JPPIPA 11(7) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Development of Physics Teaching Materials Based on Google Sites to Improve Students' Collaboration Skills

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Received: April 24, 2025
Revised: June 06, 2025
Accepted: July 25, 2025
Published: July 31, 2025

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DOI: 10.29303/jppipa.v11i7.11871

Abstract: This research is a type of Research and Development (R&D) that implements the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). This study aims to develop physics teaching materials based on Google Sites and test their effectiveness in improving students' collaboration skills. The material trial was conducted on 29 grade XI students of SMAIT Darul Fikri Makassar. The instruments used included a physics teaching material validation sheet, a teacher assessment questionnaire, a student response questionnaire, and a validated collaboration skills test. The results of the study indicate that the development of physics teaching materials is theoretically conceptualized based on the principles of social constructivism learning, connectivism theory, and the principles of collaborative instructional design based on digital technology. Through product validation, the teaching materials are in the valid category with an average Aiken's V value of 0.85. Empirically, it demonstrates practicality with a teacher response percentage of 87.38% and a student response percentage of 76.86%, categorized as very practical. Meanwhile, effectiveness with an average N-Gain of 0.66 is categorized as moderate. Based on these results, the Google Sites-based physics teaching material is theoretically valid through expert assessment, empirically practical, and effective in improving collaboration skills in physics learning.

Keywords: Collaboration skills; Google sites; Teaching materials

Introduction

In the 21st century, the world of education is faced with the challenge of producing a generation that is not only academically superior, but also has character and skills that are relevant to the needs of the times. One strategic effort undertaken by the Indonesian government is through the implementation of the Independent Curriculum. The Independent Curriculum promotes diverse intracurricular learning with a more focused presentation of material, providing space for students to understand concepts in depth and develop their competencies to the fullest. This curriculum emphasizes a student-centered learning approach and provides teachers with flexibility in designing contextual and meaningful learning processes. Implementing the curriculum enables the development of skills that are crucial in the modern world.

According to Wagner (2010), there are seven key skills that students must possess in the modern era: critical thinking and problem-solving, collaboration, agility and adaptability, initiative, effective communication, the ability to access and analyze information, and curiosity and imagination. These skills are expected to prepare students to adapt and succeed in the ever-changing society of the digital age. Chen (2021) explains that collaboration skills are one of the essential skills that must be mastered in today's digital age, due to the rapid development of technology that has made the world increasingly connected and interdependent.

In this era of global connectivity, students are required to be able to work effectively in teams, across

How to Cite:
Nurwina, A., Yani, A., & Arsyad, M. (2025). Development of Physics Teaching Materials Based on Google Sites to Improve Students' Collaboration Skills. *Jurnal Penelitian Pendidikan IPA*, *11*(7), 359–370. https://doi.org/10.29303/jppipa.v11i7.11871

disciplines, and technologies. Collaboration is defined as the process of cooperation and coordination within a group that involves positive interdependence among members to achieve common goals, and enables individuals to work effectively in teams, resolve conflicts, build constructive relationships, and play an active role in group success (Musyaddad et al., 2024; Yuhana & Kusdaryani, 2023).

In an educational context, these skills contribute to improving students' understanding of collaboration, opening new horizons, and strengthening interpersonal skills, which are essential in both academic and professional life. Arifah et al. (2024) emphasize that collaboration skills are an essential 21st-century competency that needs to be developed from an early age, considering that humans, as social beings, are required to adapt and collaborate in both society and the workplace. Students need to be trained to develop these skills through social interactions with peers, teachers, and their surroundings, which can be facilitated through classroom learning, including physics.

According to Arsyad et al. (2020), physics is the backbone of technological development, where a country's technological mastery depends heavily on its people's ability to understand physics. This aligns with Saiye et al. (2024) assertion that physics plays a crucial role in various aspects of life through concepts and principles related to facts and natural laws. As a branch of science that demands an understanding of abstract concepts and the ability to solve complex problems, physics is often considered difficult by students. Therefore, in physics learning, strategies are needed that support the active involvement of students, one of which is through strengthening collaboration skills.

Collaborative learning activities can enhance students' conceptual understanding through meaningful social interactions, where each individual supports and shares responsibility for shared success (Slavin, 1995). Cooperative learning also encourages students to develop the interpersonal skills needed to collectively complete scientific assignments (Johnson & Johnson, 2009). In a collaborative approach, students are encouraged to express their ideas, take greater responsibility for the team's learning outcomes, and are motivated and more actively involved in the learning process, thus positively impacting learning outcomes (Shafira & Amalia, 2023; Qureshi et al., 2023).

