European Journal of Education and Pedagogy
Vol 6 | Issue 4 | August 2025
ISSN 2736-4534

RESEARCH ARTICLE

Communication Ability and Mathematical Literacy of Junior High School Students in the TSTS Learning Model Assisted with Codular Application

Shilvina Annisa, Mohammad Syaifuddin*, and Rizal Dian Azmi

ABSTRACT

The selection of appropriate methods and media in math learning is crucial for student competence improvement. Inappropriate methods and media lead to low communication ability and mathematical literacy in students. The objective of this research is to provide a description of communication skills and mathematical literacy through the implementation of the Two Stay Two Stray learning model, with the assistance of the codular application. The subjects of this qualitative research were 32 7th-grade students in Malang. Data on learning implementation and student responses were collected using questionnaires, and communication skills and mathematical literacy were assessed using essay tests. Results showed that teachers can conduct math learning effectively using Two Stay Two Stray (TSTS) with codular applications. The results of this research are that the teacher's ability to manage learning in the classroom using the media-assisted TSTS learning model obtained a final score of 74% in the good category, and student activities during learning scored 70% in the good category. Student response questionnaire to media with a score of 82.58% in the agree category. Students' abilities in answering test questions vary. Based on the results of calculations, students' overall mathematical communication skills obtained an average percentage of 80.73% in the high category. Meanwhile, students' mathematical literacy skills obtained an average percentage of 78.91% in the high category.

Keywords: Codular, communication ability, mathematical literacy, Two Stay Two Stray (TSTS).

Submitted: May 16, 2025

Published: August 26, 2025

10.24018/ejedu.2025.6.4.968

University of Muhammadiyah Malang, Indonesia.

Corresponding Author:
e-mail: syaifuddin@umm.ac.id

1. Introduction

To enhance the achievement of learning objectives and improve student learning outcomes, it is essential to optimize the implementation of the learning process by employing suitable learning models (Kaharuddin & Hajeniati, 2020; Rahayu *et al*., 2020). By choosing the right learning model, teachers are expected to possess the ability to foster an active classroom environment that facilitates students' understanding of the subject matter and prepares them to tackle real-life problems related to the material (Aviandari *et al*., 2021; Apriakanti *et al*., 2020). Applying the learning model also requires the use of learning media. Learning media can changes learning success and create an active classroom atmosphere (Hidayat & Muhson, 2018; Puteri & Ibrahim, 2023; Handican & Nasution, 2023). Students are given the freedom to study anywhere, depending on comfort, and complete learning facilities provide facilities and motivate students to learn (Ishaq *et al*., 2020).

One of the recurring issues in the learning process lies in the selection of an appropriate learning model, as students often exhibit passivity during their learning experiences (Kaharuddin & Hajeniati, 2020; Septiadi & Wahidah, 2022). Learning models that are less varied result in less attention from students, and students tend to be passive when learning occurs. The results of interviews with several 7th-grade students and mathematics teachers at a junior high school in Malang stated that Android-based interactive media was not used in the learning process.

Based on the above description, there are differences in the learning models and media used. Ideal learning

requires a student-centered learning model. The use of media is also necessary as learning support to maximize learning outcomes. To overcome to the problems can be done by changing the learning model and media used. By implementing a cooperative learning approach that promotes student collaboration and facilitates sophisticated engagement, the issue can be effectively tackled, specifically TSTS (Aviandari *et al*., 2021; Jayanta & Agustika, 2021). Interactive media used as an alternative to the above problem is an application created via a modular website. Research by Aviandari *et al*. (2021) revealed that, furthermore, by utilizing the Two-Stay Two-Stray (TSTS) learning model in conjunction with learning media such as the Wolfram Mathematics application, students' mathematical communication skills can be further enhanced.

The TSTS learning model is collaborative learning, in wich students work together to solve problems and exchange information with other groups (Dewanto *et al*., 2019; Jayanta & Agustika, 2021; Agustika *et al*., 2019; Afriliani *et al*., 2022). The teacher's role in theTSTS is to explain the basic material to be discussed, divide groups, provide direction, monitor the progress of the discussion, and provide evaluation (Aviandari *et al*., 2021; Septiadi & Wahidah, 2022). Steps in the TSTS learning model (Suwangsih *et al*., 2019; Firman *et al*., 2020): 1. The teacher provides initial learning instructions to introduce the material and media according to the learning plan that has been made, 2. The students were organized into multiple groups, each comprising four members: 3. The instructor assigned sub-topics to each group for discussion within their respective groups prior to their visit: 4. Upon completion of the discussion, two individuals from each group assumed the role of guests in the remaining two groups: 5. The two individuals who remain within their original group are responsible for disseminating information to guests from the other groups: 6. The two individuals who partook in the visit returned to their original group to report the information acquired: 7. Each group engaged in a discussion with the other groups regarding the outcomes of their respective group's work: 8. Made conclusions, 9. The groups present the results of the discussion.

The codular is a website for creating Android applications that includes tools with the concept of drag-and-drop block programming (Kholifah & Imansari, 2022; Rismayanti *et al*., 2022). Advantages and disadvantages of coding websites (Safitri & Aziz, 2022; Hasanudin *et al*., 2022; Rizqiyani *et al*., 2022). The advantages include the following: 1) The appearance is simple; therefore, it is easier to understand. 2) Do not use coding, drag, and drop components and combine them with several blocks. Meanwhile, the disadvantages of a modular website are as follows: 1) It must be connected to the Internet when creating the application. 2) The maximum capacity for creating applications is 5 MB, if the application cannot be exported.

Mathematical communication skills are the ability to receive, understand, and express mathematical ideas verbally or in writing, either from oneself or others (Mahadewi *et al*., 2020; Qohar & Fazira, 2022; Amin *et al*., 2022; Mujiasih *et al*., 2021). The mathematical communication used in this study is written as mathematical communication (Wahyudiati, 2023). The ability of students to effectively communicate mathematical concepts has been demonstrated through the utilization of visual representations, symbols, and written notations (Asmana *et al*., 2018; Kurniawan & Darmono, 2021). Mathematical communication indicators that are used as benchmarks to calculate students' ability levels are writing, drawing, and mathematical expressions (Wahyuni *et al*., 2019).

