

THE DEVELOPMENT OF GOOGLE SITES QUIZZIZ- ASSISTED COOPERATIVE LEARNING MODEL TO IMPROVE STUDENTS' MATHEMATICAL COMMUNICATION SKILLS AND LEARNING INDEPENDENCE ON JUNIOR HIGH SCHOOL

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ABSTRACT

Mathematical communication skills and learning independence are essential in junior high school mathematics, allowing students to express ideas, solve problems systematically, and participate actively in learning. However, many students still struggle to explain concepts, represent solutions, and regulate their own learning. This study aimed to develop and test the feasibility and effectiveness of a Cooperative Learning model assisted by Google Sites and Quizziz to improve students' mathematical communication skills and learning independence. This research used a Research and Development (R&D) design adapted from Borg and Gall, including needs analysis, product design, expert validation, preliminary and main trials, operational revisions, and final implementation. The study involved eighth-grade students at SMP Negeri 1 Pante Bidari, East Aceh. Data were collected using mathematical communication tests, learning independence questionnaires, observations, and interviews. Quantitative data were analyzed with normalized gain (N-gain) and the Mann-Whitney test, while qualitative data were interpreted descriptively. The results indicated that the learning model, student worksheets (LKPD), and digital media were feasible and practical based on expert validation and trial feedback. Students in the experimental class showed greater improvement in mathematical communication skills than the control class, with N-gain scores from 0.58 to 0.77 and a significant difference ($p < 0.05$). Students' learning independence also improved significantly after implementation. In conclusion, the Cooperative Learning model assisted by Google Sites and Quizziz is feasible, practical, and effective for enhancing students' mathematical communication skills and learning independence, providing an interactive, student-centered learning environment in junior high school mathematics.

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INTRODUCTION

Mathematical communication ability is one of the essential competencies in mathematics learning because it helps students express ideas, explain concepts, use notation and symbols accurately, and construct logical mathematical arguments both orally and in writing (Afifah et al., 2020). The development of mathematical communication skills also supports deeper conceptual understanding and improves critical thinking and problem-solving abilities relevant to 21st-century skills (Zahrotin et al., 2020). Through good mathematical communication, students do not only memorize formulas but are able to explain their thinking processes and solutions systematically.

However, various research findings show that the mathematical communication ability of junior high school students is still relatively low (Suhenda & Munandar, 2023). Students often experience difficulties in interpreting word problems, representing mathematical ideas in the form of symbols, tables, or diagrams, and explaining solution steps in a logical and coherent manner. This condition causes students to be less able to relate mathematical concepts to contextual situations and affects overall learning outcomes (Hariati et al., 2022). The low level of mathematical communication ability also affects students' confidence in expressing opinions and participating in classroom discussions.

In addition to mathematical communication ability, learning independence is an important factor determining student success in mathematics learning (Ghassani et al., 2023). Learning independence is reflected in students' initiative in learning, ability to manage time, responsibility for assignments, and active participation in discussions and group work (Ependi et al., 2025). However, classroom learning practices are still mostly dominated by teacher-centered approaches, causing students to be passive and have limited opportunities to develop learning independence (Rusyadi et al., 2026). Observations at SMP Negeri 1 Pante Bidari showed that students still experienced difficulties in communicating mathematical understanding and had not demonstrated optimal learning independence, especially in mathematics subjects.

One learning approach believed to be able to improve students' mathematical communication skills and learning independence is the Cooperative Learning model (Sari & Fitraini, 2021). This model emphasizes student cooperation in small heterogeneous groups to achieve common learning goals. Through group discussions and interactions, students are encouraged to exchange ideas, express opinions, and take responsibility for the learning process and group outcomes (Sekarningrum et al., 2023). Research shows that the implementation of Cooperative Learning can improve students' mathematical communication skills and encourage active engagement and learning independence in mathematics learning (Ali, 2021). The results of the study also indicate that the cooperative learning model is effective in improving students' mathematical communication skills through social interaction, discussion, and collaborative problem-solving processes (Sarah et al., 2021).

Along with technological development and learning demands in the digital era, the implementation of the Cooperative Learning model needs to be supported by interactive and easily accessible technology-based learning media. One relevant medium is Google Sites, a web-based platform that allows teachers to present learning materials in a structured, interactive, and attractive manner (Rahmafani & Sulistyaningrum, 2025). The use of Google Sites in mathematics learning has been shown to improve students' mathematical communication skills and support independent learning because materials can be accessed anytime and anywhere (Nego et al., 2025). In addition, the use of Google Sites as a web-based learning medium also plays a role in providing more flexible learning feedback and supporting the student evaluation process (Yılmaz & Yaşar, 2023). The development of Google Sites—

based learning media integrated with the cooperative learning model is also designed to create a more contextual, collaborative, and student-centered learning experience, thereby improving the quality of mathematics learning outcomes (Santosa & Haryani, 2025).

