

## Improving Elementary School Students Understanding of Concepts through Student Worksheets Based on Realistic Mathematics Education

Fatkhur Rohman<sup>1</sup>, Dea Andini<sup>2</sup>, Shella Dyah Wulansari<sup>3</sup>, Kenny Rama Dhany<sup>4</sup>, Nurhanurawati<sup>5</sup>

<sup>1,2,3,4,5</sup>Universitas Lampung, Bandar Lampung, 35145, Indonesia  
[fatkhur.rohman @fkip.unila.ac.id](mailto:fatkhur.rohman@fkip.unila.ac.id)

**Abstract.** One of the main problems in learning mathematics is the low conceptual understanding of students, which is reflected in the low category of the pretest results. Innovative approaches such as Realistic Mathematics Education (RME) through RME-based Student Worksheets are needed to overcome this. This study aims to test the effectiveness of RME-based Student Worksheets in improving the understanding of mathematical concepts. The method used is developmental research with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The research subjects included validation by two subject matter experts, two media experts, two language experts, and one teacher, and trials on 25 students in grade V of SDN 2 Sawah Brebes. The validation results showed scores of 0.7465 (subject matter expert), 0.8381 (media expert), and 0.7986 (language expert), which were considered valid. The statistical analysis of the paired sample t-test produced a significance value of 0.000 ( $<0.05$ ), thus rejecting  $H_0$  and accepting  $H_a$ . This proves a significant increase between the pretest and posttest scores, indicating that the RME-based Student Worksheet effectively improves students' understanding of concepts. The researcher recommends using the RME model to implement the stage of understanding contextual problems. Scaffolding is needed for students because of the diverse zone of proximal development (ZPD).

**Keyword:** Elementary School; Student Worksheets; Concept Understanding

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Corresponding Author: Fatkhur Rohman; [fatkhur.rohman @fkip.unila.ac.id](mailto:fatkhur.rohman@fkip.unila.ac.id)



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### INTRODUCTION

21st-century learning has become very popular because it brings changes, especially the rapid development of science and technology, which changes the learning paradigm characterized by curriculum, media, and technology (Afrijal et al., 2023; Rahayu et al., 2022; Rohman et al., 2020). Science and technology have a reciprocal relationship with education and curriculum. Education

and curriculum must respond to the rapid development of Science and Technology because education is an effort to prepare students for a better future (Bishop et al., 2020; Bray & Tangney, 2016; Rohman, Astuti, et al., 2024; Rohman et al., 2019).

The development of science has influenced changes in the curriculum in Indonesia that reflect the improvement of the quality of education and adapt it to the times (Sari, 2022). The curriculum is one of the main strategic components of the education system. This assumption provides the basis that the curriculum not only contains the goals to be achieved but also provides an understanding of the learning experience for students (Hafiluddin & Wahyudin, 2023). Indonesia is implementing the Merdeka curriculum. The curriculum merdeka has diverse intracurricular learning where content will be optimized so learners have enough time to explore concepts and strengthen competencies. Teachers can choose various teaching tools to tailor learning to learners' needs and interests (Ben Gurion & Nasir, 2024; Halah & Patrick, 2015; Zais, 1976). Merdeka Curriculum aims to free students from the shackles of an overly theoretical curriculum and promote learning that is more contextual and relevant to real life (Buchori Muslim, 2020; Kurt & Kaya, 2024; Santoso et al., 2020).

In general, the implementation of a Curriculum Merdeka has advantages and disadvantages (Ben Gurion & Nasir, 2024). The advantages of a Curriculum Merdeka are that it is simpler, focuses more on essential knowledge and learner development based on stages and processes, learning is more meaningful, and students are free to determine their subjects of interest (Witraguna et al., 2024). Meanwhile, for teachers, the advantages of implementing a Curriculum Merdeka when implementing learning are that the assessment is adjusted to students' achievement and development level (Putri Lestari et al., 2023; Witraguna et al., 2024). The weaknesses of implementing a Curriculum Merdeka are that the education and teaching system design has not been well realized, the lack of human resources and an unstructured system (Ben Gurion & Nasir, 2024). The current implementation of the Curriculum Merdeka still experiences several obstacles, including teachers still having experience with low learning independence, limited references, uneven access to learning, time management and so on (Fauzan et al., 2023; Marthawati & Setyo, 2024).