Assessing mathematical communication serves to enhance students' proficiency in mathematical literacy (Pantaleon *et al*., 2019; Kurniawati & Mahmudi, 2019). Mathematical literacy refers to an individual's capacity to describe, formulate, interpret, and apply mathematical principles in diverse scenarios while adapting the employment of procedures, concepts, facts, and mathematical tools to elucidate and predict events (Hindun Permatasari & Dwi Kurniasih, 2021). The measurement of students' mathematical literacy abilities can be achieved by administering tests consisting of descriptive or narrative questions. The indicators of students' mathematical literacy include formulating, applying, and interpreting (Amalia *et al*., 2021).

The facts that occur in the field are that the written mathematical communication skills of class VII MTS Muhammadiyah 1 Malang students are relatively low. Students still have difficulty giving answers in mathematical form because they are afraid of writing down the ideas from the answers incorrectly. Surveys carried out by *Programme for International Student Assessment* show that students' abilities in mathematical literacy are very worrying (Samawati & Kurniasari, 2021; Septian & Maghfirah, 2021). Several other factors include an inappropriate learning style that makes students unable to convey their ideas, which are used to being given questions that are directly linked to formulas so that students are only able to memorize and apply formulas (Samawati & Kurniasari, 2021; Wandani *et al*., 2023; Menggo *et al*., 2023).

Khoerunnisa & Cahyani (2021) researched at TSTS learning model assisted by geogebra media to improve mathematical communication skills. The results of Pradana *et al*. (2020) show that the use of digital media such as VMK (Virtual Mathematics Kits) can increase students' mathematical literacy. Research by Rizqiyani *et al*. (2022) shows that the development of modular-assisted e-modules is suitable for use in learning at school and home to improve mathematical literacy skills.

Much research has been conducted on TSTS and mathematical communication. Among them, the TSTS is related to mathematical communication (Asmana *et al*., 2018; Aviandari *et al*., 2021). Codular research has already been conducted (Rizqiyani *et al*., 2022; Rismayanti *et al*., 2022; Safitri & Aziz, 2022). The difference with this research is that TSTS learning, apart from enabling students to communicate mathematically, must also be able to solve problems related to mathematical literacy. Previous research only developed e-modules with the help of code; in this research, the application created was equipped with example questions, video learning materials, and quizzes.

Based on the description above, this research is in line with the research by Suwangsih *et al*. (2019), Andriningsih and Sugianto (2021), which focuses on the use of the

TSTS learning model on students' mathematical communication skills. This study aims to describe communication skills and mathematical literacy using the TSTS learning model assisted by at codular application. It is hoped that this research will help teachers understand the importance of implementing the TSTS learning model assisted by a modular application for students in communication skills and mathematical literacy related to shape material.

2. Method

2.1. Types and Approaches

This type of research is a descriptive qualitative research. The data presented are data on the application of the TSTS model assisted by coding on mathematical communication and literacy skills.

2.2. Participants

The participants in this study were 32 students. This study was conducted at MTS Muhammadiyah class VII C. This study was conducted offline (face-to-face). This study was conducted during the odd semester of the 2023/2024 academic year.

2.3. Instruments

Instruments used in this study were: 1. Observation sheets and questionnaires; observation sheets in the form of statements given to observers to assess teacher and student activities, while students responded to questionnaires media in the form of 10 statements given to 32 students. 2. Tests and, test questions described the communication skills and mathematical literacy of 32 students who were the subjects of the study. The test instrument was in the form of 1 descriptive question that was adjusted based on the indicators.

2.4. Data Analysis

Data analysis related to response validation from 32 students was obtained from the results of the questionnaire based on the percentage of student responses to the media and data analysis related to students' communication and mathematical literacy tests. The data were analyzed using the following percentage formula (Damayanti *et al*., 2020).

$$Pr = \frac{F}{N} \times 100\%$$

Information:
Pr = average percentage
F = student response score
N = maximum score

The percentage of observation results collected from the observation questionnaire is categorized in Table I. The percentage of student response data collected from the media validation questionnaire is categorized in Table II.

Data analysts use tests. The tests examined communication skills, categorized in Table III, and mathematical literacy, categorized in Table IV.

TABLE I: Criteria for Observation Success Rates

Percentage (%)	Assessment category
$85 \leq P \leq 100$	Very good
$70 \leq P < 84$	Good
$55 \leq P < 70$	Pretty good
$40 \leq P < 55$	Not good

Note: (Paris *et al.*, 2021)

TABLE II: Media Eligibility Criteria

Percentage (%)	Assessment category
$85 \leq P \leq 100$	Very good
$70 \leq P < 84$	Good
$55 \leq P < 70$	Pretty good
$40 \leq P < 55$	Not good

Note: (Rismayanti *et al*., 2022)

TABLE III: Mathematical Communication Ability Category

Percentage (%)	Category
$81 \leq P \leq 100$	Very high
$61 \leq P < 81$	High
$41 \leq P < 61$	Currently
$21 \leq P < 41$	Low

Note: (Damayanti *et al*., 2020)

TABLE IV: Mathematical Literacy Ability Category

Percentage (%)	Category
$80 \leq P \leq 100$	Very high
$60 \leq P < 80$	High
$40 \leq P < 60$	Currently
$20 \leq P < 40$	Low

Note: (Amalia *et al*., 2021)

2.5. Research Procedure

2.5.1. Survey

In the pre-field stage, the researcher made several preparations that would be carried out during the research, including: a. Obtaining permission from the school, namely the principal, vice principal of curriculum and mathematics subject teachers to ask for permission to conduct research at MTS Muhammadiyah Malang school; b. Preparing teaching materials; c. Compiling a questionnaire instrument for the TSTS learning model and a questionnaire for validating learning media, communication skills and mathematical literacy test questions for flat shape material; d. Preparing the media used for the research; e. Validating research instruments to lecturers and mathematics teachers. f. Consulting with mathematics teachers to determine the implementation time and research subjects.

