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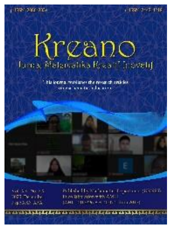

Development of Canva-Based Student Worksheets (LKPD) to Support Students' Mathematical Communication Skills

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Abstract

Mathematical communication skills remain low, particularly in expressing ideas, using representations, and constructing logical arguments. Previous studies on Canva-based Student Worksheets (LKPD) mainly emphasized visual attractiveness and learning motivation, while the integration of mathematical communication indicators remains limited. This study aimed to develop a Canva-based LKPD integrated with a Problem-Based Learning (PBL) approach and examine its validity, practicality, and effectiveness in supporting students' mathematical communication skills. The study employed a Research and Development (R&D) method using a modified 4D model consisting of Define, Design, and Develop stages. The participants were 30 eleventh-grade students from a public senior high school in Indonesia. Data were collected through validation sheets, mathematical communication tests, observation sheets, and questionnaires. The results showed that the LKPD was very valid, very practical, and moderately effective with an N-gain score of 0.48. These findings indicate that Canva-based visual-static LKPD can support mathematical communication in mathematics learning.

Keywords: Canva-based learning; mathematical communication; problem-based learning; mathematics education; student worksheet.

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Abstrak

Kemampuan komunikasi matematis siswa masih tergolong rendah, terutama dalam mengemukakan ide matematis, menggunakan representasi, dan menyusun argumen logis. Penelitian sebelumnya mengenai Lembar Kerja Peserta Didik (LKPD) berbasis Canva umumnya lebih berfokus pada aspek kemenarikan visual dan motivasi belajar, sedangkan integrasi indikator komunikasi matematis dalam aktivitas LKPD masih terbatas. Penelitian ini bertujuan untuk mengembangkan LKPD berbasis Canva yang terintegrasi dengan pendekatan Problem-Based Learning (PBL) serta menguji validitas, kepraktisan, dan efektivitasnya dalam mendukung kemampuan komunikasi matematis siswa. Penelitian ini menggunakan metode Research and Development (R&D) dengan model 4D yang dimodifikasi menjadi tiga tahap, yaitu Define, Design, dan Develop. Subjek penelitian terdiri atas 30 siswa kelas XI SMA Negeri 9 Kendari. Data penelitian dikumpulkan melalui lembar validasi, tes kemampuan komunikasi matematis, lembar observasi, dan angket respons siswa. Hasil penelitian menunjukkan bahwa LKPD yang dikembangkan tergolong sangat valid, sangat praktis, dan cukup efektif dengan nilai N-gain sebesar 0,48. Temuan ini menunjukkan bahwa LKPD visual-statis berbasis Canva berpotensi mendukung kemampuan komunikasi matematis siswa dalam pembelajaran matematika.

INTRODUCTION

Mathematical communication skills remain one of the important competencies in mathematics learning because they enable students to express ideas, use mathematical representations, and construct logical arguments in problem solving. Students with strong mathematical communication skills tend to demonstrate deeper conceptual understanding and more meaningful mathematical reasoning. Recent international studies also indicate that mathematical communication contributes significantly to students' reasoning, conceptual understanding, problem-solving abilities, and mathematical literacy in contemporary mathematics classrooms (Erbay, 2024; OECD, 2023; Sfard & Lavie, 2023; Stacey & Turner, 2022). Communication-oriented learning activities also support students in interpreting mathematical information, relating representations, and articulating mathematical reasoning more systematically (Moschkovich, 2015; Stylianides & Stylianides, 2022). Therefore, mathematical communication is regarded as an essential component of mathematics learning that emphasizes not only final answers but also students' thinking and reasoning processes.

Mathematical communication is not merely the ability to convey answers, but constitutes an essential component of mathematical proficiency that supports reasoning, problem solving, and conceptual understanding. The National Council of Teachers of Mathematics emphasizes that students should be able to organize mathematical thinking, communicate ideas coherently, and use mathematical language appropriately during problem-solving activities (NCTM, 2020). Similarly, Kilpatrick et al. (2001) identify communication as an inseparable aspect of productive mathematical proficiency because students' understanding develops through the processes of explaining, representing, and justifying mathematical ideas. Recent international studies also indicate that students' abilities to use representations, formulate arguments, and communicate mathematical reasoning are closely associated with higher-order mathematical competencies assessed in international frameworks such as PISA and OECD mathematics literacy (OECD, 2023; Schoenfeld, 2023). Accordingly, mathematical communication should be positioned not only as a learning outcome but also as an integral process through which students construct mathematical meaning and reasoning during classroom learning activities.

In mathematics learning, communication also plays an important role in supporting students' ability to connect representations, interpret mathematical relationships, and justify problem-solving procedures. Students who are encouraged to explain mathematical reasoning through verbal explanations, symbolic representations, tables, and diagrams tend to develop more flexible mathematical understanding and stronger problem-solving strategies (Schoenfeld, 2023). Furthermore, recent studies in mathematics education emphasize that mathematical argumentation and representation are closely interconnected processes because students' conceptual understanding becomes more visible when they are able to communicate and justify mathematical ideas systematically (Kaiser & Sriraman, 2023; Prediger & Erath, 2024). Therefore, communication-oriented mathematics learning is increasingly viewed as an essential component of meaningful mathematical activity rather than merely a complementary classroom skill.

However, various studies in Indonesia indicate that students' mathematical communication skills remain relatively low, particularly in explaining solution strategies, connecting mathematical representations, and expressing reasoning systematically. Mathematics learning in classrooms is still frequently oriented toward procedural completion and final answers, causing students to become passive recipients of teacher explanations rather than active communicators of mathematical ideas, a condition also reflected in studies on students' mathematical difficulties in literacy and numeracy problem solving (Rosyadi et al., 2024; Uddin et al., 2023). Preliminary observations in classroom learning also showed that students were more accustomed to following worked examples than explaining the meaning and reasoning behind the procedures used. Consequently, students often experienced difficulties when asked to write explanations, justify solutions, or communicate mathematical ideas independently. These conditions indicate a gap between the expected goals of mathematics learning and actual classroom practices.