The physics learning process can improve students' collaborative skills, one of which is if the learning is designed using appropriate methods and the presentation of teaching materials that are appropriate to the students' needs. According to Prastowo (2015), teaching materials act as supporting tools that facilitate students' independent learning activities. Arends (2012) explains that effective teaching materials must be arranged systematically and relevant to the applicable curriculum, and can support students in developing cognitive and psychomotor skills. In physics learning, the preparation of teaching materials must consider their suitability with scientific principles, so that students not only understand the theory but can also apply it in real life (Sanjaya, 2011).

Research has found that physics is considered difficult, often leading to misconceptions, where students are unable to explain physics concepts accurately according to scientific understanding (Astari et al., 2022). One of the challenges of these misconceptions, particularly regarding temperature and heat, is evident in students' difficulty solving physics problems (Siregar et al., 2024). To address these challenges, the use of technology in learning is a promising solution.

Physics learning is currently undergoing various changes along with the development of digital technology. One platform that can be used is Google Sites (Hakim & Susilawati, 2022). Google Sites is a Google facility that offers features for visiting websites. These sites are managed as websites containing text and instructional videos (Sevtia et al., 2022). According to Harsanto (2014), Google Sites is very easy to manage and use because its menus and features are easy to understand, especially for new users.

The use of Google Sites in physics learning can be tailored to the learning materials being developed and the learning objectives to be achieved. Teachers can add virtual laboratory features to support student collaboration. This aligns with Lestari et al. (2023) and Sulasmianti (2021) who stated that Google Sites-based learning offers benefits for both teachers and students. Google Sites' features facilitate teachers in communicating learning content and actively engage students. Furthermore, Google Sites-based learning tools can support student understanding of the material, enable them to study independently in various locations, and encourage interactive learning activities and improve the quality of learning in schools.

The potential of Google Sites to support collaboration is supported by various studies. Yusuf (2023) research shows that implementing Google Sites in contextual learning can significantly improve student collaboration, marked by an increase in engagement from low to very high during the learning process (61.1 to 100%), as well as increased student activity (30.6 to 81.0%). Similarly, Novira et al. (2024) also showed that the use of Google Sites is quite effective in improving student collaboration skills by up to 98%.

Research by Raffa & Hartina (2022) shows that using Google Sites on temperature and heat can increase student interest and understanding through engaging and interactive visual displays. Furthermore, Wafro

(2024) developed an e-module integrated with Google Sites and found that this approach encouraged active student participation in exploring the concepts of heat and temperature change through discovery-based activities. These research findings reinforce the point that using Google Sites not only provides flexibility in presenting material but also increases engagement and deeper understanding of physics concepts.

Based on theoretical and empirical background and considerations, it is known that improving collaboration skills can be influenced by the design of learning activities, namely the preparation of teaching materials that are appropriate to the needs of students. One platform that can be used as a tool to develop teaching materials that are relevant to current developments is by utilizing technology, such as Google Sites. Therefore, this study was conducted with the aim of developing Google Sites-based physics teaching materials on the topic of temperature and heat, as an effort to improve students' collaboration skills.

Method

Type of Research

This research is a type of research and development (R&D) study using the ADDIE model development method. The ADDIE stages can be seen in the Figure 1.

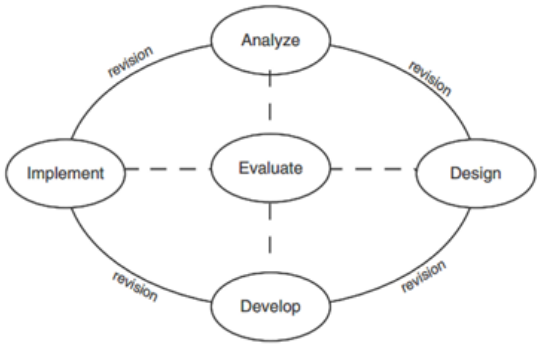


Figure 1. Stages of ADDIE model development (Branch, 2009)

Analysis Stage (Analyze)

The analysis phase is the process of gathering information used to create a product. The product produced in this research is physics teaching materials based on Google Sites. Information collection was conducted through several methods: needs analysis, student analysis, and learning material analysis.

