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REALISTIC MATHEMATIC EDUCATION-BASED STUDENT WORKSHEET TO IMPROVE STUDENTS' MATHEMATICAL REASONING ON CIRCLE MATERIAL

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ABSTRACT

Mathematical reasoning is a critical feature emphasized in the objective of mathematics education since it may be utilized to solve mathematical problems and other difficulties. This study aims to provide student worksheets based on Realistic Mathematics Education (RME) on circle material that are valid, practical, and useful in increasing students' mathematical reasoning abilities. This research used a 4-D development model. Validation sheets, practicality questionnaires, and test questions were employed as research tools. As a result of this research, the RME-based student worksheet on circle material is declared valid in content/material with an average of 4.05 and constructively valid with an average of 3.85. The practical findings show a value of 80.77% in the practical category. The effectiveness test revealed an N-Gain value of 0.57 with a fairly effective category. It may be concluded that the RME-based student worksheet developed is feasible, practical, and effective. As a result, the RME-based student worksheet can be used in learning to improve students' mathematical thinking abilities.

LEMBAR KERJA SISWA BERBASIS *REALISTIC MATHEMATICS EDUCATION* UNTUK MENINGKATKAN KEMAMPUAN PENALARAN MATEMATIS SISWA PADA MATERI LINGKARAN

Kata Kunci:

Penalaran matematis
Realistic mathematics education
Lembar kerja siswa

ABSTRAK

Penalaran matematis merupakan salah satu aspek penting yang ditekankan dalam tujuan pendidikan matematika, karena dapat digunakan untuk menyelesaikan persoalan matematika dan masalah-masalah lain. Penelitian ini bertujuan untuk menghasilkan lembar kerja siswa berbasis *Realistic Mathematics Education* (RME) pada materi lingkaran yang valid, praktis, dan efektif dalam meningkatkan kemampuan penalaran matematis siswa. Model pengembangan yang digunakan dalam penelitian ini adalah model 4-D. Instrumen penelitian yang digunakan lembar validasi, angket praktikalitas, dan soal tes. Hasil penelitian ini adalah LKS berbasis RME pada materi lingkaran dinyatakan valid secara isi/materi dengan rata-rata 4.05 dan valid secara konstruktif dengan nilai rata-rata 3.85. Hasil praktikalitas menunjukkan nilai 80.77% dengan kategori praktis. Hasil tes efektifitas menunjukkan nilai N-Gain sebesar 0,57 dengan kategori cukup efektif. Dapat disimpulkan bahwa LKS berbasis RME yang dikembangkan sudah valid,

praktis, dan efektif. Dengan demikian, LKS berbasis RME yang dikembangkan dapat digunakan dalam pembelajaran untuk meningkatkan kemampuan penalaran matematis siswa.

1. INTRODUCTION

Learning mathematics aims to cultivate students' abilities and personality traits [1]. Mathematical reasoning, problem-solving, mathematical communication, mathematical representation, and mathematical connections all fall under the category of mathematical ability [2]. The mathematical reasoning ability is one of the skills that students need to acquire to learn mathematics[3]-[5]. Mathematics reasoning ability is essential for students because they require systematic, critical, logical and effective thinking [6]. Mathematical reasoning is a process that can foster activity and creativity, and students are expected to be able to generate hypotheses and draw conclusions based on them. In addition, mathematical reasoning ability can be interpreted as a student's ability to conclude formal analysis and interpretation of problems based on the causal relationships of information. [7], [8]. The reasoning is a flow of thought or thought process to try to complete a task [9], [10].

Students' mathematical reasoning is one of the important aspects emphasized in mathematics education objectives because it can be used to solve mathematical and other problems. This idea is supported by the statement [11] That reasoning is required in every aspect and content of life for every citizen of the nation to analyze every problem that arises, solve problems appropriately, assess things critically, and express opinions and ideas logically. Given the significance of students' mathematical reasoning, a teacher must seek learning that engages students to develop students mathematical reasoning power. A Student Worksheet is one of the media or teaching materials teachers can use in the classroom learning process (student worksheet). Student worksheets are a guide for students to carry out the investigation or problem-solving activities that contain material, work steps to make it easier to find the concept of the material being studied, and student worksheet can be done individually or in groups [12], [13]. However, the student worksheet that is commonly used is only in the form of questions that usually contain a summary of the material, sample questions, and exercises. It does not require mathematical reasoning abilities.