2.5.2. Research Implementation

In the field stage, several steps were carried out by researchers, including: a. Informing students about the learning activities carried out during the research. b. Starting activities by installing the application, explaining the use of the application, and explaining the material using the TSTS learning model assisted by media that has been created. c. Explaining work on flat building worksheets. d. Producing work on mathematical communication and

literacy skills tests and filling in the chicken at the last meeting. e. Collect the results of the questionnaire, and mathematical communication and literacy tests. f. Ending and closing the research class. g. Analyzing the results of the observation sheet, student response questionnaires to the media, and mathematical communication and literacy skills testsc.

2.5.3. Analysis

This is the final stage of this research. Researchers have created reports containing the analysis of student data results. The report is written descriptively and explained based on existing facts.

3. Results and Discussion

3.1. Implementation of TSTS Learning Assisted by the Kodular Application

Before learning takes place, the teacher informs the students of the procedures for the activities that will be carried out during the lesson in class. When conveying the procedures, students appeared confused about the learning model that would be used. This is because the TSTS learning model has never been applied in this class. Therefore the teacher guided each stage of the learning process so that it was carried out well. Meeting Steps I, II, and III in the initial activities in classroom learning begin with the teacher giving greetings, then giving an apperception through students' experiences regarding flat shapes, and then sharing information regarding the learning objectives.

The core activities of the first meeting included the teacher dividing students into several groups, the teacher arranging students to scan the application barcode starting from the first group in turn with the help of observers and mathematics teachers at the school, and the teacher guiding students to install the application according to the division of sub-materials for each group. When installing the application, several students experienced problems because their cellphones were not Android and their Internet connections were not sufficiently supported. With these problems, the teacher provided support to students by lending cellphones and hotspots. After the students install the application, the teacher explains how to use the application and the students follow it. The teacher begins the lesson by asking the students to study the sub-material and make a summary in each group's worksheet regarding the material obtained at the first meeting regarding the characteristics of flat shapes. The teacher then instructed two people from each group to look for information on the other group's sub-material, and two other people from that group received guests from other groups to provide information related to their group's material. Two people tasked with seeking information from other groups brought a worksheet to write down the information they obtained or asked about. The teacher guides and monitors all groups that find it difficult to work on the worksheet. At this stage, the teacher is assisted by observers and mathematics teachers to direct the students so that the class conditions remain conducive. After this stage, the teacher asked the students to return to their original group. At this stage, the teacher experiences difficulties when asking students to return to their original groups to discuss the results of material information from other groups because during this transfer, there is a bit of commotion, which results in a less conducive classroom atmosphere. After the discussion, the teacher chose one of the groups to present the results of the discussion and conclusions.

The core activities of the second meeting included the teacher instructing students to join groups like in the first meeting, and the teacher informed students about the menu used at this meeting. The teacher asked the students to understand the material regarding the area and perimeter of flat shapes and to make a summary on the worksheet. Then, the teacher guides the students as in the first meeting, namely looking for information from other groups, after which they return to the original group to discuss the information obtained from other groups with their group, and the teacher instructs students to work on the practice questions in the application and chooses one group to present the results of the discussion on the second material.

The core activities of the third meeting include the teacher asking students to join according to the group, the teacher instructing students to access the material according to the second meeting and continue working on the practice questions in the application, the teacher asks two people from each group to give the worksheet to the group pairs listed in The worksheet is for correcting the practice questions that have been done, then students are asked to return to their original group and discuss the practice questions that have been corrected by other groups, the teacher asks one of the groups to write down the practice questions, then at the last meeting, the teacher gives test questions and student response questionnaire regarding the use of the kodular application. In this activity, the second and third meetings, students were already using their respective cell phones for learning activities, but the teacher still provided hotspots for students who experienced Internet problems. During the stay and stray activities, until they returned to their home groups, the students were able to condition themselves, and there was no chaos. The teacher continued to guide every step in learning. When carrying out presentations, students appear active in conveying the results of their discussions.

TABLE V: Observation Calculation Results from Teacher Activities

Meeting	Percentage	Category
1	65,43%	Pretty good
2	72,84%	Good
3	82,72%	Good
Total	74%	Good

TABLE VI: Observation Calculation Results from Student Activities

Meeting	Percentage	Category
1	50,62%	Pretty good
2	74,07%	Good
3	83,95%	Good
Total	70%	Good

TABLE VII: Results of Student Response Questionnaires to Learning Media

No	Statement	Category				Average (%)
		SA	A	QA	DA	
1	Learning using T2DAPP interactive media is a new experience for me	25	7			94,53 Strongly agree
2	Using the T2DAPP learning media made me understand more about plane material	10	22			82,81 Agree
3	Using T2DAPP learning media makes me study diligently	2	30			76,56 Agree
4	Learning using T2DAPP interactive media is very interesting and fun	12	20			84,38 Agree
5	The delivery of material in the T2DAPP application is very complete	15	17			86,72 Strongly agree
6	Using T2DAPP disrupts my learning process			21	11	83,59 Agree
7	I am enthusiastic about studying in groups using the T2DAPP application	4	28			78,13 Agree
8	I easily remember the material by using the T2DAPP application	8	24			81,25 Agree
9	I can easily understand the questions by using the T2DAPP application	6	26			79,69 Agree
10	My group of friends and I were able to work on the questions according to the examples given in the T2DAPP application	4	28			78,13 Agree
	Total					82,58 Agree

In the closing activities of meetings I, II, and III, the teacher concludes the material studied at each meeting. Before ending the lesson, the teacher evaluated the implementation of the lesson at each meeting. Then, give direction to the students regarding learning at the next meeting.

Based on the teacher observation data in Table V, in managing learning from meetings I, II, and III, there was an increase at each meeting. Of the nine aspects observed, the total average obtained was 74%; therefore, it can be assumed that the learning activities carried out by the teacher were carried out well.

Based on student observations in TSTS learning assisted by the codular application in Table VI, there was an increase in each meeting, from meetings I, II, and III. Of the nine aspects observed, the total average obtained was 70%, so it can be said that student learning activities are in a good category.

The average student response to the media questionnaire in Table VII was 82.58% in the agreed category. This indicates that media can facilitate student learning.

