is shown in Table 1.

**Table 1.** Summary of Learning Media Validation Results

| Nu. | Validation Aspects | Percentage (%) | Category |
|---|---|---|---|
| 1 | Material Expert Validation Phase I | 83.87% | Very Valid |
| 2 | Phase II Material Expert Validation | 92.74% | Very Valid |
| 3 | Media Expert Validation | 91.67% | Very Valid |
| 4 | Linguist Validation | 91.67% | Very Valid |
| **Average** | | **89.99%** | **Very Valid** |

Based on Table 1 above, validation by material experts was conducted twice, as shown in Table 1 above. The very valid category obtained a percentage of 83.87% in the initial validation. The validator provided several recommendations for improvement, including changing the text color to make it easier to read and improving the language of the LKPD. The results of the second validation increased to 92.74% with a very valid category after the changes. The findings indicate that the content created is in accordance with learning objectives, learning outcomes, and student characteristics. Validation by media experts resulted in a very valid category with a score of 91.67%. This evaluation considered presentation elements, visual design, effectiveness, and media quality. The validator recommended that font colors be used in a way that is easier to see. The media was deemed suitable for educational use after the changes were made. In addition, validation by language experts resulted in a very valid category with a score of 91.67%. According to the validator, the language is easy to understand and appropriate for the students' developmental stage. However, the validator recommended that the wording be more interesting and able to arouse children's curiosity.

Implementation stage: Both large-scale and small-group trials were used in the implementation stage. Ten fifth-grade students from SDN 26 Kayu Pasak participated in the small-group trial to assess the usability of the media, as shown in Table 2.

**Table 2. Summary of Learning Media Practicality Results**

| Nu. | Respondents | Percentage (%) | Category |
|---|---|---|---|
| 1 | Practicality by Students | 97% | Very Practical |
| 2 | Practicality by Teacher | 95% | Very Practical |
| | Average | 96% | Very Practical |

Based on Table 2 above, 97% of students who completed the student practicality questionnaire were categorized as very practical. Students reported that the media was interesting, easy to use, helped them understand the subject matter, and increased their enthusiasm for learning. Furthermore, 95% of respondents to the teacher practicality questionnaire were categorized as "very practical." The media was easy to use, the content was in line with the learning objectives, the display was good, and the learning films were easy to understand, according to the teachers' assessment. These findings indicate that the use of Google Sites-based learning resources for teaching science is feasible. Twenty fifth-grade students from SDN 25 Koto Alam participated in a large-scale experiment to evaluate the effectiveness of the educational materials they created. The results of the effectiveness test are shown in Table 3.

**Table 3. Summary of Learning Media Effectiveness Results**

| Nu. | Indicator | Results | Category |
|---|---|---|---|
| 1 | Pretest Average | 62.45 | - |
| 2 | Posttest Average | 93.95 | - |
| 3 | Improving Learning Outcomes | 31.50 | Tall |
| 4 | Average HOTS ability of students | 95% | Very high |

Based on Table 3 above, the average student score on the pretest was 62.45, but increased to 93.95 on the posttest. This increase in scores indicates that the use of Google Sites-based learning resources can improve students' understanding of ecosystem-related content. Because the content is presented visually, dynamically, and contextually through photos, videos, worksheets, and digital assessments, students are better able to grasp the concepts.

The learning materials created not only improve learning outcomes but also help students develop Higher-Order Thinking Skills (HOTS). The findings from STEAM-based assessments and learning activities, which achieved a 95% very high percentage, demonstrate this. Students solved basic problems, demonstrated critical thinking skills, observed interactions between living things in an ecosystem, and connected what they had learned to real-world situations. Students' HOTS skills improved as a result of the interactive features of Google Sites-based learning materials, which included instructional videos, STEAM-based worksheets, and HOTS assessment questions that encouraged students

to think more critically. Thus, the development of critical thinking, creativity, and problem-solving skills in elementary school students was effectively supported by the use of web-based learning resources utilizing Google Sites.

