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Liveworksheets-Based Interactive Student Worksheets for Enhancing Elementary Students' Mathematical Conceptual Understanding

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a b s t r a c t

Background: The integration of digital learning media in elementary mathematics education is increasingly important for supporting students' conceptual understanding in 21st-century learning. However, studies examining the development and effectiveness of Liveworksheets-based interactive student worksheets for improving mathematical conceptual understanding at the elementary level remain limited.
Aims: This study aimed to develop a Liveworksheets-based interactive student worksheets and examine its validity, practicality, and effectiveness in enhancing fifth-grade students' mathematical conceptual understanding. The novelty of this study lies in the integration of interactive Liveworksheets features into interactive student worksheets specifically designed for elementary mathematics learning.
Methods: This study employed a Research and Development (R&D) approach using the ADDIE model, which includes analysis, design, development, implementation, and evaluation stages. The participants were 28 fifth-grade students at one of the public elementary school in Gajah District, Demak Regency, Central Java. The product was validated by media, material, and language experts. Practicality data were collected through teacher and student questionnaires, while effectiveness was measured using pretest–posttest scores analyzed through paired sample t-tests and N-gain analysis.
Results: The liveworksheets-based interactive student worksheets obtained very good validity scores from media experts (3.47), material experts (3.65), and language experts (3.95). Practicality assessments from teachers (3.8) and students (3.6) were also categorized as very good. Students' mean scores increased from 54.54 on the pretest to 76.57 on the posttest. Statistical analysis showed a significant improvement ($p < 0.05$) with a moderate N-gain score of 0.4898.
Conclusion: The Liveworksheets-based interactive student worksheets is valid, practical, and moderately effective in supporting students' mathematical conceptual understanding in elementary mathematics learning.

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1. Introduction

Mathematical conceptual understanding is an essential competency in mathematics learning because it serves as the foundation for students to transform procedural knowledge into a more meaningful, flexible, and applicable understanding in various real-life contexts (Boylan et al., 2018; Malone, 2023). Conceptual understanding emphasizes not only the ability to recall procedures but also encompasses the ability to explain, represent, and coherently connect mathematical ideas in problem-solving (Nasir et al., 2008; Esmonde & Caswell, 2010). However, various studies indicate that mathematics instruction in elementary schools remains dominated by procedural approaches, resulting in students' conceptual understanding not developing optimally (Hunt et al., 2015; Larbi-Cherif, 2019; Susanto, 2021). This situation is reinforced by findings that students often struggle to construct profound meanings of mathematical concepts, especially when faced with context-based problems or mathematical modeling (Radiusman, 2020; Simbolon, 2021; Fauziah, 2021).

Furthermore, recent research indicates that low mathematical conceptual understanding is also influenced by limited variety in instructional representations, insufficient use of innovative instructional media, and minimal integration of real-life contexts into the learning process (Malone, 2023; Plomp & Voogt, 2009; Alhashem et al., 2017). Additionally, teachers still face challenges in developing meaningful concept-based learning due to limitations in pedagogical content knowledge and technology integration (TPACK), resulting in instruction that tends to focus on routine problem-solving (Assadi & Hibi, 2020; Alhashem et al., 2017). In a broader context, mathematics learning reforms that call for a mastery learning approach and student-centered learning have not yet been fully effective due to limitations in teachers' professional competencies as well as pressures from test-based curricula and assessments (Boylan et al., 2018; Higgins & Parsons, 2021; Marshall & Buenrostro, 2021).

Additionally, the literature highlights a gap between mathematics learning policies emphasizing conceptual understanding and classroom practices that remain traditional and insufficiently inclusive (Freeman-Green et al., 2021; Comstock, 2025). This disparity becomes even more complex when linked to students' cultural and linguistic diversity, where students from CLD (Culturally and Linguistically Diverse) groups often face barriers in accessing meaningful mathematics learning (Esmonde & Caswell, 2010; Nasir et al., 2008). Therefore, a learning approach is needed that focuses on content and connects students' cultural experiences with mathematical concepts in a contextual and inclusive manner (Freeman-Green et al., 2021; Stovel, 2022).

With the advancement of 21st-century educational technology, the integration of digital media into learning has become crucial for creating interactive, flexible, and student-centered learning experiences (Wang, 2021; Tang et al., 2020; Kerimbayev et al., 2023). One rapidly growing digital learning medium is Liveworksheets, an interactive digital worksheet that enables students to learn independently with immediate feedback. Research indicates that the use of Liveworksheets significantly enhances student engagement, learning motivation, and mathematics achievement (Novianti et al., 2022; Triningsih & Amidi, 2023; Afifah & Junaedi, 2024). Additionally, Live worksheets have also proven effective in improving numeracy literacy, conceptual understanding, and student learning activities in elementary schools (Rusdan & Mulya, 2023; Audiana & Rusnilawati, 2024; Husnawati & Nurharini, 2024).