The importance of mathematical communication is supported by learning theories emphasizing the role of interaction, representation, and reflection in constructing mathematical understanding. Students who actively communicate mathematical ideas through explanations, representations, and discussions tend to develop deeper conceptual understanding and mathematical reasoning (Bruner, 1964; Vygotsky, 1978). Recent empirical studies further confirm that communication-oriented learning activities can support students' conceptual understanding, reasoning, and mathematical literacy more effectively (Kaiser & Sriraman, 2023; Sfard & Lavie, 2023). Several studies in Indonesia also report that low mathematical communication skills are associated with learning activities that provide limited opportunities for students to express ideas, use representations, and explain reasoning explicitly. Learning that positions students as passive recipients of information tends to restrict opportunities for mathematical discussion, reflection, and argumentation during the learning process. Therefore, mathematics learning requires instructional tools and activities that systematically facilitate students' communication and reasoning processes.

Accordingly, learning tools are needed that explicitly facilitate students' opportunities to communicate mathematical ideas and reasoning during mathematics learning activities. In this context, Student Worksheets (LKPD) have strategic potential because they not only function as task resources but also guide students' thinking and communication processes through structured learning activities. Through open-ended tasks, reflective questions, and opportunities for discussion, LKPD can provide learning experiences that encourage students to communicate mathematical ideas more systematically. Previous studies indicate that instructional materials integrating communication-oriented activities can support students' mathematical reasoning, representation, and conceptual understanding more effectively (Bach & Jankvist, 2024; Qohar & Fazira, 2022). Furthermore, well-designed worksheets may function as scaffolding tools that support students in organizing mathematical ideas and constructing written explanations during problem-solving activities (Ainsworth, 2020; Mainali, 2021).

Along with advances in digital technology, opportunities have emerged to design LKPD that are more visually structured, flexible, and communicative. Visual design platforms such as Canva enable the integration of text, images, diagrams, and visual representations that can support students' conceptual understanding and mathematical communication processes. Recent studies indicate that visually designed instructional materials can function as cognitive scaffolding that facilitates mathematical reasoning, representation, and communication in digital learning environments (Arcavi, 2022; Engelbrecht & Borba, 2024). Digital learning environments integrating visual representations and reflective activities have also been reported to enhance students' engagement and support mathematical meaning-making processes more effectively (Hannula et al., 2022). In mathematics learning contexts, Canva-based LKPD provide opportunities to design contextual and communicative learning activities that encourage students to express ideas, explain solution strategies, and use multiple mathematical representations.

In addition, previous studies on Canva-based instructional media generally position visual design primarily as a motivational or aesthetic component rather than as pedagogical scaffolding that guides students' mathematical thinking processes. Several studies on Canva-assisted mathematics teaching materials mainly focused on improving engagement, independence, or problem-solving skills, while the explicit integration of mathematical communication indicators remains limited (Ainsworth, 2020; Amirudin & Zanthy, 2024; Gravemeijer & Stephan, 2023). Furthermore, studies investigating the role of visual-static instructional materials in supporting mathematical communication remain limited, as many recent studies tend to emphasize interactive digital technologies and multimedia-based learning environments. Consequently, empirical evidence regarding the pedagogical potential of visual-static Canva-based LKPD in supporting mathematical communication is still insufficient.

The role of visual-static instructional materials in mathematics learning should not be limited to aesthetic presentation alone. Well-structured visual layouts may help students organize information, relate mathematical representations, and focus attention on important conceptual relationships during problem-solving activities. In communication-oriented learning contexts, visual-static scaffolding can also support students in expressing mathematical ideas more systematically because information is presented through organized representations, reflective prompts, and sequential learning structures (Engelbrecht & Borba, 2024). This condition suggests that the pedagogical effectiveness of Canva-based LKPD may depend not only on visual attractiveness but also on how visual elements are intentionally designed to facilitate reasoning, representation, and written mathematical communication.

To address this gap, the present study integrates the Problem-Based Learning (PBL) approach into the design of Canva-based LKPD. The integration of PBL is considered relevant because contextual problem-solving activities encourage students to express ideas, interpret representations, discuss solution strategies, and construct mathematical arguments collaboratively during the learning process. Previous studies indicate that PBL environments can support mathematical communication by providing opportunities for students to externalize reasoning, compare solution strategies, and justify mathematical conclusions through discussion and reflection activities (Hmelo-Silver, 2022). In the context of Canva-based LKPD, the integration of PBL enables learning activities to be systematically organized through contextual tasks, visual representations, reflective prompts, and structured communication activities that guide students in communicating mathematical ideas more meaningfully.

The integration of PBL into Canva-based LKPD is also important because contextual problem-solving activities provide opportunities for students to externalize mathematical reasoning through explanation, discussion, and argumentation processes. During collaborative problem-solving activities, students are encouraged not only to identify solutions but also to communicate the reasoning underlying the procedures used. Reflective questions and contextual tasks embedded within the LKPD may support students in comparing representations, evaluating solution strategies, and constructing mathematical arguments more explicitly (Stylianides & Stylianides, 2022). Consequently, the combination of visual-static LKPD design and PBL activities has the potential to create communication-oriented mathematics learning environments that support students' reasoning and mathematical communication simultaneously.

Accordingly, the novelty of this study lies in the development of a Canva-based visual-static LKPD that explicitly integrates indicators of mathematical communication, including written explanation, mathematical representation, and logical argumentation, within a Problem-Based Learning framework. Unlike previous studies that mainly emphasize visual attractiveness or general student engagement, this study positions visual-static Canva-based LKPD as pedagogical scaffolding specifically designed to facilitate students' mathematical communication processes in mathematics learning.

