



Developing an interactive e-worksheet based on group investigation, integrating local wisdom to distinguish facts and opinions in informative texts

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Abstract

This study aims to analyze the needs, media design, validity, feasibility, and effectiveness of the media to enhance elementary school students' reading literacy in distinguishing facts from opinions. This study used the ADDIE approach, with 9 fifth-grade students for limited testing and 16 students for field testing at the Muhammadiyah Ngadirejo Elementary School. Data collection was carried out through participatory observation, interviews, questionnaires, pre-test, and post-test. Addressing student passivity and difficulties in verifying facts and opinions, Gemini Ai was used to design interactive features of an e-worksheet integrating group investigation syntax and Temanggung local wisdom. Deemed very feasible across content, language, and display aspects, the media scored 96.43% from material experts and 93.75% from media experts. Additionally, the response rates from teachers and students were 88.33% and 92.22%, respectively, in the very practical category, while participatory observation showed a student activity score of 90.4%. The media proved to be effective (Sig. (2-tailed) = 0.000 < 0.05) with an N-Gain score of 0.69 in the limited trial and 0.68 in the field trial. These findings indicate that using Gemini Aito to develop an interactive e-worksheet based on group investigation and integrated with local wisdom is feasible, practical, and effective in improving grade V students' ability to distinguish opinions from facts in informative texts.

ARTICLE HISTORY

Received:

13 January 2026

Accepted:

12 February 2026

Published:

31 March 2026

KEYWORDS

Fact and Opinion;
Group Investigation;
Interactive e-
worksheet;
Local Wisdom;
Prompt Engineering.



1. Introduction

Indonesian basic education in the 21st century faces complex challenges in strengthening students' reading literacy and critical thinking skills. The latest report from the Programme for International Student Assessment (PISA) in 2022 notes that Indonesia's reading literacy score has dropped to 359, placing Indonesia at the lowest level, namely 1 C (Amelia et al., 2024; OECD, 2023). To overcome this deficiency, applying Higher Order Thinking Skills (HOTS) is essential to cultivate students' independent problem-solving abilities (Wiranata et al., 2024). Furthermore, reading literacy skills must be integrated through Indonesian language learning—specifically in comprehending informative texts—



because language skills and reading are the gateway to transferring knowledge (Simbolon, 2023; Tarigan, 2015).

In particular, the ability to distinguish facts and opinions in informative texts remains an issue that needs attention. This skill requires a high level of analytical reasoning to verify the validity of information. Recent studies emphasize that analytical thinking skills are essential to empower individuals to critically evaluate information and reduce vulnerability to disinformation in the digital age (Leba et al., 2025). Although this skill can theoretically be improved through technological interventions and structured learning, the reality on the ground shows that efforts to train elementary school students in Indonesia in critical thinking skills still face various fundamental obstacles.

Based on the preliminary study conducted at the Elementary School of Muhammadiyah, the reality on the ground confirms these theoretical concerns. The results of participatory observation in the classroom showed that the learning process applied is still conventional and teacher-centered. The teacher's explanations take a long time, reducing the time students must practice questions independently. As a result, students become more passive listeners without being actively involved in discussion or problem-solving activities. Accordingly, the survey results given to fifth-grade students show that 57.95% of students find the teacher's lessons boring, and more strikingly, 62.66% of students have difficulty verifying facts and opinions in the text. These problems need to be addressed immediately with a learning model that is no longer teacher-centered but actively involves students in the learning process.

Specifically, the core issue lies in the students' low proficiency in distinguishing facts and opinions in informative texts. This skill is a crucial component of 'elementary clarification' in critical thinking, which requires students to focus on a question and analyze arguments. Research indicates that this specific clarification skill is often underdeveloped in elementary students, limiting their ability to verify information validity (Kumala et al., 2022). To address this, empirical evidence demonstrates that active learning models assisted by interactive media effectively improve students' mastery of fact and opinion sentences (Widyastuti & Afrita, 2025). Therefore, the model integrated into the media in this study is proposed as the optimal solution, as it provides the active engagement necessary to transform theoretical knowledge into practical analytical skills.

A student-centered learning model that can be applied is the Group Investigation cooperative model. According to Jarolimek and Parker (as cited in Hasanah & Himami, 2021), this model creates a positive classroom climate, tolerates differences, and makes class enjoyable. In addition, students learn in

small groups to share knowledge, ask questions, and work together so that they can deepen their understanding, develop social skills, and broaden their perspectives (Salamun et al., 2023). The syntax of the group investigation model, which consists of grouping, planning, investigating, organizing, presenting, and evaluating, enables active student participation in the learning process (Purwati, 2024; Yohana, 2022). This indicates that the group investigation model is suitable for application in elementary schools that have been selected as research sites.

Learning media also needs to be developed to support the success of the teaching and learning process. The purpose of learning media is to convey learning messages so that they can stimulate students' attention, interest, thoughts, and feelings in learning activities (Sapriyah, 2019). Mayer's multimedia theory is more effective when text and images are presented simultaneously (Suprihatin et al., 2024). Moreover, fifth-grade elementary school students are generally aged 10–11 years old, which is the stage of concrete operational development in Piaget's theory. Students are already capable of thinking logically about real objects and events, understanding cause-and-effect relationships, and developing the ability to classify and sort information (Nainggolan & Daeli, 2021). Therefore, the media developed must facilitate students' cognitive and psychological needs.