According to observations at SMPN 1 Sungai Penuh, the school's student worksheet is the conventional student worksheet, where only formulas and brief theories are written in the theory section. Furthermore, the available student worksheet does not employ an approach and thus does not train students' mathematical reasoning abilities.

The researchers chose the Realistic Mathematical Education (RME) approach to develop this student worksheet because it can help students find and search for a pattern of material concepts studied individually or in groups, supports students to participate actively to reach a level of ability and can draw conclusions about daily life [14]-[18]. Also, students can understand the material in theory, simulation, and real-world practice by using student worksheets [19]-[21]. This theory is also emphasized by research [22] on learning instruction. A teacher must create innovative teaching materials that meet students' needs. Teaching materials must have a distinct and interesting form, content, and presentation method. Media or teaching materials have the form, content, and method of presenting material that can pique students' interest so that the teaching materials used can support students' academic achievement and affect the quality of teaching during the

teacher's learning. As a result, a student worksheet that can train students' reasoning abilities is required.

An RME-based student worksheet can help students develop their ideas, creativity, and critical thinking skills. Furthermore, RME-based student worksheet can assist students in being active participants in the learning process because it includes activities that involve students, the material used is relevant to the student's world, and it captures students' attention. This will help to develop an integrated mindset and strengthen reasoning abilities. This is consistent with the circle material, which necessitates picture explanations to explain the material by using examples that are close or familiar to students, making mathematical reasoning easy to explore and improving that the RME approach encourages students to be physically and mentally active by presenting learning through real-world examples that students can see or experience [23]-[25].

There has been research on the development of RME-based student worksheets, including the development of RME-based student worksheets on spatial material [26]. Student worksheet development based on RME on speed and discharge material [27], creation of RME-based student worksheets to improve mathematical representation abilities [28], character-based student worksheet with Realistic Mathematics Education (RME) [29], and the application of RME-based student worksheets on mathematical reasoning abilities on rectangular material [30]. However, no research has been conducted to develop student worksheets based on Realistic Mathematics Education (RME) to improve mathematical reasoning abilities on circle material. Based on this explanation, this research aims to describe the process and outcomes of creating valid, practical, and effective student worksheets for improving students' mathematical reasoning abilities on circle material.

2. METHOD

The researcher employed a research and development method with a 4-D development model. The 4-D development model is divided into four stages: define, design, develop, and disseminate (Figure1).

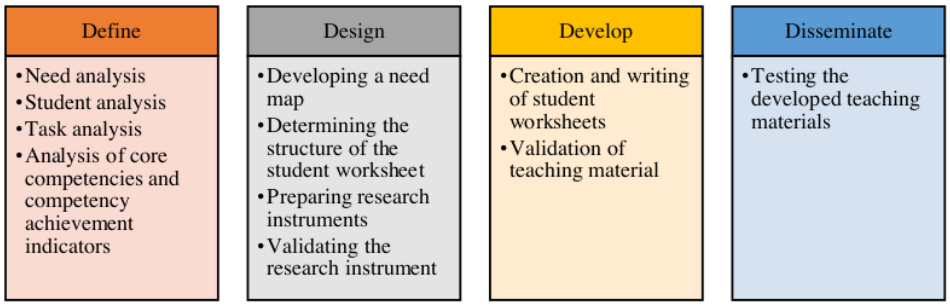


Figure 1. Development Stage

Furthermore, the product was validated by experts before being tested on SMP N 2 Sungai Penuh students. Researchers used a validation sheet filled out by two material experts to collect data, and two media experts completed the media validity questionnaire. The table below shows data collection methods, which include targets, data collection instruments, and research subjects.

Table 1. Data Collection Methods

No	Target	Method	Instrument	Subject
1	The validity of the student worksheet	Questionnaire	Questionnaire sheets for the material experts and questionnaire sheets for the media experts	Lecturer
2	The practicality of the student worksheet	Questionnaire and interview	Questionnaire sheets and interview sheets	Students and teachers
3	Students'reasoning ability	Tests and tasks	Test items	Students

The feasibility of the RME-based student worksheet was determined through data analysis. The obtained results were taken into account when improving the student worksheet. A Likert scale was used in the questionnaire instrument. Furthermore, the test instrument used was a mathematical reasoning description test. Data analysis techniques determined the product's validity, practicability, and effectiveness. The following formula was used to analyze product validity tests in the form of questionnaires and practicality.

$$R = \frac{\sum_{i=1}^{n} Vi}{n} \text{ where Vi} = \frac{Gain\ score}{Maximum\ score} \qquad (1)$$

The calculation results were adjusted following [31], which is described in Table 2 as follows.