Learners who understand mathematical concepts well during the learning process tend to have high learning achievement because learning becomes easier to follow than learners who do not understand concepts (Siems-Muntoni et al., 2024). Lack of understanding of concepts affects the low learning outcomes of students. The causes of students' lack of understanding of concepts include not mastering the indicators of concept understanding, students' lack of understanding of the material, students' lack of interest in learning, and difficulty interpreting questions, especially story-shaped questions (Prasasti et al., 2020). In addition to the problems that occur in students, the cause of students' low concept understanding ability is that teachers rarely use student worksheets and do not develop student worksheets according to the needs of students. Student worksheets are teaching materials that assist and facilitate teaching and learning activities that can improve their concept understanding and learning achievement (Umbar, 2021). The category of problems found is the lack of understanding of students' mathematical concepts, among others: 1) Students do not think about the concepts that have been learned, so the concepts learned do not last long; 2) Students are reluctant to understand practice questions first in working on problems and think that these problems are difficult to work on, 3) Students find it difficult to apply the material in everyday life (Isrotun, 2014).

In elementary school students, understanding learning still requires concrete things where students use real/contextual situation problems as a starting point for students in learning to support the implementation of a rediscovery process so that formally students can understand mathematical concepts (Fitriani & Yuliani, 2016). Concept understanding ability is important in learning mathematics, so teachers are expected to arrange activities and learning processes to improve their ability to understand concepts (Mayasari & Habeahan, 2021). Closely related

between one concept and another, thus making the ability to understand concepts very important in learning. Students with qualified concept-understanding skills can support their learning process so that they can solve the problems they face (Sari, 2019). According to Wahida et al. (2018), students' concept understanding can improve other critical thinking skills. Students' success level in achieving learning objectives is proportional to the level of understanding of students' concepts. Learners with new knowledge are better able to solve problems (Nasir et al., 2017). Being able to solve problems that are related to concepts and use them in solving problems is the goal of learning mathematics (Aprilia et al., 2021). Skills or skills that systematically digest, understand and absorb ideas or various mathematical ideas are also called concept understanding (Nurani et al., 2021).

RME-based student worksheets can improve students' concept understanding ability and valid and practical product quality criteria so that they can be used in learning mathematics (Gustin et al., 2020). RME-based worksheets developed with mathematics materials positively and effectively impact mathematics learning ability and increase students' interest in learning (A. Hidayat & Irawan, 2017; Kohar et al., 2024; Rohman, Hendra, et al., 2024; Sevinc & Lesh, 2022). The advantages of the RME model are constructing their learning, making students happier in learning because they feel involved, and requiring students to think and express their understanding and feel valued because every result of their work is always assessed (Çakıroğlu et al., 2023). The RME approach also has several characteristics, including the use of context so that mathematics learning is not presented as a finished product but a process or in principle which is often called Guided Reinvention, which is the peculiarity of RME (Arcavi, 2020; Muchtar et al., 2020; Yayuk & Husamah, 2020). In addition, RME-based math lessons are more relevant, meaningful, and interesting, consider students' abilities, use context as a starting point for learning mathematics, and provide mathematical problem-solving (Sriwijaya, 2020).

One of the recommended solutions to overcome this problem is to use student worksheets based on realistic mathematics education (RME) to help students solve problems, especially in understanding the concept of teaching material by using an exciting way and not giving an abstract impression (Siregar et al., 2020). According to (E. I. F. Hidayat et al., 2020), optimizing learning led to an innovation in real mathematics learning called Realistic Mathematics Education (RME). The development of RME-based student worksheets in mathematics learning can improve the ability to understand mathematical concepts (Sevinc, 2023).