In addition, another digital learning media that effectively supports cooperative learning is Quizizz (Lestari et al., 2023). Quizizz is a gamification-based learning application that allows students to complete quizzes interactively, either individually or in groups. The use of Quizizz in mathematics learning can increase student motivation, activity, and participation, as well as promote healthy competition in understanding learning materials (Aisyah et al., 2025). Furthermore, the use of Quizizz in collaborative learning also contributes to improving student learning independence because students are encouraged to actively practice, discuss, and evaluate their own learning outcomes (Arini & Hidayanto, 2025). The results of the study indicate that the cooperative learning model assisted by Quizizz is able to improve students' cognitive abilities through interactive practice activities and immediate feedback on students' answers (Untajana et al., 2024). Similar findings also show that Quizizz, as a formative assessment tool, can support students' self-regulation processes and increase their learning engagement in digital learning environments (Capuno, 2023).

Although studies on Cooperative Learning, Google Sites, and Quizizz have been widely conducted separately, studies that integrate these three components into a systematically developed and tested learning model to improve junior high school students' mathematical communication skills and learning independence are still limited. Therefore, the novelty of this study lies in the development of a Cooperative Learning model assisted by Google Sites as a medium for presenting learning materials and Quizizz as an interactive evaluation tool, as well as in examining the feasibility and effectiveness of the model in junior high school mathematics learning.

Based on this description, this study aims to develop a Cooperative Learning model assisted by Google Sites and Quizizz, which includes the development of a product prototype, limited trials, field trials, and overall product testing. In addition, this study aims to determine the feasibility of the Cooperative Learning model assisted by Google Sites and Quizizz in improving junior high school students' mathematical communication skills and learning independence. This study also aims to determine the feasibility of the Student Worksheet (LKPD) and the interactive learning media used in the model in improving students' mathematical communication skills and learning independence. Furthermore, this study seeks to measure the effectiveness of the teaching materials/LKPD and interactive learning media within the Cooperative Learning model assisted by Google Sites and Quizizz in improving junior high school students' mathematical communication skills and learning independence.

METHOD

Research Type and Design

This study employed the Research and Development (R&D) method aimed at developing and testing the feasibility and effectiveness of a Cooperative Learning model assisted by Google Sites and Quizizz in improving junior high school students' mathematical communication skills and learning independence. The R&D method was selected because it focuses on developing educational products followed by validation, trial implementation, and evaluation of their effectiveness in real classroom contexts (Borg & Gall, 1983).

The development design in this study adapted the simplified steps of Borg and Gall, which include: (1) Research and Information Collecting, (2) Planning, (3) Develop Preliminary Form of Product, (4) Preliminary Field Testing, (5) Main Product Revision, (6) Main Field Testing,

(7) Operational Product Revision, (8) Operational Field Testing, (9) Final Product Revision, and (10) Dissemination and Implementation.

Research Subjects and Sample

The population of this study consisted of all students of SMP Negeri 1 Pante Bidari, East Aceh Regency. The research subjects in the product development stage involved several stages of trials. The preliminary field testing was conducted with two students individually to evaluate the feasibility and ease of use of the product. After revisions were made, the product was tested in the main field testing stage with five students in a small group to obtain feedback regarding the clarity of the material, the implementation of the learning process, and the media display. Furthermore, the revised product was tested again in the operational field testing stage with one class consisting of 29 students to examine the implementation and the initial effectiveness of the learning model. At the dissemination and implementation stage, the validity and reliability of the research instruments were tested on 30 ninth-grade students. After the instruments were declared valid and reliable, the implementation of the learning model was carried out with eighth-grade students selected using purposive sampling by considering the equivalence of initial abilities and student characteristics. The implementation sample consisted of two classes: Class VIII-1 as the experimental class with 28 students and Class VIII-6 as the control class with 25 students. The experimental class was taught using the Cooperative Learning model assisted by Google Sites and Quizizz, while the control class received conventional learning to examine the effectiveness of the model in improving students' mathematical communication skills and learning independence.

Research Location and Time

The study was conducted at SMP Negeri 1 Pante Bidari, located in East Aceh Regency, Aceh, Indonesia. The location was selected based on the availability of digital learning support facilities, such as internet access and learning devices. The research was carried out during the first semester of the 2025/2026 academic year, from August to September 2025.

Development and Implementation Procedures

The initial stage of the research began with a needs analysis through classroom observations of mathematics learning and interviews with teachers to identify problems related to students' mathematical communication skills and learning independence.

