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Local instructional theory of probability topics based on realistic mathematics education for eight-grade students

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Abstract

This study examines the development of learning designs based on Realistic Mathematics Education (RME) on the probability topic at the eighth-grade junior high school level. Probability abounds in everyday life, and the RME approach is believed to develop students' mathematical communication skills. This learning design development used the Plomp model combined with Gravemeijer and Cobb model. The research phase includes preliminary research, prototyping phase, and assessment phase. The products of this research are a valid, practice, and effective Local Instructional Theory (LIT) and teacher and student books. The results showed that the students who participated in learning using RME-based designs could determine the concept of probability and effectively improve students' mathematical communication skills.

Keywords: Communication, Local Instructional Theory, Probability, RME

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Probability is the possibility of an event (Komarudin, 2016; Anggara, 2019; Prihartini, Sari, & Hadi, 2020). According to Putridayani and Chotimah (2020), the probability is a topic that measures the occurring uncertainty in everyday life and is a part of basic literacy in mathematics (Garfield & Ahlgren, 2020). An example of the application of this concept is when someone chooses a university to continue their study. Suppose university A has more enthusiasts than B, then it is likely that an individual will place A as the first choice (Sya'bani et al., 2021).

The probability topic is essential for every student. This topic could train students' mathematical thinking skills, such as probabilistic thinking, mathematical communication skills, problem-solving, and other high-level abilities (Greer, 2001, 2016; Shodiqin et al., 2022). Furthermore, probability also has many benefits and uses in everyday life. These include helping to make the right decisions, predicting what will happen, and minimizing losses (Cunningham et al., 2009).

The fact is that students struggle to solve problems related to probability topics because they only memorize formulas and follow the teacher-taught pattern of completion without having an explicit understanding (Rada & Fauzan, 2019). Another difficulty experience is identifying the right approach that must be taken to solve the probability-related problem (Borovcnik & Bentz, 1991; Fitri & Abadi, 2021; Kolloffel et al., 2010; Sa'idah, 2016; Tinungki & Nurwahyu, 2021). The difficulties in solving these problems include factual, conceptual, procedures, and difficulty in principles. In the factual, students have problems making a settlement plan due to misinterpreting the questions' intent. In the conceptual, they cannot distinguish between combination and permutation formulas. In the case of procedures, they have difficulty working on the factorial arithmetic operation. Finally, in the case of principle, students have difficulty using existing principles such as "crossing out rules" in the form of division factorial numbers. They also struggle with describing the sample space, composing forms of experimental events, creating mathematical models, and understanding the principles of events and prerequisite concepts (Anggrayni et al., 2021; Astuti, 2015; Batanero et al., 2005; Cheng, 2011; Falk & Konold, 1992; Saniyah & Alyani, 2021; Wilensky, 1995).

Students need to understand the concept of probability and overcome their difficulties. Hence, learning should begin by experimenting. For example, using dice and coins in games can help students understand the concepts (Komarudin, 2019). Without experimental learning, they tend to forget what has been taught and are incapable of applying the concept (Mustamin, 2017).

Teaching materials and innovative learning methods will help students understand and overcome probability topic difficulties (Mezhennaya & Pugachev, 2019). In a previous study, Zeng (2020) used models and media to overcome students' difficulties in probability. Zeng (2020) also adopted MATLAB for the learning process. Several studies also have been conducted using mathematical ideas models, character learning, problem-based, cooperative-type team-assisted individualization, and three-zone concepts to improve outcomes and overcome difficulties in the probability topic learning process (Purwanto, 2013; Madawistama, Heryani, & Kurniawan, 2022; Maulida et al., 2015; Nodira, Gulchekhra, Nodira, Maprat, & Saida, 2021; Sagala & Andriani, 2019; Tinungki, 2015; Zhang, 2016).

One of the learning methods or approaches that can help students in this topic is the Realistic Mathematics Education (RME) learning approach. RME is a learning theory developed by Hans Freudenthal in the Netherlands, which views mathematics as a human activity, including problem-solving, searching for problems, and organizing the subject matter (Sya'bani et al., 2021). Several studies related to RME have been carried out. An example is the RME-based probability topic learning design for the twelfth-grade senior high school (Misdalina et al., 2013; Rada & Fauzan, 2019; Zulkardi, 2003). The products of these studies are LIT and student worksheet, and the result positively impacts student learning development. Furthermore, the RME is essential in designing probability learning using lottery coupons in the seventh grade of junior high school (Yanti et al., 2016). This is because the RME is a valuable starting point in learning. Nevertheless, the limitation of Yanti et al. (2016) is that it focuses solely on finding the sample space and points; hence, how students discover the concept/formula of probability is unclear. The following research is developing the junior high school's didactic design in probability, creating a Contextual Socratic learning-based lesson plan (Yunarti, 2014). The results showed good teachers-students, students-students, and students-learning materials interactions. However, students are still assisted with various small demonstrations (experimental activities) to understand the questions. Thus, the available time is insufficient to master the concept.

