Enhancing mathematical communication skills through cooperative learning model-based worksheets of talking stick type

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Received: 7 June 2023; Revised: 8 August 2023; Accepted: 13 August 2023

Abstract: This study addresses the deficiency in students' mathematical communication skills attributed to teaching materials that do not effectively contribute to their development. The unappealing presentation of teaching materials leads to student boredom during learning activities and the adoption of inappropriate learning models. Therefore, enhancing communication skills through worksheets (LKPD) based on the cooperative talking stick model is essential. This research is research and development (R&D) using the research design of the development model of Borg and Gall (1983) with ten stages. However, in this study, only nine stages are considered, including 1) potential and problems, 2) data collection, 3) product design, 4) product validation, 5) product revision, 6) initial trials, 7) revisions, 8) usage trials, 9) Final revision, because this model has high validation that has been tested by several experts and produces an effective product. The research subjects comprised 35 ninth-grade students for the small-scale trials and 70 eighth-grade students for the large-scale trials. Data collection techniques in the form of questionnaires, tests, and documentation. The results of the feasibility test conducted by material experts, considering content, presentation, and language feasibility, yielded a score of 83.5%, and the results of media experts with aspects of model size, cover design, content design, component suitability obtained a value of 86.8% so that very feasible criteria were obtained. Based on teacher responses, the practicality test results yielded a score of 86.67%, and the results of the student's response obtained a value of 82.55%, so the response obtained very practical criteria. The effectiveness test results, employing N-Gain to measure student improvement after using the developed products to enhance mathematical communication skills, yielded 61.14%, indicating moderate effectiveness. Based on this, the products developed meet the criteria of feasibility, practicality, and effectiveness in the learning process.

Keywords: Mathematical communication skills; Talking stick; Teaching materials


INTRODUCTION

Education of a nation becomes quality if the teaching and learning activities of students are required to always be creative, innovative and active. Education is an important part of the progress of a nation and can determine its future, because to realize this, educational institutions must prepare an educational unit curriculum that suits their needs (Himmawan & Juandi, 2023). According to Subagyo and Safrudiannur (2014) the curriculum is an instrument that can provide direction to create the development of the quality of student skills. The curriculum applied is the 2013 curriculum. Learning curriculum 2013 teachers are directed to be active, innovative, and creative given at the beginning of the meeting, with the hope that...
students are more enthusiastic in learning and teachers have the task to direct students in completing learning. In subjects such as statistics, for example, the use of the school curriculum is an indication of student achievement. Mathematics should be taught starting at the elementary and secondary levels, as it can be considered when wanting to proceed to higher education.

Mathematics is a basic knowledge that serves as a supporting tool in aspects of education and real life (Tresna & Effendi, 2023). In high school mathematics learning, usually the material presented is quite complex, this makes students who have logical power less obstacles in learning (Hidajat et al., 2018). As a result, most students view mathematics as challenging, convoluted, and stressful, even though mathematics education is considered important (Fauzy & Nurfauziah, 2021). As the opinion Kholil and Zulfiani (2020) students consider mathematics as boring and difficult. As a result, many students become less fond of the lesson and even consider it something bad to avoid. Conditions like this result in students being less enthusiastic before learning mathematics. Many students find it difficult to understand the mathematical material because it is abstract, so it is expected that the delivery of the material by the teacher is done well and follows the characteristics of the student (Febriyanti et al., 2021).

The purpose of studying mathematics is so that students are able to master mathematical theory, foster mathematical thinking, elaborate problems and know the usefulness of mathematics in life. Communication is an important thing in learning activities and can make learning activities more active so that the goals of learning mathematics can be achieved (Samawati & Ekawati, 2021). As the opinion Salsabila and Desniarti (2021), mathematical communication is a skill that needs to be improved because it provides opportunities for students to improve their understanding of mathematical concepts both orally and in writing. Communication is very important in math learning because it helps students solve math problems and build relationships between students and teachers. In addition, communication serves as a liaison between students and teachers and also helps otherwise convey ideas, therefore communication skills are important and must be possessed by students (Suciati et al., 2021). Therefore, mathematical communication is also important for every student. A student's communication ability is said to be effective when the ability has met the indicator of access to communication skills (Handayani et al., 2021). According to Hodiyanto (2017) there are indicators of mathematical communication skills, including: 1) Written text, which explains the solution or idea of an image or problem using its own language; 2) Drawing, which explains the solution or idea of a mathematical problem in the form of a picture; 3) Mathematical expression, which shows events and everyday problems in the language of mathematical models.