Next, the researcher designed a Cooperative Learning model integrated with Google Sites as a learning material presentation medium and Quizizz as an evaluation and reinforcement tool. The initial product developed included Learning tools and lesson plans, Learning materials presented through Google Sites, Cooperative Learning group activities, and Evaluation instruments. The product was validated by subject-matter experts and instructional media experts. After revision, the product was tested in a limited trial and subsequently implemented in the experimental class. The overall research and development process followed the procedural flow adapted from Borg and Gall.

Research Instruments

The research instruments consisted of test and non-test instruments. The test instrument was a mathematical communication skills test administered during the pretest and posttest stages, designed to measure students' ability to express mathematical ideas, use mathematical symbols and representations appropriately, and explain solution steps clearly in written form. Meanwhile, the non-test instruments included observation sheets of learning activities, a student learning independence questionnaire, and interview guidelines. The learning independence questionnaire was developed based on indicators of learning initiative, responsibility, and active

participation in the learning process. Content validity of all instruments was established through expert judgment, while the reliability of the test instrument was analyzed using the Cronbach Alpha coefficient.

Data Analysis Techniques

Quantitative data were analyzed using descriptive and inferential statistics. Descriptive statistics were used to describe the mean, standard deviation, minimum, and maximum values of the pretest and posttest results. Data on students' mathematical communication skills were analyzed using parametric tests after meeting prerequisite tests, including normality and homogeneity tests. Hypothesis testing was conducted using an independent-sample t-test to compare the initial abilities (pretest) between the experimental and control classes. If the posttest data did not meet the assumptions of normality or homogeneity, non-parametric testing using the Mann–Whitney test was applied. The learning independence questionnaire data obtained through a Likert scale were first transformed from an ordinal scale into an interval scale using the Method of Successive Interval (MSI). After the transformation, prerequisite tests including normality and homogeneity tests were conducted. If the parametric assumptions were not met, hypothesis testing was carried out using the non-parametric Mann–Whitney test to compare the differences between the experimental and control classes. The effectiveness of the learning model was analyzed using normalized gain (N-gain), while the magnitude of the model's effect was analyzed using effect size. Qualitative analysis was used to interpret the results of observations and students' responses to the implementation of the learning model.

RESULTS AND DISCUSSION

Result

Research and Information Collecting

This stage was conducted through preliminary classroom observations, interviews with eighth-grade mathematics teachers, and a literature review on Cooperative Learning and the use of digital media (Google Sites and Quizizz).

The analysis results indicated that the learning process was still teacher-centered, students' mathematical communication skills were relatively low, learning independence had not developed optimally, and the use of digital media was still very limited.

Table 1. Summary of Needs Analysis Results

Aspect	Findings
Learning Model	Learning was still dominated by lecture methods and teacher-centered instruction
Student Activity	Students tended to be passive; group work was rarely implemented
Mathematical Communication Skills	Still low and not yet optimally developed
Learning Independence	Most students had not demonstrated independence in completing tasks
Use of Digital Media	Very limited use of digital media; mainly relied on textbooks

These findings served as the foundation for developing the proposed learning model.

Planning

The planning stage was conducted based on the results of the needs analysis from the previous phase. This stage included designing the syntax of the Cooperative Learning model assisted by

Google Sites and Quizizz, preparing learning tools, and developing research instruments. The design aimed to produce a systematic and structured learning model aligned with the characteristics of the topic *Systems of Linear Equations in Two Variables (SLETV)*.

The learning syntax was developed by integrating the steps of Cooperative Learning with the use of digital media to support interaction and evaluation. The developed model syntax is presented in Table 2.

Table 2. Syntax of the Cooperative Learning Model Assisted by Google Sites and Quizizz

Stage	Activities
1	Conveying learning objectives and motivating students
2	Presenting SLETV material through Google Sites
3	Organizing students into learning groups
4	Guiding groups to work and learn using student worksheets (LKPD)
5	Conducting evaluation through Quizizz and written tests
6	Giving rewards to high-achieving groups

Based on this syntax, supporting learning tools were designed to ensure optimal implementation of the model. These tools were structured to facilitate a systematic learning process and to measure improvements in students' mathematical communication skills and learning independence. The details of the designed learning tools are presented in Table 3.

Table 3. Designed Learning Tools

Learning Tool	Description
Lesson Plan (RPP)	Developed as a guide for implementing the Cooperative Learning model assisted by Google Sites and Quizizz on the SLETV topic
Teaching Materials	Contain systematically organized SLETV content integrated with cooperative learning activities
Student Worksheet (LKPD)	Includes contextual SLETV problems, solution steps, and group discussion spaces
Learning Media (Google Sites and Quizizz)	Google Sites functions as a material presentation and learning resource platform, while Quizizz serves as an interactive practice and evaluation tool
Learning Independence Questionnaire	Used to measure students' level of learning independence before and after the implementation of the learning model
Pretest	Used to measure students' initial ability on the SLETV topic before implementation
Posttest	Used to measure students' learning achievement after implementation, particularly mathematical communication skills

The designed learning tools were subsequently developed into a preliminary product and validated by experts before proceeding to the trial stage.