3.2. *Mathematical Communication Ability Test*

Student answer sheets are shown in Fig. 1. One of the results of completing AP is the students' very high written mathematical communication skills. The student answers met all the highest scores for each indicator of written mathematical communication. Indicator 1, AP, received a score of 4 because he was able to write down information in the form of known data and asked questions completely and correctly. Indicator 2 obtains a score of 4 and can solve problems in mathematical form accurately and completely. Indicator 3 also received a score of 4 for writing mathematical expressions accurately and completely.

In Fig. 2 one of the results of solving the low written mathematical communication skills of JIM students. Students' answers only met all the highest scores on one indicator of written mathematical communication skills. Indicator 1, JIM received a score of 4 because he was able to write information in the form of known data and ask questions correctly and completely. Indicators 2 and 3 recevied a score of zero because they did not provide an answer.

Based on Table VIII, the total average of the students' mathematical communication skills was 80.73% in the high category. This shows that the students' written mathematical communication was better.

Table IX shows that the percentage of students' written mathematical communication ability test results varied based on student frequency. The highest frequency of students was in the very high category (68.75%), indicating that the majority of students could fulfill mathematical communication indicators.

3.3. *Mathematical Literacy Ability Test*

Student answer sheets are shown in Fig. 3. One result of completing the very high mathematical literacy abilities of RGH students. The student answers met all the highest scores for each mathematical literacy indicator. Indicator 1, RGH, obtains a score of 4 because it can change the question into a mathematical form by writing down what is known and asked mathematically correctly and completely. Indicator 2 obtains a score of 4, is able to write down the solution steps accurately and completely, and uses a formula that suits the question request. Indicator 3 also received a score of 4, providing appropriate solutions, results, and conclusions for the problems given.

In Fig. 4 one of the results of solving the low mathematical literacy skills of JIM students. Student answers

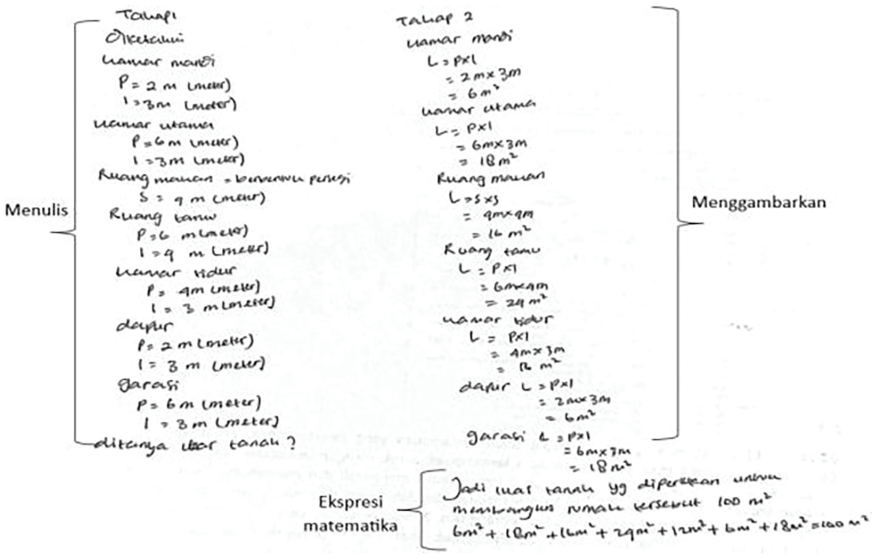

Fig. 1. Student whose written mathematical communication ability test results very high.

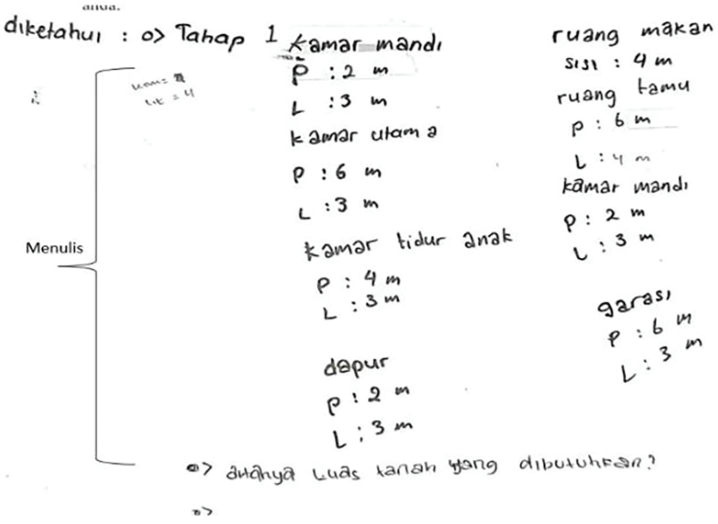

Fig. 2. Student whose low written mathematical communication ability test results.

TABLE VIII: Mathematical Communication Skills Test Results Based on Indicators

Indicator	Question items	Score	Number of students	Average (%)
Writing	1	4	24	86,72
		3	5	
		2		
		1		
		0	3	
Drawing		4	13	80,47
		3	15	
		2	3	
		1		
		0	1	
Mathematical expressions		4	16	75,00
		3	8	
		2	4	
		1		
		0	4	
Total			80,73	

only had the highest score on one mathematical literacy indicator. Indicator 1, ST, gets a score of 4 because it can change the question into a mathematical form by writing down what is known and asked mathematically correctly and completely. Indicators 2 and 3 received a score of zero because they did not provide an answer.