Nevertheless, the results of the literature review indicate that there are still issues in the implementation of digital learning media. First, the use of Liveworksheets remains primarily focused on improving learning outcomes and motivation, rather than specifically on enhancing mathematical conceptual understanding (Harmawati et al., 2025; Widiantho et al., 2023). Second, most studies are still limited to specific topics such as fractions, numeracy, or science, so the development of materials for fifth-grade elementary school mathematics remains suboptimal (Firdaus et al., 2024; Rohman et al., 2025). Third, there has been little research systematically developing Liveworksheets media through a Research and Development (R&D) approach specifically targeting the improvement of mathematical conceptual understanding (Maysara et al., 2023; Maharani & Marhamah, 2024; Welly Lucardo et al., 2026).

Based on this analysis, there is *a research gap* regarding the need to develop Liveworksheets-based learning media that are not only oriented toward learning outcomes but are also specifically designed to improve elementary school students' mathematical conceptual understanding. Furthermore, there has been limited research systematically and measurably integrating interactive instructional design with indicators of conceptual understanding (Novianti et al., 2022; Tang et al., 2020; Kerimbayev et al., 2023). Therefore, this study offers a novelty in the form of the development of Liveworksheets-based learning media specifically designed to improve the mathematical conceptual understanding of fifth-grade elementary school students through interactive activities, self-directed practice, and automatic feedback. Another novelty lies in the integration of the R&D approach with the reinforcement of mathematical concept understanding indicators in digital technology-based learning (Afifah & Junaedi, 2024; Rusdan & Mulya, 2023; Widiantho et al., 2023).

Thus, the objectives of this study are (1) to develop a Liveworksheets-based interactive student worksheets for fifth-grade elementary school mathematics; (2) to test the feasibility of the developed medium; and (3) to analyze the medium's effectiveness in improving students' mathematical concept comprehension skills.

1.1 Mathematical conceptual understanding ability

The ability to understand mathematical concepts is an essential competency in mathematics education because it serves as the foundation for students to build meaningful, flexible knowledge that can be applied in various problem-solving contexts. Conceptual understanding encompasses not only mastery of procedures but also the ability to model, explain, and connect mathematical ideas coherently (Boylan et al., 2018; Malone, 2023; Szymanski et al., 2022). Learning that emphasizes conceptual reinforcement through varied representations, the use of manipulatives, and inquiry-based approaches has been shown to enhance students' conceptual understanding (Plomp & Voogt, 2009; Nasir et al., 2008; Esmonde & Caswell, 2010). Additionally, the integration of technology in learning also makes a significant contribution to enhancing the visualization and exploration of mathematical concepts in a more interactive manner (Plomp & Voogt, 2009; Szymanski et al., 2022). In a pedagogical context, strengthening teachers' competencies through TPACK is a key factor in designing effective and adaptive concept-based learning (Alhashem et al., 2017; Assadi & Hibi, 2020) and is supported by a coaching approach oriented toward educational equity to improve the quality of learning (Marshall & Buenrostro, 2021; Freeman-Green et al., 2021).

However, various studies indicate a gap between concept-based learning policies and actual classroom practices. Many teachers still face difficulties in implementing concept-oriented learning due to limited content mastery, the selection of appropriate learning strategies, and the dominance of procedural approaches in mathematics instruction (Boylan et al., 2018; Larbi-Cherif, 2019). Test-based evaluation pressures also reinforce a tendency toward learning focused on outcomes rather than the process of conceptual understanding (Higgins & Parsons, 2021). Additionally, the cultural and linguistic diversity of students poses a challenge in mathematics learning, as students from CLD backgrounds often face barriers in accessing meaningful learning when their cultural contexts are not sufficiently integrated into the learning process (Esmonde & Caswell, 2010; Nasir et al., 2008; Freeman-Green et al., 2021). Therefore, a more inclusive, contextual, and technology-based learning approach is needed to bridge these gaps and strengthen students' understanding of mathematical concepts more effectively (Alhashem et al., 2017; Malone, 2023; Marshall & Buenrostro, 2021).

1.2 Liveworksheets-based interactive student worksheets

The use of Liveworksheets as a mathematics learning tool shows significant potential for enhancing interactivity, student engagement, and the quality of mathematical problem-solving through the design of more contextual and multimodal digital worksheets. Various studies reveal that Liveworksheets, as a form of e-worksheets, can increase learning interest, ease of use, and students' positive perceptions of learning materials due to their interactive and responsive nature (Azzahra & Kowiyah, 2022; Fadlelmula, 2022; Mawaddah & Siswanto, 2022). Additionally, this medium allows for the integration of visual and audio elements, as well as context-based tasks, which support the reinforcement of mathematical concept understanding in a more meaningful way (Rahmah et al., 2023; Clements et al., 2023). The use of Live worksheets has also proven effective in enhancing mathematical problem-solving skills through collaborative learning models such as Numbered Heads Together (NHT), which emphasizes social interaction and active student discussion in solving mathematical problems (Junaidi & Lu'luilmaknun, 2023). In the context of modern mathematics education, the transition from conventional worksheets to digital worksheets like Liveworksheets is also considered capable of expanding access to conceptual representations, thereby helping students understand the material in a more visual and interactive manner (Plomp & Voogt, 2009; Fadlelmula, 2022).