This study aims to develop and test the effectiveness of Realistic Mathematics Education (RME) based Student Worksheets to improve the understanding of mathematics concepts for elementary school students within the framework of the Merdeka curriculum, which emphasises contextual learning (Kohar et al., 2024). The specific objectives include the creation of a Student Worksheet prototype according to the principle of competency strengthening, analysis of its impact on concept understanding, and evaluation of the implementation's feasibility. The urgency of the research arises from the lack of RME-based resources that are in line with the Merdeka curriculum, the low ability of students to understand abstract mathematical concepts, and constraints such as teacher unpreparedness and limited references (Rohman, Hendra, et al., 2024). The research gap lies in the lack of RME integration in the design of Student Worksheets for primary schools, the mismatch of teaching materials that are too theoretical with contextual needs, and the focus of previous studies that were limited to validity without exploring holistic aspects such as the role of teachers and supporting policies. Through the development of real-life-based Student Worksheets and systemic factor analysis, this research is expected to produce valid products, strategic recommendations for optimising the Merdeka curriculum, and strengthen the synergy between learning theory and classroom practice.

## METHOD

This research adopts the ADDIE model, which consists of five steps: Analysis, Design, Development, Implementation, and Evaluation. In the subsequent sections, we will elaborate on how the ADDIE model steps are implemented to create RME-based worksheets that better understand mathematics concepts for learners at SDN 2 Sawah Brebes Lampung.

### Analysis

In the analysis stage of this study, researchers observed the learning process, identified problems faced by teachers and students, and evaluated existing learning resources. This stage's purpose is to identify existing problems, as this article does. This research explicitly analyses the specific learning needs of SDN 2 Sawah Brebes to develop effective learning materials in accordance with the curriculum Merdeka.

### Design

The design stage in this research involved preparing RME-based student worksheets with learning syntax that integrates contextual problems, such as everyday problem solving, group discussion, and reflection, as well as designing expert validation instruments (material, media, and language) to test product quality. The implementation of this stage aims to create a systematic prototype and evaluation instrument (Branch, 2010). This article is in line with this principle, where the design of the LKPD follows the RME syntax and fulfils the criteria of instructional alignment between learning objectives, activities, and assessment (Van Merriënboer & Kirschner, 2017).

### Development

The product development stage was conducted through expert validation involving six experts (material, media, and language) to ensure the validity and feasibility of RME-based student worksheets. The development stage aims to test the feasibility of the product through expert assessment to ensure the accuracy of the content and suitability to user needs (Branch, 2010). The analysis was carried out in the validity test in this study by calculating the Aiken's index coefficient (V-Aiken) of the expert team's assessment results (Aiken, 1985). The V-Aiken index coefficient was interpreted with reference to Table 1.

**Table 1** Validity Interpretation *Aiken's*

No	Correlation Coefficient	Validity Interpretation
1	$V \geq 0,80$	Very Valid
2	$0,60 \leq V < 0,80$	Valid
3	$0,40 \leq V < 0,60$	Moderately Valid
4	$0 \leq V < 0,40$	Not Valid

### Implementation

After the RME-based student worksheets were validated, the implementation stage was carried out through a small-scale trial involving 25 students of class IV D SDN 2 Sawah Brebes. The implementation stage aims to test the practicality of the RME-based student worksheets and the responses from students and teachers to the product when used in the learning process.

### Evaluation

The evaluation carried out is an evaluation of the learning program and an evaluation of learning outcomes. This development product was piloted on 6-16 May 2024 with students in grade V of SDN 2 Sawah Brebes Lampung. There was one control class with 15 students and one

experimental class with 25 students. The evaluation stage in this study was carried out by giving a pre-test and post-test to assess the effectiveness of RME-based student worksheets in improving students' understanding of concepts. The evaluation was carried out by statistical analysis using paired t-tests and gain score calculations. The improvement in students' ability to understand concepts in this study was analyzed using the gain score of the following equation <math>\langle g \rangle</math> (Hake, 1998).

$$\langle g \rangle = \frac{\langle S_{post} \rangle - \langle S_{pre} \rangle}{100\% - \langle S_{pre} \rangle}$$

Interpretation of the gain score of the pre-test and post-test analysis of students' concept comprehension ability refers to Table 2.