The RME or this meaningful learning is expected to develop students' mathematical communication skills. One of the characteristics of RME that can help students to improve their mathematical communication skills is the interactive point. Through this approach, students can communicate ideas, strategies, or procedures for solving a problem verbally, in writing, or in pictures. Therefore, learning mathematics with the RME approach can provide space for students to practice communication skills (Izzati, 2012). The realistic mathematics educations (RME) approach can help students communicate their ideas and build students' communication skills (Silvianti & Bharata, 2016; Asikin, 2013; Hidayanto, 2013).

This study presents the Local Instructional Theory (LIT) on probability topics based on Realistic Mathematical Education (RME) for eighth-grade junior high school students. Unlike the previous studies, in this study, a learning design will be developed as a Hypothetical Learning Trajectory (HLT) and implemented in teacher and student books. In the HLT, there are several demonstrations to make the students understand the probability with sub-topics of empirical and theoretical probability. The HLT, books, and other components are based on RME by utilizing problems close to students' daily lives.

METHODS

This learning design was developed using the Plomp Model combined with Gravemeijer and Cobb Model (Plomp & Nieveen, 2013). This combination aims to produce valid, practical, and effective HLT, teacher, and student books. The process of the development of the learning design can be seen in Table 1.

Table 1. The Development Process

Development Process	
Preliminary Research	Literature review, Needs Analysis, Curriculum Analysis, Concept Analysis, and Students Analysis (Plomp-Gravemeijer Model).
Development Phase	Plomp: Self Evaluation, Expert Review, One-to-One, Small Group. The One-to-One and Small Group Evaluations are combined with the Gravemeijer and Cobb Model. The complete process can also be seen in Figure 1.
Assessment Phase	This phase is to find the LIT's effectiveness in improving the Students' Mathematical Communication skills.

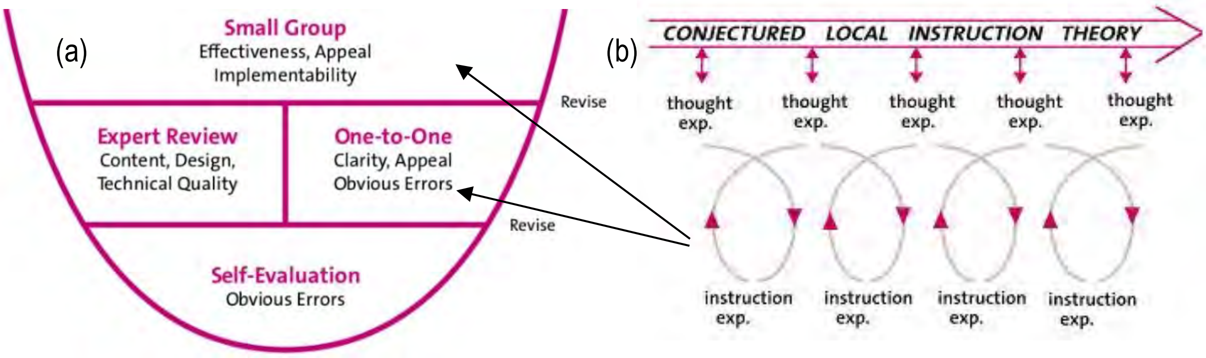


Figure 1. Development Phase, (a) Plomp Model, (b) Gravemeijer & Cobb Model

After the development and evaluations, the students that participated in the one-to-one and the small group evaluation were given a questionnaire to determine the products' usability. They were also given questions about mathematical communication skills to assess the product's effectiveness. It is effective when the number of students who scored above the standard mark (in this case, 75 out of 100) is ≥ 60% (Sahroni, 2021).