Previous literature has proven that the transformation of learning media from conventional to electronic effectively improves student learning outcomes. Supporting this, Friska et al. (2022) demonstrated that digital E-LKPDs containing text, images, and interactive navigation help students understand material more easily. These tools enable direct interaction via features like digital page flips and video links, which are not available in printed versions. However, technological advances alone are not enough if the learning content is not contextual (Sutarto et al., 2025). The integration of local wisdom into the curriculum has proven crucial in bringing learning materials closer to the realities of students' lives while strengthening character in the era of globalization (Annisha, 2024; Fitriyeni, 2023; Rizal & Nur, 2024). Despite this digital advancement, the availability of electronic learning media that integrates Temanggung's local wisdom is still limited.

Based on these backgrounds, there is a need to develop an interactive e-worksheets that is capable of presenting attractive visualizations, increasing motivation, and providing immediate feedback to students (Rusfriyanti & Rondli, 2023; Shelviana et al., 2023). The effectiveness of digital media is maximized when integrated with cultural context. Safitri et al. (2024) found that e-worksheets based on local potential successfully overcome the limitations of conventional materials, resulting in higher student involvement and critical thinking skills. In line with these findings, the development of media by incorporating

Temanggung's local wisdom into an interactive e-worksheet allows abstract material to become more relevant and easier for students to understand.

Although platforms such as Canva Pro, Wizer.me, or Live worksheets are effective in improving student learning outcomes (Anti & Wardani, 2024; Anggoro, 2023; Sobri et al., 2023; Suprihatin et al., 2024), these platforms are limited by premium costs and rigid interfaces. Therefore, Gemini AI was chosen as a free, fully customizable alternative that can compete with similar AI for media development needs (Masalkhi et al., 2024; Nader et al., 2022; Sančanin & Penjišević, 2022). The wise use of AI is in line with recent research showing that the appropriate use of AI can improve the technical efficiency of teaching material development and facilitate the digital literacy of teachers and students (Arini & Nursa'ban, 2024; Fauziddin & Agustin, 2024; Pratiwi et al., 2025). Hence, with the help of AI, researchers can ensure that these media products can be developed effectively and efficiently.

This study offers novelty through Group Investigation (GI)-based e-worksheets that synthesize Temanggung's local wisdom with the efficiency of Generative AI. Importantly, this utilization is grounded in academic competence and responsibility, as emphasized by Sugiyono (2025). To mitigate risks such as hallucinations and dependency, researchers have undergone specialized training in the development of artificial intelligence (AI)-based media and studied prompt engineering techniques. This expertise enables the establishment of strict contextual boundaries, including explicit instructions for Gemini AI to acknowledge its inability or refuse requests rather than fabricating information. As a result, Gemini AI functions solely as a collaborative discussion partner and tool, ensuring that researchers retain full control over the validity and accuracy of the media developed. The synergy between GI-based media structure, local cultural content, and Gemini AI technology efficiency is specifically formulated to address students' challenges in distinguishing facts and opinions in informative texts.

This study fills gaps in previous research in three main ways. First, it develops interactive electronic worksheets based on the Group Investigation Model, which is grounded in Vygotsky's social constructivism, proven to be essential for the cognitive development of Generation Alpha students (Malik et al., 2025). Second, this study integrates local wisdom from Temanggung to make literacy contextually relevant (Fadilah, 2025), while ensuring cognitive rigor through the validation of informative texts (Putri et al., 2024). Third, this study uses Generative AI to accelerate the production of visual assets and program code, improving development efficiency, supported by the TPACK framework related to teacher-led technology integration (Habibi et al., 2023). This integrative

approach addresses the weaknesses of conventional learning models and media innovation in improving elementary school students' information validation skills.

Based on the background described above, this study aims to develop an E-worksheet for fifth-grade students at SD Muhammadiyah Ngadirejo, specifically to: (1) describe the needs analysis and media design; (2) analyze the validity of the product through assessment by subject matter and media experts; (3) evaluate the feasibility of the media based on teacher and student responses; and (4) determine the effectiveness of the media in improving students' ability to distinguish between facts and opinions.

2. Methods

This research applied the ADDIE approach developed by Branch (2009) to ensure that learning is designed in a structured, effective manner that is tailored to the needs of students (Rayanto, 2020). Media development is geared toward creating innovative, student-centered learning experiences that are adaptable to situations without barriers of space and time (Shelviana et al., 2023). This model allows for continuous evaluation during the development process, resulting in learning products that are effective and relevant.

The researchers initiated the analysis stage with a needs analysis at the Muhammadiyah Ngadirejo elementary school, which included an examination of learning outcomes for Phase C of the Indonesian Language Subject for Grade 5, an analysis of the characteristics of Grade 5 students, and an assessment of the potential of the Temanggung region. The analysis showed that conventional teacher-centered learning caused student passivity and difficulties in learning Indonesian, especially in reading comprehension, particularly in distinguishing facts from opinions. As a result, the Group Investigation model was chosen to encourage active collaboration, while Temanggung's local wisdom, presented in visual and audio-visual forms and attractive interactive features, was integrated to provide a familiar context that reduced boredom and improved conceptual understanding. In addition, the researchers designed materials with the integration of local cultural topics at the design stage. The design process continued with the creation of flowcharts and storyboards, as well as the development of evaluation instruments, including pre-tests, post-tests, and validation sheets.

The development stage was carried out using Gemini AI through prompt engineering techniques, while the learning videos were produced using Canva and CapCut. The resulting prototypes were then verified by subject matter and media experts, who were selected based on their academic backgrounds (teaching courses relevant to the criteria of subject matter and media experts)

and at least five years of experience in their respective fields. The verification instrument was adapted from BSNP standards and consisted of 21 indicators for material verification (covering content, presentation, and linguistic appropriateness) and 12 indicators for media verification (relevance of group investigation models, technical quality, audio-visual quality, and usability). After receiving feedback, the prototype was revised to ensure product feasibility.