The analysis phase was conducted at SMAIT Darul Fikri Makassar, one of the schools implementing the "Merdeka Curriculum". Through in-depth analysis, it was discovered that physics learning currently takes place exclusively in classrooms. The availability of laboratory space does not support student experimentation due to limited laboratory equipment. Based on interviews with students, it was revealed that physics learning activities rarely involve activities involving collaborative skills. In terms of technological devices, each classroom at SMAIT Darul Fikri Makassar is equipped with a smartboard, or interactive whiteboard, which plays a crucial role in supporting the learning process in the classroom.

The analysis phase was also conducted with students. Information was collected from 11th-grade students at SMAIT Darul Fikri Makassar. The analysis was conducted through direct observation and questionnaires to determine students' basic digital skills, basic collaboration skills, and learning styles. Next, the analysis phase focused on the learning materials. The analysis involved determining the appropriate learning materials for the school curriculum and the students' needs. The materials selected for this study were temperature and heat, which were the main topics for developing the learning materials.

Evaluation at this stage was conducted after the researchers completed all analysis stages. The results of this analysis phase yielded a proposed solution based on the identified problem at SMAIT Darul Fikri, namely the need to design learning that could improve students' collaboration skills through the development of structured and easily accessible learning materials for both students and teachers.

Design Stage (Design)

The design stage is a continuation of the analysis stage, aimed at facilitating researchers in developing the teaching materials to be developed. The design stage consists of data collection criteria, prototype development, and storyboarding.

Data collection is the initial step in developing teaching materials. This includes obtaining teaching materials to be integrated, in the form of concepts, theories, facts, and physics principles relevant to the designated learning topic. In addition to the materials, relevant practice questions are also collected. These practice questions serve to test students' understanding and hone their problem-solving skills. Other data that may be collected could include images, videos, animations, or other digital resources that will enrich and support the delivery of the material. After the data is collected, the next stage is prototype creation. In the context of developing Google Sites-based physics teaching materials, a prototype serves as a draft of how the teaching materials will look and function. A complete prototype for developing Google Sites-based physics teaching materials can be seen in Table 1.

After developing the prototype, the design phase continued with the creation of a storyboard. A storyboard is a series of sketches arranged sequentially following a storyline. This helps researchers convey ideas and facilitates explanations of the teaching materials. The design process utilized the design

application Canva. After the teaching materials were compiled, they were then designed on Google Sites. The researchers ensured that the teaching materials were accessible to anyone with a website link.

Table 1. Prototype of physics teaching material product development based on google sites

Menu	Description
Home page	The Physics Vibes website's initial appearance includes a logo as the platform's identity, the topic title "Temperature and Heat," and supporting banners relevant to the topic. Navigation is provided through menu icons representing key features, and user guides are provided to help users access the content effectively.
Presence	The attendance menu is designed to facilitate student data collection through barcode scanning integrated with Google Forms. This display also includes a navigation button to return to the previous page, ensuring ease of access and use.
Teaching module	This menu contains learning outcomes, learning objectives, teaching modules structured according to the Independent Curriculum format, and a concept map of the Temperature and Heat material. Equipped with a back navigation button, this menu provides systematic access to other components.
Teaching materials	The main material menu presents learning content structured according to the needs of each meeting, following the designed learning flow. There's also a back navigation button for easy access between pages.
Summary	Contains a concise summary of the material on temperature and heat
Student Worksheet	The assignment menu contains collaborative-based activities packaged as student worksheets, tailored to the learning stages. Navigation to the next menu is also provided to support a smooth user experience.
Collaboration space	It provides guidance on implementing collaborative activities, a space for submitting group assignments, and a reflection sheet to evaluate the collaborative process. It also includes navigation buttons to other menus to support ongoing learning activities.
Exercises	The practice questions menu presents short questions arranged based on learning subtopics. There is a special space for collecting assignments, as well as navigation buttons to other menus to support the orderliness and completeness of the learning process.
Assessment	The final learning assessment page contains questions on temperature and heat material.
Developer profile	Contains information about the developer of the teaching materials, including name, photo, and university of origin. Also included is a motivational statement for developing the media as a contribution to improving the quality of learning.

The results of the Google Sites-based physics teaching material design in this study can be seen in Table 2.