Nevertheless, the literature review also indicates that the effectiveness of Liveworksheets has primarily focused on enhancing learning motivation, student responses, and overall learning outcomes, rather than being specifically directed toward strengthening deep and systematic understanding of mathematical concepts (Azzahra & Kowiyah, 2022; Mawaddah & Siswanto, 2022; Rahmah et al., 2023). Several studies also indicate that the outcomes of Liveworksheets implementation can vary depending on task design, content context, and the instructional model used, making its effectiveness context-dependent (Fadlelmula, 2022; Junaidi & Lu'luilmaknun, 2023). Therefore, there is a need to develop Liveworksheets that not only function as an evaluation tool or interactive exercise but are also systematically designed to strengthen students' understanding of mathematical concepts through the integration of multiple representations, higher-order thinking activities, and meaningful automatic feedback (Clements et al., 2023; Plomp & Voogt, 2009).

2. Methods

2.1 Research design

This study employs a Research and Development (R&D) approach using the ADDIE development model (Analyze, Design, Develop, Implement, Evaluate). The ADDIE model is a systematic, structured, and continuous development framework for producing learning products suitable for use (Branch, 2009). ADDIE also provides a clear framework for each stage of development, from needs analysis to evaluation of the final product (Yuliarni et al., 2019). The product developed in this study is a Liveworksheets-based interactive student worksheets to improve elementary school students' mathematical concept comprehension skills.

2.2 Research procedure

Based on the ADDIE development model, the research procedure was carried out through five stages, namely Analyze, Design, Development, Implementation, and Evaluation. The stages of the research procedure are presented in the following flowchart.

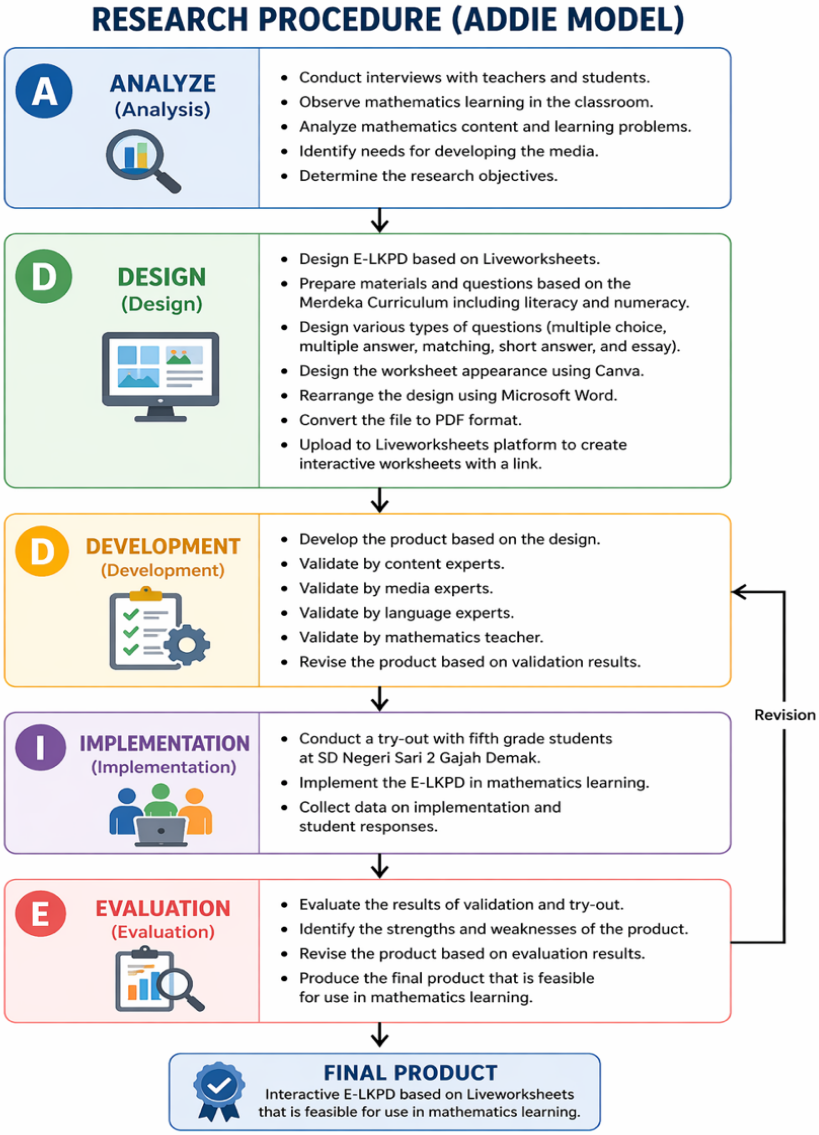


Figure 1. Research Procedures

Based on the figure 1, the research procedures consists of five stages, namely analysis, design, development, implementation, and evaluation. In the analyze stage, the researchers identified learning problems and needs through interviews with teachers and students, classroom observations, and analysis of mathematics learning materials. This stage aimed to determine the problems faced in mathematics learning and to formulate the objectives of developing the interactive student worksheets based on Liveworksheets.