The subjects of the implementation phase in this study consisted of fifth-grade students at Muhammadiyah Ngadirejo Elementary School in the 2024/2025 academic year. Participants were selected through purposive sampling to ensure diverse representation in academic ability, which was categorized as high, medium, and low. This study involved 9 students in the limited trial phase and 16 students in the field trial phase. Ethical standards were strictly maintained through official permission from the school and university. To ensure privacy, all identities were anonymized; for example, S1-1 code identified the first student in the limited trial, while S2-1 code indicated the first participant in the field trial. The data collected was used exclusively for research and product development purposes.

Data collection was conducted using expert validation sheets, teacher response questionnaires, student activity observation sheets, and learning outcome tests. According to Sugiyono (2025), combining these various techniques and data sources is called data triangulation to ensure the objectivity and validity of the research results. Data collection used instruments with different Likert scales. Expert validation and participatory observation use a 4-point Likert scale to avoid central tendency bias, while teacher and student response questionnaires use a 5-point Likert scale to accommodate a wider variety of user responses (Koo & Yang, 2025). The teacher's response questionnaire consisted of 12 items across three aspects: interest (4 items), material and learning (5 items), and language (3 items). Similarly, the student's questionnaire contained 10 items measuring interest (4 items), material comprehension (4 items), and language clarity (2 items). The results of the point recapitulation were then converted into a total percentage with categorization according to the measurement concept (Abubakar, 2021). Categorization refers to Table 1.

Table 1.

Categorization of Percentage Score Conversions.

No.	Percentage Range	Category (Validity / Activity / Practicality)
1.	81% – 100%	Very Valid / Very Active / Very Practical
2.	61% – 80%	Valid / Active / Practical
3.	41% – 60%	Quite Valid / Quite Active / Quite Practical
4.	21% – 40%	Less Valid / Less Active / Less Practical
5.	0% – 20%	Invalid / Inactive / Impractical

Source:(Abubakar, 2021)

As evidence to reinforce the effectiveness of the product, an N-Gain (Normalized Gain) test was conducted to measure the extent of improvement in students' understanding after being given the treatment. The calculation used SPSS version 25 to facilitate data processing with the N-Gain formula = (Posttest Score - Pretest Score) / (Maximum Score - Pretest Score) developed by Hake (1998). Given that the sample size was less than 50 ($N < 50$), the Shapiro-Wilk test was used to test the normality of the data. Once the prerequisite was met, hypothesis testing was performed using a Paired Sample T-Test with a significance level of 0.05. Categorization based on scores is presented in Table 2 below.

Table 2.

Categorization of N-gain scores.

N-Gain Score (g)	Category
$g > 0,70$	High
$0.30 \leq g \leq 0.70$	Medium
$g < 0,30$	Low

Source: (Hake, 1998)

The hypotheses proposed are H_0 (there is no significant difference between learning outcomes before and after the use of media) and H_a (there is a significant difference). The basis for decision-making is that if the Sig. (2-tailed) value is < 0.05 , then H_0 is rejected, and H_a is accepted, which means that learning media effectively improves learning outcomes. The results of the expert validation, teacher responses, student responses, and participatory observation are then presented as averages for each indicator and as percentages.

3. Results

3.1 Need and design of group investigation-based interactive e-worksheet

The needs analysis conducted at the elementary school of Muhammadiyah Ngadirejo indicates that the main causes of passive learning were instructional dependence on static textbooks, which were often contextually irrelevant, and conventional learning models that did not provide enough time for students to think and solve problems. To overcome this, the group investigation model-based interactive e-worksheet was developed using some digital applications to allow students to take on the role of detectives and actively participate in discussions. For example, video assets with narration and voice-overs recorded by the researchers, which were edited using CapCut and Canva. In addition, Gemini AI was used as a coding assistant with prompt engineering techniques to translate storyboards into HTML5 code structures.

The group investigation-based interactive e-worksheet also leverages the rich potential of Temanggung Local Wisdom. For example, informative texts were compiled with the following investigation: Warok Art, Bambu Runcing, Ayam Cemani, Posong Tourism, Kampung Dolanan, and Pringapus Temple. The specifications of the group investigation-based interactive e-worksheet include interactive features, work instructions, tiered missions aligned with learning objectives, and automatic evaluation (See figures 1 and 2).

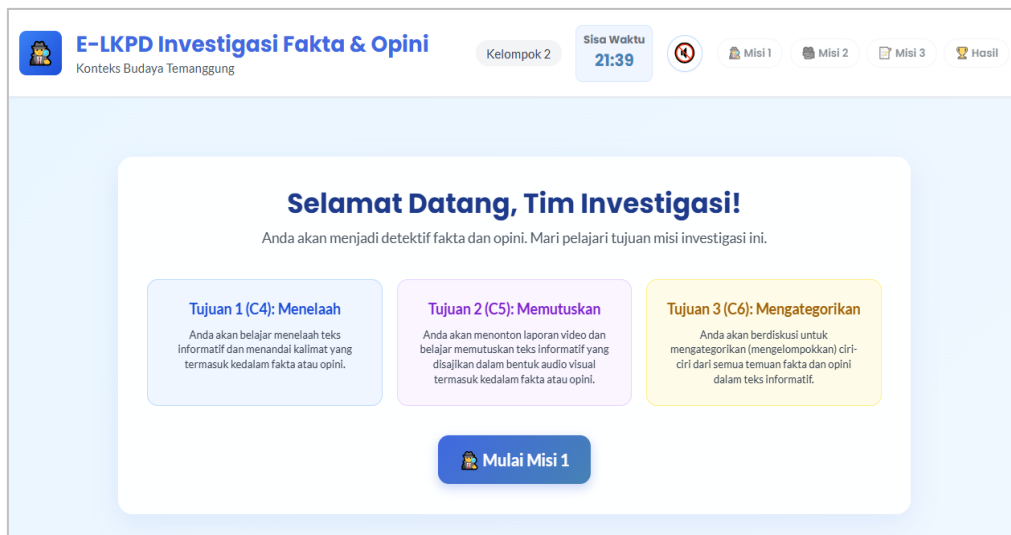


Fig. 1. Activity investigation briefing page.