Table 2. Draft design of physics teaching materials based on google sites

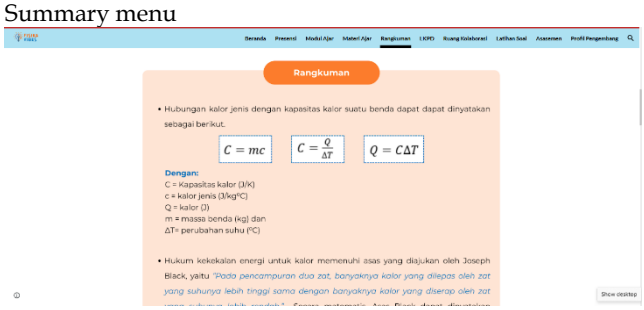
Home page menu

Attendance menu

Teaching module menu

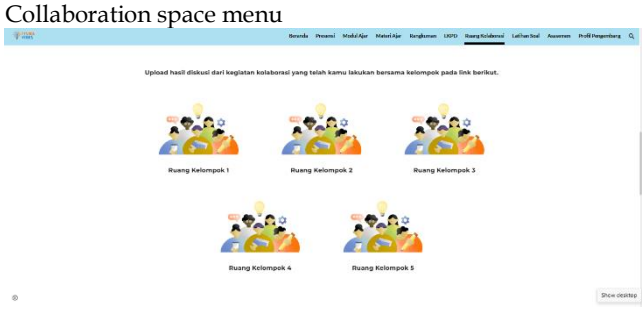
Teaching material menu

Summary menu



Student worksheet menu

Collaboration space menu



Student worksheet menu

Assessment menu

Developer profile menu

After the design phase is complete, the design results are evaluated. Feedback and suggestions from the evaluation are then used as the basis for revisions before proceeding to the development phase.

Development Stage

Development is the stage of realizing what was prepared in the design phase. The teaching materials have been created, printed, and bound, resulting in teaching materials ready for use. At this stage, a product validation process is carried out to assess the validity of the Google Sites-based physics teaching materials and the instruments developed. Several aspects of expert assessment of the Google Sites-based physics teaching materials include the appropriateness of the material/content, presentation, language, and graphics.

Evaluation at this stage involves revisions based on the experts' suggestions and criticisms to improve the Google Sites-based physics teaching materials before implementation at SMAIT Darul Fikri Makassar. The revised teaching materials become the final product used in the implementation phase.

Implementation Stage

The implementation phase is the process of using the developed product in the context of school learning. The implementation phase was conducted after validation by experts and revisions based on feedback received. The trial subjects consisted of 11th-grade students at SMAIT Darul Fikri Makassar. The implementation phase aimed to observe how the teaching materials were used in the learning process and to assess the extent to which the materials could be practically applied, understood by users, and supported the achievement of learning objectives. This phase provided an initial overview of the teaching materials' potential to encourage active student engagement during the learning process.

The implementation phase involved several learning sessions designed to integrate the Google Sites-based teaching materials into classroom activities. Researchers assisted students throughout the learning process and observed the use of the teaching materials. Observations focused on ease of access, clarity of content

presentation, and interactions during use. The observations served as baseline data for assessing the practicality of the teaching materials and identifying potential obstacles during the research process.

Evaluation Stage

The evaluation stage is conducted to measure the extent to which the developed learning product is able to achieve the stated objectives. The evaluation is conducted using a one-group pretest-posttest design, with trials conducted twice, before and after the experiment. The one-group pretest-posttest design can be described as follows (Arikunto, 2013):

O_1	X	O_2

Figure 2. One group pretest-posttest design

Data Analysis

Qualitative Data Analysis

Qualitative descriptive analysis techniques were used to process validator review data in the form of suggestions and comments regarding the developed teaching materials. In this case, the data were obtained in the form of research field notes during observations regarding the use of Google Sites-based physics teaching materials and input from interviews with physics teachers.

Quantitative Data Analysis

Data Analysis for Teaching Material Validation

The content validity coefficient (Aiken's V) was used to determine the level of relevance by experts. The Aiken's V formula is used to calculate the content validity coefficient based on the assessment results of each expert on the product being developed (Azwar, 2012).

$$V = \frac{\Sigma s}{n(c-1)} \quad (1)$$

Description:

V : expert agreement index regarding item validity

s : the difference between the score determined by each expert and the lowest score in the category used

s : $s = r - l_0$

r : rater-assigned score

L_0 : lowest rating score

n : many experts

c : the highest validity assessment number

Aiken test conditions, after calculations are carried out, if $V \geq 0.4$ then the expert agreement index is said to be valid (Azwar, 2012).

Analysis of Practicality Test Results

Practicality data was obtained by analyzing assessment questionnaires completed by subject teachers and student response questionnaires. To analyze the practicality of the developed physics teaching materials, the following steps were taken:

1. Determine the maximum score.
2. Determine the score obtained by adding up the scores from each validator.
3. Determine the percentage of practicality:

$$\text{Practical value} = \frac{\text{Total scores obtained}}{\text{Highest score total}} \times 100\% \quad (2)$$

The percentage of teacher and student responses for each statement using the criteria according to Table 3.