Table 2. Validation Results Criteria

Criteria	Range
Highly valid	4.21-5
Valid	3.41-4.20
Quite valid	2.61-3.40
Less valid	1.81-2.60
Invalid	1.00-1.80

The validity test results were analyzed descriptively. This analysis generated suggestions and comments based on the questionnaire questions. The practicality calculation criteria are presented in the following table [32].

Table 3. Practicality Results Criteria

Criteria	Range
Highly Practical	$85 < N \leq 100$
Practical	$70 < N \leq 85$
Quite Practical	$55 < N \leq 70$
Less Practical	$N \leq 55$

3. RESULTS AND DISCUSSION

3.1 The Define Stage

The Define stage was divided into five stages: front-end analysis, student analysis, task analysis, concept analysis, and objective learning analysis. The front-end analysis seeks to identify problems and barriers to learning. The following table summarizes the findings of the analysis stage.

Table 4. The Results of the Front-End Analysis

Technique	Results
Interview with teachers	According to the findings of teacher interviews, there were still obstacles or problems in the learning process, such as students who did not understand the material in the textbooks, students' lack of understanding of each step of the work contained in the textbooks, and students' inability to study independently due to a lack of adequate teaching materials.

Interview with students	According to student interviews, some still believe learning mathematics is difficult, particularly in materials that use formulas and teaching materials that are less interesting.
Direct observation	The results of direct observations are that when learning occurs, there is a lack of learning tools that are only focused on textbooks and student worksheets provided by the school. Student worksheets and textbooks were not used, and students were not required to work independently. As a result, students find it difficult to understand and draw conclusions during learning.

Based on interviews and observations with teachers and students, grade VIII students at SMPN 1 Sungai Penuh expect the student worksheet to be based on core competencies and indicators of competency achievement. Furthermore, the students lack textbooks and other learning resources.

The following stage was student analysis, including age, subject motivation, academic ability, and psychomotor and social skills. The subjects in this study were class VIII-C students aged 12-13 years. These students were either in the formal operational stage or could think abstractly. Students could understand the abstract meaning and principles underlying formal concepts at this point. The results of administering the questionnaire show that students had different characteristics, such as academic ability, student motivation, and skills. Thus, introducing these characteristics is very useful to make it easier to plan to learn and choose the right method to help the learning process's effectiveness. The materials were mapped for task analysis. The results of this task analysis became one main material, namely the circle material, which was divided into several parts, including the elements of a circle, the area of a circle, and others. The term concept analysis refers to task analysis, which states that each material section has a task that students must complete to master the teaching materials. The assignments are all about RME and reasoning questions.

Furthermore, the learning objectives analysis stage is critical. Learning objectives were developed based on the knowledge and skills outlined in the lesson plans. The following is a description of the learning objectives: (1) students can figure out what the circle means; (2) students can deduce the meaning of circle elements; (3) students can draw conclusions based on the questions provided; (4) students can find the formula for calculating the area of a circle; (5) students can discover the formula for calculating the circumference of a circle; (6) students can work alone or in groups; (7) students can work actively.