Based on the identified research gap, further research is needed to develop Canva-based LKPD grounded in explicit mathematical communication indicators and integrated with a Problem-Based Learning (PBL) approach. This study contributes to the development of mathematics learning tools that systematically facilitate students' written communication, representation, and mathematical argumentation in both printed and digital learning contexts. Accordingly, this study aimed to develop a Canva-based Student Worksheet

(LKPD) integrated with a Problem-Based Learning (PBL) approach and examine its validity, practicality, and effectiveness in supporting students' mathematical communication skills.

METHOD

This study employed a Research and Development (R&D) approach aimed at developing a Canva-based Student Worksheet (LKPD) integrated with a Problem-Based Learning (PBL) approach and examining its validity, practicality, and effectiveness in supporting students' mathematical communication skills. The development procedure adopted a modified 4D model proposed by Thiagarajan, Semmel, and Semmel (1974), consisting of three stages: Define, Design, and Develop. The Disseminate stage was not implemented extensively because the study focused on product development and limited classroom implementation.

The study was conducted during the 2025/2026 academic year in one public senior high school in Kendari, Indonesia. The participants consisted of 30 eleventh-grade students from one intact class selected purposively. The class was chosen because the students were studying the topic of Arithmetic Sequences and Series during the implementation of the developed LKPD. The topic was selected because it provides opportunities for students to express mathematical ideas, use representations, and construct logical arguments through contextual problem-solving activities.

At the Define stage, curriculum analysis, student characteristic analysis, and analysis of instructional materials previously used in mathematics learning were conducted to identify students' needs and problems related to mathematical communication skills. The findings indicated that mathematics learning was still dominated by procedural activities and final-answer orientation, with limited opportunities for students to communicate mathematical ideas systematically.

At the Design stage, the Canva-based LKPD was designed by integrating the syntax of Problem-Based Learning (PBL) and indicators of mathematical communication skills into learning activities. The indicators consisted of: (1) expressing mathematical ideas, (2) using mathematical representations, and (3) constructing logical arguments. Learning activities in the LKPD were systematically structured through contextual problems, reflective questions, and discussion activities to encourage students to explain ideas, represent solutions using mathematical symbols, tables, or diagrams, and justify mathematical reasoning. The LKPD was developed in a visual-static format using Canva so that it could be implemented flexibly in both printed and digital learning contexts. At this stage, the validation sheets, mathematical communication skills tests, observation sheets, and student response questionnaires were also designed.

At the Develop stage, the LKPD and research instruments underwent expert validation and revision before classroom implementation. Validation was conducted by mathematics education and instructional media experts to ensure the appropriateness of the content, language, presentation, and visual design aspects. Revisions were conducted based on validators' suggestions before the field trial was implemented. The classroom implementation was conducted in three learning meetings using the developed LKPD.

The instruments used in this study consisted of: (1) LKPD validation sheets, (2) mathematical communication skills tests, (3) observation sheets, and (4) student response questionnaires. The mathematical communication skills test was developed in the form of open-ended essay questions based on three indicators of mathematical communication skills, namely written mathematical expression, mathematical representation, and logical mathematical argumentation. The instruments were reviewed and revised through expert validation before classroom implementation. The student response questionnaire employed a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) to evaluate the practicality of the developed LKPD in terms of clarity, attractiveness, usefulness, and ease of use during learning activities. Meanwhile, the observation sheet was used to identify students' mathematical communication activities during classroom learning, including expressing ideas, using representations, and explaining mathematical reasoning.

Quantitative data obtained from validation sheets, mathematical communication skills tests, and student response questionnaires were analyzed descriptively using Microsoft Excel to calculate mean scores, percentages, and N-gain values. The validity and practicality of the LKPD were determined based on the average scores of validator assessments and student responses. The LKPD was categorized as very valid and very practical if the mean score was within the interval of 4.21–5.00. The effectiveness of the LKPD was analyzed using normalized gain (N-gain) scores obtained from students' pretest and posttest results. The use of N-gain analysis was intended to identify the level of improvement in students' mathematical communication skills after participating in learning activities using the developed LKPD. The effectiveness criteria referred to Hake (1998), where N-gain scores of 0.70 or higher were categorized as high, $0.30 \leq$ N-gain < 0.70 as moderate, and N-gain < 0.30 as low.

Qualitative data obtained from observation sheets and documentation were analyzed descriptively to support the interpretation of students' mathematical communication activities during the learning process, particularly activities related to expressing ideas, using representations, and constructing mathematical arguments during contextual problem-solving activities.

RESULT AND DISCUSSION

Results

This study aimed to develop a Canva-based Student Worksheet (LKPD) integrated with a Problem-Based Learning (PBL) approach to support students' mathematical communication skills on the topic of Arithmetic Sequences and Series. The development process followed a modified 4D model consisting of the Define, Design, and Develop stages. The developed LKPD was designed not only as a visual learning medium but also as a communication-oriented instructional material that explicitly facilitates students in expressing mathematical ideas, using mathematical representations, and constructing logical mathematical arguments during problem-solving activities. The quality of the developed LKPD was evaluated in terms of validity, practicality, and effectiveness through expert validation, classroom implementation, observation activities, student response questionnaires, and mathematical communication tests.

The preliminary analysis conducted during the Define stage indicated that mathematics learning activities were still predominantly oriented toward procedural completion and final answers.

Students tended to imitate solution procedures demonstrated by teachers without adequately explaining the reasoning underlying the procedures used. Classroom observations also showed that students experienced difficulties in expressing mathematical ideas systematically, using mathematical representations appropriately, and constructing logical mathematical arguments during problem-solving activities. Students were generally more accustomed to obtaining numerical answers than communicating mathematical reasoning explicitly. These findings confirmed the need for instructional materials that explicitly facilitate mathematical communication activities through structured tasks and contextual mathematical problems.