Table 3. Practitioner assessment scoring criteria (Riduwan, 2010)

Percentage (%)	Category
76–100	Very Practical
56–75	Practical
26–55	Less practical
0–25	Not Practical

Analysis of the Effectiveness of Google Sites-Based Physics Teaching Materials

The effectiveness of Google-based physics teaching materials can be determined by testing students' collaboration skills. To measure the improvement in students' collaboration skills before and after using the teaching materials, the normalized average gain formula is used. The N-Gain test is conducted using the following formula (Sundayana, 2014):.

$$< g > = \frac{X_{posttest} - X_{pretest}}{X_{maximum} - X_{pretest}} \times 100\% \quad (3)$$

The N-Gain calculation is then interpreted using the categories in Table 4.

Table 4. Normalized gain score categories (Sundayana, 2014)

Limits <g>	Category
$0.70 < g \leq 1.00$	High
$0.30 < g \leq 0.70$	Medium
$0.00 < g \leq 0.30$	Low

The average results of the standard gain values which are converted into percentage form are then categorized based on the interpretation of the effectiveness of the standard gain as in Table 5.

Table 5. Interpretation of standard gain effectiveness (Puspita & Setyaningtyas, 2022)

Interval (%)	Category
$g \leq 55$	Not effective
$g \geq 56$	Effective

The use of physics teaching materials based on Google sites is said to be able to improve students' collaboration skills if 70% or more of students feel that the gain score is ≥ 56% or in the effective category.

Result and Discussion

Development of Google Sites-Based Physics Teaching Materials to Improve Students' Collaboration Skills Theoretically

The development of teaching materials is a crucial part of educational innovation to address 21st-century challenges, particularly in the context of science learning, such as physics. To support students' collaborative skills, the developed teaching materials must address aspects of scientific substance and foster active interaction, team communication, and shared responsibility. Development is based on constructivist theory, which explains that learning is more meaningful when students are actively involved in constructing knowledge through collaborative activities (Wadsworth, 2004; Vygotsky, 1978).

The development of teaching materials begins with an analysis phase involving three aspects: needs analysis, student analysis, and learning materials analysis. The analysis results indicated that students often struggle to understand the concepts of temperature and heat due to their abstract nature, necessitating interactive teaching materials that encourage teamwork. The physics topic of temperature and heat was chosen because of its conceptual and applicable nature, necessitating a learning approach involving discussion and collaborative exploration to strengthen understanding. The topic of temperature and heat requires students to understand the concepts of heat transfer, specific heat, heat capacity, and practical applications such as changes in state and latent heat. These concepts require a visual approach, experiments, and conceptual discussions.

The results of the analysis serve as the basis for continuing the development of teaching materials to the design stage. The design of the Google Sites-based physics teaching materials developed in this study includes a structure that supports collaborative activities, including dedicated pages for group collaboration and reflection, and Google Docs integration for collaborative manuscripts designed for collaborative work. The Google Sites-based physics teaching materials enable independent learning, significantly strengthening individual accountability as part of a team. In the temperature and heat lessons, students can explore videos, graphs, and simulations independently before discussing them with their group mates. According to Siemens (2005), connectivism emphasizes that effective learning occurs within digital social networks that enable the open exchange of information.

Google Sites was chosen because of its advantages in terms of ease of access and the ability to integrate various learning components. This is supported by the opinion of Nuraeni et al. (2023), who stated that Google Sites is easily accessible and effective in capturing students' attention in physics learning. Google Sites is an efficient learning medium because it allows students to quickly access learning information, anytime, anywhere (Rosiyana, 2021). The development of Google Sites-based physics teaching materials on temperature and heat has been designed in accordance with collaborative and digital learning principles relevant to the needs of today's students. These teaching materials support the achievement of 21st-century educational goals and contribute to improving students' collaboration skills through structured and directed learning activities. Collaborative skills are essential for students to solve problems more effectively and encourage better critical thinking.

According to Serevina et al. (2022), collaborative skills are crucial for training students to work effectively together and not be individualistic. Collaborative skills are crucial in physics learning because they can improve understanding of physics concepts, where students can help each other solve problems and explain concepts to other group members. Collaboration in physics learning can also help increase student motivation and engagement in learning because they are given the opportunity to work together and contribute within a group (Tran, 2019; Vauras et al.; 2019).

