

**Developing Constructivism-Based Student Worksheets to Improve
Learning Outcomes on Surface Area in Phase C**

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Abstract

Mathematics learning practice in Elementary Schools on the topic of surface area often reveals a gap between procedural knowledge and conceptual understanding, where students can memorize formulas but struggle to comprehend surface area as the sum of the constituent faces of three-dimensional figures. This gap reflects a learning process dominated by formula-based instruction rather than activities that engage students in constructing their understanding of geometric concepts. This study aims to develop a constructivism-based Student Worksheet (*Lembar Kerja Peserta Didik/LKPD*) that is valid, practical, and effective in improving students' conceptual learning outcomes on surface area. This study employed a Research and Development (R&D) approach using the 4D model (Define, Design, Develop, and Disseminate), with a limited trial involving 21 Grade VI students of SDN Sumberwuluh. The result showed that in the Develop stage the LKPD achieved a Highly Valid category with an average validator score of 3.65, confirming its alignment with students' cognitive development and constructivist learning principles. The LKPD was also categorized as highly practical, as indicated by an average student response of 81.32%, demonstrating ease of use and positive engagement during learning activities. In terms of effectiveness, the LKPD showed a High-category N-Gain score of 0.7964, supported by the results of a paired t-test that revealed a statistically significant improvement in learning outcomes ($p < 0.001$). In conclusion, the developed constructivism-based LKPD meets the criteria of validity, practicality, and effectiveness, and thus can serve as an innovative and reliable learning resource to support meaningful mathematics learning in elementary schools.

Keywords: constructivism, student worksheet, learning outcomes, surface area, phase c

INTRODUCTION

Education in the contemporary era, often referred to as the 21st century, is characterized by rapid social, economic, and technological transformations that require a fundamental shift in the orientation and practice of learning. Current global educational paradigms no longer prioritize the mere mastery of factual or procedural knowledge but emphasize the development of higher-order competencies such as reasoning ability, mathematical literacy, and problem-solving skills (Jiang et al., 2025; Rambe et al., 2023; Jannah et al., 2025; Ria et al., 2023; Kusuma & Sukestiyarno, 2025; Azizah et al., 2025). These demands are institutionally reinforced in Indonesia through the Decree of the Minister of Education, Culture, Research, and Technology of the Republic of Indonesia Number 262/M/2022, which mandates learning outcomes aligned with the 8-Dimensional Graduate Profile, including critical reasoning, independence, and creativity (Widiyati, 2022). In the context of elementary mathematics education, this policy implication is crucial: learning should not be reduced to mechanical procedures but must foster deep conceptual understanding as a foundation for sustainable mathematical thinking at higher levels of education.

Despite these curriculum demands, mathematics learning practices in elementary schools, particularly on the topic of surface area of three-dimensional figures, continue to face substantial structural and pedagogical challenges. Classroom instruction is still dominated by conventional, teacher-centered approaches that emphasize formula memorization and routine algorithmic problem solving. As a result, learning tends to be mechanistic, offering limited opportunities for exploration and meaning-making. Field observations conducted at SDN Sumberwuluh, supported by interviews with classroom teachers, reveal that Phase C students (Grades V–VI) are generally able to recall surface area formulas procedurally, yet struggle to understand the conceptual origin of surface area as the total area of the constituent faces (nets) of three-dimensional shapes. This difficulty is intensified by the abstract and visual–spatial nature of surface area concepts, which require students to mentally transform three-dimensional objects into two-dimensional representations, an ability that is cognitively demanding for learners at the elementary level (Departemen Pendidikan Nasional Depdiknas, 2008). Consequently, students' understanding becomes fragile and context-dependent, reinforcing a persistent gap between procedural proficiency and conceptual mastery. This condition is further reflected in international assessment data, where Indonesian students' mathematical literacy, as reported by the Program for International Student Assessment (PISA), consistently remains below the international average. These findings underline the urgent need for learning innovations that move beyond procedural fluency toward meaningful conceptual understanding.