In the design stage, the researchers designed the interactive student worksheets according to the results of the analysis stage. The learning materials and exercises were prepared based on the Merdeka Curriculum indicators and learning objectives. Various types of questions, such as multiple-choice, matching, short-answer, and essay questions, were developed to support students' mathematical conceptual understanding. The worksheet layout was designed using Canva, arranged in Microsoft Word, converted into PDF format, and uploaded to the Liveworksheets platform to produce an interactive worksheet accessible through a link.

The development stage focused on producing the interactive student worksheets and validating the product. The developed product was evaluated by material experts, media experts, language experts, and mathematics teachers to assess its validity and suitability. Suggestions and feedback from the validators were used to revise and improve the product before implementation.

In the implementation stage, the revised interactive student worksheets was tried out with fifth-grade students at one of the public elementary school in Gajah District, Demak Regency, Central Java. The product was used in mathematics learning activities, and data were collected through teacher and student responses as well as learning outcomes to determine the practicality and effectiveness of the developed media.

Finally, in the evaluation stage, the researchers evaluated the overall process and results of the product implementation. The strengths and weaknesses of the interactive student worksheets were identified based on validation and trial results. Revisions were then made to produce a final product that is feasible for use in elementary mathematics learning.

2.3 Participants

The participants in this study consisted of 28 fifth-grade students enrolled at one of the public elementary school in Gajah District, Demak Regency, Central Java, who were selected as the target users of the developed learning product. The study also involved one classroom teacher who participated in the implementation and evaluation stages by providing practical feedback regarding the usability and applicability of the product in classroom learning. In addition, two lecturers with expertise in Primary School Teacher Education and Mathematics Education were invited to serve as validators. They evaluated the product from the perspectives of content accuracy, instructional design, media quality, and language appropriateness. Their assessments were used to determine the validity of the Liveworksheets-based interactive student worksheets, while feedback from the teacher and students was utilized to assess its practicality and user acceptance in the learning process.

2.4 Data collection

Data collection techniques in this study included questionnaires and tests to obtain data regarding the validity, practicality, and effectiveness of the Liveworksheets-based interactive

student worksheets. The questionnaires were used to collect validity and practicality data, while the tests were used to measure students' mathematical conceptual understanding.

The validation instruments were developed based on content validity and construct validity frameworks covering aspects of material suitability, media design, language, presentation, and usability. The validation rubrics were adapted from relevant instructional media evaluation literature and arranged using a four-point Likert scale ranging from 1 (poor) to 4 (very good). The instruments were validated by media experts, material experts, language experts, and mathematics teachers. Inter-rater agreement was considered by comparing the consistency of scores among validators on each assessment indicator. In addition, the reliability of the instruments was tested using Cronbach's Alpha coefficient to ensure internal consistency. Before the main implementation, pilot testing was conducted on a limited scale to identify unclear instructions, readability issues, and technical problems in the interactive student worksheets. The results of the pilot testing were used as the basis for revising and improving the product and instruments before the implementation stage.

The research instruments consisted of questionnaires for media expert validation, material expert validation, language expert validation, teacher responses, student responses, and mathematical conceptual understanding tests. The mathematical conceptual understanding test was administered in the form of a pretest and post-test based on indicators such as restating concepts, classifying objects, providing examples and non-examples, and applying concepts to problem-solving.

Questionnaires were used to collect data on the validity and practicality of the product. The validity questionnaire was administered to experts including subject matter experts, media experts, and language experts to assess the suitability of the developed Liveworksheets-based interactive student worksheets. Meanwhile, the practicality questionnaire was administered to teachers and students to gauge user responses regarding the ease of use, appeal, and applicability of the media in the mathematics learning process.

In addition to the questionnaires, this study also utilized a mathematical concept comprehension test. This test was administered as a pretest and post-test to fifth-grade elementary school students to measure improvements in concept comprehension following the use of the Liveworksheets-based interactive student worksheets. The test instrument was designed based on indicators of mathematical concept comprehension, such as the ability to restate concepts, classify objects, provide examples and non-examples, and apply concepts to problem-solving. The following is a grid table 1 used in data collection techniques.