Based on the results of the needs analysis, the Canva-based LKPD was designed by integrating Problem-Based Learning activities with indicators of mathematical communication skills. The LKPD was developed in a visual-static format to ensure flexibility in implementation in both printed and digital classroom contexts. The learning activities were systematically arranged to facilitate students in expressing mathematical ideas, using representations such as tables and diagrams, and constructing logical mathematical arguments through contextual problems, reflective questions, and discussion activities. The contextual problems were selected from situations closely related to students' daily experiences to encourage meaningful mathematical communication during problem-solving activities.

The implementation of mathematical communication indicators in the Canva-based LKPD can be observed through several activity excerpts presented in Figure 1. The activities were intentionally designed to encourage students to communicate mathematical ideas in written form, organize information using representations, and construct logical mathematical arguments during contextual problem-solving activities.

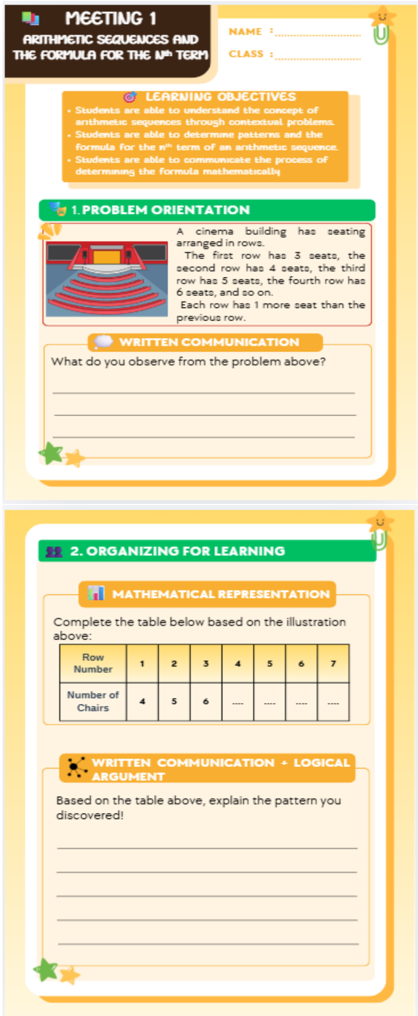

Figure 1. Excerpts of Canva-Based LKPD Activities at the Organizing-for-Learning Stage

The developed LKPD and research instruments subsequently underwent expert validation and revision before classroom implementation. The validation results showed that the material validation obtained a mean score of 5.00 and was categorized as very valid, while the media validation obtained a mean score of 4.88 and was also categorized as very valid. These findings indicate that the developed LKPD fulfilled pedagogical and visual feasibility criteria in terms of content appropriateness, communication-oriented activities, language clarity, and visual organization. The validation results of the developed Canva-based LKPD are presented in Table 1. The results indicate that both the material and media aspects achieved very valid categories, suggesting that the developed LKPD fulfilled pedagogical and visual feasibility criteria for mathematics learning.

Table 1. Validation Results of the Canva-Based LKPD

Validation Aspect	Mean Score	Category
Material Aspect	5.00	Very Valid
Media Aspect	4.88	Very Valid

Several revisions were conducted based on validators' suggestions, particularly related to the clarity of instructions, organization of communication tasks, and optimization of visual representations supporting students' mathematical communication activities. The mathematical communication test, observation sheet, and student response questionnaire were also revised to improve consistency with the indicators of mathematical communication skills examined in this study.

The practicality of the LKPD was analyzed using students' response questionnaires administered after classroom implementation. The results showed that the developed LKPD obtained a practicality percentage of 80.39%, categorized as very practical. Students generally responded positively to the readability of instructions, organization of learning activities, visual presentation, and opportunities provided for expressing mathematical ideas during learning activities.

Observation results during classroom implementation also indicated gradual improvement in students' participation in mathematical communication activities. During the initial meeting, several students still experienced difficulties in writing explanations and providing mathematical justification. Some students tended to provide short numerical answers without explaining the reasoning underlying their procedures. However, students gradually became more active in expressing ideas, presenting mathematical representations, and discussing reasoning processes during subsequent learning meetings. Students also began to use tables, symbolic representations, and written explanations more consistently when solving contextual mathematical problems.

The effectiveness of the developed LKPD was evaluated using students' pretest and posttest results on mathematical communication skills. The normalized gain (N-gain) analysis produced a mean score of 0.48, which falls into the moderate category. The findings indicate that the implementation of the Canva-based LKPD contributed positively to improving students' mathematical communication skills. Improvements were observed in students' ability to explain solution procedures coherently, use mathematical representations appropriately, and communicate mathematical ideas more systematically after participating in learning activities using the developed LKPD. Nevertheless, improvement in the argumentation aspect tended to be lower compared to the aspects of written expression and representation because several students were still limited in providing complete conceptual justifications and linking procedures with underlying mathematical concepts. The practicality and effectiveness results of the developed Canva-based LKPD are presented in Table 2. The findings indicate that the LKPD obtained a very practical category based on students' responses and demonstrated moderate effectiveness in improving students' mathematical communication skills.

Table 2. Practicality and Effectiveness Results of the Canva-Based LKPD

Aspect	Result	Category
Practicality	80.39%	Very Practical
N-gain	0.48	Moderate

Discussion

The findings of this study indicate that the development of Canva-based LKPD integrated with a Problem-Based Learning approach can support students' mathematical communication skills through structured communication-oriented learning activities. The results demonstrate that mathematical communication develops more effectively when students are provided with systematic opportunities to express ideas, use representations, and explain reasoning processes during mathematics learning activities. The developed LKPD functioned not only as a worksheet for completing exercises but also as pedagogical scaffolding that guided students to communicate mathematical thinking explicitly through contextual problems, representational tasks, reflective questions, and written explanations.