Develop Preliminary Form of Product

The development stage was conducted after the planning phase had been completed. At this stage, the preliminary product was produced in the form of a Cooperative Learning model assisted by Google Sites and Quizizz, along with its supporting learning tools and evaluation instruments to be used in the trial phase.

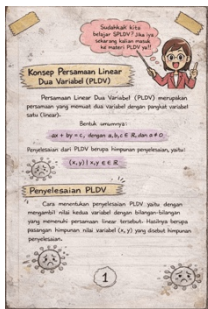
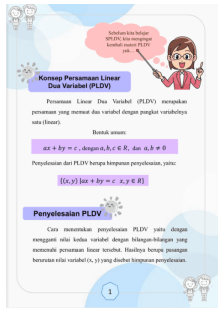
The preliminary product was validated by three expert validators: a subject-matter expert, a media expert, and a language expert. The validation aimed to assess content feasibility, alignment with the Cooperative Learning syntax, integration of mathematical communication skill indicators, quality of media design, and clarity of language used in the learning tools and research instruments.

Table 4. Expert Validator Profiles

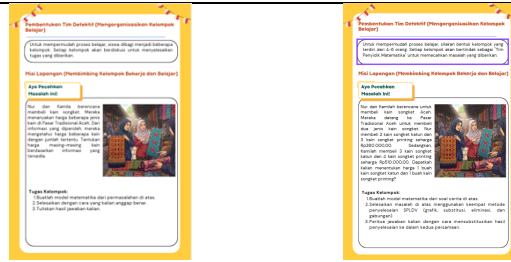
No	Validator Name	Expertise	Educational Background
1	Iden Raisal Ihsan, M.PMt.	Subject-Matter Expert	Lecturer in Mathematics Education at Universitas Samudra. Holds a Master's degree (M.Ed.) in Mathematics Education and is currently pursuing a Doctoral degree (Ph.D.) in Mathematics in Taiwan. Experienced in mathematics content development and instructional material review.
2	Rizky Amelia, M.Pd.	Media Expert	Lecturer in Mathematics Education at Universitas Samudra. Holds a Master's degree (M.Ed.) in Mathematics Education and is currently pursuing a Doctoral degree (Ph.D.) in Mathematics Education at Universitas Pendidikan Indonesia. Experienced in technology-based mathematics learning media development.
3	Roni Priyanda, M.Pd., Ph.D.	Language Expert	Lecturer in Mathematics Education at Universitas Samudra. Completed a Doctoral degree (Ph.D.) in Mathematics Education at Universitas Pendidikan Indonesia. Experienced in linguistic review, terminology accuracy, and clarity of academic and instructional texts.

The validation results consisted of suggestions and recommendations used to revise and refine the product to make it more systematic and aligned with the learning objectives. A summary of the validation results before and after revision is presented in Table 5.

Table 5. Summary of Product Validation Results

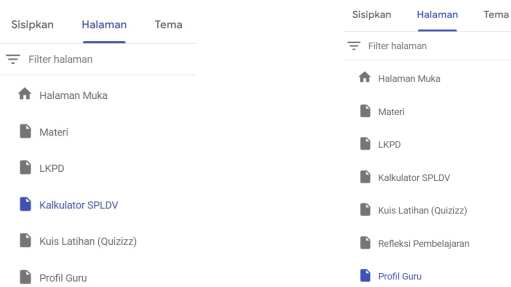
Component	Before Validation	After Validation	Description
RPP	INTI (PERTemuan Kedua) - Guru menjelaskan materi SPLDV secara langsung melalui Google Sites, meliputi pengertian dan bentuk umum SPLDV - Guru meminta siswa membentuk kelompok seperti biasa tanpa penjelasan peran atau struktur kerja sama yang jelas - Guru membagikan LKPD dan meminta siswa mengerjakan soal tentang penyusunan model SPLDV dari soal cerita - Guru berkeliling berkeliling kelas untuk melihat pekerjaan siswa tanpa panduan tahap kerja yang terstruktur - Setelah selesai, siswa mengerjakan soal evaluasi melalui Quizizz dan tes tertulis - Guru mengemukakan kelompok dengan nilai tertinggi tanpa kriteria penghargaan yang dirumuskan secara sistematis	INTI (PERTemuan Kedua) - Guru menyajikan materi SPLDV melalui Google Sites, meliputi: - Pengertian SPLDV - Bentuk umum SPLDV - Guru mengorganisasikan siswa dalam kelompok yang sama - Guru membagikan LKPD Pertemuan 2 dan membimbing kelompok untuk: - Membuat pemilihan variabel - Menyusun dua persamaan dari soal cerita - Memuliskan model SPLDV dengan benar - Guru memantau dan membimbing proses diskusi kelompok - Evaluasi dilakukan melalui Quizizz dan tes tertulis - Guru memberikan penghargaan kepada kelompok berprestasi	The core activity structure was revised to align systematically with the six stages of the Cooperative Learning syntax.
Teaching Materials			The initial design appeared less organized, with inconsistent layout, faded colors, and disproportionate illustrations. The revised version features a more structured layout, improved color contrast, proportional illustrations, and clearer text organization for better readability.