TABLE IX: Percentage of Mathematical Communication Ability Test Results

Category	Frequency (Students)	Average (%)
Very high	22	68,75
High	6	18,75
Currently	3	9,38
Low	1	3,13
Very low	–	

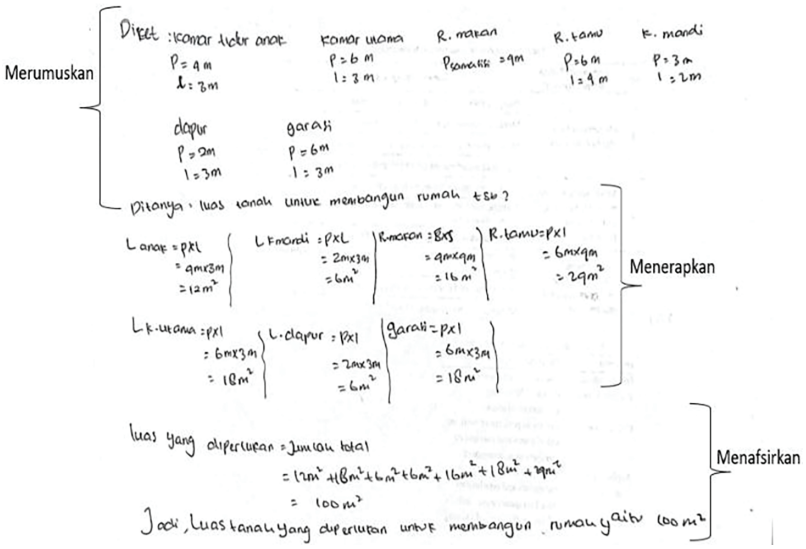

Fig. 3. Student whose written mathematical literacy ability test results very high.

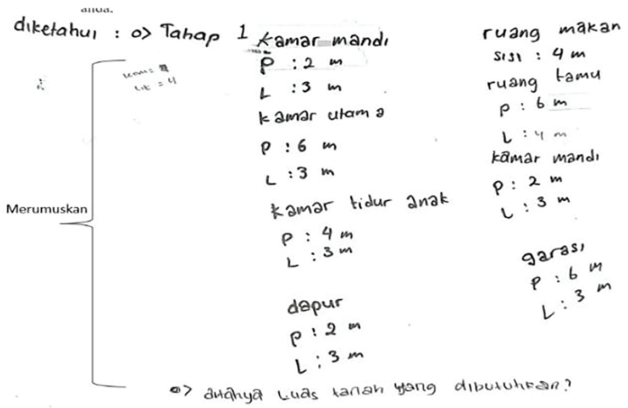

Fig. 4. Student whose written low mathematical literacy ability test results.

The percentage of written literacy test results from 32 students, based on indicators, obtained a total average of 78.91% in the high category. This shows that the students' mathematical literacy abilities were high. The percentages of mathematical literacy ability test results based on these indicators are shown in Table X.

Table XI shows that the percentage of students' written mathematical literacy ability test results varied based on student frequency. The highest frequency of students was in the very high category (68.75%), which shows that the majority of students can meet mathematical literacy indicators.

Based on empirical evidence gathered through systematic observational methods, the educator effectively facilitated the process of knowledge acquisition within the educational setting by employing a teaching strategy for teacher students in conjunction with a specialized modular software application designed for educational purposes, specifically focusing on plane geometry concepts classified under the 'good' pedagogical category. Recent scholarly investigations conducted by Harahap *et al.* (2020) and Agustika *et al.* (2019) have underscored that the instructional procedures associated with the TSTS pedagogical framework have been meticulously adhered to, thereby indicating a level of instructional quality deemed satisfactory by experts in the field. Moreover, the outcomes of observational studies pertaining to student engagement and participation have consistently demonstrated a commendable performance that falls within the parameters of the 'good' classification. Correspondingly, in accordance with the findings reported by Dewanto *et al.* (2019), the application of the trust approach in educational contexts has been associated with a discernible enhancement in the quality and intensity of student learning activities, thus corroborating the positive impact of this pedagogical model on student academic engagement.

The educational model, known as the TSTS learning approach, requires students to engage in collaborative group study sessions for effective knowledge acquisition. These student groups were carefully formed by means of an application designed specifically for this purpose, ensuring a diverse mix of individuals with varying perspectives and strengths. The facilitator of the learning process then delivers educational materials in various multimedia formats through the aforementioned application, meticulously crafted using a unique coding system to enhance the students' understanding of the subject matter at hand. Recent scholarly inquiries conducted by Rizqiyani *et al.*

TABLE X: Mathematical Literacy Ability Test Results

Indicator	Question items	Score	Number of students	Average (%)
Formulate	1	4	24	86,72
		3	5	
		2		
		1		
		0	3	
Apply		4	13	80,47
		3	15	
		2	3	
		1		
		0	1	
Interpret		4	9	69,53
		3	15	
		2	4	
		1		
		0	4	
Total			78,91	

TABLE XI: Percentage of Mathematical Literacy Ability Test Results

Category	Frequency (students)	Average (%)
Very high	22	68,75
High	4	12,5
Currently	5	15,63
Low	1	3,13
Very low	–	

(2022) and Pradana *et al*. (2020) underscored the critical role of teachers in furnishing students with the necessary learning tools and resources essential for creating conducive learning environments. Central to the success of the TSTS model is the integration of modular media components, which bolster the overall learning experience for students. Within the TSTS framework, students assume different roles in their respective groups, each of which contributes to the collaborative learning process. Students entrusted with the responsibility of gathering information from other groups are commonly referred to as "strays," while students designated to share information with peers from external groups are labeled as "stayers." Through this structured approach, TSTS effectively mitigates the risk of student disengagement by fostering an environment that encourages active participation and engagement TSTS effectively mitigates the risk of student disengagement by fostering an environment that encourages active participation and engagement. This pedagogical strategy not only prevents boredom among students but also cultivates a culture of knowledge sharing and idea exchange, thereby enabling students to effectively complete the assigned tasks, as highlighted in the studies by Listiana and Prasetyowati (2021).

Based on the outcomes derived from the questionnaire that aimed to evaluate the responses provided by students in relation to the utilization of multimedia resources within the context of the learning process, it was noted that a discernible level of interest was exhibited by the students in the application of said resources. The utilization of learning media based on Android applications has the capacity to instill a sense of enthusiasm for the process of learning, consequently leading to a heightened level of interest among students in engaging with the educational materials at hand, as highlighted in the studies conducted by Rismayanti *et al*. (2022) and Rizqiyani *et al*. (2022). The integration of digital teaching materials into the educational framework simplifies the comprehension of subject matter through the utilization of visual aids such as pictures and videos. The incorporation of the TSTS learning model, when augmented by the support provided through the application, exhibited the potential to enhance students' communication skills and literacy capabilities. This assertion is validated in the insights gleaned from research outcomes as posited by Rizqiyani *et al*. (2022), wherein the development of e-modules with the assistance of modular technology has been demonstrated to yield improvements in mathematical literacy skills. The development of these learning modules is underpinned by the outcomes of post-literacy evaluations, which indicate that the proficiency levels achieved fall within a spectrum deemed satisfactory.