RESULT AND DISCUSSION

Preliminary Research

Based on the needs analysis results from interviews with mathematics teachers, mathematics learning in school is teacher-centered and textbooks-based. Furthermore, the lack of learning time is also a problem of probability topic learning. Learning hours are frequently ineffective due to school holidays such as pre-final and Final Examinations. The low desire of students to discuss mathematical ability questions is also a problem. When the teacher poses mathematical questions which not all students can answer, the teacher needs to re-explain the answer. This is due to the lack of discussion of questions related to the learning.

The curriculum and concept analysis results show the need for additional achievement indicators and sub-topics in learning the concept of probability. The added indicators are determining and finalizing the value of the probability and the frequency of expectations. Therefore, adding sub-materials (topics) in learning is the probability value and the frequency of expectations. The analysis results of student characteristics and literature review yielded the information required for the design of HLT.

Development Phase

This study designed HLT to determine empirical and theoretical probability, probability values, and the frequency of expectations. The HLT uses the RME approach uses contextual problems that are close to students' daily lives. In the HLT, the students found the concept by themself. The HLT has contained three activities. The three activities used the same problem to determine the empirical probability formula. The designs are as follows.

Activity 1.1: Record the number of number or figure sides are appearing in the toss of a coin and odd or even number appearing in the roll of a dice

This activity aims to enlighten the students that every coin toss is not only the number or the figure side. Furthermore, by rolling the dice, not only a few numbers appear, but all are on each side. In this activity, the students will record the results of coin tossing and dice rolling. From this data, they will solve the problem that can be seen in Figure 2.

Adi and Ani are siblings that are home from school together. They both ran to the computer room to complete their homework. They talked about how to take turns using the computer because they could not use it together. The problem is that they both want to get their turn first. Finally, they think of a fair way to determine who will use the computer first.

1. *Adi proposes tossing a coin of IDR1000, - which he took out of his pocket. If a number appears on the side of the toss, he has the right to use the computer first. However, if the side of the figure appears, then Ani will use the computer first.*
2. *Ani proposes to rolling a dice that she picked up near her toy rack. If what appears on the top side is an even number, Ani has the right to use the computer first. However, if the top side appears to be an odd number, then Adi has the right to use the computer first.*

Calculate the empirical probability of each given idea!

Figure 2. Problem to Find Empirical Probability for activity 1.1, 1.2, and 1.3

To solve the problem in Figure 2, several questions lead the students to the final answer and find the concept.

Question:
1. Write down the results of tossing a coin and rolling the dice with the conditions:
   a. A coin is tossed repeatedly 10 to 20 times.
   b. The dice are rolled repeatedly at least ten times and at most 20 times

The predictions of the student's answers and the anticipation of the teachers for this question can be seen in Tables 2 and 3.

Table 2. The Predictions of Student Answers and Anticipations of Teacher for conditions a)

Prediction of the student answers	The anticipation of Teachers
Students do not answer.	The teacher will ask: "why are there no answers? Haven't you ever tried tossing a coin?" If no one answers or is silent, the teacher will give again probing question in the form of "you try to toss this coin once. What do you get?".
Students answer, "the number of each side appearing is equal."	If students answer as predicted, the probing question is, "if the sides that appear are the same, who will use the computer first?"
Students answer, "the number of each side appearing is different."	Teacher: "in group A they get x results, then group B gets y results, and so on. Your answers are all different. Is there something wrong with data collection?". To make them think, the teacher will state that the students are correct.

Table 3. The Predictions of Student Answers and the Anticipation of Teacher for Condition b)

Prediction of the student answers	The anticipation of teacher
Students do not answer the questions.	The teacher: "why haven't you answered yet? Have you tried rolling the dice yet?" If no one answers or is silent, the teacher will again give a probing question: "try rolling the dice once. What side appears?".
Students answer, "the even and numbers appearing are equal."	If students answer as predicted 2, the probing question is, "if the sides that appear are the same, who will use the computer first?"
Students answer, "the even and numbers appearing are different."	Teacher: "in group A they get x results, then group B gets y results, and so on. your answers are all different. Is there something wrong with data collection?". To make them think, the teacher will state that the students are correct.

Activity 1.2: Compare the results of data collection with the number of experiments carried out

After the previous activity, students were asked to record their results and review their notes from their findings when tossing coins and rolling dice—this activity aimed at understanding how a possibility occurs. The concept of ordinary fractions will also guide students in articulating that an occurrence will not exceed 1 since the probability is a value between 0 and 1.

This activity was also conducted to solve the problem in Figure 2.