LKPD



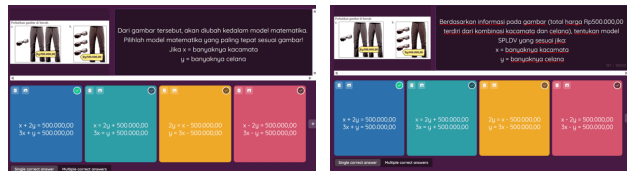
Instructions were initially too general and lacked clear guidance regarding solution steps, group member roles, and expected mathematical communication indicators.

Google Sites



The initial interface was less attractive and did not include a Learning Reflection page. Revisions improved visual design and added a reflection page to strengthen the learning flow.

Quizizz



Several items were revised in terms of construction and content to ensure contextual relevance, systematic structure, and validity in measuring students' mathematical communication skills.

Learning Independence Questionnaire

Statement 4

A. Indikator: Inisiatif dan Motivasi Belajar Mandiri			
1	Saya belajar matematika tanpa harus disuruh oleh guru.		
2	Saya tetap berusaha memahami materi meskipun tidak ada tugas.		
3	Saya hanya belajar jika akan ada ulangan.		
4	Saya mudah menyerah ketika menemukan soal yang sulit.		

Statement 4

A. Indikator: Inisiatif dan Motivasi Belajar Mandiri			
1	Saya belajar matematika tanpa harus disuruh oleh guru.		
2	Saya tetap berusaha memahami materi meskipun tidak ada tugas.		
3	Saya hanya belajar jika akan ada ulangan.		
4	Saya cenderung berhenti mencoba ketika menemui soal matematika yang sulit.		

Six out of 30 items were revised in wording and clarity based on validator suggestions to avoid extreme phrasing, clarify mathematical context, and improve measurability of independent learning behavior. Items were refined in terms of wording and contextual clarity, structured instructions were added, and detailed scoring rubrics

Pretest & Posttest

A. Indikator: Inisiatif dan Motivasi Belajar Mandiri			
1	Saya belajar matematika tanpa harus disuruh oleh guru.		
2	Saya tetap berusaha memahami materi meskipun tidak ada tugas.		
3	Saya hanya belajar jika akan ada ulangan.		
4	Saya mudah menyerah ketika menemukan soal yang sulit.		

Revisions were conducted based on validators' suggestions to enhance content relevance, linguistic clarity, and the overall quality of the learning media. After improvements were made, the product was declared feasible for implementation in the trial stage.

Preliminary Field Testing

At the preliminary field-testing stage, the researcher conducted an initial trial of the product with two students individually to evaluate its feasibility and ease of use. The products tested included Google Sites as the learning media, Quizizz as the interactive evaluation tool, and the Student Worksheet (LKPD) as a task guide. This trial aimed to determine whether students could access the materials, understand the instructions, and complete the quizzes smoothly, as well as to obtain initial feedback for product improvement before larger-scale implementation.

The results of the preliminary trial were documented to show the condition of the product before revision based on students' feedback, as presented in Table 6.

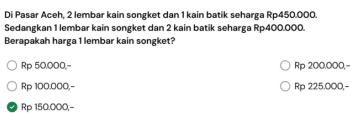
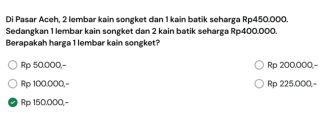
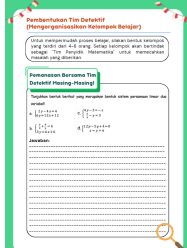
Table 6. Preliminary Field-Testing Results

Product	Student Activities	Problems / Difficulties Encountered
Google Sites	Browsing materials and opening pages	Some links were inactive
Quizizz	Completing interactive quizzes	Time allocation was too short
LKPD	Completing tasks according to instructions	Some instructions were unclear and confusing

Main Product Revision

After the preliminary field testing, revisions were made to the main products Google Sites, Quizizz, and the Student Worksheet (LKPD) based on student feedback and observational findings. Improvements focused on enhancing the navigation of Google Sites, clarifying instructions and task sequences in the LKPD, and refining Quizizz questions and usage guidelines. These revisions aimed to ensure that the product became more user-friendly, engaging, and supportive of cooperative learning, while also strengthening students' mathematical communication skills and learning independence before proceeding to small-scale testing.