The construction process began with the creation of a systematic workflow that included team login features, objective briefings, and tiered missions with varied interactive elements. Specifically, the researchers designed an automated assessment system by defining mandatory keywords that the algorithm must detect to validate student arguments in essay tasks. Furthermore, evaluation logic was applied to each mission with different weightings, which were then accumulated in real-time into a total score. Finally, instructions were added to refine the 'Download PDF' feature, which facilitates group presentations and teacher reflection.

The code from the prompt engineering results is copied into a simple text editor (such as Notepad) on a computer device and reviewed through a browser. The display and coding logic of the interactive E-worksheet is refined using refinement prompting techniques until the media runs optimally without technical obstacles. The final result is a portable Single HTML File that stores all video (MP4), image (PNG/JPG), and audio (MP3) assets in a single folder that can be accessed offline after opening a browser to display the HTML.

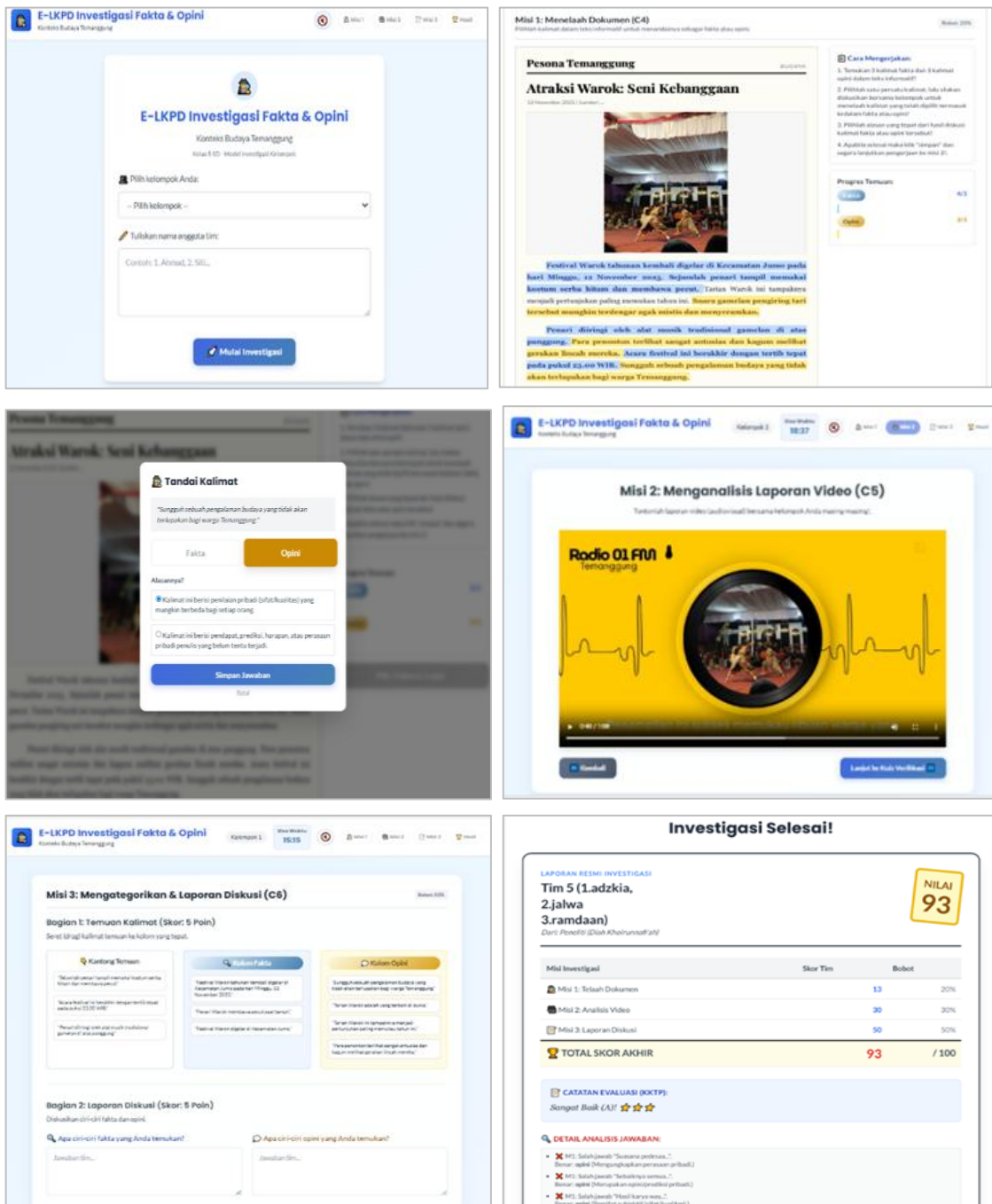


Fig 2. Display of the interactive e-worksheet.

The structure of the e-worksheet is aligned with the group investigation syntax through three interconnected main missions. Mission 1 presents informative text with a JavaScript-based digital highlighter feature, Mission 2 displays educational videos built using the Tailwind CSS framework, followed by a comprehension verification quiz. The stages end with Mission 3, which presents a drag-and-drop game for categorizing findings and essay questions.