To address conceptual difficulties in abstract and visual–spatial mathematical content, constructivist learning theory provides a highly relevant pedagogical foundation. Rooted in Piaget's cognitive constructivism, this perspective views knowledge not as information transmitted by teachers, but as actively constructed by learners through interaction with objects and learning environments (Piaget, 1972). According to Piaget's theory of cognitive development, Phase C students (approximately ages 7–11) are situated in the Concrete Operational Stage, in which reasoning is strongly tied to tangible objects and direct manipulation (Nortje, 2023). Learning becomes most effective when students engage with concrete materials that allow them to observe, manipulate, and reorganize ideas. Conceptual development occurs through cognitive processes of assimilation and accommodation, driven by cognitive conflict (disequilibrium), a condition in which

existing schemas are challenged by new experiences, prompting learners to reconstruct their understanding (Wardani, 2022). In surface area learning, this implies shifting instruction from passive formula application to active exploration, such as manipulating geometric nets of cubes and prisms. Through such activities, students are encouraged to inductively discover that surface area represents the total area of all faces, resulting in a deeper and more transferable conceptual understanding.

To facilitate constructivist learning experiences that align with students' cognitive development, an appropriate instructional instrument is required, namely the Student Worksheet (*Lembar Kerja Peserta Didik/LKPD*). LKPD functions as a learning scaffold that systematically guides students through exploration, discussion, and reflection activities, both individually and collaboratively (Amri, 2013; Fadilah et al., 2025; Rahmania et al., 2023). Within the Merdeka Curriculum framework, an effective LKPD must support student-centered learning by encouraging inquiry, conceptual construction, and reflective thinking, rather than merely presenting repetitive calculation exercises (Trianto, 2012). Practically, a well-designed LKPD assists teachers in organizing learning activities, managing classroom interaction, and ensuring that students actively engage with learning objects. For students, LKPD serves as a structured pathway to explore concepts independently, reducing cognitive overload while strengthening conceptual clarity (Prastowo, 2011).

To ensure that constructivist learning activities are not only experiential but also systematically structured, this study integrates Piaget's constructivist principles with Gagné's Nine Events of Instruction. Gagné's framework provides a sequential instructional structure, from gaining attention and guiding learning to eliciting performance and enhancing retention and transfer (Gagné, 1985). The integration of these two frameworks enables constructive alignment, defined as the coherence between learning objectives, learning activities, and assessment strategies (Biggs & Tang, 2011). Importantly, previous studies on constructivist-based LKPD have generally applied constructivism as a broad philosophical approach or focused on different mathematical content. To date, there is no operational LKPD that explicitly integrates Piaget's cognitive development theory with Gagné's instructional model for surface area learning. This integration constitutes the central novelty of the present study.

Empirical studies have demonstrated the effectiveness of constructivist approaches in improving learning outcomes and higher-order thinking skills in elementary mathematics (Romdhon et al., 2024; Minarni & Napitupulu, 2020). Constructivist-based LKPD has also been shown to enhance critical thinking and conceptual understanding, particularly when supported by concrete objects (Septian et al., 2022; Adhiyah, 2023). However, existing studies often focus on flat geometry, apply Realistic Mathematics Education, or lack systematic instructional sequencing. This gap indicates the need for a structured, theory-integrated LKPD specifically designed for surface area learning at the Phase C level.

Based on these considerations, this study aims to: (1) develop a constructivism-based LKPD that meets high validity standards in terms of content, theoretical alignment, and instructional design; (2) examine the practicality of the LKPD in terms of ease of implementation by teachers and usability for Phase C students; and (3) evaluate the effectiveness of the LKPD in improving students' conceptual learning outcomes on surface area topics. Theoretically, this study contributes to mathematics education by strengthening the instructional design foundation of constructivist learning through the integration of Piaget's and Gagné's frameworks. Practically, it offers a validated LKPD

model that supports teachers in facilitating active, meaningful surface area learning while helping students to bridge the gap between procedural calculation and conceptual understanding.

METHOD

This study employed a Research and Development (R&D) approach aimed at producing, validating, and refining a constructivism-based Student Worksheet (LKPD) for surface area learning in Grade VI elementary students. The development procedure followed the 4D model proposed by Thiagarajan et al. (1974), consisting of Define, Design, Develop, and Disseminate stages, due to its systematic structure and suitability for instructional material development.

Define Stage

The Define stage was conducted to identify instructional needs and learning constraints. This stage involved curriculum analysis, analysis of student characteristics, identification of learning difficulties related to surface area concepts, and a review of constructivist-based mathematics learning literature. Data were collected through classroom observations, semi-structured interviews with teachers, and documentation analysis. The collected data were analyzed qualitatively using the Miles and Huberman (2014) model, including data reduction, data display, and conclusion drawing. The results of this stage formed the basis for determining learning objectives and LKPD design requirements.