**Table 2** Student Pretest Results

No	Skor	Kriteria
1	$g > 0,7$	High
2	$0,3 \leq g \leq 0,7$	Medium
3	$g < 0,3$	Low

(Hake, 1998)

### LKPD Validity Test

Stating that validity is the degree of accuracy between the data that occurs on the object of research and the data that does not differ between the data reported by researchers and the data that actually occurs on the object of research. The characteristics that will be validated are: language, material, and media, the validator analyzes the designed LKPD and provides suggestions and input on the LKPD design (Sugiyono, 2015).. The assessment sheet will produce data that will be used to determine the validity of the product in the form of LKPD using the RME model. LKPD validity assessment data obtained from lecturers of linguists, material experts and media experts, the LKS validity assessment sheet data is identified by the following steps:

- Give a score for each item with the answers very good (4), good (3), not good (2), and very bad (1).
- The validity score is given using the following formula:

$$V = \frac{\sum S}{n(c-1)}$$

Description:

$s = r - lo$

$r$  = The number given by an appraiser

$lo$  = The lowest validity rating number

(in this case = 1)

$n$  = Number of Validators (in this case=1)

$c$  = The highest validity rating number

(in this case = 4)

- LKPD Validity (Hendryadi, 2017).

**Table 1** Validity Interpretation *Aiken's*

Correlation Coefficient	Validity Interpretation
$V \geq 0,80$	High

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$0,60 \leq V < 0,80$	Moderately High
$0,40 \leq V < 0,60$	Fair
$0 \leq V < 0,40$	Poor

### Effectiveness Test

In this study using the N-Gain test for students' concept understanding ability. The category of improvement in students' concept understanding ability can be seen by using the N-Gain formula equation, namely:

$$\langle g \rangle = \frac{(Sf) - (Si)}{(100) - (Si)}$$

Description:

$\langle g \rangle$  = score gain

$Si$  = score pretest

$Sf$  = score posttest

**Table 2** Student Pretest Results

No	Skor	Kriteria
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3	$g < 0,3$	Low

(Hake, 1998)

## RESULTS AND DISCUSSION

### Analysis

Researchers conducted a needs analysis to determine the problems and solutions. The needs analysis showed that the concept understanding ability of fifth grade students of SDN 2 Sawah Brebes was low. This conclusion is based on the results of the pretest conducted. In the pretest results it was found that of the 25 students there were 19 students in the low category and 6 students in the medium category. The following is the categorization of students' pretest results.

**Table 3** Student Pretest Results

No	Category	Number of students
1.	Very High	0
2.	High	0
3.	Medium	6
4.	Low	19
Total		25

The results of the pretest on 25 students in grade V of SDN 2 Sawah Brebes showed that 76% (19 students) had a low understanding of mathematical concepts and 24% (6 students) had a moderate understanding, with no students in the high category. This indicates the weakness of conventional learning methods, which have minimal real context and cognitive scaffolding, in accordance with (Gravemeijer, 1999) findings that traditional learning focuses on mechanical procedures, not meaningful concept construction. This lack of understanding is the basis for the need for Realistic Mathematics Education (RME) based intervention, which emphasizes contextual problems to build concepts through guided reinvention (Zolkower et al., 2020).

Research by (Wijaya et al., 2015) Wijaya et al. (2017) proves that RME-based student worksheets improve students' understanding of concepts through visual representations and realistic analogies. This finding is in line with (Hattie, 2008) argument that evidence-based

interventions (such as contextual student worksheets) have a significant impact (effect size  $>0.6$ ) when involving problem posing and reflection. However, the implementation of RME requires scaffolding to bridge informal-formal knowledge, as emphasized by (Van Den Heuvel-Panhuizen, 2003). Without this stage, students find it challenging to internalize abstract concepts from concrete experiences.

### Design

The design stage is carried out to develop student Worksheets based on Realistic Mathematics Education (RME). Student Worksheets are arranged according to RME syntax. The following is an RME-based student Worksheet.

**Tabel 4** Steps of RME

No.	Steps of RME
1.	Understand the problem/context
2.	Explaining contextual problems
3.	Solving contextual problems
4.	Comparing and discussing answers
5.	Concluding

(Source: (Isrok'atun & Rosmala, 2018))



**Figure 1** RME-based student worksheet design

### Development

The implementation of the student worksheet development stage is designed based on RME. Subsequently, the student worksheets are adjusted to the Merdeka Curriculum, learning

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outcomes, and learning objectives. The instruments are then developed for validation, including content, media, and language. The Student Worksheets developed based on the RME have undergone three stages: content validation, media validation, and language validation. The V Aiken equation is used to calculate the expert team's assessment, and the results of the V Aiken coefficient are interpreted by referring to Table 1. The results of the V Aiken coefficient for the content aspect are shown in Table 5.