Table 1. Research Instrument Blueprint

No.	Instrument Type	Aspect/Material Scope	Indicator	Instrument /form	Item number	Total items
1	Media Expert Validation Questionnaire	Integration	Title integration, font size, text clarity	Questionnaire	1–3	3
		Balance	Shape, size, and variation of images	Questionnaire	4–6	3

		Color	Suitability of background, text, and image colors	Questionnaire	7–9	3
		Language	Language level and appropriateness	Questionnaire	10–13	4
		Presentation	Logical presentation, student involvement, media usefulness	Questionnaire	14–20	7
2	Material Expert Validation Questionnaire	Content Quality and Objectives	Suitability with Learning Objective Flow (ATP), Learning Outcomes (CP), and indicators	Questionnaire	1–3	3
		Material	Suitability of material, material accuracy, systematic presentation	Questionnaire	4–8	5
		Language	Language accuracy and readability	Questionnaire	9–10	2
3	Language Expert Validation Questionnaire	Language	Language level, terminology usage, language appropriateness	Questionnaire	1–10	10
4	Teacher Response Questionnaire	Content Quality and Objectives	Suitability with ATP, CP, and indicators	Questionnaire	1–3	3
		Material	Material suitability, accuracy,	Questionnaire	4–6	3

			and systematic presentation			
		Language	Language accuracy and readability	Questionnaire	7–8	2
		Presentation	Encouraging active student participation	Questionnaire	9–10	2
5	Student Response Questionnaire	Content Quality	Ease of use of the digital interactive student worksheets	Questionnaire	1–2	2
		Presentation	Visual appearance and mathematical conceptual understanding	Questionnaire	3–10	8
6	Mathematical Concept Understanding Test	Characteristics of Plane Figures	Identifying types of triangles based on angles	Essay Test	1	1
		Characteristics of Plane Figures	Classifying triangles based on angles	Essay Test	2	1
		Characteristics of Plane Figures	Determining the sum of angles in triangles	Essay Test	3	1
		Characteristics of Plane Figures	Comparing triangles based on side lengths	Essay Test	4	1
		Characteristics of Plane Figures	Identifying the characteristics of parallelograms	Essay Test	5	1

All research instruments were tested for validity and reliability before use, particularly the mathematical conceptual understanding test instrument. The test instrument was declared valid, and the reliability test using Cronbach's Alpha obtained a value of 0.72, indicating that the instrument was reliable. In addition, the difficulty level analysis showed that the test items ranged from easy to difficult categories, while the discrimination index analysis indicated that the instrument had good ability to distinguish between high- and low-ability students.

2.5 Data analysis

Data analysis was conducted using descriptive and inferential quantitative methods. Questionnaire results were analyzed using percentages to determine the level of suitability and practicality of the media based on established criteria (Sugiyono, 2017).

Table 2. Level of criteria validity results /practical

Average	Classification
$3{,}00 < \bar{x} \leq 4{,}00$	Very Good
$2{,}00 < \bar{x} \leq 3{,}00$	Good
$1{,}00 < \bar{x} \leq 2{,}00$	Fair
$0{,}00 < \bar{x} \leq 1{,}00$	Poor

To test the effectiveness of the media in improving mathematical conceptual understanding, the pretest and posttest data were analyzed through several stages. First, a normality test was conducted to determine whether the data were normally distributed, a prerequisite for parametric testing. Next, a paired sample t-test was conducted to determine significant differences between the pretest and posttest results. The media was deemed effective if there was a significant difference between before and after the use of Liveworksheets-based interactive student worksheets, as indicated by a significance value (Sig. 2-tailed) < 0.05.

3. Results

3.1 Analysis phase

The analysis phase was conducted through classroom observations, interviews with teachers and students, and an analysis of the mathematics materials. The results of the analysis indicate that instruction is still dominated by conventional worksheets and makes insufficient use of interactive digital media, resulting in students' conceptual understanding not yet being optimal. Based on these conditions, the development of more interactive digital-based instructional media is necessary.

3.2 Design phase

At this phase, the design of the Liveworksheets-based interactive student worksheets was developed by organizing several key components to support the learning process. The interactive student worksheets include a front cover displaying the title, student identity section, and a QR code for easy access, while the back cover presents the researcher's profile. A preface is provided to explain the purpose and rationale for developing the media in response to students' learning needs. The learning objective flow outlines the expected learning outcomes and instructional objectives. The main menu consists of an introduction, learning objective

flow, learning materials, practice exercises, and the developer's profile. To facilitate conceptual understanding, the learning materials are presented through various digital resources, including YouTube videos, PowerPoint presentations, and website links. Furthermore, the interactive student worksheets contain diverse practice question formats, such as multiple-choice, grouping, matching, selection, listening, and short-answer items, all designed to measure and strengthen students' conceptual understanding. The format of the developed interactive student worksheets media can be seen in Figure 2.