The mean level of mathematical communication proficiency among all students was 80.73%, falling within the high category. In accordance with the investigations conducted by Damayanti *et al*. (2020) and Andrianingsih and Sugianto (2021), the mean score attained by students in the realm of mathematical communication skills falls within a commendable category. Throughout the instructional process, educators consistently remind students to adhere to the three specified indicators when tackling mathematical problems to cultivate habitual practice. A notable disparity between the outcomes of the current study and previous research is evident in the inability of students with lower aptitude levels to effectively articulate the problem scenario presented in the questions through

written explanations, failing to logically present the outcomes of their problem-solving endeavors, as noted by Rahimah and Asy'ari (2022), Puspa *et al*. (2019), Caligaris *et al*. (2019), and Mujiasih *et al*. (2021). Similar to the mathematical communication domain, the assessment of mathematical literacy based on individual indicators yields diverse outcomes. A comprehensive breakdown of student performance across each indicator is outlined in Table IX. The mean level of mathematical literacy proficiency among all students was 78.91%, with the formulating indicator having the highest mean score of 86.72%.

4. Conclusion

Based on the outcomes of the conducted research, it is evident that the TSTS educational framework, supported by a modular application, has yielded a favorable influence, as evidenced by the discernible enhancements noted during each session. The utilization of a modular-based tool has notably facilitated the learning process for students, enabling them to navigate through the educational material with greater ease while also enhancing their capacity to convey information to their peers. Through the incorporation of media into the TSTS approach, a notable enhancement in students' aptitude for communication and mathematical literacy emerges, as they engage in collaborative inquiry and discourse by posing inquiries pertaining to sub-topics explored by other student cohorts, consequently fostering problem-solving skills in real-world contexts. Moreover, there was a noticeable upturn in students' communication processes and mathematical acumen, as evidenced by the outcomes of their assessments.

Funding

This research was funded by the University of Muhammadiyah Malang.

Conflict of Interest

There is no conflict of interest.

References

Afriliani, D., Murdiono, M., & Hajuan, M. A. (2022). Increasing student activity using the TSTS learning model assisted by digital comics media. *AL-ISHLAH: Jurnal Pendidikan*, *14*(4), 5873–5884. https://doi.org/10.35445/alishlah.v14i4.2043.

Agustika, G. N. S., Yusi Lestari, N. M., & Wiarta, I. W. (2019). The effectiveness of cooperative learning model of the TSTS type observed from the interpersonal intelligence toward the mathematical competency. *Journal of Education Research and Evaluation*, *3*(2), 46. https://doi.org/10.23887/jere.v3i2.20973.

Amalia, R., Fadilah, F., Komarudin, M., & Kusuma, J. W. (2021). Development of mathematics e-books in improving mathematical literacy and entrepreneurial spirit. *AL-ISHLAH: Jurnal Pendidikan*, *13*(3), 2425–2434. https://doi.org/10.35445/alishlah.v13i3.987.

Amin, A., Alimni, A., Kurniawan, D. A., Triani, E., & Pratama, W. A. (2022). Implications of teacher interpersonal communication ability on student learning motivation in islamic religious education lessons during pandemic. *Journal of Education Research and Evaluation*, *6*(1), 156–167. https://doi.org/10.23887/jere.v6i1.39547.

Andrianingsih, V., & Sugianto, S. (2021). Mathematical communication ability assessed by student self-efficacy in learning the two stay two stray (TSTS) model on ability of process approach. *Unnes Journal of Mathematics Education Research*, *10*(2), 140–146. http://journal.unnes.ac.id/sju/index.php/ujmer.

Apriakanti, D., Kusuma, M., & Nurhayati, M. (2020). The effectiveness of two stay two stray (TSTS) cooperative learning model in improving students' critical thinking skills. *Journal of Science Education Research*, *4*(1), 40–43. https://doi.org/10.21831/jser.v4i1.34240.

Asmana, A. T., Laili, N. H., & Ardiyansah, A. A. (2018). Profil Komunikasi Matematika Tertulis Dalam Pemecahan Masalah Matematika Di Smp Ditinjau Dari Kemampuan Matematika [Profile of written mathematical communication in solving mathematical problems in junior high school in terms of mathematical abilities]. *Jurnal Inovasi Pendidikan Dan Pembelajaran Matematika*, *4*, 1–12. https://doi.org/10.26740/mathedunesa.v9n2.p442-454.

Aviandari, E. I., Shodiqin, A., & Purnomo, D. (2021). Efektivitas Model Pembelajaran Two Stay Two Stray Dan Think Pair Share Berbantu Media Wolfram Mathematica Terhadap Kemampuan Komunikasi Matematis Di SMA [The effectiveness of the two stay two stray and think pair share learning model assisted by Wolfram Mathematica media on mathematical communication skills in high school]. *Imajiner: Jurnal Matematika Dan Pendidikan Matematika*, *3*(2), 139–149. https://doi.org/10.26877/imajiner.v3i2.7480.

Caligaris, M. G., Schivo, M. E., & Romiti, M. R. (2019). Communication competence in mathematics: Analysis of the evolution of calculus student skills throughout their freshmen year. *International Journal of Learning, Teaching and Educational Research*, *18*(4), 49–62. https://doi.org/10.26803/ijlter.18.4.3.

Damayanti, R. R., Zulkarnain, I., & Sari, A. (2020). Kemampuan Komunikasi Matematis Siswa Dalam Pembelajaran Matematika Menggunakan Model Quick on the Draw [Students' mathematical communication skills in mathematics learning using the quick on the draw model]. *EDU-MAT: Jurnal Pendidikan Matematika*, *8*(1), 54–61. https://doi.org/10.20527/edumat.v8i1.8352.