Design Stage

At the Design stage, a prototype of the constructivism-based LKPD was developed, emphasizing exploratory activities, problem-solving tasks, and active student engagement through manipulation of geometric nets. In addition, research instruments were prepared, including expert validation sheets (content, media, and pedagogy), student response questionnaires, observation sheets, and learning outcome tests (pretest–posttest). Content validity of the instruments was examined using Aiken’s V coefficient (Aiken, 1985), while test reliability was calculated using Cronbach’s Alpha (Cronbach, 1951) to ensure internal consistency.

Develop Stage

The Develop stage involved expert validation and limited field testing. The LKPD prototype was reviewed by three validators to assess content accuracy, pedagogical suitability, and media design. The level of validity was determined using the average validation score formula:

$$V_A = \frac{\sum S}{n}$$

where V_A is the average validity score, $\sum S$ is the total score from all validators, and n is the number of validators. The validity category was determined based on the criteria shown in Table 1.

Table 1. Validity Category Score Range

Score Range	Category
$3.25 < Va \leq 4.0$	Highly Valid
$2.5 < Va \leq 3.25$	Valid
$1.75 < Va \leq 2.5$	Less Valid
$1.00 \leq Va \leq 1.75$	Invalid

Riduwan (2015)

The LKPD was considered feasible if it reached at least the *Valid* category, following Nieveen (1999). Validation results were used as the basis for revising content structure, activity sequencing, and clarity of instructions before field implementation.

Practicality was measured to determine the ease of LKPD use by teachers and students during classroom implementation. Practicality was calculated using the following formula:

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

Pr is the practicality percentage, *f* is the obtained score, and *N* is the maximum score. The practicality level was interpreted using the criteria presented in Table 2.

Table 2. Practicality Score Interpretation Criteria

Percentage	Category
$80 < Pr \leq 100$	Very Practical
$60 < Pr \leq 80$	Practical
$40 < Pr \leq 60$	Quite Practical
$20 < Pr \leq 40$	Less Practical
$0 \leq Pr \leq 20$	Impractical

Riduwan (2015)

Practicality results informed minor revisions related to wording clarity, activity flow, and time allocation during learning. Effectiveness was evaluated based on improvements in students' learning outcomes measured through pretest and posttest scores. The magnitude of improvement was calculated using the normalized N-Gain score (Hake, 1999).

$$g = \frac{Posttest - Pretest}{Maximum Score - Pretest}$$

The N-Gain interpretation followed the criteria in Table 3.

Table 3. Criteria Gain Normalized

Value g	Interpretation
$0.70 \leq g \leq 1.00$	High
$0.30 \leq g < 0.70$	Medium
$0.00 \leq g < 0.30$	Low
$g = 0.00$	No Increase
$-1.00 \leq g < 0.00$	There is a decline

Hake (1999)

In addition, product effectiveness was categorized using the effectiveness criteria shown in Table 4.

Table 4. Criteria for Determining the Level of Effectiveness

Value g	Interpretation
< 40	Ineffective
40 – 55	Less Effective
56 – 75	Quite Effective
>76	Effective

Riduwan (2015)

To ensure statistical significance, a paired-sample t-test was conducted. The LKPD was declared effective if the calculated *t*-value exceeded the critical *t*-table value at a significance level of 0.05.

Disseminate Stage

In making the decision, if the value of *t* is calculated $> t$ table, at a significance level of 0.05, then the LKPD is declared effective in improving student learning outcomes. The Disseminate stage involved final product documentation, preparation of scientific manuscripts, and limited distribution of the LKPD to Grade VI teachers. Feedback obtained from teachers and students during this stage was used for final refinements, particularly in improving instructional clarity and usability of the LKPD for classroom practice. This research was conducted at SDN Sumberwuluh from September to November 2025, involving 21 Grade VI students, one mathematics teacher, and three expert validators. The LKPD was considered feasible if it met three criteria: valid (Aiken's $V \geq 0.80$), practical (response and observation scores $\geq 80\%$), and effective (minimum medium N-Gain and significant t-test results at $p < 0.05$).