The preliminary findings revealed that previous classroom learning practices were still dominated by procedural completion and teacher explanations, causing students to become passive recipients of information rather than active communicators of mathematical ideas. Such conditions limited opportunities for students to communicate mathematical reasoning explicitly and meaningfully during problem-solving activities. This finding is consistent with studies emphasizing that procedural-oriented mathematics learning often reduces students' opportunities to construct and communicate mathematical understanding independently (Mercer et al., 2022; Sfard & Lavie, 2023). Consequently, students tended to rely heavily on example imitation and experienced difficulties when required to explain reasoning processes independently.

The integration of mathematical communication indicators into the LKPD structure became one of the main aspects contributing to the improvement of students' communication skills. Through contextual problems, reflective tasks, representational activities, and argumentation prompts, students were encouraged not only to obtain answers but also to organize and communicate mathematical reasoning systematically. This finding supports previous studies explaining that instructional materials can facilitate communication and reasoning processes when activities are intentionally designed to encourage explanation, representation, and justification (Ainsworth, 2020; Effendi et al., 2024). Furthermore, the scaffolding process embedded in the LKPD activities aligns with the perspective that meaningful mathematics learning requires students to actively construct and communicate mathematical understanding through guided inquiry and reflective reasoning activities (Gravemeijer & Stephan, 2023).

The very valid category obtained from both material and media validation indicates that the developed LKPD fulfilled pedagogical and visual feasibility criteria for mathematics learning. The high material validation score demonstrates that the contextual problems, communication-oriented tasks, and mathematical concepts integrated into the LKPD were aligned with learning objectives and students' characteristics. Meanwhile, the high media validation score indicates that visual organization, readability, and presentation quality supported students' engagement during learning activities. The visual-static Canva format also contributed positively to the organization of learning activities because the consistent layout and structured presentation helped students follow learning stages and mathematical problem-solving processes more systematically.

The effectiveness of the developed LKPD was influenced not only by the visual appearance of the instructional material but also by the pedagogical organization embedded within the learning activities. The visual-static layout helped students focus attention on important mathematical information because tasks, representations, and reflective prompts were arranged sequentially and systematically. Organized visual structures may reduce cognitive distraction and support students in identifying relationships among contextual problems, symbolic representations, and written explanations during mathematical problem-solving activities.

Structured prompts integrated into the LKPD also played an important role in supporting the externalization of students' mathematical thinking processes. Rather than directly asking students to produce final answers, the LKPD encouraged students to explain procedures, organize information into representations, and justify reasoning step by step. This condition may have contributed to the gradual improvement observed in students' written explanations and representational abilities during classroom learning activities.

Contextual tasks integrated with Problem-Based Learning activities further supported mathematical communication because students were encouraged to interpret real-life problem situations before formulating mathematical solutions. Such activities enabled students to discuss ideas collaboratively, compare alternative solution strategies, and communicate reasoning processes more explicitly. This finding also aligns with previous studies reporting that Canva-assisted mathematics teaching materials integrated with problem-based activities can support students' active engagement and mathematical problem-solving processes through systematically structured learning tasks (Fifiana et al., 2024; Hmelo-Silver, 2004). Reflective questions embedded within the LKPD also appeared to stimulate students' awareness of conceptual relationships underlying mathematical procedures, thereby supporting the development of mathematical reasoning and communication simultaneously.

These findings indicate that Canva-based visual-static instructional materials can function not merely as aesthetic learning media but also as pedagogical structuring tools that systematically organize students' mathematical communication activities. In this study, the combination of contextual problems, structured representations, reflective prompts, and communication-oriented tasks created learning conditions that supported students in expressing mathematical ideas more meaningfully throughout the problem-solving process.

The practicality results further indicate that students responded positively to the developed LKPD. The practicality percentage of 80.39% suggests that students considered the LKPD easy to use, visually clear, and supportive of classroom learning activities. In this study, practicality was not limited to technical usability but also reflected how the LKPD structure facilitated students in engaging with mathematical communication activities. Students were able to follow activity sequences, interpret contextual problems, and participate in communication-oriented tasks more systematically during classroom learning. These findings are consistent with studies reporting that visually organized instructional materials can improve students' engagement and understanding during mathematics learning activities (van den Heuvel-Panhuizen & Drijvers, 2020).

Observation results also demonstrated gradual improvement in students' participation during communication-oriented learning activities. Initially, students still experienced difficulties in writing explanations and providing mathematical arguments because they were not accustomed to communicating reasoning processes explicitly during mathematics learning. However, students gradually became more active in expressing ideas, using mathematical representations, and discussing mathematical reasoning during subsequent learning meetings. Students also demonstrated better ability to connect symbolic representations with contextual problem situations and written explanations. This finding supports studies emphasizing that mathematical communication skills develop progressively through repeated engagement, discussion, and reflective learning activities (Stylianides & Stylianides, 2022).

Observation activities during classroom implementation further revealed changes in students' participation patterns throughout the learning process. At the beginning of the implementation, several students tended to focus primarily on obtaining numerical answers and still relied heavily on procedural imitation. During group discussions, students often waited for direct confirmation from peers or the teacher before expressing mathematical ideas independently. However, after several learning meetings using the developed LKPD, students gradually demonstrated greater confidence in communicating mathematical reasoning through written explanations, tables, symbolic representations, and verbal discussions.

Students also began to participate more actively in collaborative communication activities during contextual problem-solving tasks. Reflective questions and structured prompts embedded within the LKPD encouraged students to explain why particular procedures were used rather than merely presenting final answers. In several learning activities, students attempted to compare different representations and discuss alternative solution strategies with peers before formulating conclusions. Such classroom interactions indicate that communication-oriented LKPD activities may support students in externalizing mathematical reasoning processes more systematically during mathematics learning.

In addition, classroom observations suggested that contextual problems integrated into the LKPD helped students connect mathematical concepts with familiar situations encountered in daily life. This condition appeared to facilitate students in interpreting problem situations, organizing information into representations, and communicating reasoning more meaningfully. Although some students still experienced difficulties in constructing complete mathematical arguments, the overall participation in explanation, representation, and discussion activities increased gradually throughout the implementation process.