**Table 5** Material Validation Results

Assessed Aspect	Coefficient V Aiken's	Interpretation
Material Suitability	0,7083	Valid
Accuracy of Material	0,7500	Valid
Model Relevance	0,8125	Very Valid
RME		
Presentation	0,7500	Valid
Technique Material		
Presentation Support	0,7083	Valid
Coherence and Order	0,7500	Valid
<b>Average</b>	<b>0,7465</b>	Valid

(Source: research, 2024)

The results of the validation of student worksheets based on Realistic Mathematics Education (RME) using Aiken's V coefficient showed an average score of 0.7465 (Valid), with the RME Model Relevance aspect reaching 0.8125 (Very Valid). This confirms the alignment of the design with RME principles such as guided reinvention (Gravemeijer, 2020) and integration of real-world contexts (Van den Heuvel-Panhuizen & Drijvers, 2014). However, the aspects of Material Suitability and Presentation Support (0.7083 each) are still below the ideal threshold of  $\geq 0.8$  (Aiken, 1985), indicating the need for improvements in visualization and scaffolding (Mayer, 2014). Recent studies emphasize the need for an iterative approach in instructional material design to address these gaps (Bakker et al., 2018).

The accuracy and coherence of the material (0.7500) meet clarity standards, reducing the risk of misconceptions. Although the student worksheets are suitable, presentation optimization is needed to encourage active learning). Contemporary research recommends blended learning strategies to increase student engagement (Manizade et al., 2023) and teacher training in the dynamic application of RME (van den Heuvel-Panhuizen, 2020; Van Zanten & Van den Heuvel-Panhuizen, 2021). Therefore, although valid in content, technical improvements and teacher support remain crucial to maximize learning outcomes, as advocated in recent studies on pedagogical innovation (Wijaya et al., 2015). The following feasibility test result is the assessment of the media aspect. Table 6 shows the results for this aspect.

**Table 6** Media Validation Results

Assessed Aspect	Coefficient V Aiken's	Category
Design Media	0,8393	Very Valid
Teks	0,8500	Very Valid
Graphic	0,8250	Very Valid
<b>Rata-rata</b>	<b>0,8381</b>	<b>Very Valid</b>

(Source: research, 2024)

The validation of student worksheets based on Realistic Mathematics Education (RME) showed an average Aiken's V score of 0.8381 (Highly Valid), with the text (0.8500), design (0.8393), and graphics (0.8250) aspects achieving the highly valid category. The clarity of the text, according to students' cognitive levels, supports the principle of multimedia learning (Mayer &

Fiorella, 2021), while the intuitive design and graphics reinforce the representation of mathematical concepts in line with responsive design in interactive learning (Van den Heuvel-Panhuizen & Drijvers, 2020). These findings reinforce (Manizade et al., 2023) argument that RME requires integrating visual-verbal elements for cognitive scaffolding. However, recent studies emphasize the need for user experience testing to ensure the suitability of media for the heterogeneous needs of students (Bakker, 2019).

Although media validation is excellent, the sustainability of implementation requires adaptation to technological developments and diverse learning styles, as (Mayer & Fiorella, 2021) emphasized. Integrating gamification and interactive feedback (Bishop et al., 2020; Cabero-Almenara & Roig-Vila, 2019) can increase intrinsic motivation, while teacher training in using RME-based media is key to effectiveness (Hattie & Clarke, 2023). (Bini et al., 2023) further note that collaboration between technology experts and educators is necessary to optimize the pedagogical digital design. Thus, although the student Worksheets are highly valid, the synergy between infrastructure, content innovation, and teacher capacity remains essential for transforming contextual mathematics learning. The following feasibility test results are assessments of language aspects. Table 7 shows the results for this aspect.