Figure 2. Liveworksheets-based interactive student worksheets

3.3 Development phase

The initial Liveworksheets-based interactive student worksheets product was then validated by media experts, subject matter experts, and language experts. The validation results from media experts regarding the developed product are presented in Table 3.

Table 3. Media expert validation

Expert	Indicator	Item	Validator	
			1	2
Media expert	Integration	3	12	10
	Balance	3	11	11
	Color	3	11	11

	Language	4	13	12
	Presentation	7	27	21
Total Score		20	74	65
Average			3,7	3,25
Average		3,475		
Category		Very Good		

Based on the table 3, the media expert validation questionnaire obtained an average score of 3,475. When viewed from the validation test criteria, this falls within the interval of$3{,}00 < x \leq 4{,}00$, which means it has very good validity criteria.

In addition, the validation results from subject matter experts regarding the developed product are presented in Table 4.

Table 4. Content expert validation

Expert	Indicator	Item	Validator	
			1	2
Subject Matter Expert	Content Quality and Objectives	3	10	12
	Content	5	19	18
	Language	2	8	6
Total Score		10	37	36
Average			3,7	3,6
Average		3,65		
Category		Excellent		

Based on Table 4, the results of the expert validation questionnaire assessment yielded an average score of 3.65. When evaluated against the validation criteria, this score falls within the range of$3{,}00 < x \leq 4{,}00$, indicating very good validity.

The last is language expert validation. The validation results from language experts regarding the developed product are presented in Table 5.

Table 5. Language expert validation

Expert	Indicator	Item	Validator	
			1	2
Language Expert	Language Level	3	12	12
	Appropriate Use of Terminology	3	12	12
	Language Appropriateness	4	16	15
Total Score		10	40	39
Average			4	3,9
Average Total			3,95	
Category		Excellent		

Based on Table 5, the results of the expert validation questionnaire assessment yielded an average score of 3.95. When evaluated against the test criteria, this falls within the range of$3{,}00 < x \leq 4{,}00$, indicating that the validity criteria are very good.

Based on the validation results conducted by the experts, various inputs and suggestions were obtained regarding the initial design of the Liveworksheets-based interactive student worksheets. These inputs were used as a basis for making improvements so that the developed

product would be better, more practical, and more effective for use in mathematics learning. The suggestions and inputs from the validators are presented in Table 6.

Table 6. Validators' suggestions and feedback

No.	Expert type	Suggestions and Feedback
1	Media expert	The layout needs to be improved to be more balanced, color usage should be more consistent and less jarring, and navigation within the media should be made easier for students to use. Add interactive features such as automatic feedback to encourage students to be more active in the learning process.
2	Content expert	The content aligns with the core competencies, but contextual examples should be added to make it easier for students to understand. The core concepts need to be reinforced, and a variety of practice questions ranging from easy to difficult should be added to help students practice their conceptual understanding.
3	Language expert	Improve sentence structure to make it more effective, simple, and appropriate for the students' developmental level. Avoid ambiguous and overly long sentences. Ensure proper use of EYD/PUEBI and maintain consistency in mathematical terminology to prevent confusion.

Based on the feedback and suggestions provided, improvements and further development of the product were carried out in accordance with the findings and guidance from these experts.

3.4 Implementation phase

The student worksheet developed were implemented with fifth-grade students at one of the public elementary school in Gajah District, Demak Regency, Central Java. At this phase, data was collected through teacher and student response questionnaires as well as tests of mathematical conceptual understanding (pre-test and post-test).

The teacher response questionnaire was evaluated by the fifth-grade teacher at one of the public elementary school in Gajah District, Demak Regency, Central Java. The results of the teacher's observational questionnaire regarding the Liveworksheets-based interactive student worksheets product are presented in Table 7.

Table 7. Results of teacher learning observations

Indicator	Item	Total Score	Average Score	Criteria
Content Quality and Purpose	3	12	4	Very Good
Content	3	12	4	Very Good
Language	2	7	3,5	Excellent
Presentation	2	7	3,5	Excellent
Total	10	38	3,8	Very Good

Based on the table 7, the teacher response questionnaire obtained an average score of 3,8. When viewed from the practicality test criteria, this falls within the interval of $3{,}00 < x \leq 4{,}00$, which means it meets the criteria for very good practicality.

Student response questionnaire evaluation for Grade 5 at one of the public elementary school in Gajah District, Demak Regency, Central Java. The results of the student response

questionnaire after participating in the lesson yielded an average score of 3.6. Based on the practicality test criteria ($3{,}00 < x \leq 4{,}00$), this indicates a very good level of practicality.

Although the practicality findings suggest that the Liveworksheets-based interactive student worksheets was positively perceived by teacher and students, the ultimate effectiveness of the product must also be evaluated through learning achievement outcomes. Accordingly, students' mathematical concept understanding before and after the intervention was analyzed using pretest and posttest scores, as summarized in Table 8.