FINDINGS AND DISCUSSION

Findings

This section presents the results and interpretation of data obtained from the entire series of research and development (Research and Development). The discussion focused on two main problem formulations: (1) The constructivism-based Student Worksheet (LKPD) development process for the material of Building Spatial Surface Area; and (2) Product feasibility as measured through the aspects of validity, practicality, and effectiveness in improving students' conceptual learning outcomes. The development process of this LKPD adopts the 4D Model (Define, Design, Develop, Disseminate) from Thiagarajan and Semmel (1974), which systematically integrates the assessment of product feasibility at the Development Stage, so that the results of the discussion will be elaborated sequentially based on the stages of the 4D Model. The LKPD combines Gagné's Nine Events of Instruction (2023) with constructivist principles to create a constructive alignment (Biggs & Tang, 2011).

Table 5. The LKPD Combines Gagné's Nine Events of Instruction

LKPD Cycle	Instructional Focus	Classroom Activity Example	Cognitive Level (Bloom)
Activation	Connect prior knowledge	Recall everyday objects' surfaces	C3
Exploration	Hands-on discovery	Manipulate and measure geometric nets	C4
Elaboration	Peer discussion & reasoning	Justify calculations in groups	C5
Concept Formation	Independent synthesis	Derive formula for surface area	C5–C6
Application	Problem-solving	Apply formula to real-life objects	C5–C6
Reflection	Metacognition	Write conceptual conclusion	C6

This table helps visualize the six-cycle structure, making the progression from procedural to conceptual knowledge clearer. Unlike conventional worksheets, which often provide a single-step instruction or formula to apply, the LKPD actively guides students through discovery, reasoning, and reflection.

Define Stage

The Define stage aimed to conduct a comprehensive needs analysis to identify gaps, challenges, and determine development goals (Thiagarajan & Semmel, 1974). The analysis involved 21 Grade VI students of SDN Sumberwuluh and covered three aspects: (1) phenomenon analysis (learning needs), (2) student characteristics, and (3) curriculum and material analysis. The goal was to ensure the developed LKPD is relevant and capable of addressing real classroom problems.

Learning Needs Analysis (Field Phenomena)

Field data from interviews, classroom observations, and document reviews revealed a significant gap between the Independent Curriculum and PISA demands, which emphasize reasoning, and actual classroom practices. Findings showed that learning remained focused on rote memorization of abstract formulas (e.g., $L = 6 \times s^2$) without understanding the concept of geometric nets. Existing LKPDs were rigid and textbook-based, lacking exploratory activities or manipulation of real objects. Consequently, students' knowledge was stalled at the procedural level and failed to reach the conceptual understanding required to solve contextual and spatial problems. This directly contributed to low conceptual learning outcomes, as students could not explain formula origins or apply surface area concepts flexibly.

Analysis of Student Characteristics and Determination of Approaches

Based on the phenomenon findings, the learning approach was determined according to students' cognitive characteristics. Referring to Piaget's theory, Grade VI students are at the concrete operational stage and learn best through manipulation of real objects and direct interaction, particularly for visual-spatial and abstract topics like surface area. Accordingly, a constructivist approach was adopted to bridge the conceptual gap.

Design Stage

The Design stage realized the needs identified in the Define stage, focusing on prototype LKPD development and preparation of research instruments. The LKPD was designed following constructivist principles (Piaget), aiming to improve students' conceptual understanding of surface area. Each LKPD component had a clear and sequential didactic function.

LKPD Didactic Model Design (Prototype 1)

The prototype adopted a discovery learning approach, divided into six main cycles targeting conceptual understanding. This cycle structure reflected the constructivist learning process.

Table 6. Prototype LKPD Constructivism

No	LKPD Levels	Implementation of Piaget's Theory (Constructivism)	Target Cognitive Bloom	Main Focus of Activity
1	Activation	Assimilation	C3 (Analyzing characteristics)	Connecting the student experience with new concepts.
2	Exploration	Accommodation	C4 (Analyzing/Inference)	Manipulate concrete objects to find formula patterns.
3	Elaboration	Initial Equilibrium	C5 (Evaluating and reasoning)	Group discussions and justifications of concepts.
4	Concept Formation	Advanced Equilibrium	C5–C6 (Creating Representations)	Formulation of formulas and synthesis of concepts independently.
5	Application/Transfer	Re-Assimilation	C5–C6 (Evaluation and Solution Creation)	Complex contextual problem-solving.
6	Self-Reflection	Final Equilibrium	C6 (Metacognitive reflection)	Review and strengthening understanding.

This structure ensured students progressively constructed surface area concepts through exploration, reasoning, and reflection rather than merely practicing formula application.