Based on the results of interviews with mathematics teachers, information was obtained that there were low mathematical communication skills of students. The reason is that the teaching materials used are of poor quality, because teachers only use textbooks in which there is a description of the material that is too long, it looks less attractive, as a result in learning activities students are less active, besides that the learning method applied is not appropriate. Both of these are not in accordance with the learning characteristics of the 2013 curriculum where students are asked to be active in learning and student-centered learning. This can happen if there is communication between students and students or teachers with students.

Various ways to develop students' mathematical communication include using group discussions or cooperative learning models. To carry out the discussion is divided into several small groups and each group has different abilities, where each member in completing the task must help each other and work together (Purnama & Afriansyah, 2016). Through the discussion method, students are expected to be able to exchange opinions and dialogue without any hard rules both with teachers and discussion partners, so that they can provide maximum participation while still following the agreed rules. This is supported by Silalahi and Hutauruk (2020) reveals that collaborative learning emphasizes collaboration between students in
groups, as students are better at defining and understanding mathematical concepts. Group discussions allow students to practice improving understanding, training thought processes, giving opinions or providing solutions if they experience difficulties. Based on this, the cooperative model allows students to group discussions so that learning can run smoothly. There are several types of cooperative learning models including STAD, group investigation, jigsaw, TGT, to stay-two stray. However, in this study using the talking stick type to improve mathematical communication skills. This is supported by Solihah (2018) that the talking stick learning model is one way to develop mathematical communication skills by creating fun and exciting situations and encouraging students to boldly express their opinions. According to Nilayanti et al. (2019), using a talking stick can increase student activeness in following the learning that takes place, because students must be ready when they get a stick to answer questions. It is also easier for teachers to know the extent of knowledge each student has. So, it is expected that students' mathematical communication skills can improve by applying the talking stick type cooperative model.

The advantages are being able to find out readiness in mastering the material quickly, train students' abilities and courage in expressing opinions and can build pleasant teaching situations, active students and expected communication skills to improve. In its application, teaching materials are needed that help students' difficulties related to lack of mathematical communication skills, one of which is by developing student's worksheet.

According to Nilayanti et al. (2019), using a talking stick can increase student activeness in following the learning that takes place, because students must be ready when they get a stick to answer questions. It is also easier for teachers to know the extent of knowledge each student has. So, it is expected that students' mathematical communication skills can improve by applying the talking stick type cooperative model.

Research already carried out by Windra et al. (2020) with the title application of the cooperative learning model type talking stick to the ability of mathematical communication students obtained the results of the research on the test of the ability to communicate mathematically seen using the learning model talking stick significant influence on the communication mathematics students demonstrated with the result rate of the posttest class higher experimentally achieved 56.17%. Furthermore, the research carried out by Pansa (2017) with the title Development of LKPD to Improve the Mathematical Communication Ability of Students obtained the results that the research already done by implementing learning using LKPD can improve the ability of the students to communicate mathematically with a percentage of students passing the KKM of 80% and reaching the criteria of minimum proficiency of 70%. Research conducted by Kesumawati (2021) with the title Development of mathematical learning devices using a cooperative learning model-type talking stick obtained the result that the average validation of RPP and LKPD was 89.58% and 86.95%, respectively, with a very valid category.

Based on several previous studies, the researchers developed LKPD based on a cooperative model of talking sticks and students' mathematical communication abilities. The aim of this development is to see the improvement of the student's mathematical communication skills related to the LKPD and produce an effective, practical, and valid LKPD. Thus, by developing
a LKPD-based cooperative model-type talking stick, it is expected to improve student communication skills.

**METHOD**

This research includes R&D (Research and Development), the aim is to carry out product development and validation. Product validation, meaning that the product is available and researchers test the effectiveness or validity of the product developed (Sugiyono, 2021). The development that will be made is the development of LKPD based on a talking stick type cooperative model on students' mathematical communication skills. The subject of this study is 35 students of class IX for a small-scale test, selected because the valid test carried out in class one above the class of large-scale testing will produce a valid test as well as because class 9 has already studied the statistical material. For the large-scale test, 70 students from class VIII are chosen because their mathematical communication ability is the lowest and they have not studied statistics. The technique used is purposive sampling which is determined according to certain conditions and considerations. Figure 1 is the flow of research procedures in developing products is the development model of Borg and Gall (1983) adopted from Sugiyono (2021).