Table 8. Descriptive statistics

		Mean	N	Std. Deviation	Standard Error of the Mean
Pair 1	pre-test	54.54	28	10.344	1.955
	Posttest	76.57	28	7,500	1,417

Based on the results of the *paired simple statistics* test, the average *pre-test* score was 54,54 and the average *post-test* score was 76,57. This indicates that the post-test scores were higher than the pre-test scores by a margin of 22,03.

The effectiveness test for this Liveworksheet-based interactive student worksheets was obtained from the results *of the paired sample T-test* and the N-gain test. Before conducting the effectiveness test, a normality test was performed to determine whether the data were normally distributed.

Table 9. Results of the data normality test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
pre-test	.134	28	.200*	.937	28	**.091**
posttest	.167	28	.045	.934	28	**.077**

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

The results of the data normality test are shown in the *Shapiro-Wilk* column. The normality test for the *pre-test* data yielded a significance value of 0.91, while the normality test for *the post-test* data yielded a significance value of 0.77. Since the normality tests for both the *pre-test* and *post-test* questions in this study yielded significance values > 0.05, the null hypothesis (H_o) is accepted. Therefore, based on the decision criteria for the data normality test, the *pre-test* and *post-test* data in this study are normally distributed. Next, a paired-sample t-test was conducted using SPSS 25. The *results* of the *paired sample t-test* are presented in Table 10.

Table 10. Paired sample t-test

	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Standard Deviation	Standard Error of the Mean	Lower	Upper	t	Df	Sig. (2-tailed)

Pair 1	pre-test - post-test	-22.036	6,580	1,243	-24,587	-19,484	-17,721	27	.000

Based on Table 9, the value of the t-$sig\ (2-tailed\ =\ 0{,}000)$ t is < 0.05; therefore, the null hypothesis (H_o) is rejected. Thus, there is a difference between the *pre-test* scores and the *post-test* scores. Since the mean *pre-test* score is lower than the mean *post-test* score, the fifth-grade students at one of the public elementary school in Gajah District, Demak Regency, Central Java have improved their conceptual understanding of the characteristics of two-dimensional shapes.

The results of *the post-test* and *pre-test* questions were used to conduct an N-Gain analysis. This test was conducted to determine the improvement in the learning outcomes of fifth-grade students after instruction, as assessed by their conceptual understanding. The results of the N-Gain test in this study can be seen in Table 11.

Table 11. N-gain result

	N	Minimum	Maximum	Mean	Standard Deviation
Total	28	.32	.64	.4898	.10465
Valid N (listwise)	28				

Table 10 shows a mean value of 0.4898. Based on the N-Gain test criteria, this value falls within the range *of* $0{,}3 < x \leq 0{,}7$, which indicates a moderate category. Therefore, based on the N-Gain test, the fifth-grade students at one of the public elementary school in Gajah District, Demak Regency, Central Java, after learning about the characteristics of two-dimensional shapes, experienced an improvement in their conceptual understanding at a moderate level according to the normalized N-Gain criteria.

4. Discussion

The results of this study indicate that the Liveworksheets-based interactive student worksheets developed meets the criteria of validity, practicality, and effectiveness in enhancing elementary school students' mathematical conceptual understanding. Validation by experts in media, content, and language yielded an "excellent" rating, indicating that the product meets the standards of quality in terms of design, content, and language. These findings align with various studies stating that the quality of interactive student worksheets is determined by three main indicators: validity, practicality, and effectiveness, as the primary prerequisites in the development of digital learning media (Wijaya et al., 2022; Ningrum et al., 2023; Purnamayanti et al., 2023; Wahyuni et al., 2024). Thus, the validation results in this study reinforce that the developed product aligns with the standards for technology-based media development in mathematics education.

In terms of practicality, the results of the teacher and student response questionnaires indicated the "very good" category, suggesting that the interactive student worksheets are easy to use, engaging, and effectively supports the learning process. This practicality is a crucial aspect in the implementation of digital learning media, as it determines the sustainability of its use in the classroom. Previous research has shown that digital-based interactive student

worksheets have a high level of practicality because they can be accessed via simple devices such as smartphones without requiring complex installation (Susanti & Sholihah, 2021; Komalasari et al., 2022; Tambunan & Tambunan, 2023). This is also evident in this study, where students can use the digital worksheets independently and teachers can manage the learning process more efficiently.

In terms of effectiveness, the research results indicate a significant increase between pretest and post-test scores, with the average rising from 54.54 to 76.57. The results of the paired-sample t-test revealed a significant difference ($p < 0.05$), along with an N-gain value of 0.4898, which falls into the moderate category. This indicates that Liveworksheets-based interactive student worksheets is effective in improving students' mathematical concept comprehension. These findings are consistent with the research by Siregar and Suparman (2022) and Apriliana et al. (2024), which state that digital-based interactive student worksheets can enhance concept comprehension and problem-solving skills through interactive learning activities that demand higher-order thinking.