According to the study findings, STEAM-based teaching resources created using Google Sites have met the requirements as valid, useful, and efficient resources for use in teaching fifth-grade science in elementary schools. High media validity indicates that the display, content, and language use are aligned with the learning needs of elementary school students. Media usability indicates how easy the media is to use by both teachers and students, and its effectiveness is demonstrated by the improvement in student learning outcomes and their enthusiasm for learning after using the educational media. These research findings are consistent with other research showing that the use of technology-based learning materials can improve motivation, learning interest, and learning outcomes in elementary school children. The Merdeka Curriculum, which prioritizes active, creative, and student-centered learning, is also supported by the use of Google Sites. Therefore, STEAM-based learning materials and Google Sites for the ecosystem theme are highly appropriate as cutting-edge learning resources to improve elementary school children's attention and learning outcomes.

## DISCUSSION

In development research, validity plays a crucial role in assessing a product's feasibility before it is implemented in the learning process. In his book, Research and Development Methods (2022), Sugiyono defines validity as the level of accuracy between the data reported by the researcher and the data actually occurring in the research object. Therefore, validation is necessary to ensure that the product truly meets the learning objectives and student needs.

Three validators a subject matter expert, a media expert, and a linguist conducted the validation procedure in this study. The learning materials using the Google Sites-based STEAM method achieved a score of 83.87% in the first stage, classified as highly valid, according to the subject matter expert's evaluation findings. This score increased to 92.74%, still classified as highly valid, after changes were made according to the validators' recommendations. The learning materials are now clearer and easier for students to understand thanks to revisions made to text readability, material composition, and terminology usage. Furthermore, validation by the media expert resulted in a very valid category with a validity level of 91.67%. The evaluation covered elements of the learning media's presentation, visual design, effectiveness, and quality. The validators noted that the use of font color needs to be improved to make it more readable and aesthetically pleasing. After the changes, the media became more engaging and suited to the characteristics of elementary school students. Meanwhile, 94.44% of the validation findings from the linguist were included in the very valid category. Language clarity, communication power, interaction, and conformity to Indonesian language standards were all evaluated. To increase students' enthusiasm in learning, the validator recommends using more interesting and communicative language.

Sugiyono's (2022) perspective, which states that a product is considered authentic if it can be used to measure precisely according to the stated objectives, supports the findings of this study. Furthermore, studies on digital-based STEAM education show how the use of technology in the classroom can enhance learning through interactive and contextual media that meet the demands of students in the 21st century. Therefore, learning materials created using the Google Sites-based STEAM method have met the requirements as highly valid and appropriate materials for use in science learning in elementary schools, according to validation results from subject matter experts, media experts, and linguists.

Practicality refers to how easy it is for instructors and students to use educational materials during the learning process. Nienke Nieveen (1999) stated that a product is considered practical if it is easy to use and can be applied in a real educational setting. Aspects of media usability include ease of use, clarity of information, aesthetic appeal, and suitability for educational purposes. Ten fifth-grade students from SDN 26 Kayu Pasak participated in a small-group test, resulting in a practicality percentage of 97%, classified as highly practical. The findings indicated that the Google Sites-based learning resources were easy to use, engaging, and aided students' understanding of the subject matter. Because the media included visuals, educational videos, STEAM-based worksheets, and interactive assessments, students also felt more engaged and motivated. Furthermore, 95% of respondents to the teacher practicality questionnaire fell into the highly practical category. The media presentation, accessibility, relevance to learning objectives, and the use of instructional films that provided students with a more concrete understanding of the ecological content were all praised by the teachers.

The findings of this study support Nienke Nieveen's (1999) statement that a development product is considered practical if users can use it easily and do not face significant learning challenges. Furthermore, according to Riduwan (2020), items with a percentage score higher than 75% are considered highly useful and suitable for use in educational settings. Therefore, teaching resources created using the Google Sites-based STEAM approach have met the

practicality requirements and are suitable for use in science learning in elementary schools, according to the results of trials by students and instructors.

Effectiveness indicates how well learning media achieves stated learning objectives. Suharsimi Arikunto (2021) defines efficacy as the degree of success of an activity in achieving its intended objectives. Improvements in student learning outcomes after using media demonstrate its efficacy in education. The research findings indicate that the use of Google Sites-based learning resources improves student learning outcomes. After using web-based learning resources, the average pretest score of 62.45 increased to 93.95 on the posttest. Each student experienced improved learning outcomes, proving that the learning materials created were useful for teaching the science ecosystem content. The N-Gain test analysis using SPSS, shown in Table 4 below, supports this conclusion.