The effectiveness analysis showed that the developed LKPD produced moderate improvement in students' mathematical communication skills with an N-gain score of 0.48. The moderate category indicates that the developed instructional material contributed positively to communication development, although the improvement had not yet reached an optimal level. One possible explanation is that mathematical communication skills require longer habituation processes and continuous communication practice during mathematics learning. The relatively limited implementation duration in this study may have influenced the level of improvement obtained, particularly in the argumentation aspect.

The moderate effectiveness result also reflects the complexity of developing mathematical communication skills within classroom learning contexts. Unlike procedural competencies that may improve relatively quickly through repeated exercises, mathematical communication involves the integration of reasoning, conceptual understanding, representation, and language organization simultaneously. Students are required not only to solve problems correctly but also to explain underlying reasoning, justify mathematical procedures, and communicate conceptual relationships coherently. Consequently, the development of mathematical communication skills generally requires continuous habituation and sustained opportunities for reflective mathematical discussion.

Another possible explanation for the moderate improvement concerns students' previous learning experiences, which were predominantly procedural and teacher-centered. Students who are accustomed to imitating worked examples may initially experience difficulties when asked to communicate mathematical reasoning independently. During the implementation process, several students still demonstrated hesitation in explaining ideas or providing complete conceptual justifications because they were not yet familiar with communication-oriented mathematics learning activities. This condition suggests that the transition from procedural learning toward communication-oriented learning environments cannot occur instantly and requires gradual adaptation processes within classroom practice.

Furthermore, the relatively short duration of implementation may have limited students' opportunities to develop deeper mathematical argumentation skills. Mathematical argumentation is a higher-level communication competency that requires students to connect conceptual understanding, logical reasoning, and mathematical language systematically. Therefore, repeated reflective discussions, extended collaborative learning activities, and longer implementation periods may be necessary to support stronger development of students' mathematical argumentation abilities in future learning contexts.

Differences in improvement across indicators also became an important finding in this study. Students showed stronger improvement in expressing ideas and using mathematical representations than in constructing logical mathematical arguments. This condition suggests that representational activities are relatively easier to facilitate through structured worksheets and visual scaffolding, whereas argumentation skills require deeper conceptual understanding and more extensive opportunities for reflective discussion. Students were generally able to complete procedures and represent information visually, but many still experienced difficulties when required to explain why a procedure was mathematically valid or conceptually appropriate. Similar findings have been reported in studies emphasizing that mathematical argumentation is among the most complex aspects of mathematical communication because it requires conceptual understanding, logical reasoning, and language organization simultaneously (Prediger & Erath, 2024; Schoenfeld, 2023).

Another important finding of this study is related to the role of visual-static instructional materials in mathematics learning. Previous studies on digital learning media frequently emphasized interactive technological features as the primary factor influencing learning quality. However, this study demonstrates that visually structured static instructional materials can still function effectively as pedagogical scaffolding when integrated with communication-oriented learning activities. In this study, the visual design did not merely serve aesthetic purposes but also contributed to supporting the organization of students' mathematical thinking, representations, and written explanations during learning activities. This finding is consistent with perspectives emphasizing that mathematical communication develops through instructional environments intentionally designed to support representation, reflection, and collaborative reasoning processes (NCTM, 2020).

The findings of this study also provide important insights into how communication-oriented instructional materials may influence students' mathematical learning processes beyond procedural achievement. In this study, mathematical communication developed not only through direct explanation activities but also through the interaction among contextual problems, visual representations, reflective prompts, and collaborative discussions embedded within the LKPD structure. Such learning conditions appeared to encourage students to interpret mathematical situations more carefully before producing final answers, thereby supporting more meaningful engagement with mathematical reasoning processes.

The integration of visual-static scaffolding within the Canva-based LKPD also demonstrates that effective mathematical communication does not necessarily depend on sophisticated interactive technologies. Although many recent studies emphasize interactive multimedia and digital applications as primary tools for improving learning quality, the findings of this study indicate that carefully structured static instructional materials may still function effectively in supporting reasoning, representation, and communication activities. The systematic organization of tasks, representations, and reflective questions helped students focus attention on conceptual relationships and guided them in communicating mathematical ideas more explicitly during problem-solving activities.

Another important aspect concerns the role of reflective communication prompts embedded within the LKPD activities. Students were not only encouraged to solve problems procedurally but were also guided to explain why particular procedures were mathematically appropriate, compare representations, and justify conclusions using written explanations. These activities may contribute to the gradual development of students' metacognitive awareness because students became more conscious of the reasoning processes underlying mathematical procedures and representations. This condition supports perspectives emphasizing that mathematical communication develops more effectively when students are consistently involved in reflective explanation and argumentation activities during learning processes (Mercer et al., 2022).

From a broader instructional perspective, the findings suggest that Canva-based visual-static LKPD can function as pedagogical structuring tools that help organize communication-oriented mathematics learning environments systematically. The coherence among contextual problems, representational tasks, communication prompts, and reflective activities became an important factor supporting students' participation in mathematical communication activities throughout the implementation process. Therefore, the contribution of this study lies not only in the development of a Canva-based LKPD product but also in demonstrating how visual-static instructional design can support communication-oriented mathematics learning in practical classroom contexts.

The novelty of this study lies in the development of a Canva-based LKPD in a visual-static format that explicitly integrates written expression, mathematical representation, and logical argumentation into communication-oriented learning activities. While many previous studies on Canva-based learning media primarily emphasized visual attractiveness or learning motivation, few studies specifically integrate mathematical argumentation into Canva-based visual-static LKPD activities designed to support mathematical communication systematically in both printed and digital classroom contexts.