Interactive features in the investigation phase are designed with a progressive weighting system that aligns with the learning objectives outlined on the briefing page. Specifically, mission 1 (20%) targets C4 (examining), requiring students to analyze textual information to identify key details; mission 2 (30%) focuses on C5 (deciding) textual quotations and their reasoning, where students must examine the accuracy of data based on visual evidence; and mission 3 (50%) increases the challenge to C6 (categorizing), forcing students to categorize findings of factual and opinion sentences through a drag-and-drop fitur, then write the reasons for categorization in the colom essay by discussing with the investigation team. This weighted scoring algorithm offers significant advantages over conventional static worksheets by automatically assessing cognitive complexity rather than treating all tasks equally. In addition, the automatic PDF report feature ensures scoring transparency, allowing students to view real-time performance analysis while significantly improving teacher efficiency by eliminating the burden of manual scoring.

3.2 The feasibility of the group investigation-based interactive worksheet

The feasibility of the developed product was assessed through a validation process with subject-matter experts to ensure its pedagogical and theoretical accuracy. After the development process was completed, the electronic worksheets underwent a comprehensive feasibility assessment conducted by experts in related fields. This assessment focused on three specific indicators, namely content feasibility, presentation feasibility, and linguistic feasibility. A summary of the assessment results is presented in Table 3.

Table 3.

Material expert validation results.

No.	Aspect	Total Indicators	Average Score
1	Content Feasibility	6	4.00
2	Presentation Feasibility	6	3.83
3	Linguistic Feasibility	9	3.77
Overall average			3.86

Based on Table 3, material expert validation results, the material validation achieved an overall average score of 3.86, which converts to a percentage of 96.43%, categorizing the product as 'Very Valid'. The highest score was obtained in the Content Feasibility aspect (4.00), indicating that the integration of Temanggung local wisdom information text is accurate and aligns perfectly with the curriculum learning objectives. Although the Linguistic Feasibility received the lowest score (3.77), it remains within the valid range, confirming that the text is readable for fifth-grade students.

Table 4.

Media expert validation results.

No.	Aspect	Total Indicators	Average Score
1	Media Suitability	3	4.00
2	Technical Quality	3	4.00
3	Audio-Visual Quality	3	3.33
4	Ease of Use	3	3.66
Overall average			3.75

Based on Table 4, the media expert validation yielded a total percentage of 93.75%, placing the product in the 'Very Valid' category. The perfect average score of 4.00 in Media Suitability and Technical Quality indicates that the web-based architecture functions flawlessly and successfully translates the Group Investigation syntax into digital interaction steps without technical glitches. Furthermore, the Ease-of-Use aspect (3.66) confirms that the navigation interface is user-friendly and intuitive for fifth-grade students. Although the Audio-Visual Quality received the lowest score (3.33), it remains within the valid criteria, ensuring that the multimedia elements effectively support the learning process.

Although the validator rated the media as highly feasible, they provided critical feedback to improve its pedagogical and technical integrity. First, the material expert recommended removing haptic feedback (vibration) in the drag-and-drop mission to maintain the integrity of cognitive level C6 (creation); initially, instant vibrations allowed students to guess answers through trial and error, while disabling them forced them to rely on critical discussion. Second, the media expert recommends that mute/unmute controls be developed to accommodate students with musical intelligence, where the challenge is synchronizing audio playback timing and name file (e.g., double file extensions) that previously caused system bugs. Third, an interactive pop-up profile was added because just displaying the developer's name does not reflect interactivity. The media has been updated as shown in Table 5.

3.3 Results of response questionnaires and participatory observations on the interactive e-worksheet

A practicality test was conducted to evaluate the applicability of the Group Investigation-based E-worksheet media. Data was obtained from the responses of fifth-grade teachers and students in a limited-scale trial. The practicality test was conducted to evaluate the applicability of Group Investigation-based E-worksheet media in learning. Practicality data were obtained from two sources, namely the responses of fifth-grade teachers and students in a limited-scale trial. The results of the teacher response assessment are presented in Table 6.

Table 5.
Suggestions from material and media experts.

No.	Before Revision	After Revision
1.	Mission 2 display with vibration mode versus Mission 2 without vibration mode.	Mission 2 display with vibration mode versus Mission 2 without vibration mode.
2.	Adding audio files and mute or unmute settings.	Adding audio files and mute or unmute settings.
3.	Adding a profile pop-up for the researcher and supervisor.	Adding a profile pop-up for the researcher and supervisor.

Table 6.
Teacher and students' response questionnaire results.

No	Aspect	Mean scores from teachers	Mean scores from students
1	Interest Aspect	4.50	4.61
2	Material and Learning Aspect	4.40	4.58
3	Language Aspect	4.33	4.66
Overall average		4.41	4.62

As shown in Table 6, the teacher's response yielded an overall average score of 4.41 (on a 5-point scale), converting to a percentage of 88.33%, which classifies the media as 'Very Practical'. The Interest aspect received the highest average score (4.50), indicating that the design, interactive features, and ease of operation of the media were rated very good. The Material and Learning aspect (score of 4.40) shows that the factual and opinion-based material and the stages of the Group Investigation model were presented appropriately. Meanwhile, the Language aspect (score of 4.33) shows that the instructions and sentences in the media were easy to understand. Overall, the media received a score of 88.33% (Very practical).

Moreover, the student response achieved an impressive overall score of 4.62, equivalent to 92.22%. In detail, the language aspect obtained the highest average score (4.66), indicating that the writing and command sentences in the E-worksheet were very easy for students to read and understand. The interest aspect (4.61) shows that students found it exciting, not boring, and easy to use the media in their notebooks. Finally, the material aspect (4.58) shows that the presentation of factual and opinion-based material and stories about Temanggung local wisdom was easy to understand and interesting for students.