Question:

c. Pay attention to the data that you got earlier. Who will use the computer first when using a coin toss?
d. Based on the experiments you have done, what is the probability that Ani or Adi can use the computer?
e. Pay attention to the data that you obtained earlier. Who will use the computer first when rolling the dice?
f. What is the probability that Ani/Adi (based on the previous answer) uses the computer first by rolling the dice?

The predictions of the student's answers and anticipation of the teachers for this question can be seen in Tables 4, 5, 6, and 7.

Table 4. The Predictions of Student Answers and Anticipations of Teacher for Condition c)

Prediction of the student answers	The anticipations of teachers
Possible student answers: a) Adi will use the computer first b) Ani will use the computer first	The probing question will be given by the teacher, namely, "how do you choose Ani/Adi first?". On this question, students' answers may vary, or all be the same according to the data they have obtained. Then another anticipation that must be done is to ensure that their answers are correct. If the number side appears more, then Adi will use the computer first. If the side of the image appears more, then Ani will use it first, depending on the data collection results that students do.

Table 5. The Predictions of Student Answers and Anticipation of Teacher for Condition d)

Prediction of the student answers	The anticipations of teachers
Students do not answer.	The teacher will give a probing question in the form of "how many times have you tried?" if no one answers or is silent then the teacher will return provide a probing question in the form of Predict student answers. Teacher: "If you faced a statement that you will get 2 out of 3, what do you think?"
Only answer the amount of data from the occurrence of events (x).	The teacher will guide students by asking a probing question, "then what about the number of trials you did?"
Just answer the number of trials performed (y).	The teacher will guide students by asking a probing question, "then what about the data you collected earlier?"
y out of x	The teacher will ask students to review the data they got. Then

Prediction of the student answers	The anticipations of teachers
	give a probing question in the form of "if you get 2 of 3 will you get all three? Or only 2?"
x out of y	The teacher will ask why they answered like that. Then convince students that the answers are correct and provide probing questions in the form of "are there other forms of expressing the word 'of' in mathematics?"
$\frac{x}{y}$ because the number of the appearing is x out of y.	The teacher will ask why the students answered like that. Then convince students that the answer is correct.

Table 6. The Predictions of Student Answers and Anticipation of Teacher for Condition e)

Prediction of the student answers	The anticipations of teachers
Possible student answers: a) Adi will use the computer first b) Ani will use the computer first	The teacher will ask the probing question, "how did you determine Ani/Adi first?". On this question, students' answers may vary, or all be the same according to the data they have obtained. Then another anticipation that must be done is to ensure that their answers are correct. If there are more even sides, then Adi can use the computer first. Whereas if there are more odd sides, Ani can use the computer first.

Table 7. The Predictions of Student Answers and Anticipation of Teacher for Condition f)

Prediction of the student answers	The anticipations of teachers
Students do not answer.	The teacher will give a probing question in the form of "how many times have you tried?" if no one answers or is silent, then the teacher will return and provide a probing question in the form of Predict student answers. Teacher: "If you faced a statement that you will get 2 out of 3, what do you think?"
Only answer the amount of data from the occurrence of events (x).	The teacher will guide students by asking a probing question, "then what about the number of trials you did?"
Just answer the number of trials performed (y).	The teacher will guide students by asking a probing question, "then what about the data you collected earlier?"
y out of x	The teacher will ask students to review the data they got. Then give a probing question: "if you get 2 of 3 will you get all three? Or only 2?"
x out of y	The teacher will ask why they answered like that. Then convince students that the answers are correct and provide probing questions in the form of "are there other forms of expressing the word 'of' in mathematics?"

Prediction of the student answers	The anticipations of teachers
$\frac{x}{y}$ because the number of the appearing is x out of y.	The teacher will ask why the students answered like that. Then convince students that the answer is correct.

Activity 1.3: Find empirical probability formula using existing data.

This activity aims to help students determine their empirical probability formula. The reference is the data collection carried out in activities 1.1 and 1.2. In the previous activity, students could describe how side-by-side comparisons emerged with many experiments. Therefore, they are closer to the empirical formula to determine empirical probability. They were directed to notate or symbolize the data they had found.

This activity was also conducted to solve the problem in Figure 2.

Question:

g. From the activities carried out above, how can you notate what you found? And how do you write down the probability of an event?

The predictions of the student answers and the anticipation of the teachers for this question can be seen in Table 8.