Nevertheless, this study has several limitations. The implementation was conducted in one intact classroom with a relatively limited duration, so the findings cannot yet be generalized broadly. In addition, the moderate effectiveness result indicates that the improvement of mathematical argumentation skills requires longer implementation periods, more intensive reflective discussions, and continuous communication practice during mathematics learning activities. Therefore, further studies involving broader implementation and longer learning duration are recommended to examine the long-term effectiveness of Canva-based LKPD in supporting students' mathematical communication skills.

Implication

The findings of this study imply that Canva-based LKPD can be implemented as an alternative instructional material to support students' mathematical communication skills in mathematics learning. The visual-static design integrated with Problem-Based Learning (PBL) activities provides students with structured opportunities to express mathematical ideas, use representations, and construct logical arguments during contextual problem-solving activities. In classroom practice, the developed LKPD can be flexibly implemented in both printed and digital formats without requiring complex technological infrastructure, making it applicable across diverse school contexts.

This study also indicates that the effectiveness of instructional materials in supporting mathematical communication is influenced not merely by visual attractiveness, but by the coherence among activity structure, learning approach, and communication indicators embedded within the LKPD design. The findings suggest that teachers and instructional material developers need to design learning activities that explicitly facilitate written explanations, mathematical representations, and argumentation processes rather than focusing primarily on procedural task completion.

From a theoretical perspective, the findings reinforce the view that visual-static instructional materials can function as pedagogical and cognitive scaffolding in supporting students' mathematical communication processes. Previous studies on Canva-assisted mathematics teaching materials also indicate that carefully designed visual structures can support mathematical reasoning and communication processes when learning activities are systematically organized (Pratiwi et al., 2025). The integration of contextual problems, structured representations, reflective questions, and argumentation activities demonstrates that mathematical communication develops through systematically organized learning experiences. This finding extends previous studies on Canva-based learning media, which have predominantly emphasized visual engagement and learning motivation, by showing that visual-static LKPD can also support the development of written mathematical communication and argumentation skills.

In addition, this study contributes to the development of mathematics instructional design by demonstrating that explicit integration of mathematical communication indicators into LKPD activities can create stronger alignment among learning objectives, classroom activities, and learning evaluation. Therefore, the results of this study may serve as a reference for the development of instructional materials oriented toward competency-based mathematics learning and meaningful student participation.

Future studies are recommended to examine the implementation of Canva-based LKPD in different mathematics topics, educational levels, and longer instructional periods to obtain a more comprehensive understanding of the sustainability of students' mathematical communication development. Further research may also employ more in-depth analytical approaches, such as discourse analysis or qualitative examination of students' written responses, to explore the dynamics of mathematical communication during learning activities more comprehensively.

Limitation

This study has several limitations that should be considered in interpreting the findings. First, the study involved students from only one classroom in a single school context, limiting the broader generalizability of the results to different educational environments and student characteristics. Second, the developed Canva-based LKPD was implemented only on the topic of arithmetic sequences and series, so the findings may not fully represent its effectiveness for mathematics topics with different conceptual characteristics.

Another limitation concerns the relatively short implementation period. The improvement in students' mathematical communication skills remained in the moderate category, indicating that mathematical communication requires continuous practice and sustained learning experiences. In addition, the Canva-based LKPD developed in this study employed a visual-static format and did not involve comparisons with interactive digital learning media. Therefore, the relative effectiveness of visual-static Canva-based LKPD compared with other technology-based instructional media has not yet been comprehensively examined.

Despite these limitations, the study provides empirical evidence that pedagogically designed Canva-based LKPD can support students' written communication, mathematical representation, and argumentation skills in mathematics learning. Future studies are recommended to implement Canva-based LKPD across broader educational contexts, different mathematics topics, and longer instructional periods. Further research may also compare visual-static LKPD with interactive digital media and employ deeper qualitative analyses to examine the development of students' mathematical communication processes more comprehensively.

CONCLUSION

Based on the research objectives and questions, it can be concluded that the development of Canva-based LKPD in a visual-static format using a Problem-Based Learning approach is valid, practical, and effective in gradually improving students' mathematical communication skills. The developed LKPD successfully facilitates students in expressing mathematical ideas, using mathematical representations, and constructing logical arguments more systematically through structured activity designs and visual layouts. The results of the effectiveness analysis indicate a moderate improvement in students' mathematical communication skills, reflecting a shift in students' learning orientation from procedural completion toward more meaningful mathematical thinking and communication processes. Therefore, this study affirms that pedagogically designed visual-static Canva-based LKPD has strong potential as a relevant instructional tool for supporting the development of students' mathematical communication skills in mathematics learning, particularly on the topic of sequences and series.

REFERENCES

Ainsworth, S. (2020). *The Role of Multiple Representations in Learning*. https://doi.org/10.1007/978-3-030-41956-6_51

Amirudin, N. H., & Zanthy, L. S. (2024). The Development of Canva-Assisted Problem-Solving Approach Teaching Materials to Improve Students' Mathematical Communication Ability on Vocational School based on Learning Independence. *Journal of Innovative Mathematics Learning*, *7*(2), 220–230. https://doi.org/10.22460/jiml.v7i2.19743

Arcavi, A. (2022). Visualization, representations, and mathematical communication. *Educational Studies in Mathematics*, *109*(2), 173–189. https://doi.org/10.1007/s10649-021-10115-7

Bach, C. C., & Jankvist, U. T. (2024). New Possibilities of Representational Expressivity for Mathematical Communication: A Case of DGE in an 8th-Grade Classroom. *International Journal for Technology in Mathematics Education*, *31*(1), 3–10. https://doi.org/10.1564/tme_v31.1.01

Bruner, J. S. (1964). The Course of Cognitive Growth. *American Psychologist*, *19*(1), 1–15.

Effendi, M. M., Rosyadi, A. A. P., Fatihah, S. M., Purnomo, H., & Abdullah, A. H. (2024). Web-Based Window Shopping: A Learning Model in High School's Mathematics Curriculum. *TEM Journal*, *13*(1).