During the small-scale trial phase, the researchers also emphasized the process and performance aspects of the students through participatory observation. The results of participatory observation and the final scores obtained by each team in completing the investigation mission in the e-worksheet can be seen in Table 7.

Table 7.

Participatory observation results and e-worksheet scores.

Groups	Participatory Observation	Interactive E-Worksheet Score	Category
Group 2	96.4%	93	Very Good
Group 1	89.2%	90	Very Good
Group 3	85.7%	80	Good
Overall average	90.4%	87.7	Very Good

Table 7 shows a clear relationship between student participation and their final scores. Group 2, which recorded the highest participation (96.4%), also achieved the highest E-Worksheet score (93). From observation, this group stood out because they engaged in intense debates; group members actively discussed evidence and ensured that everyone had read the text carefully before collectively deciding on an answer. They also showed high initiative by confirming instructions with the teacher. On the other hand, Group 3 had the lowest participation (85.7%) and the lowest score (80). This result occurred because interactions were uneven; high-ability students tended to dominate decision-

making because they finished reading and decided on the facts and opinions before their groupmates completed their analysis. Despite these variations, the overall average of 90.4% proves that e-worksheets effectively encourage active participation across various ability levels.

3.4 The effectiveness of the group investigation-based interactive e-worksheet

Learning outcome data was obtained through pretest and posttest instruments with reference to the Learning Objective Achievement Criteria (KKTP) for Grade V Indonesian Language at SD Muhammadiyah Ngadirejo of 75. In the limited trial (9 students), the pretest average was 64.44, with 77.8% of students in the 'Insufficient' category. After using the media, the post-test average was 88.33. The final score distribution showed that 33.3% of students achieved the 'Very Good' category and 66.7% achieved the 'Good' category. Furthermore, in the field trial (16 students), the pre-test average was 54.06, with 87.5% of students not yet achieving mastery. The average posttest score obtained was 85.63. The distribution of final scores showed that 18.75% of students were in the 'Very Good' category, 50% in the 'Good' category, and 31.25% in the 'Fair' category, with a classical mastery level of 100%.

The pretest and posttest results were tested using SPSS version 25 to facilitate the researcher in processing scores and interpreting data. Before testing the hypothesis, the pretest and posttest data from the two trial stages were analyzed using the Shapiro-Wilk normality test to ensure that the data were normally distributed. The normality test results are shown in Table 8.

Table 8.
Normality Test Results.

Group	Data	Statistic	df	Sig.	Conclusion
Trial 1 (Limited)	Pretest	0.916	9	0.360	Normal
	Posttest	0.936	9	0.545	Normal
Trial 2 (Field)	Pretest	0.945	16	0.557	Normal
	Posttest	0.903	16	0.103	Normal

The analysis results show that all significance values (Sig.) obtained are greater than the significance level of 0.05. In the limited trial, the pretest significance value was 0.360, and the posttest was 0.545. Meanwhile, in the field trial, the pretest significance value was 0.557, and the posttest was 0.103, which means that the data can be considered normal. With this assumption of normality fulfilled, parametric statistical analysis can proceed to the next stage of testing.

Hypothesis testing was conducted using a paired sample t-test to verify the significance of the effect of media use on student learning outcomes before and after media use. The statistical calculation results show a significance value (Sig.

2-tailed) of 0.000, both in the limited trial and the field trial. Furthermore, the N-Gain results to measure the effectiveness of improving student learning outcomes in the use of this E-worksheet are shown below.

Table 9.

N-gain score.

Group	N	Minimum	Maximum	Mean	Std. Deviation
Small Scale (Uji 1)	9	0.56	1.00	0.6959	0.13211
Large Scale (Uji 2)	16	0.50	1.00	0.6846	0.15599

In limited trials, an average N-Gain score of 0.6959 was obtained. Consistent results were also obtained in field trials with an average N-Gain score of 0.6846. Both values fall into the “medium” category.

4. Discussion

4.1 Design of the group investigation-based interactive e-worksheet

The development of this e-worksheet design is focused on facilitating higher-order thinking skills (HOTS). Referring to Bloom's Taxonomy, the media is designed to guide students through the cognitive levels from analyzing (C4) to creating (C6) (Anderson&Krathwohl, 2001). The use of HOTS levels was adopted due to the urgency of current learning needs that demand assessment instruments based on critical reasoning and problem-solving, rather than simply memorizing material (Darmawati & Mustadi, 2023). This learning design ensures that each activity has measurable cognitive content that is relevant to current competency standards.

The media design applies the syntax of the Group Investigation (GI) model. This model was chosen because it is student-centered, thereby improving learning outcomes and student activity through group investigation, especially when integrated with topics of local wisdom (Ardithayasa & Yudiana, 2020). The grouping syntax is manifested in logging in according to group divisions, planning on the learning objectives page (activity briefing), investigating (completing missions 1, 2, and 3), presenting (group work presentation activities), and evaluating (real-time score analysis). Interaction in these small groups helps students exchange opinions before making final decisions. Therefore, the E-worksheet shifts the learning paradigm from one-way instruction to active investigative collaboration.

The media construction is aligned with the characteristics of fifth-grade students who are in the concrete operational stage. At this stage, students need a bridge in the form of real objects or concrete visualizations to understand abstract material. Therefore, the E-worksheet interface is visualized to resemble

a physical newspaper. This visualization serves as a cognitive bridge that helps students process complex information through a familiar display. The media is developed with the help of AI with specific competency requirements such as the ability to think critically, create correct prompts, and have academic ethics (Sugiyono, 2025).