In this study, students' collaboration skills were measured using an assessment instrument consisting of a pretest with 25 items and a posttest with 25 items. Consistent with Simamora et al. (2024), each student's collaboration skills can be determined by measuring them using an assessment instrument. An instrument is a tool used to measure and collect data or information in research and assessment (Arikunto, 2010). Instruments play a crucial role in determining the quality of research and assessment. After the design phase, the teaching materials and instruments were validated by experts to assess their suitability for use in this study. This validation served as the basis for theoretical development before empirical field testing. The results of the expert validation are presented in the following paragraphs.

Content Validation Results of Physics Teaching Materials Based on Google Sites with Aiken's V Index

The assessment of the validity of the developed Google Sites physics teaching materials was carried out by three experts who provided assessments and input on four aspects of feasibility, including the content

feasibility aspect containing 13 statement items, the presentation feasibility aspect containing 12 statement items, the language feasibility aspect consisting of 7 statement items, and the graphic feasibility aspect consisting of 8 statement items, with a total of 40 statement items. The obtained test scores for the validity coefficient analysis of the expert agreement index with the Aiken's V index are presented in Table 6.

Table 6. Analysis test of physics teaching materials based on google sites with Aiken's V index

Aspect	Total validity item scores	Validation Index	Category
Content	11.11	0.69	Valid
Presentation	10.11	0.84	Valid
Language	5.89	0.84	Valid
Graphics	6.78	0.85	Valid
Average	33.89	0.85	Valid

Source: processed primary data (2025)

Based on the data presented in Table 6, the validity test results for the content feasibility aspect obtained an index of 0.69, for the presentation feasibility and language feasibility aspects obtained the same index of 0.84, while for the graphic feasibility assessment aspect obtained an index of 0.85. Overall, the average index value of the four aspects analyzed was 0.85, meaning that the analyzed V index was ≥ 0.4, indicating that the expert agreement index was valid. This indicates that the physics teaching materials based on Google Sites are worthy of being continued for limited trials. The results of the development of physics teaching materials based on Google Sites that have been validated by experts can be accessed at the following link: https://sites.google.com/view/fisikavibes/

Validation Results of Teacher/Practitioner Assessment Questionnaire for Google Sites-Based Physics Teaching Materials

The expert validation data on the teacher assessment questionnaire instrument from 25 statement items were then analyzed using the Aiken's V expert agreement index. The results of the validity analysis test of the teacher assessment questionnaire instrument obtained an expert agreement index of 0.88 which is in the valid category. Based on this, the teacher/practitioner assessment questionnaire for physics teaching materials based on Google sites is declared suitable for use in the field without revision.

Validation Results of Student Response Questionnaire for Physics Teaching Materials Based on Google Sites

The expert validation data on the student response questionnaire instrument from 25 statement items were then analyzed using the Aiken's V expert agreement index. The analysis was used to see the feasibility of the student response questionnaire instrument before use. The results of the validity analysis test of the student response questionnaire instrument obtained an expert agreement index of 0.84 which is in the valid category. Based on this, the student response questionnaire was declared suitable for use in the field with minor revisions.

Collaboration Skills Test Validation Results

The instrument was validated by three experts to determine the feasibility of each statement. Each statement consisted of 25 items, each comprising five indicators: focus on shared goals, positive interactions, roles and responsibilities, active involvement, and flexibility and compromise. The results of the validity analysis of the collaboration skills test instrument for the pretest are shown in Table 7.

Table 7. Pretest analysis test of collaboration skills with Aiken's V index

Indicator	Total validity item scores	Validation Index	Category
Focus on shared goals	4.45	0.89	Valid
Positive interactions	6.34	0.91	Valid
Roles and responsibilities	4.23	0.85	Valid
Active involvement	3.34	0.84	Valid
Flexibility and compromise	3.67	0.92	Valid
Average	22.00	0.88	Valid

Source: processed primary data (2025)

The results of the validity analysis of the collaboration skills test instrument for the posttest can be seen in Table 8.

Table 8. Posttest analysis test of collaboration skills with Aiken's V index

Indicator	Total validity item scores	Validation Index	Category
Focus on shared goals	4.56	0.91	Valid
Positive interactions	5.79	0.83	Valid
Roles and responsibilities	4.45	0.89	Valid
Active involvement	3.67	0.92	Valid
Flexibility and compromise	3.34	0.84	Valid
Average	21.78	0.87	Valid

Source: processed primary data (2025)

The expert assessment of the pretest and posttest instruments to measure students' collaboration skills was found to be suitable for use in the field with minor revisions. The expert's suggestions and input included revising the sentence structure used in each ambiguous statement. The revised instrument is ready to be

implemented to measure the collaboration skills of 11th-grade students at SMAIT Darul Fikri Makassar.