Dewanto, M. D., Budiyono, & Pratiwi, H. (2019). The experiment of TAPPS, TSTS, and DL learning models viewed through adversity quotient in mathematics learning achievement. *IOP Conference Series: Earth and Environmental Science*, *243*(1), 1–10. https://doi.org/10.1088/1755-1315/243/1/012124.

Firman, F., Aswar, N., Sukmawaty, S., Mirnawati, M., & Sukirman, S. (2020). Application of the two stay two stray learning model in improving indonesian language learning outcomes in elementary schools. *Jurnal Studi Guru Dan Pembelajaran*, *3*(3), 551–558. https://e-journal.my.id/jsgp/article/view/621.

Handican, R., & Nasution, E. Y. P. (2023). Mobile technology-based instructional edutainment media "Number Game" to improve mathematical conceptual understanding. *Jurnal Edutech Undiksha*, *11*(1), 119–127. https://doi.org/10.23887/jeu.v11i1.53913.

Harahap, M. S., Lubis, R., & Harahap, L. A. (2020). Efektivitas Model Pembelajaran Kooperatif Tipe Two Stay Two Stray (Tsts) Terhadap Kemampuan Pemecahan Masalah Matematis Siswa [The effectiveness of the two stay two stray (Tsts) cooperative learning model on students' mathematical problem solving abilities]. *Jurnal Pendididkan Matematika*, *12*(2), 148–160. https://doi.org/10.26618/sigma.v12i2.

Hasanudin, C., Fitrianingsih, A., Nuri, D., Utomo, P., Baihaqi, M. A. R., Language, I., Java, E., & Java, E. (2022). Strategies to create digital learning materials of early reading for elementary school students using. *Internasional Conference on Education Innovation and Social Science (ICEISS)*, 34–47. https://proceedings.ums.ac.id/index.php/iceiss/article/view/959.

Hidayat, T. M., & Muhson, A. (2018). The impact of think pair share and two stay two stray learning model towards learning outcomes and cooperation ability. *Dinamika Pendidikan*, *13*(1), 119–129. https://doi.org/10.15294/dp.v13i1.15045.

Hindun Permatasari, V., & Dwi Kurniasih, M. (2021). The analysis of mathematical literacy on plane geometry material with Batik Betawi Tumpal pattern. *Kalamatika: Jurnal Pendidikan Matematika*, *6*(1), 83–98. https://doi.org/10.22236/kalamatika.vol6no1.2021pp83-98.

Ishaq, K., Rosdi, F., Zin, N. A. M., & Abid, A. (2020). Usability and design issues of mobile assisted language learning application. *International Journal of Advanced Computer Science and Applications*, *11*(6), 86–94. https://doi.org/10.14569/IJACSA.2020.0110611.

Jayanta, I. N. L., & Agustika, G. N. S. (2021). A comparison of the effectiveness of two stay-two stray and pair checks cooperative learning models towards primary school mathematics learning outcomes. *Proceedings of the 2nd International Conference on Technology and Educational Science (ICTES 2020)*, *540*(Ictes 2020), 1–5. https://doi.org/10.2991/assehr.k.210407.205.

Kaharuddin, A., & Hajeniati, N. (2020). The effect of combination of number head together and two stay two stray learning models on mathematical learning outcomes and activeness of senior high

school students. *International Journal of Educational Best Practices*, *4*(2), 78. https://doi.org/10.31258/ijebp.v4n2.p78-87.

Khoerunnisa, S., & Cahyani, R. (2021). Peningkatan Kemampuan Komunikasi Matematis Peserta Didik Dengan Model Kooperatif Tipe Two Stay Two Stray Berbantuan Geogebra [Improving students' mathematical communication skills using the two stay two stray cooperative model assisted by Geogebra]. *Ujmes*, *06*(01), 1. https://doi.org/10.30999/ujmes.v6i1.1735.

Kholifah, U., & Imansari, N. (2022). Pelatihan Membangun Aplikasi Mobile Menggunakan Kodular Untuk Siswa Smpn 1 Selorejo [Training on building mobile applications using Kodular for Smpn 1 Selorejo students]. *Abdimas Galuh*, *4*(1), 549. https://doi.org/10.25157/ag.v4i1.7259.

Kurniawan, H., & Darmono, P. B. (2021). Use of open-ended student worksheet to improve mathematics communication skills in algebra. *International Journal for Innovation Education and Research*, *9*(5), 402–416. https://doi.org/10.31686/ijier.vol9.iss5.3106.

Kurniawati, N. D. L., & Mahmudi, A. (2019). Analysis of mathematical literacy skills and mathematics self-efficacy of junior high school students. *Journal of Physics: Conference Series*, *1320*(1), 1–6. https://doi.org/10.1088/1742-6596/1320/1/012053.

Listiana, R. D., & Prasetyowati, D. (2021). Studi Komparasi Model Pembelajaran Kooperatif Tipe Student Team Achievement Devision dan Two Stay Two Stray Berbantu Macromedia Flash Terhadap Prestasi Belajar Siswa [Comparative study of cooperative learning models type student team achievement division and two stay two stray assisted by macromedia flash on student learning achievement]. *Imajiner: Jurnal Matematika dan Pendidikan Matematika*, *3*(1), 7–14. https://doi.org/10.26877/imajiner.v3i1.6909.

Mahadewi, N. K. N., Ardana, I. M., & Mertasari, N. M. S. (2020). Kemampuan Komunikasi Matematis Melalui Model Reciprocal Teaching Berbantuan Media Interaktif [Mathematical communication skills through the reciprocal teaching model assisted by interactive media]. *JNPM (Jurnal Nasional Pendidikan Matematika)*, *4*(2), 338. https://doi.org/10.33603/jnpm.v4i2.3606.

Menggo, S., Merlyna Yuda Pramesti, P. D., & Krismayani, N. W. (2023). Integrating project-based learning in preparing students' interpersonal communication skills on speaking courses in Indonesia. *International Journal of Learning, Teaching and Educational Research*, *22*(9), 219–240. https://doi.org/10.26803/ijlter.22.9.12.