Table 7. Main Product Revision

Component	Before Revision	After Revision	Description of Revision
Google Sites			All links were checked and corrected to ensure full accessibility for students.
Quizizz			The quiz duration was adjusted according to the level of difficulty of the questions.
LKPD			Instructions were rewritten using simpler and more systematic language to support students' understanding and learning independence.

Main Field Testing

In the small-scale trial stage, the revised product was tested on a group of five students. This stage aimed to examine the implementation of the Cooperative Learning model assisted by Google Sites and Quizizz, evaluate the clarity of the LKPD, assess the smoothness of media usage, and gather students' responses to the instruments used. Additionally, this stage sought to observe student engagement in learning activities that support mathematical communication skills and learning independence. The results of the small-scale trial are presented in Table 8.

Table 8. Small-Scale Trial Results

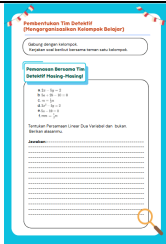
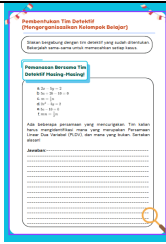
Product	Student Activities	Problems / Difficulties Encountered
LKPD	Discussing and completing tasks collaboratively	Some students were less active in discussions and required additional guidance

Google Sites	Accessing materials and following the learning flow	No technical issues; however, some students needed initial guidance in navigation
Quizizz	Completing quizzes individually after discussion	Some students lacked carefulness in reading questions
Learning Independence Questionnaire	Completing the questionnaire honestly	Some students asked for clarification about certain statements
Pretest & Posttest	Completing pretest and posttest questions	Students had difficulty understanding contextual SLETV word problems and writing solution steps systematically

Operational Product Revision

At the operational product revision stage, further refinements were made to the learning tools and research instruments based on the results of the small-scale trial. Revisions focused on improving the wording of the LKPD, the learning independence questionnaire, and the pretest and posttest instruments to ensure clarity and suitability to students' ability levels. These improvements were intended to enhance instructional clarity, reduce student confusion, and optimize the implementation of the learning process.

Table 9. Operational Product Revision

Component	Before Revision	After Revision	Description of Revision
LKPD			Sentences were revised to provide clearer guidance, encouraging more active and structured group discussions.
Learning Independence Questionnaire	25 Saya menggunakan cara belajar yang sama meskipun tidak efektif.	25 Saya tetap menggunakan cara belajar yang sama walaupun kurang efektif.	Statements were reworded to be clearer, simpler, and easier for students to understand.
Pretest & Posttest	26 Saya membuat rangkuman atau peta konsep untuk membantu belajar.	26 Saya membuat rangkuman atau peta konsep untuk mempermudah belajar.	Question wording was refined to improve clarity, especially for contextual SLETV word problems.

Operational Field Testing

At the operational field-testing stage, the revised learning product was implemented in one class consisting of 29 students to examine the effectiveness and practicality of the Cooperative Learning model assisted by Google Sites and Quizizz. This large-scale trial aimed to obtain a comprehensive overview of student activities, the usability of the LKPD and digital learning media, and students' responses to the learning independence questionnaire as well as the pretest and posttest instruments. The results of this stage were expected to demonstrate the feasibility of the product in supporting improvements in students' mathematical communication skills and learning independence.

Table 10. Large-Scale Trial Results

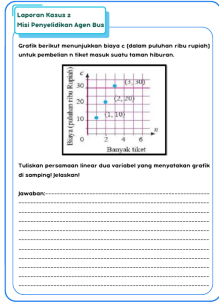
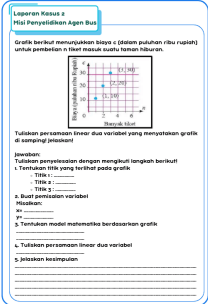
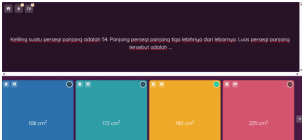
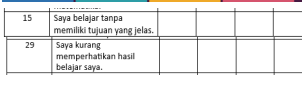
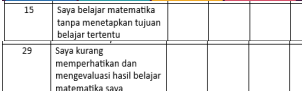
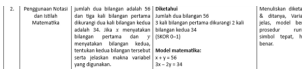
Product	Student Activities	Problems / Difficulties Encountered
LKPD	Discussing and completing SLETV tasks collaboratively	Students still required guidance in writing solution steps systematically