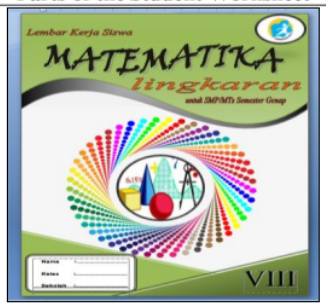
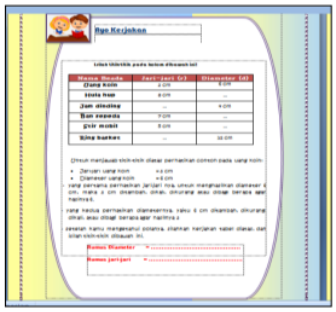
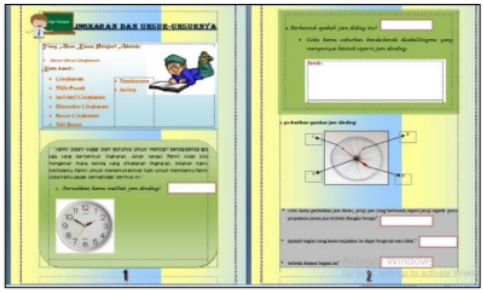
The MRE approach begins with a phenomenon or activity as a baseline for instilling concepts in students to emphasize learning activities. According to the opinion [33], MRE is a mathematics learning approach that emphasizes student activities and is based on real (contextual) cases.

3.2 The Design Stage

The design stage aims to create student worksheets and RME-based evaluation tools that correspond to the predetermined learning objectives. Student worksheet design was accomplished by selecting a format appropriate for writing and correcting student worksheets that adhere to construction and technical specifications. This stage is consistent with the belief [34] that teaching materials contain content that students must learn either in print or through facilitation by the teacher to achieve certain goals. The initial planning was carried out after the Design stage for each developed student worksheet was completed. Writing, reviewing, and editing the prepared learning tools, this preliminary design was carried out.

The RME-based student worksheet's initial design included a cover, core competencies (KI) and basic competencies (KD), and learning activities in the form of circular material related to the RME approach and reasoning. The following is a summary of the RME-based student worksheets created following the 2013 curriculum.

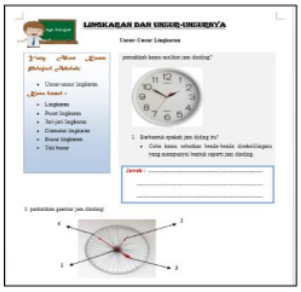
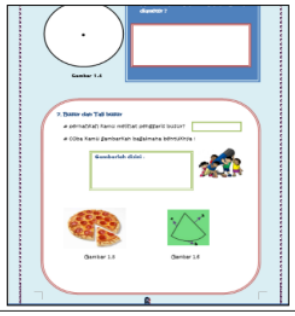
Table 5. RME-Based Student Worksheet

Parts of the Student Worksheet	Description
	Cover Display: The title of the material, school and grade levels, and student names are all included on the cover. The cover's initial appearance is designed to be as appealing as possible, with a combination of contrasting and matching colors to entice students to open and read it.
	Core Competencies and Basic Competencies: Before moving on to the learning material, this section describes the core and basic competencies. Students must first read them before proceeding to the learning material.
	Task Display The display of exercises in the student worksheet is intended to allow students to discover their approaches to mathematical concepts.
	Content and Materials: This section is designed as attractive as possible by following the RME stage. The content display directs students to learn using the RME approach, which includes contextual questions for everyday students.

3.3 The Develop Stage

After the Define and the Design stages, the next stage was where the researcher validated the student worksheet. The product was validated by the material and the media experts. The comments from material experts are presented in the following table.

Table 6. The Results of Material Experts' Validation

Before Revision	After Revision
	
	
	

The material on page 1 was changed to contextual questions so that the RME approach can be seen because the approach used in the student worksheet before revision was unclear. The sample images in the arc material section are changed to show which part of the circular arc is. Meanwhile, the sample questions section has been replaced with let's do it because this is a task that students must complete. It is replaced in the problem by a method to obtain the diameter formula using the RME approach so that students can determine their formula using reasoning and remember it longer.

In addition, the material expert validator advises paying attention to the grammar in the student worksheet. This observation is supported by the opinion [13] that students regularly interpret student worksheets due to a lack of attention to standard Indonesian and

sentence structure. Material validation aims to test the completeness of the material, its truth, and its systematics. Student worksheet meets the validity criteria if the percentage is 3.41 until 4.20 [35]. The table below shows the results of the material validation analysis.