Development of Google Sites-Based Physics Teaching Materials to Empirically Improve Students' Collaboration Skills

The empirical approach encompasses the stages of product implementation in the classroom and field evaluation. Implementation was conducted on trial subjects: physics teachers and 11th-grade students at SMAIT Darul Fikri Makassar. At this stage, the teaching materials were used directly in learning activities to assess the practical application of the product and to observe student responses to the Google Sites-based physics teaching materials. This stage provides an initial overview of the quality of the teaching materials, particularly in encouraging active student participation, facilitating group work, and developing communication skills and shared responsibility.

The results of the practitioner assessment and student responses to the developed Google Sites-based physics teaching materials are presented in the following paragraphs.

Practitioner Assessment of Google Sites-Based Physics Teaching Materials

The assessment of the practicality of the Google Sites-based physics teaching materials was obtained through a questionnaire completed by high school physics teachers. The questionnaire was designed to evaluate the appropriateness of the content, appearance, language, and graphics of the developed teaching materials. Based on the results of the data analysis, the average percentage of the practitioners' assessment score was 87.38%. This percentage is included in the very good category, indicating that the Google Sites-based physics teaching materials are considered practical and suitable for use in classroom learning. The assessment from practitioners reflects the extent to which the developed products can be implemented effectively in the classroom. The data obtained indicate that the developed teaching materials are easy to use and appropriate to the needs of teachers and learning conditions in the field.

Student Responses to Google Sites-Based Physics Teaching Materials

Student responses provide a direct picture from the perspective of the primary user, namely the student, regarding the extent to which the developed teaching materials are able to meet learning needs, encourage group interaction, and provide a fun and meaningful learning experience.

Based on the analysis of the collected questionnaire data, the average percentage of student responses was 76.86%, which is considered very good. This indicates that students responded positively to the teaching materials used, both in terms of content, language, and the developed presentation. This response indicates that the developed teaching materials are not only technically easy to use but also able to stimulate active student involvement in collaborative activities, as is the main objective of developing these teaching materials.

Effectiveness of Google Sites-Based Physics Teaching Materials

The effectiveness of the developed Google Sites-based physics teaching materials can be seen from the results of measuring students' collaboration skills. Measurement of the collaboration skills of grade XI students of SMAIT Darul Fikri Makassar was carried out using a test of 50 statements, each given 25 items in the pre-test and 25 items given after learning using Google Sites-based physics teaching materials. The results of the analysis of students' collaboration skills test scores during the pre-test can be seen in Table 9.

Table 9. Results of collaboration skills test score analysis

Parameter	Pretest Score	Posttest Score
Minimum ideal score	0	0
Maximum ideal score	100	100
Minimum empirical score	49	67
Maximum empirical score	70	91
Average	59.39	85.03

Source: processed primary data (2025)

Based on Table 9, we can see an improvement in students' collaboration skills, as seen from the pretest and posttest scores of 29 students. The average score before the treatment was 59.39, while after learning using Google Sites-based teaching materials, the average score obtained through the posttest was 85.03. The diagram of the pretest and posttest results can be seen in Figure 3. The results of the collaboration skills test scores from the pretest and posttest were then analyzed to determine the effectiveness of using Google Sites-based teaching materials. The results of the N-gain analysis can be seen in Table 10.

Based on the data presented in Table 10, the effectiveness of using Google Sites-based physics teaching materials shows variation among students. Through the analysis conducted, it shows that there are 8 students who are in the ineffective category in improving collaboration skills, on the other hand, the majority of students, namely 21, showed effective results. The average N-Gain score for student collaboration skills is 0.66 which is in the moderate category. The N-Gain percentage of 65.63% indicates that the use of Google Sites-based physics teaching materials is effective in improving student collaboration skills.