The implementation of the learning flow is translated into three-tiered missions. Mission 1 presents visually informative newspaper texts so that students can analyze the structure of information (C4). Mission 2 increases complexity with audiovisual stimuli, requiring students to decide on the validity of opinions and facts (C5). Finally, Mission 3 assigns students to categorize factual and opinion sentences through group consensus (C6). This systematic mission structure serves as scaffolding to train students' reasoning skills gradually.

The investigation material is integrated with six topics of local wisdom in Temanggung, namely Warok Art, Bambu Runcing, Ayam Cemani, Posong Tourism, Kampung Dolanan, and Pringapus Temple. The integration of local wisdom in learning media is in line with findings that using the surrounding environment as a learning resource can significantly improve students' mastery of knowledge competencies (Ardithayasa & Yudiana, 2020). Muhammadiyah Ngadirejo Elementary School is located in Temanggung Regency, so through these various topics, the E-worksheet seeks to build an educational ecosystem that fosters a sense of pride in the surrounding environment.

Although the media has been designed with a mature concept, the development process of the E-worksheet has encountered technical obstacles in coding. This was due to a lack of detail in the prompts, which resulted in the interactive E-worksheet display not matching the concept. The role of humans remains important as product quality evaluators, while AI serves as a tool. The experience of overcoming these technical obstacles has prompted researchers to continue adapting, improving their digital competencies, and becoming lifelong learners.

4.2 Feasibility of the group investigation-based interactive e-worksheet

This group investigation-based interactive e-worksheet has met very high feasibility standards. Based on expert assessment of the material, the feasibility percentage reached 96.43% (highly feasible). As emphasized by Akbar (2013), the high content validity score—which in this study reached an average of 4.00—is a crucial indicator to ensure that the material content is in line with the basic competencies. This is reinforced by the findings Rahmita & Wasis (2022) and Wati et al. (2021), who conclude that perfect content validity in the developed media is very effective in minimizing the potential for misconceptions of abstract concepts among students.

Meanwhile, media experts gave a percentage of 93.75% in the very feasible category. The support of visual and interactive technology in presenting informative texts improves comprehension skills (Al Haq et al., 2024). However, an in-depth analysis shows a gap between the technical quality aspect, which received a perfect score (4.00), and the audio-visual quality aspect, which received the lowest score (3.33). The audio-visual score is in line with the qualitative findings of validators who suggest the need to improve sound features. This shortcoming was immediately addressed because balanced audio-visual elements are a distinguishing factor between high-quality E-worksheets and conventional student worksheets and have a direct impact on student attention.

Following up on these findings, substantive improvements were made to the product. First, based on the interactivity of Mission 3, the haptic feedback feature was removed. Referring to Sweller's Cognitive Load Theory, extraneous sensory elements can be minimized so as not to overload students' cognitive capacity (Zarkasyi et al., 2024). Removing distracting features from the HOTS E-worksheet actually helps students focus more on using critical thinking (C6) to solve problems.

Second, improvements were made to the multimedia aspect based on the Media Expert's recommendation to enhance student engagement. The expert suggested integrating background audio to create a more dynamic and fun learning atmosphere. However, to prevent potential cognitive overload, the researcher embedded a Mute/Unmute control. This feature implementation aligns with the Learner Control Principle proposed by Clark & Mayer (2016) which suggests that giving learners control over sensory input is crucial. This mechanism allows students to disable the audio if it becomes distracting, thereby accommodating individual learning preferences while satisfying the expert's suggestion. Third, the researchers added a developer profile page and a supervisor page to the initial media interface. These improvements increase the suitability of the media for trials with users.

4.3 Practicality of the group investigation-based interactive e-worksheet

The practicality test results show that the Group Investigation-based E-worksheet that was developed meets the criteria of being "very practical." The achievement of a teacher response score of 88.33% and a student response score of 92.22% confirms that this media has a high level of usability. The practicality of digital media in elementary schools is not only seen from the sophistication of its features, but also from how effectively it simplifies complex material into activities that are easy for students to understand.

The high teacher response in terms of interest (4.50) and material (4.40) indicates that the E-worksheet has succeeded in lightening the instructional load on teachers. The Group Investigation model requires intensive class

organization, but the presence of the E-worksheet helps teachers visualize abstract material in concrete terms.

The integration of technology in learning is driven by diverse pedagogical motivations ranging from operational efficiency to profound innovation. Successful integration does not depend solely on the availability of digital tools, but rather on how teachers align these resources with specific educational goals. As a result, the authors recommend tailored professional development programs to help teachers move from basic substitution strategies to more transformative and meaningful learning experiences (Raave et al., 2024).

Technology integration should not only be a shift from conventional to digital forms, but should be accompanied by more substantive, transformative, and meaningful objectives. Based on teachers' responses, the use of interactive E-worksheets based on group investigation can transform the role of teachers into more efficient facilitators. Instructions are presented systematically in the media, making learning time more effective.

Meanwhile, from the students' perspective, the highest score was obtained in the Language aspect (4.66). This finding proves that the narrative used in the E-worksheet is highly communicative. This is in line with the principle (Mayer & Moreno, 2003), which states that presenting material through the integration of concise text and relevant visual elements (such as Canva designs) can reduce extraneous cognitive load. The high response from students proves that the development of appropriate interactive multimedia can create an immersive learning experience, thereby improving students' reading comprehension of text-based material (Jati & Purwati, 2024). Instructions, straightforward language, and informative text topics about contextual local wisdom, coupled with visual aids in digital worksheets, can boost students' understanding by minimizing cognitive load even though the media is designed for HOTS learning objectives.