**Table 4.** Descriptive Statistics

| | N | Minimum | Maximum | Mean | Standard Deviation |
|---|---|---|---|---|---|
| Ngain_Score | 20 | ,61 | 1.00 | ,8483 | ,12768 |
| Gain_Percent | 20 | 60.61 | 100.00 | 84,8299 | 12.76779 |
| Valid N (listwise) | 20 | | | | |

According to Table 4, it is known that 20 students formed the research sample based on the findings of descriptive statistical analysis. According to the analysis results, students' N-Gain Scores ranged from 0.61 to 1.00, with an average of 0.8483 and a standard deviation of 0.12768. The average value of 0.8483 is in the range of values > 0.7, which places it in the high group according to the N-Gain interpretation criteria. This indicates that the use of Google Sites-based STEAM teaching tools can significantly improve student learning outcomes. Furthermore, the N-Gain Percentage data shows an average of 84.8299% and a standard deviation of 12.76779, with a minimum value of 60.61% and a maximum value of 100.00%. Since the average N-Gain percentage is higher than 76%, the average percentage indicates that the level of effectiveness of the learning material is included in the effective group. Because it can improve students' understanding and learning outcomes well, it can be said that the Google Sites-based learning resources created are used in science learning on ecosystem content.

To determine the significance of differences in student learning outcomes before and after using Google Sites-based learning media, a paired sample t-test was conducted on the pretest and posttest data. The test results showed a significant difference between the pretest and posttest scores. This is indicated by a significance value (Sig.) of less than 0.05 ($p < 0.05$), so $H_0$rejected and $H_a$ accepted. Thus, it can be concluded that there is a significant influence of the use of Google Sites-based learning media on improving student learning outcomes.

Furthermore, the higher average posttest score compared to the pretest score also reinforces the finding that learning using web-based media is effective in improving students' understanding of ecosystems. These results indicate that learning media not only improves students' cognitive achievement but also supports a more active, interactive, and meaningful learning process.

**Table 5.** Paired Samples Test

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Standard Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | Pretest - Posttest | -31,50000 | 5,72621 | 1,28042 | -34,17995 | -28.82005 | -24,601 | 19 | ,000 |

The learning materials created not only improve learning outcomes but also help students develop Higher-Order Thinking Skills (HOTS). The HOTS questionnaire findings, which achieved an average percentage of 95% in the very high category, clarified this. Students were encouraged to think critically, creatively, solve problems, and connect course topics to real-world situations through STEAM-based learning. These research findings support Robert E. Slavin's (2020) statement that teaching is considered successful if it significantly improves students' understanding and learning objectives. Furthermore, through problem-based learning, STEAM-based education can encourage the development of 21st-century skills including critical thinking, creativity, communication, and teamwork. Therefore, it can be said that the Google Sites-based STEAM teaching resources created meet the effectiveness criteria because they can improve student learning outcomes and HOTS skills for ecosystem content in elementary schools.

## CONCLUSION

Based on research and development of STEAM-based teaching materials using Google Sites with ecosystem content for fifth-grade elementary school students, it can be concluded that the teaching materials created have met the requirements of being valid, useful, and efficient for use in the learning process.

First, based on validation findings from content experts, media experts, and linguists, the STEAM-based teaching materials created on Google Sites were deemed highly valid. The validation percentages from content experts, media experts, and linguists were 92.74%, 91.67%, and 94.44%, respectively. These findings indicate that the learning materials are suitable for use in teaching science in elementary schools in terms of content, appearance, presentation, and language.

Second, based on the results of small-group testing, the resulting learning materials were deemed highly practical. Students scored 97% in the highly practical area of the practicality questionnaire, while the professor scored 95% in the same category. This indicates that the learning resources are easy to use, engaging, and support students' active and enjoyable understanding of the subject matter.

Third, it has been determined that the use of Google Sites-based STEAM teaching resources improves student learning outcomes and HOTS skills. The average pretest score increased from 62.45 to 93.95 in the posttest, which indicates this. Furthermore, the average score of 0.8483 with a high category and an average percentage of 84.82% with an effective category are shown in the N-Gain analysis findings. In addition, the findings of the student HOTS questionnaire show a very high category with an average percentage of 95%. Consequently, students' critical thinking skills, creativity, and active participation in the learning process can be improved by using Google Sites-based teaching resources. Based on these findings, it can be said that Google Sites-based STEAM teaching materials are suitable for use as cutting-edge learning resources in elementary school science classes about ecosystems.

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