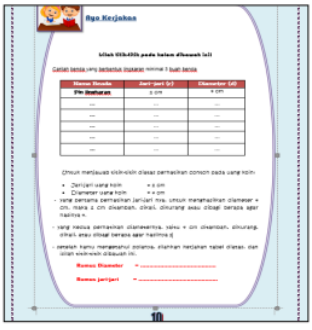
Table 7. The Results of Material Experts' Validation

No	Indicators	The Mean Score by Material Expert-I	The Mean Score by Material Expert-II
1	The suitability of the material with KD and GPA	3	4.5
2	Material Accuracy	3.75	4.75
3	Supporting Learning Materials	4	4.2
4	Material Update	4	4
5	Presentation Support	3,5	4
6	Learning Presentation	4	4
7	Straightforward	3	4
8	Communicative	3.5	4
9	Dialogic and Interactive	3.5	4
10	RME Characteristics	3.33	4
	Mean score	3.6	4.5
	The mean score by material experts I and II	4.05	

Based on the validity of material experts I and II, student worksheets obtained an average value of 4.05 with valid categories and can be testable.

Furthermore, media experts performed the validation. Media expert validation aimed to put RME-based student worksheets in learning mathematics to the test. A lecturer from IAIN Kerinci's Mathematics Department performed the validation. Table 8 contains the opinions of the media experts.

Table 8. The Results of Media Experts' Validation

Before Revision	After Revision
	
	

The media experts asked for the background color to be more attractive. Furthermore, on page 1 of the student worksheet before revision, the location of the wall clock image is on the left side, with only one clock. The validator concurs with [36] that narration and illustrations, such as photos and pictures, aid students' reasoning. The media expert suggests adding another clock image or placing it in the center of the clock image so that the right side looks empty and neat. Furthermore, the expert requested that a circle example be avoided and that the students measure the circle themselves. [37] stated that because student worksheets motivate students to learn, their development must be appropriate to improve their abilities. The table below shows the results and analysis of media validation.

Table 9. The Validation Results by Media Experts I and II

No	Indicators	The Mean Score by Media Expert-I	The Mean Score by Media Expert-II
1	Cover layout	4	4,4
2	Letter	4	4
3	Layout consistency	3.7	4
4	Harmonious layout elements	3.5	3.5
5	Complete layout elements	3.5	3.5
6	Simple book content typography	4	4
7	Easy-to-read typography	4	4
8	Content Illustration	3,75	4.25
	Mean score	3.8	3.9
	The mean score by validators I and II	3.85	

Based on the validity of media experts I and II, the student worksheets obtained an average value of 3.85 with valid categories and can be tested.

Product trials were conducted to determine the feasibility of the RME-based student worksheets in mathematics learning. The product trials were divided into two stages: small-group trial and large-group trial. The small-group trials involved six students divided into three groups based on their ability level: high, medium, and low. Students were given RME-based student worksheets to understand and study. The students were then interviewed individually to gather feedback or suggestions on the product they had used. The small-group trial yielded an average score of 80.6 out of 10 indicators, with six students participating. The large-group trial with 30 students and ten indicators yielded an average assessment result of 80 with practical criteria. The following are the outcomes of the small-group trial and the large-group trial.

Table 10. The Trial Results

No	Assessed Aspects	Small-Group Trial	Large-Group Trial
1	The student worksheet is exciting and makes me want to learn more.	25	125
2	The pictures on the student worksheet make me want to learn math.	24	115
3	The student worksheet helps me understand the material better.	25	130
4	The student worksheet outlines steps that will help me understand better.	23	120
5	The size of the letters on the student worksheet is appropriate for clear reading.	25	130
6	The material or assignments in the student worksheet encourage me to use my reasoning skills more.	23	115

7	The student worksheet contains practices I must complete understanding the material in the student worksheet.	25	120
8	Instructions for group projects are clear.	24	110
9	The information presented is relevant to my daily life.	23	110
10	The use of student worksheets based on the amount of time available	25	12
	Total	242	1.200
	Percentage	80,77%	

Small-group and large-group trials yielded a value of 80.77% with practical categories. [38] explained that teaching materials must be practical to carry out the mathematics learning process. As a result, the learning process becomes more communicative, and the material is simpler to grasp. As a result, the RME-based student worksheet is appropriate for use in the learning process as teaching material.

The test assessed students' mathematical reasoning abilities before and after using the student worksheet based on Realistic Mathematic Educational (RME). It was also used to determine whether or not the student worksheet improved students' mathematical reasoning ability. The examination is in the form of a written examination. The test was only given to class VIII C students who used the developed student worksheet to demonstrate that it can help students improve their mathematical reasoning. Table 11 shows the data from the pretest and posttest.