Engelbrecht, J., & Borba, M. C. (2024). Recent developments in using digital technology in mathematics education. *ZDM – Mathematics Education*, *56*, 281–292. https://doi.org/10.1007/s11858-023-01530-2

Erbay, H. N. (2024). The role of mathematical communication in problem solving processes. *Journal of Mathematical Behavior*, *73*, 101045. https://doi.org/10.1016/j.jmathb.2023.101045

Fifiana, Q., Bernard, M., & Yuliani, A. (2024). The Development of Problem Based Learning Canva-Assisted Teaching Materials to Improve Mathematical Problem Solving Ability on Integer. *Journal of Innovative*

Mathematics Learning, *7*(2), 195–205. https://doi.org/10.22460/jiml.v7i2.20127

Gravemeijer, K., & Stephan, M. (2023). Emergent perspectives on mathematical communication in inquiry classrooms. *Educational Studies in Mathematics*, *113*(1), 45–63. https://doi.org/10.1007/s10649-023-10211-5

Hannula, M. S., Haataja, E., Löfström, E., Garcia Moreno-Esteva, E., Salminen-Saari, J. F. A., & Laine, A. (2022). Advancing video research methodology to capture the processes of social interaction and multimodality. *Zdm Mathematics Education*, *54*(2), 433–443. https://doi.org/10.1007/s11858-021-01323-5

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review*, *16*(3), 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Hmelo-Silver, C. E. (2022). *Problem-Based Learning: What and How Do Students Learn?* Cambridge University Press. https://doi.org/10.1017/9781108750363

Kaiser, G., & Sriraman, B. (2023). Advances in mathematical reasoning and communication research. *ZDM Mathematics Education*, *55*(4), 601–615. https://doi.org/10.1007/s11858-023-01421-6

Kilpatrick, J., Swafford, J., & Findell, B. (2001). *Adding It Up: Helping Children Learn Mathematics*. National Academy Press.

Mainali, B. (2021). Representation in teaching and learning mathematics. *International Journal of Education in Mathematics, Science, and Technology*, *9*(1), 1–21. https://doi.org/10.46328/ijemst.1111

Mercer, N., Wegerif, R., & Major, L. (2022). *The Routledge International Handbook of Research on Dialogic Education*. Routledge. https://doi.org/10.4324/9780429441677

Moschkovich, J. (2015). Academic literacy in mathematics for English learners. *Journal of Mathematical Behavior*, *40*, 43–62. https://doi.org/10.1016/j.jmathb.2015.01.005

NCTM, N. C. of T. of. (2020). *Principles to Actions: Ensuring Mathematical Success for All*. National Council of Teachers of Mathematics.

OECD. (2023). *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Pratiwi, W. D., Zulkardi, Putri, R. I. I., & Hiltrimartin, C. (2025). Students' Communication Skill and Algebraic Thinking through Commognitive Framework in Algebra Learning. *Mathematics Education Journal*, *19*(3), 413–436. https://doi.org/10.22342/jpm.v19i3.pp413-436

Prediger, S., & Erath, K. (2024). Mathematical argumentation and language development in classroom interaction. *ZDM Mathematics Education*, *56*(2), 233–248. https://doi.org/10.1007/s11858-024-01572-4

Qohar, Abd., & Fazira, N. (2022). Mathematical communication ability in mathematics learning. *Journal on Mathematics Education*, *13*(2), 245–260. https://doi.org/10.22342/jme.v13i2.16345

Rosyadi, A. A. P., Kafifah, A., Cholily, Y. M., & Inganah, S. (2024). Students' Mathematical Errors in Solving Literacy and Numeracy Problems. *JRAMathEdu*, *9*(2).

Schoenfeld, A. H. (2023). *Mathematics Teaching On Target*. Routledge. https://doi.org/10.4324/9781003376903

Sfard, A., & Lavie, I. (2023). Learning mathematics through communication: Theoretical and empirical perspectives. *Educational Studies in Mathematics*, *112*(2), 237–255. https://doi.org/10.1007/s10649-022-10254-1

Stacey, K., & Turner, R. (2022). Mathematical literacy and communication in classroom practice. *ZDM Mathematics Education*, *54*(6), 1021–1035. https://doi.org/10.1007/s11858-022-01370-4

Stylianides, G. J., & Stylianides, A. J. (2022). Research on mathematical reasoning and proof. *ZDM Mathematics Education*, *54*, 1345–1360.

Uddin, P., Aulia, A., & Rizal, M. (2023). Mathematical communication of students with low performance in mathematics. *International Journal of Learning and Teaching*, *15*(3), 133–146. https://doi.org/10.18844/ijlt.v15i3.9129

van den Heuvel-Panhuizen, M., & Drijvers, P. (2020). Realistic mathematics education and students' communication processes. *ZDM Mathematics Education*, *52*(4), 627–641. https://doi.org/10.1007/s11858-020-01142-5

Vygotsky, L. S. (1978). *Mind and Society: The Development of Higher Psychological Processes* (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.). Harvard University Press.

APPENDIX

Table 1. Recap of Student Activity Observation Results

Mathematical Activity / Communication Aspects	Meeting 1	Meeting 2	Meeting 3
Written/Oral Communication	Low	Medium	Height
Use Of Mathematical Representations	Low	Medium	Medium
Presentation Of Logical Reasons/Arguments	Low	Medium	Medium

Table 2. Student Response Survey Results

Components	Grades
Number Of Students	30
Number Of Items	12
Total Score	1.447
Maximum Score	1.800
Percentage	80,39%
Category	Very Practical

Table 3. Pretest, *Posttest*, and N-gain Results of Mathematical Communication Ability

Components	Average
Pretest	47,29
Posttest	72,78
N-Gain	0,48
Category	Medium

Table 4. N-gain Value Categories

N-Gain Value	Category
$>$ 0,70	Height
0,30 – 0,70	Medium
$<$ 0,30	Low