In small-scale trials, researchers conducted in-depth observations of student activities and analyzed the results of group work on E-worksheets. This was done to ensure that E-worksheets could be fully understood and used by students to solve problems (facts and opinions) before being implemented in wider field trials. The observations showed a result of 90.4% for student active participation and 87.7 for the average group score, where the most optimal performance had an active participation rate of 96.4 % and a final score of 93. This high score was supported by the team's ability to solve Mission 2 and Mission 3 very well. The team made very few mistakes, namely only in identifying sentences that contained elements of personal judgment but were considered facts, when in fact they were opinions.

In contrast, Group 3, with the lowest activity level (85.7%), obtained a performance score of 80. Based on an analysis of the answers on the E-

worksheet, this group still experienced confusion over fairly basic concepts. This is evident from their errors in identifying opinion and fact sentences. Additionally, in their definition essay answers, Team 3 defined facts incompletely, resulting in lower scores. This indicates that the more cohesive a team is in discussing and exchanging opinions, the higher their score will be.

The importance of interactivity in learning media in Educational Engagement Theory highlights that one of the key strategies for improving student engagement is through interactive teaching (Rachmad, 2022). Engagement in education means more than just physical presence; it includes active emotional, cognitive, and behavioral participation. In the context of this study, the developed E-Worksheet successfully facilitates these three aspects, transforming students from passive recipients to active participants. This proves that digital tools are most effective when they are designed not merely as reading materials, but as comprehensive platforms for meaningful collaborative learning.

Consequently, these findings offer critical implications for teachers and developers. First, regarding Design Principles, effective digitalization requires strict adherence to cognitive guidelines. As highlighted by Désiron et al (2025) teacher-created materials often risk violating multimedia learning principles—such as the Coherence Principle—by including decorative elements that increase extraneous cognitive load. Therefore, instead of merely transferring text to a screen with decorations, developers should leverage AI-generated visuals specifically to visualize abstract concepts, ensuring every element serves a cognitive function. Second, regarding the Teacher's Role, the integration of this media into the Group Investigation model implies a shift from technical instructor to strategic facilitator. While the media handles content delivery, the teacher must remain active—providing technical guidance and conceptual reinforcement. Finally, educators are encouraged to wisely utilize design platforms integrated with Generative AI (such as Canva Pro) to create efficiency, ensuring technology simplifies the learning process rather than complicating it.

4.4 Effectiveness of the Interactive E-Worksheet on the Ability to Distinguish Opinions and Facts

This study indicates that the use of group investigation-based interactive e-worksheet has a significant positive impact on student learning outcomes. This is evidenced by the results of the Paired Sample T-Test statistical test, which produced a significant value (Sig. 2-tailed) of 0.000 (< 0.05). Statistically, this figure confirms that there is a real difference between students' abilities before and after using the media. In addition to statistical significance, the effectiveness of the media can also be seen from the 100% classical mastery achievement in the field trial. This success indicates that the media is able to facilitate an even understanding of concepts.

In terms of the magnitude of improvement, the N-Gain analysis showed a score of 0.6959 (limited test) and 0.6846 (field test), which falls into the “Moderate” category. Although it has not reached the high category, this figure shows the consistency of the media's effectiveness in Higher Order Thinking Skills (HOTS) material. A medium improvement in learning outcomes for materials that require analytical skills (C4-C6) is a positive achievement (Sari et al., 2022). Interactive E-worksheets move beyond simple memorization by engaging students in complex, higher-order thinking processes. Consequently, the improved scores reflect a deeper conceptual understanding.

Furthermore, culturally responsive learning facilitates meaningful knowledge construction, as it aligns with constructivist and cognitive learning theories (Indiati, 2021). Students process new information more effectively when it relates to their real-life experiences. Specifically, this E-worksheet incorporates Temanggung's local wisdom relevant to students at SD Muhammadiyah Ngadirejo, while allowing unfamiliar topics to be explored through peer discussion. This approach adheres to the principles of the Group Investigation model, which serves as a guide for classroom learning activities.

Culture-responsive learning will facilitate a more meaningful knowledge construction process for students because it is in line with constructivist and cognitive learning theories, where students find it easier to process new information if the material is related to real experiences or the culture around them. The topics of the informative texts discussed in the interactive E-worksheet present the local wisdom of Temanggung around the students of SD Muhammadiyah Ngadirejo, while topics that are unfamiliar can be discussed with friends. This is in line with the principle of developing interactive E-worksheets that integrate the group investigation model, which also serves as a guide for classroom learning syntax.

5. Conclusion

An interactive E-Worksheet integrating Temanggung Local Wisdom and the Group Investigation model was developed based on a needs analysis at SD Muhammadiyah Ngadirejo. This development innovatively utilized Generative AI to produce original design assets tailored to the researcher's specific analysis. Through rigorous validation, the media was proven 'Very Feasible' with material expert scores of 96.43% and media expert scores of 93.75%. Aligned with the Group Investigation syntax, the media organizes students into 'Detective Teams' supported by meaningful features like answer pop-ups, mute/unmute controls, and drag-and-drop activities. That integration successfully transformed classroom dynamics from passive listening to active collaboration, where local

wisdom topics in informative texts bridged abstract HOTS objectives into contextual learning. Finally, the result was 'Very Practical' based on teacher (88.33%) and student (92.22%) responses, and effective in improving grade V students' critical thinking skills to distinguish facts and opinions, evidenced by N-Gain scores of 0.69 in the limited trial and 0.68 in the field trial.

The development of e-worksheets leveraging AI and prompt engineering techniques can effectively and efficiently assist teachers in creating media tailored to students' needs. However, should future researchers intend to utilize AI for media development, it is essential to possess competencies in crafting prompts, critical analysis skills, and a high degree of academic responsibility and ethics.

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