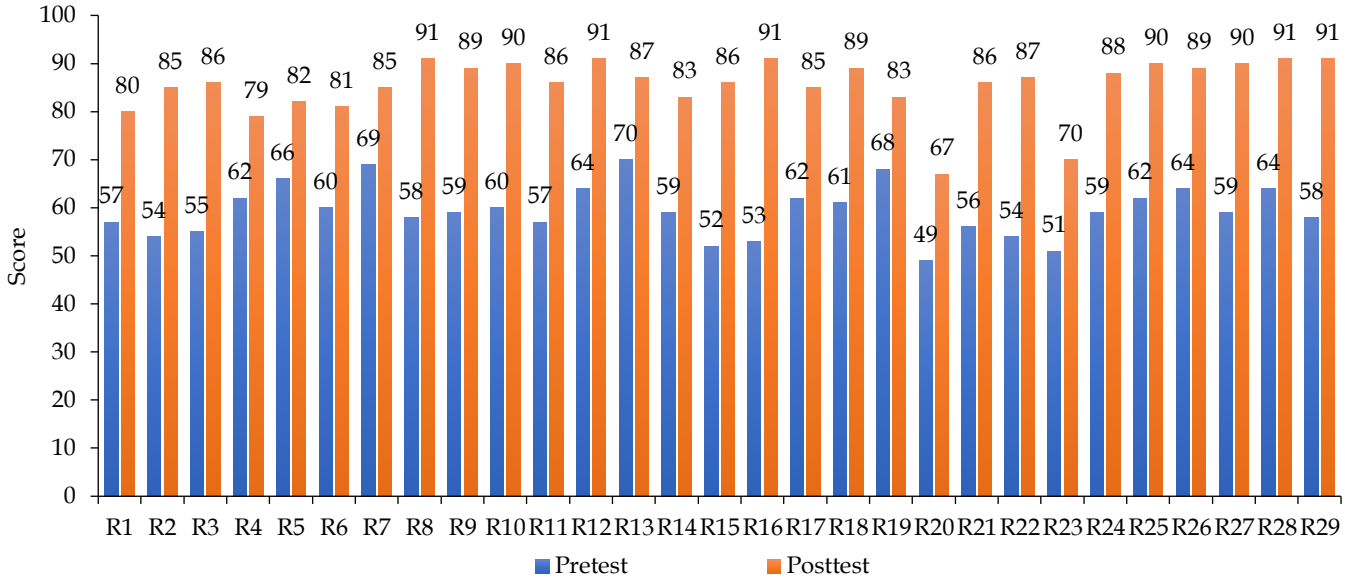


Figure 3. Pretest and Posttest of Students' Collaboration Skills (Source: Processed Primary Data, 2025)

Table 10. Percentage of effectiveness of using google sites-based physics teaching materials

Interval %	Category	Number of students	Average N-gain	% N – Gain
g ≤ 55	Not effective	8	0.66	65.63
g ≥ 56	Effective	21		

Source: processed primary data (2025)

Through observations made during the learning process, students demonstrated active involvement in group collaboration, which supported positive interactions between students. Structured learning materials, with an emphasis on role allocation, collaboration, and reflection, guided students in effectively dividing roles and responsibilities in collaboration. Physics learning materials were presented via a website, allowing students to access them again when they wanted to learn more about temperature and heat.

The developed teaching materials make it easier for educators to present various phenomena related to temperature and heat in a single platform, without having to switch applications. The use of Google Sites in learning makes it easier for teachers to share materials according to needs and allows for the addition of various types of information within a single platform, such as text, videos, presentations, and documents that can be downloaded by students (Mukti et al., 2020; Sevtia et al., 2022).

Conclusion

Based on the results of the research and discussion described, it was concluded that theoretically the development of physics teaching materials based on Google Sites was conceptualized based on the principles of social constructivism learning, connectivism theory, and the principles of collaborative instructional design based on digital technology. Through validation of the teaching material product, it was in the valid category with an average Aiken's V value of 0.85, while empirical development showed practicality with a percentage of teacher responses of 87.38% and a percentage of student responses of 76.86% in the very practical category, and effectiveness with an average N-Gain of 0.66 in the moderate category. Based on these results, physics teaching materials based on Google Sites were theoretically assessed through expert assessment as valid, empirically assessed as practical, and effective in improving collaboration skills in physics learning.

Acknowledgments

My deepest gratitude goes to the supervisor who has guided the completion of this literature study until completion, and my gratitude to the teachers of SMAIT Darul Fikri Makassar who have provided the opportunity and service facilities during the research. My gratitude to the University of Mataram for facilitating the preparation of this article. My gratitude to my parents, siblings, and friends for their prayers, cooperation, and support.

Author Contributions

A.N.: Conceptualization, methodology, original draft writing, formal analysis, investigation, visualization, writing—review and editing; A.Y. & M.A.: Validation, supervision, and resources. All authors have read and approved the published version of the manuscript.

Funding

This research received no external funding.

Conflicts of Interest
The authors declare no conflict of interest.

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