Constructivist theory explains this improvement in conceptual understanding, as students actively construct knowledge through learning experiences. In this context, the interactive student worksheets provide space for students to explore concepts through interactive activities, practice problems, and immediate feedback. Furthermore, based on multimedia learning theory, the integration of text, images, and interactions in Liveworksheets helps reduce students' cognitive load and enhances conceptual understanding (Mayer, 2020). This demonstrates that effective media design plays a crucial role in enhancing learning effectiveness.

When considered within the broader literature, the use of Liveworksheets as an interactive student worksheets platform offers advantages in terms of interactivity and automatic feedback. Rahmah et al. (2023) state that Liveworksheets enable interactive learning that supports conceptual understanding through hands-on practice and automatic evaluation. Furthermore, research by Azzahra and Kowiyah (2022) indicates that the use of Liveworksheets can improve mathematical problem-solving skills compared to conventional media. This reinforces that interactivity is a key factor in enhancing the quality of mathematics learning.

Furthermore, the effectiveness of interactive student worksheets is also influenced by the learning approach used in its design. Various studies indicate that interactive student worksheets designed using the Problem-Based Learning (PBL), Realistic Mathematics Education (RME), or PMRI approaches can enhance conceptual understanding through real-world contexts and higher-order thinking activities. Lestari et al. (2024) and Purnamayanti et al. (2023) found that the RME and PMRI approaches can enhance students' mathematical connections because learning is linked to real-world experiences. Furthermore, Margaretha et al. (2024) demonstrated that integrating STEM into interactive student worksheetss can enhance critical thinking skills and conceptual understanding through a multidisciplinary approach. Thus, contextual and problem-based interactive student worksheets design is a key factor in improving mathematical conceptual understanding.

Nevertheless, the results of this study indicate that the improvement in students' abilities falls into the moderate category. This suggests that there is still room for further development. Several factors that may influence these results include the relatively short duration of media use, students' adaptation to evolving technology, and limitations in digital facilities. Ningrum et al. (2023) and Wijaya et al. (2022) state that the effectiveness of interactive student

worksheetss is significantly influenced by student readiness, design quality, and the learning context employed.

In addition to technical factors, policy aspects and the readiness of the education system also play a crucial role in the implementation of interactive student worksheets. Research by Adelia et al. (2023) and Ananda and Soro (2023) indicates that the success of digital learning depends not only on the media but also on infrastructure support, teacher competencies, and student readiness. Therefore, the integration of interactive student worksheets into learning must be supported by teacher training, the enhancement of digital literacy, and educational policies that promote digital transformation.

Overall, the results of this study indicate that Liveworksheets-based interactive student worksheets holds significant potential for enhancing students' understanding of mathematical concepts. These findings reinforce the existing literature stating that valid, practical, and effective digital learning media can improve the quality of mathematics education. However, generalizing the results of this study requires caution due to limitations in sample size, research context, and the materials used.

The implications of this study are that teachers can use interactive student worksheets as an innovative and interactive alternative learning medium. Additionally, educational media developers must balance aspects of validity, practicality, and effectiveness to ensure that the resulting products are not only theoretically sound but also effective in actual learning practice. For future research, it is recommended to test interactive student worksheets with different subject matters at various educational levels and to integrate other learning models, such as PBL or STEM, to enhance learning effectiveness.

5. Limitations and future research

This study has several limitations. First, the research involved a relatively small sample from a single elementary school, which may limit the generalizability of the findings to broader educational contexts. Second, the intervention was conducted over a short period, preventing an assessment of the long-term effects of the Liveworksheets-based interactive student worksheets on students' conceptual understanding. Third, the study focused solely on mathematical conceptual understanding without examining other learning outcomes. Future research should involve larger and more diverse samples, investigate long-term impacts through longitudinal studies, and explore the effectiveness of the worksheets in developing other competencies, such as problem-solving, critical thinking, and digital literacy skills.

6. Conclusion

This study concludes that the Liveworksheets-based interactive student worksheets developed in this study is valid, practical, and effective in improving fifth-grade students' mathematical conceptual understanding, as evidenced by expert validation results rated "very good," highly positive user feedback, and a significant improvement in learning outcomes with a moderate N-gain. The implications of these findings suggest that digital-based interactive student worksheets can serve as an innovative learning medium supporting 21st-century learning; therefore, teachers are advised to integrate similar media into mathematics instruction to enhance student engagement and conceptual understanding, while schools need to ensure the

availability of digital resources and support teachers' competency in utilizing educational technology.

Author Contributions

Dwi Prischa Setya: Conceptualization, methodology, formal analysis, investigation, data curation, writing—original draft preparation. Yunita Sari: Validation, supervision, writing—review and editing. Nuhya Ulia: Conceptualization, supervision, visualization, writing—review and editing.

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