**Table 7** Language Validation Results

Assessed Aspect	Coefficient <i>Aiken's</i>	Interpretation
Straightforward	0,8125	Very Valid
Communicative	0,8125	Very Valid
Appropriateness of language rules	0,7708	Valid
<b>Average</b>	<b>0,7986</b>	<b>Valid</b>

(Source: research, 2024)

Based on Table 7, the validation of the language aspects of the student worksheets based on Realistic Mathematics Education (RME) obtained an average Aiken's V score of 0.7986 (Valid), with the aspects of Ease of Understanding and Communicativeness achieving a score of 0.8125 (Very Valid). This indicates that the language used in the student worksheets is clear, direct, and appropriate for the student's level of understanding, in line with the principles of cognitive load theory, which emphasizes the importance of clarity to reduce cognitive load (Mayer, 2022). The Language Conformity score (0.7708; Valid) indicates that although there is room for improvement in grammar, the student worksheets still meet pedagogical communication standards (Lederman et al., 2023).

### Implementation

At this stage, a small-scale practical test of the product was conducted involving 25 fourth-grade students from SDN 2 Sawah Brebes. Mathematics learning using RME-based student worksheets was conducted twice with a duration of 2 x 35 minutes. It was held on 6 and 7 May 2024.

**Table 8** Comparison of Pretest and Post-test Score Acquisition

Category	Pretest	Post-test
Very High	0	0
High	0	23
Medium	6	2
Low	19	0

(Source: research, 2024)

From Table 8, it can be seen that in the pretest, only 6 students obtained a moderate score and 19 other students obtained a low score. After the treatment in the form of using RME-

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based student worksheets and conducting a posttest, there was a significant increase. A total of 23 students were in the high category, 2 students were in the moderate category, while 0 students were in the low category.

The increase also occurred in the average score obtained by students. In the pretest, the average value of students was only 54.12 and increased to 77.76 in the posttest average value.

The t-test was conducted to determine the difference between the pre-test scores of students who had not been given treatment in the form of RME-based student worksheets and the post-test scores of students who had been given treatment in the form of RME-based student worksheets. The results of the t-test can be seen in Table 9.

**Table 9** Paired Samples Test

Paired Differences	
Mean	-23.64000
Std.Deviation	7.91560
Std. Error Mean	1.58312
Lower	-26.90740
Upper	-20.37260
t	-14.933
df	24
Sig.(2-tailed)	.000

(Source: research, 2024)

Based on the data in Table 9, the sig is known. (2-tailed) value is  $0.000 < 0.05$ , so  $H_0$  is rejected, and  $H_a$  is accepted. Thus, it can be concluded that there is a difference in the average pretest and post-test scores of the students, which means that there is an effect of the use of RME-based worksheets in improving the conceptual understanding of fifth-grade students at SDN 2 Sawah Brebes in the 2024 academic year. The table above also shows the mean paired difference value of -23.64000. This value indicates the average difference between the pretest and post-test scores of the students.

N-Gain was used to measure the effectiveness of using RME-based student worksheets. The N-Gain data are presented in Table 10.

**Table 10** Descriptive Statistics

	N	Min	Max	Mean	Std. Deviation
N-Gain	25	0.13	0.72	0.5089	0.14163
Valid N (listwise)	25				

(Source: research, 2024)

From the data above, an N-Gain value of 0.5089 was obtained, which is classified as moderate. Therefore, it can be concluded that using RME-based Mathematics Worksheets effectively improves the conceptual understanding of fifth-grade students at SDN 2 Sawah Brebes.

### Evaluate

The data obtained at the development stage showed that the RME-based student worksheets were valid, indicating that they could be implemented in mathematics learning on spatial figures. At the implementation stage, mathematics learning using the RME-based student worksheets increased the overall average score. This was due to their influence.

## CONCLUSION

Based on the results of the study conducted on the implementation of Student Worksheets based on Realistic Mathematics Education (RME), it can be concluded that using RME-based Student Worksheets can improve students' understanding of mathematical concepts. The post-test results showed a significant improvement, with 23 out of 25 students falling into the high category. However, this study has limitations regarding the small trial scale, which only involved 25 students. Recommendations for further research include expanding the sample size and testing the sustainability of RME use in various learning contexts. The implications of this study suggest that the RME model can be integrated more widely into the Merdeka curriculum to strengthen students' understanding of mathematical concepts.

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