Google Sites	Accessing SLETV materials, LKPD 1–3, SLETV calculator, practice quizzes, and learning reflection	Some students needed initial adaptation time to navigate the learning menus
Quizizz	Completing practice quizzes as interactive evaluation	The wording of some contextual problems was still confusing and potentially led to misinterpretation in determining variables and forming SLETV models
Learning Independence Questionnaire	Completing the questionnaire after learning	Some students required simple clarification of certain negatively worded statements
Pretest & Posttest	Attempting to understand question language and instructions	Some students needed more time to comprehend contextual word problems

Final Product Revision

Following the large-scale trial, several minor issues were identified, particularly regarding the readability of LKPD instructions and the clarity of wording in some Quizizz items and evaluation instruments. Therefore, a final revision was conducted to refine the Cooperative Learning model assisted by Google Sites and Quizizz, ensuring that the learning tools were clearer, more accessible to students, and supportive of effective implementation, while maintaining the indicators of mathematical communication skills and learning independence measured in this study.

Table 11. Final Product Revision

Component	Before Revision	After Revision	Description of Revision
LKPD			Added step-by-step guidance to help students better understand the solution process of SLETV problems
Quizizz			Revised question wording to be more contextual and clarified SLETV variables
Learning Independence Questionnaire			Refined language while maintaining positive and negative items, and used clearer frequency-related terms
Pretest & Posttest			Improved wording, clarified instructions, and simplified language without altering mathematical communication indicators

Dissemination and Implementation

The dissemination and implementation stage was conducted after the large-scale trial and the revision of the final product were completed. At this stage, the research instruments were re-tested on 30 Grade IX students to ensure their validity and reliability before being used in the main study.

The validity test results showed that 6 out of the 12 test items met the validity criteria and were used in the implementation stage. In addition, the learning independence questionnaire consisting of 30 items was also tested, and 19 items were declared valid. Only the valid items were used in the main study.

After the instruments were declared valid and reliable, the study proceeded to the implementation stage to test the effectiveness of the developed learning model.

The improvement in students' mathematical communication skills was analyzed using the N-Gain score between the pretest and posttest results. The N-Gain values in the control class ranged from 0.24 to 0.50, which fall into the low to moderate category. Meanwhile, the N-Gain values in the experimental class ranged from 0.58 to 0.77, which fall into the moderate to high category. These results indicate that the Cooperative Learning model assisted by Google Sites and Quizizz is more effective in improving students' mathematical communication skills compared to conventional learning.

To further describe the improvement in students' learning outcomes, descriptive statistics of the pretest and posttest scores are presented in Table 12.

Table 12. Descriptive Statistics of Pretest and Posttest in the Control and Experimental Classes

Descriptive Statistics				
N	Minimum	Maximum	Mean	Std. Deviation
53	34.00	56.00	41.83	5.63
53	54.00	90.00	72.91	10.52
56				

The descriptive statistical results show an increase in students' average scores from the pretest to the posttest, indicating an improvement in students' mathematical communication skills after the implementation of the learning model.

To examine the difference in learning outcomes between the control and experimental classes, the Mann–Whitney test was conducted. The results are presented in Table 13.

Table 13. Test Statistics^a Posttest of the Control and Experimental Classes

	Post Test
Mann-Whitney U	29.000
Wilcoxon W	395.000
Z	-5.920
Asymp. Sig. (2-tailed)	.000

The Mann–Whitney test results show that the Asymp. Sig. (2-tailed) value is 0.000 (< 0.05), indicating a significant difference between the control class and the experimental class. This result demonstrates that the Cooperative Learning model assisted by Google Sites and Quizizz effectively improves students' mathematical communication skills.

In addition to mathematical communication skills, this study also analyzed students' learning independence. Students' learning independence was measured using a Likert-scale questionnaire that had been transformed from an ordinal scale into an interval scale using the Method of Successive Interval (MSI).

The results of the Mann–Whitney test for learning independence are presented in Table 14.

Table 14. Mann–Whitney Test Results for the Learning Independence Questionnaire

	Test Statistics ^a	
	PREQUESTIONNAIRE	POSTQUESTIONNAIRE
Mann-Whitney U	312.500	.000
Wilcoxon W	745.000	390.000
Z	-1.142	-6.812
Asymp. Sig. (2-tailed)	.253	.000

a. Grouping Variable: Class

The Mann–Whitney test results show that the significance value for the pre-questionnaire is 0.253 (> 0.05), indicating that there was no significant difference in students' initial learning independence between the control and experimental classes. In contrast, the post-questionnaire results show a significance value of 0.000 (< 0.05), indicating a significant difference after the implementation of the learning model. These findings indicate that the developed learning model is effective in improving students' learning independence.