![Figure 1. Borg & Gall development research pipeline](image)

The collection techniques used are in the form of validity and practicality questionnaires, pretest and posttest test questions in the form of essays adjusted to indicators of mathematical communication skills consisting of 5 questions each, and documentation as evidence during research. Three instruments are applied, namely material and media expert validation instruments, instruments for teacher and student responses, and test instruments to test students' mathematical communication skills. In order for a test instrument to be used, its validity and reliability must be known. The Formula (1) used in the validity test by Pearson is the product moment correlation formula.

\[
r_{\text{counting}} = \frac{n \sum x y - (\sum x \sum y)}{\sqrt{n \sum x^2 - (\sum x)^2} \sqrt{n \sum y^2 - (\sum y)^2}} \tag{1}
\]

While the Formula (2) used in the reliability test is the Cronbach Alpha coefficient formula.

\[
r_i = \frac{k}{(k-1)} \left(1 - \frac{\sum s_i^2}{s_t^2}\right) \tag{2}
\]

A feasibility questionnaire analysis is needed based on the assessment of experts to see the feasibility of product development, the percentage of answers can be calculated with the Formula (3).

\[
\text{Percentage of Answers} = \frac{\text{sum – minimum scores}}{\text{Maximum score} – \text{Minimum score}} \times 100\% \tag{3}
\]
After the feasibility analysis, then the practicality analysis based on the assessment of student and teacher response questionnaires in order to find out the practicality of the products developed, participants can be calculated with the Formula (4) adopted from Indriani and Supriyono (2020).

\[
\text{Percentage} = \frac{\text{sum of response score}}{\text{sum of maximum score}} \times 100\% \quad (4)
\]

Furthermore, in order to see the effectiveness of the product he developed the data obtained from the posttest and pretest to be processed using the Formula (5).

\[
\text{Percentage Value} = \frac{\text{Student Score}}{\text{Maximum Score}} \times 100\% \quad (5)
\]

Table 1 is the product assessment criteria on the result of the feasibility, practicality and mathematical communication skills assessment using a percentage of 0-100 to be more accurate and these criteria were chosen because it makes it easier for readers to see the value of the test results carried out, the qualification level of the assessment criteria is modified form (Effendi et al., 2021).

![Table 1. Product assessment criteria](image)

**RESULTS AND DISCUSSION**

**Results**

The results of research on this development are based on what has been held by Borg and Gall (1983) with ten stages, but this research only reached stage nine due to time constraints. The stages include data collection, potential and problems, product validation, product design, initial trials, design revisions, product revisions, usage trials and product revisions. The following explanation was carried out in this development and research, namely: analysis of potential and problems.

**Curriculum analysis**

The researchers conducted a curriculum analysis, especially of the curricula used in class VIII. The results of the analysis showed that the curriculum used was Curriculum 2013. Thus, the learning component used is guided by the 2013 curriculum combined with indicators of mathematical communication skills.

**Needs analysis**

The results of interviews obtained by researchers found that the lack of students' mathematical communication skills was caused by educators who only used textbooks when teaching in which there were very long descriptions and looked less attractive, so that students were bored and bored in learning. When viewed from students' math scores, most students get an average score of 10-69 as much as 77% and only 23% of students get scores above the average of 70-100, this is because students do not understand the discussion in the textbook and inappropriate learning methods. With these problems, teachers expect new innovations by combining the use of LKPD with appropriate learning methods, so that students' mastery of mathematical communication can increase. This is reinforced by research of Kurniawan et al. (2019), the results of interviews with mathematics teachers in mathematics learning, using LKPD from publishers and have not been able to improve students' abilities, because the material has not met student needs.
Data collection

After knowing the problems and potentials, the researchers collected data that the samples used were small-scale and large-scale, questions in interviews led to how the learning process at school, the teaching materials used and the mathematical communication skills of students at the school. The interview was conducted face-to-face and there were no obstacles when conducting the interview. In addition, it also collects data from references sourced from previous research, such as those conducted by Pansa (2017) that the results of interviews conducted by students' mathematical communication skills are still not good, then developing LKPD obtained the results of LKPD research that is developed effectively. Based on this, researchers developed a talking stick type cooperative model based on students' mathematical communication skills.