Table 8. The Predictions of Student Answers and Anticipation of Teacher for Condition 9)

Prediction of the student answers	The anticipations of teachers
Students do not answer.	The teacher asks students to explain their answers and compare with other solutions so that they understand the basics of the commands given by the questions. Suppose the student does not answer or just silent. Then the teacher will provide a probing question: "can you give an example of what you found? "
The number of sides that appear: m. Number of trials: n. Probability = $\frac{n}{m}$	The teacher asks several representatives of the students to provide arguments related to the answers given, then invite students to review previous activities.
The number of sides that appear: n. Number of trials: m. Probability = n/m.	The teacher invites students to display them in class so that interaction (communicating) will occur between students and teachers and students with students. The teacher gives appreciation and feedback on student responses. Then the teacher will convince students that this answer is correct.

The HLT that has been designed is validated by 3 mathematics experts, 1 Indonesian language expert, and 1 educational expert. This evaluation was carried out on 3 eighth-grade students with low, medium, and high abilities at Sekolah Menengah Pertama Negeri 2 IV Koto (Junior High School). It aims to review or observe the designed student books if there is difficulty understanding the instructions, sentences, and student responses in solving contextual problems.

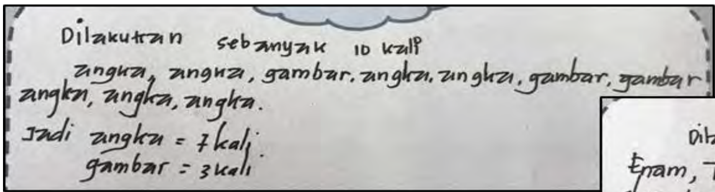
Generally, students can follow the learning activities well. The provided contextual problems serve as a starting point, allowing students to imagine the desired learning activities. The activities provided are also a guide in determining the desired probability concept. Overall, student books can be appropriately used without direction from researchers.

At the end of this stage, the students' book was analyzed by conducting informal interviews. The three students answered according to the previously designed book during the one-to-one evaluation process. This indicated that they have been able to participate in RME-based probability topic learning. However, at the beginning of the lesson, they hesitated because of the use of some ambiguous or ineffective language. Therefore, it is necessary to make improvements before using it in the small group evaluation.

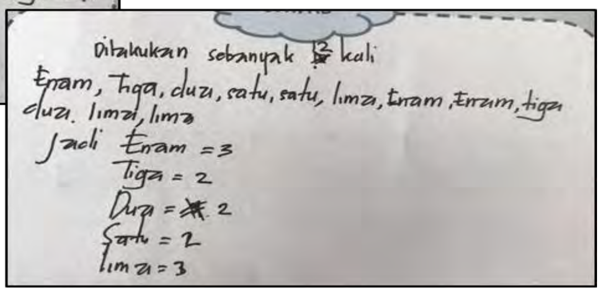
A small group evaluation was conducted on 2 high-ability, 2 medium-ability, and 2 low-ability students. They were divided into 2 groups with heterogeneous criteria. In the small group evaluation, students can participate in learning activities well and achieve the expected learning objectives. The activities provided can also guide students in determining the desired probability concept. At the small group evaluation, the group member's ability to develop ideas and explain arguments related to the ideas given is evaluated before solving the problems. One of the problems designed in this study can be seen in Figure 2.

The contextual problems above were used for three activities to determine the concept of empirical probability. The rationale is that students will conduct independent experiments and record their results to understand the concept of empirical probability. Furthermore, they will find the formulas based on the results by making their mathematical model.

Students must first record the outcomes of repeatedly tossing coins and rolling dice to solve the problems or determine the empirical probability (activity 1.1). From the data collection results, they can determine whom to use the computer first using both ideas. The solution can be seen in Figure 3.



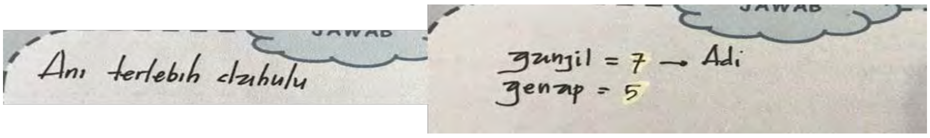
Translation: 10 times tossing,
number, number, figure, number, number, figure, figure, number, number, number.
So, Number = 7 times
Figure = 3 times



Translation: 12 times tossing,
six, three, two, one, one, five, six, six, three, two, five, five.
So, Six = 3 times, Three = 2 times, Two = 2 times, One = 2 times, and Five = 3 times

Figure 3. Student answers for activity 1.1

The students were asked to compare the results with the number of experiments carried out (activity 1.2). Before comparing, they determine who will use the computer first by using the two ideas. There was no difficulty in this activity, and students could determine who would use the computer first using both the coins and dice (see Figure 4).