Discussions

The development of the Cooperative Learning model assisted by Google Sites and Quizizz was carried out to create student-centered mathematics learning and to support 21st-century competencies. Cooperative learning emphasizes the importance of social interaction in constructing knowledge through collaborative activities. Social constructivism theory explains that students' cognitive development is influenced by the learning environment and interactions with peers. Lev Vygotsky (in Kusuma et al., 2025) states that learning occurs effectively within the Zone of Proximal Development (ZPD) through the assistance of scaffolding. Cooperative learning can increase academic responsibility and student participation in the learning process. Robert E. Slavin (in Bauw and Sucipto, 2024) emphasizes that cooperative learning aims to improve students' conceptual understanding and social skills. Research by Putri (2024) shows that cooperative learning improves students' communication and collaboration. The jigsaw model in cooperative learning has been proven to enhance students' conceptual understanding and learning motivation. Ismail (2025) reports that cooperative learning using the jigsaw technique effectively improves students' understanding through discussion activities. Technology-based cooperative learning can increase student engagement and responsibility in the learning process.

The results of the study indicate that the learning model, student worksheets (LKPD), and learning media based on Google Sites and Quizizz fall into the category of feasible for use in junior high school mathematics learning. Digital learning media provide flexible access to materials so that students can learn independently according to their own pace. The use of web-based media in mathematics learning supports the development of digital literacy and interactive learning. Google Sites has been reported by Arrahma et al. (2025) to have high levels of validity and practicality as a science learning medium. Megasari (2025) shows that the use of Google Sites positively influences students' self-regulated learning. Learning gamification

through Quizizz can increase students' motivation and participation in learning. Liu (2025) found that Quizizz improves student retention and engagement through immediate feedback. Muchuweni and Jojo (2025) concluded that Quizizz is effective in improving students' motivation and mathematics achievement. Learning gamification creates an enjoyable learning environment without causing academic pressure.

The research results show that the Cooperative Learning model assisted by Google Sites and Quizizz can improve junior high school students' mathematical communication skills. Mathematical communication skills include the ability to explain mathematical ideas verbally, symbolically, and visually. Mathematics learning based on social collaboration supports the development of students' critical and analytical thinking. Kusuma et al. (2025) explain that social interaction is an important factor in students' cognitive development. Muhammad Akhyar (2025) shows that interactive gamified learning improves students' mathematical understanding and learning motivation. Erwin (2023) states that virtual cooperative learning can improve students' learning outcomes and participation. Ulfa et al. (2024) show that cooperative learning combined with interactive evaluation increases students' interest in learning. Technology-based learning approaches help students construct mathematical knowledge more actively.

The developed learning model has also been proven to improve students' learning independence in junior high school mathematics learning. Learning independence refers to students' ability to regulate learning strategies, monitor understanding, and evaluate learning outcomes independently. The self-determination theory explains that intrinsic motivation is influenced by the need for autonomy and competence in learning. Edward L. Deci and Richard M. Ryan (2000) state that a learning environment that supports student autonomy can increase learning motivation. Tambunan (2024) shows that learning independence positively influences students' mathematics learning outcomes. Faradisha et al. (2026) report that Google Sites media helps improve students' focus and conceptual understanding. Tarakino (2025) concludes that gamification in mathematics learning can improve students' academic achievement. Web-based digital learning supports the development of students' learning responsibility and self-regulation in the learning process.

CONCLUSION

The Cooperative Learning model assisted by Google Sites and Quizizz that was developed through the Borg and Gall Research and Development procedure was declared feasible for use in junior high school mathematics learning. This feasibility was indicated by the results of expert validation and product trials, which showed that the learning model, learning tools, and digital learning media met the criteria of validity and practicality.

The implementation of the Cooperative Learning model assisted by Google Sites and Quizizz was proven to be effective in improving students' mathematical communication skills. The N-gain analysis showed that the improvement in the experimental class was higher than that in the control class, and the Mann–Whitney test results indicated a significant difference between the two classes after the learning implementation ($p < 0.05$). The developed learning model was also effective in improving students' learning independence. The results of the Mann–Whitney test showed a significant difference in learning independence between the experimental class and the control class after the implementation of the learning model.

Future research is recommended to implement this learning model in different schools, learning topics, and educational levels to examine its broader effectiveness. Further studies may also explore the integration of other digital learning technologies to enhance students' higher-order thinking skills in mathematics learning.

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