Product design

Once the data is collected, the next step is to design the product. Product design contains stages of collaborative learning models and speech steps and contains indicators of student's mathematical communication skills. This product was developed using the Canva application. After finishing designing the LKPD, then an assessment is carried out by validators first. Validation will be carried out by material experts and media experts. The following are shown in Table 2.

Table 2. Feasibility assessment recapitulation

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Percentage</th>
<th>Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material expert</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content Eligibility</td>
<td>84%</td>
<td>Very Worthy</td>
</tr>
<tr>
<td>The Presentation</td>
<td>82.5%</td>
<td>Very Worthy</td>
</tr>
<tr>
<td>The language</td>
<td>83.3%</td>
<td>Very Worthy</td>
</tr>
<tr>
<td>Totally</td>
<td>83.5%</td>
<td>Very Worthy</td>
</tr>
<tr>
<td>Expert Media</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size of model</td>
<td>85%</td>
<td>Very Worthy</td>
</tr>
<tr>
<td>Designed cover</td>
<td>86%</td>
<td>Very Worthy</td>
</tr>
<tr>
<td>Content design</td>
<td>84.6%</td>
<td>Very Worthy</td>
</tr>
<tr>
<td>Composition of Components</td>
<td>94%</td>
<td>Very Worthy</td>
</tr>
<tr>
<td>Totally</td>
<td>86.8%</td>
<td>Very Worthy</td>
</tr>
</tbody>
</table>

Table 2 is the result of tests by media experts and material experts who received very appropriate criteria, all of which got percentages of 83.5% and 86.8%. However, the product that the researcher has developed already has criteria suitable for use but must be revised in developing the product.

Design revision

After the expert validator has made an assessment, the next step is to revise the product taking into account the comments and suggestions by the expert validator including: improving the location of the researcher's name on the cover, writing mathematical symbols, sample questions, writing formulas and descriptions, questions containing two questions are separated and in the final sentence a mark exclamation points should be replaced with a sign (.), student work steps, histogram images, adding information on cooperative model steps, talking sticks and indicators of mathematical communication skills accompanied by symbols as markers and adding a question column at the end of the worksheet. The comments and suggestions given
by the validator aim to make the LKPD developed effective and more optimally used during learning.

**Initial Product Testing**

After validating and revising based on comments and suggestions for improvement, the product was tested on a small scale in class IX with a total of 35 students on 6 March-10 March 2023 by giving a pretest, then given LKPD based on the talking stick cooperative model which included ability questions students' mathematical communication which is discussed in groups and each student is randomly selected using a talking stick to present each item of questions with different students on the results of the student's work. Then at the end the students and teachers were given a response questionnaire to find out practicality after using the product being developed. The test instrument will be searched for the validity and reliability of each item before being tested at the next stage.

<table>
<thead>
<tr>
<th>Table 3. Practicality assessment recapitulation</th>
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<tbody>
<tr>
<td>Aspect</td>
</tr>
<tr>
<td>Student Response</td>
</tr>
<tr>
<td>Attractiveness</td>
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<td>Presentation</td>
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<td>Ease</td>
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<tr>
<td>Benefits</td>
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<tr>
<td>Totally</td>
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<tr>
<td>Teacher response</td>
</tr>
<tr>
<td>View</td>
</tr>
<tr>
<td>Quality</td>
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<tr>
<td>Benefits</td>
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<tr>
<td>Totally</td>
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</table>

Table 3 is the result of a teacher and student response questionnaire obtaining very practical criteria with each getting a percentage of 82.55% and 86.67%. Based on the calculation results, it can be concluded that the test instrument is valid and reliable and feasible to use using the Cronbach alpha formula with a pre-test reliability of 0.8563 and a post-test of 0.84079 in the high category.

**Product revision**

The results of the small-scale trials show that the results of the teacher's and students' responses to the product that the researchers developed received very practical criteria and the test questions were said to be valid and reliable. So, there is no improvement and can proceed to the next stage.

**Large-scale Trial**

Implementation of 70 students by giving a pretest, after that learning was carried out using a cooperative model-based LKPD talking stick, at the end of the lesson a posttest was carried out and giving a student response questionnaire to the product being developed. Presented in Table 4 are the results of student responses.