Translation: Ani will go first	Odd = 7 → Adi Even = 5

Figure 4. Students' answers to activity 1.2 condition c) and e)

The students were asked to write down the probability that Ani or Adi could use the computer first. They answered with the word "out of", as shown in Figure 5.

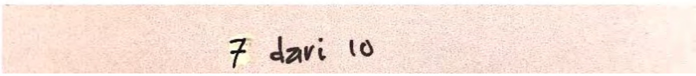


Figure 5. Students' answers to activity 1.2 condition d)

The students answered, "7 out of 10". When asked why, one of the Group 1 members responded, "Adi can use the computer first when the number side appears 7 times out of 10 experiments, Ma'am". Some guiding questions were given, reminding the form of fractions to direct students to answers consistent with mathematical concepts.

After being given stimulation in the form of guiding questions (scaffolding), the students could determine the appropriate answer by writing down the possibility of an event in informal form or the form of a fraction, as shown in Figure 6.

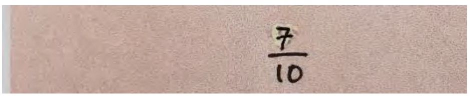
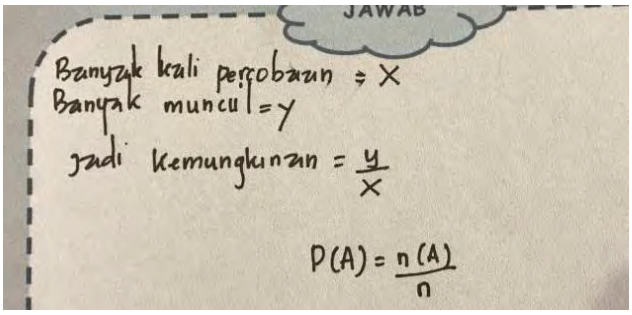


Figure 6. Student answers after anticipating activity 1.2 d)

In activities 1.1 and 1.2, students could explain the ideas in the problem and make assumptions based on the obtained facts, indicators of mathematical communication skills. Subsequently, the students were asked to determine an empirical probability formula (activity 1.3). One of the answers of the student in this activity can be seen in Figure 7.



Translation: Number of trials = x
Number of appearing = y
So, the probability = $\frac{y}{x}$
$P(A) = \frac{n(A)}{n}$

Figure 7. Student answers for activity 1.3

It is emphasized that the probability determined by the students by comparing the number of occurrences with the experiments carried out is an empirical probability. Furthermore, it confirms that the formula for the empirical probability is $\mathrm{P(A)} = \frac{\mathrm{n(A)}}{\mathrm{n}}$, where n(A) is the number of occurrences, while n is the number of trials.

In activity 1.3, it can be seen that students can use language and symbols to state the results and make conjectures according to the facts from the experiments. In this small group evaluation, it is observed how students develop ideas and argue against other group members' viewpoints. Therefore, other group members can discuss their ideas before answering the questions in each activity.

After the end of this stage, the six students' books were analyzed by conducting informal interviews. During the small group process, all the students answered almost according to the predictions that had been previously designed. Therefore, it can be concluded that the learning is already practical.

Assessment Phase

The assessment phase is carried out on a small scale to determine the product's effectiveness. The analysis results were carried out on indicators of mathematical communication skills. The indicators of mathematical communication skills in this study are 1) Using spoken or written objects, pictures, graphics, and algebra to explain mathematical situational ideas and relationships; 2) Using language or mathematical symbols to express everyday events; 3) Planning conjectures, making arguments, formulating meanings and generalizations. The test results of mathematical communication ability in one-to-one evaluation are shown in Table 9.

Table 9. Communication Ability Test Results on One-to-One Evaluation

No.	Students Cognitive Level	Questions/Indicators									Score (0-100)
		1/1	1/2	1/3	2	3/1	3/2	4/1	4/2	4/3	
1	Low	2	3	2	3	4	3	4	2	2	69.44
2	Medium	3	3	2	2	3	2	4	4	3	72.22
3	High	4	2	3	3	3	3	4	3	2	75.00
	Average						72.22				

Table 9 shows that only one student has met the standard mark. The standard mark for mathematics subjects at Sekolah Menengah Pertama Negeri 2 IV Koto is 75. Therefore, it can be concluded that the RME-based learning design on the concept of probability has no significant effect on the mathematical communication skills of students with low and medium abilities. The results of the mathematical communication ability test in the small group evaluation are shown in Table 10.