Table 11. The Results of Pretest and Posttest

No	Name	Pretest Score	Posttest Score	Differences	N-Gain	Criteria
1	Student AAP	25	80	55	0,73	Effective
2	Student AR	30	60	30	0,43	Quite Effective
3	Student ANA	60	80	20	0,50	Quite Effective
4	Student AA	40	70	30	0,50	Quite Effective
5	Student A	35	75	40	0,62	Quite Effective
6	Student E	45	87	42	0,76	Effective
7	Student FF	35	75	40	0,62	Quite Effective
8	Student G	70	95	25	0,83	Effective
9	Student IS	15	70	55	0,65	Quite Effective
10	Student KZ	30	72	42	0,60	Quite Effective
11	Student MHP	50	70	20	0,40	Quite Effective
12	Student MY	45	75	30	0,55	Quite Effective
13	Student MC	65	90	25	0,71	Effective
14	Student MBR	20	65	45	0,56	Quite Effective
15	Student MFS	45	68	23	0,42	Quite Effective
16	Student MF	55	70	15	0,33	Quite Effective
17	Student MR	60	92	32	0,80	Effective
18	Student NNG	50	70	20	0,40	Quite Effective
19	Student NS	20	55	35	0,44	Quite Effective
20	Student NKP	15	65	50	0,59	Quite Effective
21	Student RY	55	70	15	0,33	Quite Effective
22	Student RM	45	85	40	0,73	Effective
23	Student RS	50	88	38	0,76	Effective
24	Student RG	55	80	25	0,56	Quite Effective
25	Student UR	30	65	35	0,50	Quite Effective
26	Student YH	45	75	30	0,55	Quite Effective
27	Student Y	25	65	40	0,53	Quite Effective
28	Student ZT	70	91	21	0,70	Effective
29	Student Z	40	65	25	0,42	Quite Effective
30	Student ZW	45	75	30	0,55	Quite Effective

Mean score	42,33	70,33	32,43	0,57
Maximum score	70	90	55	0,83
Minimum score	15	55	15	0,33

The pretest results showed an average score of 42.33, with the highest score of 70 and the lowest score of 15. The posttest resulted in an average score of 70.33, with the highest score of 90 and the lowest score of 55. The effectiveness of the pretest and posttest data was then evaluated. Table 12 contains information on the effectiveness test results.

Table 12. The Results of Pretest dan Posttest

Class	N	Mean Value			Category
		Pretest	Posttest	N-Gain	
VIII	30	42,33	70,33	0,57	Quite Effective

The effectiveness test results show an N-gain value of 0.57, indicating that based on the student worksheet effectiveness test data, the average percentage of all aspects indicates that the RME-based student worksheet is effective. The findings of this study suggest that using RME-based student worksheets can help students improve their mathematical reasoning abilities. RME-based student worksheets are organized systematically to guide students through their learning, and the questions and materials presented are also relevant to the student's environment. These findings are supported by research [39] indicating that the RME model is appropriate for learning and [21] indicating that using student worksheets can increase student involvement in learning activities.

RME is concerned with mathematical concepts, critical thinking, creative thinking, and problem-solving [40]. Furthermore, based on real-world scenarios, the RME learning model's advantages can motivate students to study harder because they believe learning mathematics is beneficial [41]. Furthermore, [42], [43] found that abstract mathematical concepts were more easily digested by students when they were exposed to learning media in their surroundings. This stimulated students' mathematical reasoning abilities, resulting in students who were enthusiastic and interested in learning. Previous research has shown that using multimedia can improve mathematical reasoning ability. The RME approach can help you improve students' mathematical reasoning ability.

4. CONCLUSION

According to the research findings, the RME-based student worksheet on the circle material was declared valid in content/material with an average of 4.05 and constructively valid with an average of 3.85. The results indicate that the product is appropriate for use as teaching material. Based on the product practicality test, students stated that the student worksheet was interesting with a score of 80.77%, so the product was declared practical. The n-gain value of 0.57, which is included in the effective criteria, also shows that the student worksheet can stimulate mathematical reasoning abilities. Because the material and questions presented in the student worksheet are relevant to the student's reality, this RME-based student worksheet effectively improves mathematical reasoning skills.

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