Mujiasih, M., Waluya, B., Kartono, K., & Mariani, S. (2021). The students' mathematics communication skill performance after geogebra-assisted EPIC-R learning implementation. *International Journal of Learning, Teaching and Educational Research*, *20*(10), 256–273. https://doi.org/10.26803/ijlter.20.10.14.

Pantaleon, K. V., Nendi, F., & Jehadus, E. (2019). Komunikasi Matematis dalam Terang Literasi Matematika [Mathematical communication in the light of mathematical literacy]. *Joornal of Songke Math*, *2*(1), 12–22. http://jurnal.unikastpaulus.ac.id/index.php/jsm/article/view/381.

Paris, S., Jusmawati, Alam, S., Jumliadi, & Arsyam, M. (2021). Upaya Peningkatan Prestasi Belajar Siswa Melalui Model Kooperatif Dengan Pendekatan Eksperimen Pada Pembelajaran Ipa Di Kelas V Sd Inpres Bangkala Ii Kota Makassar [Efforts to increase student learning achievement through a cooperative model with an experimental approach to science learning in class V of SD Inpres Bangkala Ii Makassar city]. *Maret*, *8*(1), 101–108. https://doi.org/10.61290/pgsd.v8i1.301.

Pradana, L. N., Sholikhah, O. H., Maharani, S., & Kholid, M. N. (2020). Virtual mathematics kits (VMK): Connecting digital media to mathematical literacy. *International Journal of Emerging Technologies in Learning*, *3*, 234–241. https://doi.org/10.3991/ijet.v15i03.11674.

Puspa, S., Riyadi, R., & Subanti, S. (2019). Profile of mathematical communication skills junior high school students in problem solving. *Journal of Physics: Conference Series*, *1157*(3), 1–6. https://doi.org/10.1088/1742-6596/1157/3/032125.

Puteri, D. A. R., & Ibrahim, N. (2023). Increase student activity through the use of interactive learning videos in civics learning during the study from home. *Journal of Education Research and Evaluation*, *7*(2), 313–320. https://doi.org/10.23887/jere.v7i2.38784.

Qohar, A., & Fazira, S. K. (2022). Student mathematical communication in online discussion in introduction to geometry course using Edmodo. *Journal of Education Research and Evaluation*, *6*(4), 576–585. https://doi.org/10.23887/jere.v6i4.51241.

Rahayu, M., Sudarma, I. K., & Dibia, I. K. (2020). Enhancement of science learning outcomes through two stay two stray learning model assisted with mind mapping media. *Journal of Education Technology*, *4*(3), 218. https://doi.org/10.23887/jet.v4i3.25688.

Rahimah, N., Asy'ari, N. (2022). Profil kemampuan komunikasi matematis siswa dalam memecahkan masalah matematika ditinjau dari kemampuan matematika. *Lentera: Jurnal Ilmiah Kependidikan*, *17*(1), 51–60.

Rismayanti, T. A., Anriani, N., & Sukirwan, S. (2022). Pengembangan E-Modul Berbantu Kodular pada Smartphone untuk Meningkatkan Kemampuan Berpikir Kritis Matematis Siswa SMP [Development of modular-assisted e-modules on smartphones to improve junior high school students' mathematical critical thinking abilities]. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *6*(1), 859–873. https://doi.org/10.31004/cendekia.v6i1.1286.

Rizqiyani, Y., Anriani, N., & Pamungkas, A. S. (2022). Pengembangan E-Modul Berbantu Kodular pada Smarthphone untuk Meningkatkan Kemampuan Literasi Matematis Siswa SMP [Development of modular assisted e-modules on smartphones to improve the mathematical literacy abilities of middle school students]. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *6*(1), 954–969. https://doi.org/10.31004/cendekia.v6i1.1172.

Safitri, M., & Aziz, M. R. (2022). Bahan Ajar Digital Matematika Berbantuan Kodular [Codular-assisted digital mathematics teaching materials]. *Duconomics Sci-Meet (Education & Economics Science Meet)*, *2*, 93–103. https://doi.org/10.37010/duconomics.v2.5913.

Samawati, I., & Kurniasari, I. (2021). Students' communication skills in solving mathematical literacy problems based on mathematical abilities. *Journal of Medives: Journal of Mathematics Education IKIP Veteran Semarang*, *5*(1), 22. https://doi.org/10.31331/medivesveteran.v5i1.1421.

Septiadi, D. D., & Wahidah, A. (2022). Perbandingan Pemahaman Konsep Matematis Siswa pada Pembelajaran Kooperatif Tipe TPS dengan TSTS [Comparison of students' understanding of mathematical concepts in TPS and TSTS type cooperative learning]. *Lattice Journal: Journal of Mathematics Education and Applied*, *1*(2), 91. https://doi.org/10.30983/lattice.v1i2.4742.

Septian, A., & Maghfirah, D. (2021). Mathematical literacy skills using Google classroom on trigonometry. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *10*(4), 2515. https://doi.org/10.24127/ajpm.v10i4.4263.

Suwangsih, E., Budiarti, M. R., Ruskandi, K., Hendawati, Y., & Majid, N. W. A. (2019). Two-stay two-stray model on improving mathematical communication skill of elementary school students. *Journal of Physics: Conference Series*, *1318*(1), 0–6. https://doi.org/10.1088/1742-6596/1318/1/012127.

Wahyudiati, D. (2023). Enhancing students' communication and STEM reasoning abilities based on gender through application of IT-based chemistry teaching materials. *International Journal of Learning, Teaching and Educational Research*, *22*(5), 160–179. https://doi.org/10.26803/ijlter.22.5.8.

Wahyuni, T. S., Amelia, R., & Maya, R. (2019). Analisis kemampuan komunikasi matematis siswa SMP pada materi segiempat dan segitiga. *urnal Kajian Pembelajaran Matematika*, *3*(1), 18–23.

Wandani, S., Setyansah, R. K., & Masfingatin, T. (2023). Development of mathematics e-modules based on PjBL STEM on materials constructing flat side spaces to improve mathematical communication ability of junior high school students. *AL-ISHLAH: Jurnal Pendidikan*, *15*(1), 533–548. https://doi.org/10.35445/alishlah.v15i1.2497.