Table 10 shows that all the students met the standard mark with the lowest and highest score of 77.78 and 94.44. Therefore, it can be concluded that the RME-based learning design product on the concept of probability significantly impacts the mathematical communication skills of the six students who participated in the small group evaluation. One of the test results of low ability students is better than those with medium ability. Therefore, the results obtained by these students need to be subjected to further analysis.

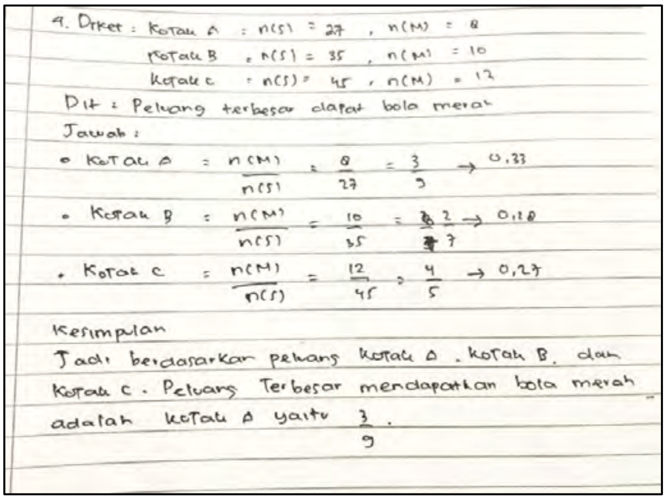
Table 10. Communication Ability Test Results on Small Group Evaluation

No.	Student	Questions/Indicators									Score (0-100)
		1/1	1/2	1/3	2	3/1	3/2	4/1	4/2	4/3	
1	Low ability 1	4	4	4	3	4	4	4	2	4	91.67
2	Low ability 2	4	3	3	3	3	4	4	3	2	80.56
3	Medium ability 1	4	2	3	4	4	3	4	3	3	83.33
4	Medium ability 2	4	4	2	3	3	3	4	3	2	77.78
5	High ability 1	4	2	3	4	4	3	4	3	3	83.33
6	High ability 2	4	4	4	4	4	3	4	3	4	94.44
	Average						85.19				

The analysis was conducted through interviews with the mathematics teacher, who redirected the interviewer to the homeroom teacher. Following a brief discussion, the teacher stated that low-ability students had good categories in Indonesian subjects because the designs were based on problems that were close to their daily lives. Hence, they can analyze the contextual problem reading provided. There was also a suggestion to conduct a short interview with the Indonesian language teacher. The result showed that students with low abilities easily understand texts and contexts. Since the designed product is a contextual problem, they can understand the information presented in stories close to their daily lives.

Table 10 also shows that the students with high and medium abilities test scores are identical. This is due to the carelessness of high-ability students in writing answers, as shown in Figure 8. Furthermore, in Figure 8, students accurately responded to the mathematical communication ability test information. However, while calculating the probability of each square, they were able to write down the formula, but their solution was incorrect. In box A, the student answers that the probability of getting a red ball is $\frac{8}{27} = \frac{3}{9} = 0.33$, which should not be a simplification of $\frac{10}{35}$. Therefore, providing an argument against the given situation regarding the box with a greater chance of getting a red ball is not entirely correct.

Based on the results, there are some similarities and differences with the previous studies. Prihartini et al. (2020) studied learning development using the RME approach to probability. The result showed that the activities designed using RME characteristics could help students understand concepts about theoretical and empirical probability (Nurmeidina et al., 2020; Prihartini et al., 2020; Tanujaya et al., 2018; Zulkardi & Putri, 2010, 2013). According to this study, students can develop mathematical communication skills using RME-based probability-topic learning designs. The similarity of this study with the previous is that both develop learning designs with the concept of probability with sub-topics of empirical and theoretical probability. The difference is that this study was conducted to develop students' mathematical communication skills.