<table>
<thead>
<tr>
<th>Table 4. Results of the student response questionnaire</th>
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<tbody>
<tr>
<td>No</td>
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<tr>
<td>1</td>
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<td>2</td>
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<td>3</td>
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<tr>
<td>4</td>
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</table>
Table 4 is a large-scale student response. Based on the results of the table, the criteria were met with a high percentage of 85.33%. That is, the LKPD is interesting, easy, and beneficial for students. After using the developed product. Based on the results of the N-Gain test, a value of 0.6114 was obtained with a percentage of 61.14%, so that it was concluded that the product was included in the moderate criteria and was effective enough to be used in learning.

**LKPD revision**

LKPD revisions are carried out if the results of trials on students fall into the criteria of ineffectiveness or ineffectiveness, there are product weaknesses that are carried out on the results of use trials. Conversely, if the revised LKPD results meet the criteria of being quite effective and effective, then the LKPD is effective and can be used.

**Discussion**

Based on the research results, an assessment of the development of valid, practical and effective LKPD was obtained. Where LKPD is in a very decent quality category, very practical and quite effective based on the results of data analysis. According to Sugiyono (2021), validating the product means that the product is ready and tested for the effectiveness and validity of the product being developed. In addition, according to Irawan and Hakim (2021), the quality of the products developed in learning at least fulfill three components, one of which is that the products produced must be practical.

The developed LKPD can motivate students to be more active in learning activities and can maximize mathematical communication skills, improve learning outcomes, thereby providing new experiences for students. In Umbaryati (2016) opinion, In the classroom, learning materials can help and facilitate students who can improve their learning activities and achievements so that there is a good interaction with educators. According to Pawestri and Zulfiati (2020), LKPD is a teaching material that can be used as a study guide that requires students to participate actively in learning. LKPD is designed to ease interaction between teacher and student or vice versa so that learning will be more effective (Putri et al., 2022). The developed worksheet has a different presentation from the worksheet in general, in which there are cooperative model steps and talking sticks with questions according to students' mathematical communication indicators.

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The cooperative learning model is a learning model that is carried out collaboratively in small groups that allows students to work together (Salma, 2022). By doing group learning, learning activities will be effective, efficient and there will be interaction through discussion activities in solving a problem, so as to train students' mathematical communication abilities and social skills possessed by students will increase. As the opinion Kuncoro (2022) one of the effective learning methods is cooperative learning, in which small groups of people work together, interact, and exchange ideas during the learning process. The talking stick learning model is learning in the form of a stick game that focuses on students being actively involved in learning activities (Rosdiani et al., 2022). Thus, students are encouraged to express their opinions in public and the learning atmosphere is more enjoyable, because students in the class are challenged to answer questions using a talking stick. Therefore, it can be concluded that the cooperative model of the talking stick type is a learning model that is useful for training students' mathematical communication skills because in learning activities there is active interaction between students and other students or students and teachers during group discussions.

The development of a talking stick-based cooperative model of LKPD is necessary in mathematical learning because the talking stick model trains students to boldly express their opinions and train their self-confidence, because through communication, students are able to explore understanding of mathematics and guide mathematical thinking, develop knowledge and in completing problem can use mathematical language, then mathematical communication
is very important. This was reinforced by research by Annisa (2020) through the application of the talking stick learning model directing students to better prepare themselves because all students have the same opportunity to have their turn answering the teacher's questions. According to Saputra and Muhsin (2022), the results of the study show that the talking stick learning model can improve students' abilities in mathematical communication, with an average experimental value of 70.5 compared to conventional learning models, which get an average control score of 60.94. So, the stick learning model helps students become more active and better at communicating with the lessons in class.

CONCLUSION

Based on the research and development results, the development of student worksheets is said to be valid, practical, and effective. Material experts and media experts got very decent results, with a percentage of 83.5% and 86.8%, respectively. The effectiveness of getting an N-Gain score with a percentage of 61.14% obtained the criterion of being quite effective. Students' mathematical communication skills increased significantly by 61 students in the high category and 9 in the low category. So that the product developed can be used to maximize students' mathematical communication abilities. The development of LKPD contributes to learning mathematics to improve communication skills.

DECLARATION

Author Contribution : EFK: Conceptualization, Writing - Original Draft, Methodology, Editing and Visualization. RS: Writing - Review & Editing, Formal analysis, Validation and Supervision
Funding Statement : -
Conflict of Interest : The authors declare no conflict of interest.
Additional Information : Additional information is available for this paper.

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