4. Diket : Kotak A : $n(S) = 27$, $n(M) = 8$
Kotak B : $n(S) = 35$, $n(M) = 10$
Kotak C : $n(S) = 45$, $n(M) = 12$
Dit : Peluang terbesar dapat bola merah
Jawab :
• Kotak A $= \frac{n(M)}{n(S)} = \frac{8}{27} = \frac{3}{9} \to 0{,}33$
• Kotak B $= \frac{n(M)}{n(S)} = \frac{10}{35} = \frac{2}{7} \to 0{,}28$
• Kotak C $= \frac{n(M)}{n(S)} = \frac{12}{45} = \frac{4}{5} \to 0{,}27$

Kesimpulan
Jadi berdasarkan peluang kotak A, kotak B, dan kotak C. Peluang terbesar mendapatkan bola merah adalah kotak A yaitu $\frac{3}{9}$.

Translation: Given: Box A $\rightarrow \mathrm{n(S)} = 27, \mathrm{n(M)} = 8$
Box B $\rightarrow \mathrm{n(S)} = 35, \mathrm{n(M)} = 10$
Box C $\rightarrow \mathrm{n(S)} = 45, \mathrm{n(M)} = 12$
Question: What is the biggest probability of picking the red ball?
Answer: Box A $\rightarrow \frac{\mathrm{n(M)}}{\mathrm{n(S)}} = \frac{8}{27} = \frac{3}{9} = 0{,}333$
Box B $\rightarrow \frac{\mathrm{n(M)}}{\mathrm{n(S)}} = \frac{10}{35} = \frac{2}{7} = 0{,}28$
Box C $\rightarrow \frac{\mathrm{n(M)}}{\mathrm{n(S)}} = \frac{12}{45} = \frac{4}{5} = 0{,}27$
Conclusion
So, based on the probability of Box A, B, and C. Box A is the biggest probability of picking the red ball, which is $\frac{3}{9}$.

Figure 8. Answers to the communication ability test of high-ability students

The second is the development of learning tools using the RME approach to support mathematical communication skills (Rohati, 2015). This development has been validated and tested in this study and can be used as an alternative to overcome learning problems. Furthermore, the activities that students engage in when comparing and discussing answers are highly supportive of communication during learning, namely, providing responses, suggestions, and questions to other students/groups and conveying ideas through presentations. The similarity of this study with the previous is that both use the RME approach and develop/support students' mathematical communication skills. The result showed that this approach could improve their skills and help the student develop ideas in finding concepts independently and in groups (Freudenthal, 1968; Haryani et al., 2015; Rahayu et al., 2021; Thompson & Findlay, 2002). Another difference is that its products are in the form of lesson plans and worksheets, and the topic developed is the material for building flat sides. Conversely, the topic developed in the study is the probability of making productions in the form of LIT and teacher and student books.

The third is the development of RME-based integral topic learning designs (Sarvita, 2020). This study develops a learning design that is implemented in teacher and student books. The results show that it potentially impacts mathematical abilities with the products designed is valid, practical, and effective categories. Furthermore, the similarity is that they develop learning designs implemented in teacher and student books. The difference is that the previous study develops integral topics and mathematical reasoning abilities. This study developed the concept of junior high school probability and students' mathematical communication skills.

Developing learning materials is one aspect of teachers' professionalism that assist students in overcoming problems. Student success depends on professionalism (Armiati et al., 2020; Harisman, Kusumah, & Kusnandi, 2019). The higher the teacher's creativity in developing teaching materials, the greater the probability for students to comprehend concepts (Harisman, Noto, Hidayat, Habibi, & Sovia, 2021). Teaching materials with a realistic approach to mathematics are considered one of the most effective tools for developing higher-order thinking skills (Bilad & Ekawati, 2022).

CONCLUSION

This study produces Local Instructional Theory (LIT), teacher and student books based on the results of learning design for RME-based probability topics. The existence of problems that are close to students' daily lives and the experimental context in the product can be a reference for students in finding a concept. The use of RME-based learning design on the concept of probability helps students to develop mathematical communication skills. The test results of the students who participated in the study showed that more than 60% were above the standard mark. Additionally, there was a relationship between text understanding and the reading context in learning using the RME approach. This research was only piloted on a small number of students due to the pandemic conditions, making it impossible to conduct trials in large groups. For this reason, it is suggested that the next researcher try out the results of his development on a group of students with a larger number so that the results can be seen more clearly.

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Declarations

Author Contributions	:	A: Conceptualization, Writing- Original Draft, Visualizations, and Templating AF: Visualizations, Review Formal Analysis, Language Proofreading YH: Visualizations, Review Formal Analysis, Language Proofreading FS: Visualizations, Review Formal Analysis, Language Proofreading
Conflict of Interest	:	The authors declare that there is no conflict of interest.

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