Constructivism for Conceptual Learning Outcomes

The LKPD facilitated the assimilation–accommodation–equilibrium cycle (Piaget). In the Exploration stage, students carried out concrete activities such as cutting, measuring, and comparing geometric nets, discovering relationships between building sides and surface area. For example, in one Exploration activity, students are given a cube with sides of 5 cm and a prism with bases measuring 6 cm × 4 cm and a height of 10 cm. Students are instructed to cut the nets, measure each face, and calculate total surface area independently. During the Elaboration stage, students compare results in groups, discuss inconsistencies, and justify the method used. Such concrete activities reinforce

understanding of the formula's origin and illustrate the relationship between two-dimensional nets and three-dimensional objects, promoting cognitive construction over rote memorization

Didactic Specification and Completion Format

The LKPD had clear instructions, visual icons for each stage, and sections for exploration results, conceptual conclusions, and diagram representation. Observation columns and independent conclusions ensured that activities measured conceptual understanding (C4–C6), not just numerical answers.

Preparation and Validation of Research Instruments

Research instruments included: (1) Expert Validation Sheet (product validity); (2) Student Response Questionnaire (practicality); (3) Conceptual Learning Outcome Test (pretest–posttest, effectiveness). Instruments were tested for theoretical feasibility and reliability (Pearson correlation, Cronbach's Alpha), ensuring objectivity in measuring conceptual understanding.

Develop Stage

The develop stage is a prototype development phase that aims to test the quality of the product in terms of validity, practicality, and effectiveness, while ensuring that the revisions given in the previous stage are appropriate. The form of the LKPD as a result of the development is shown as follows:

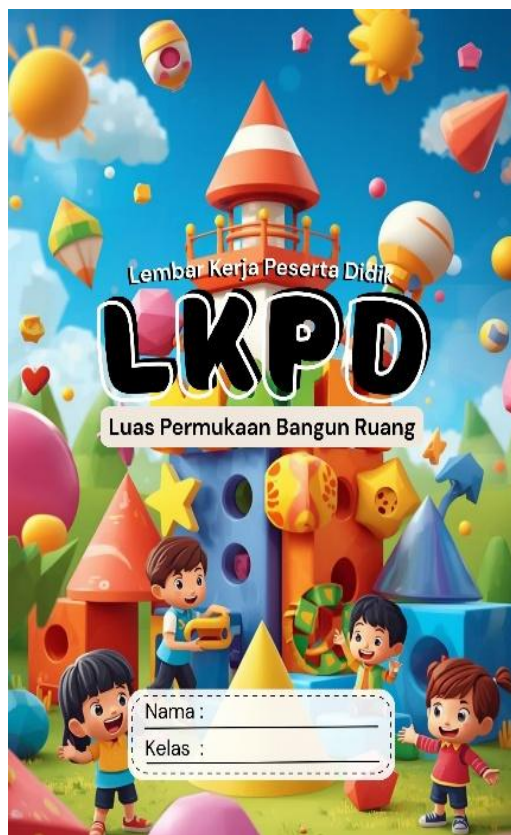


Image 1. LKPD Cover



Image 2. CP & ATP



Image 3. Table of Contents



Image 4. Early Knowledge Activation

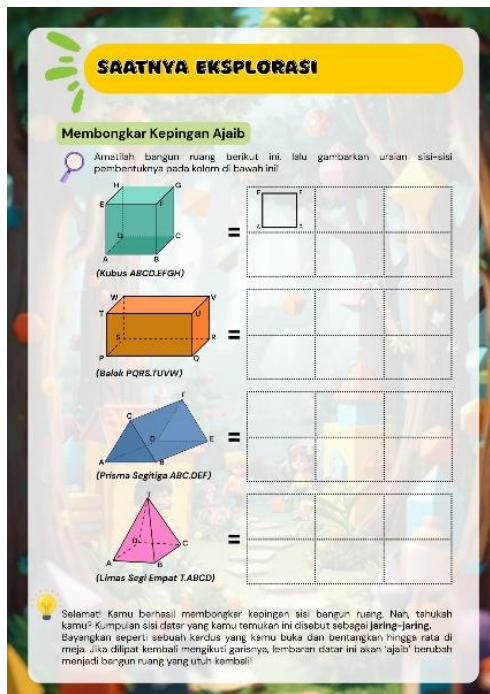


Image 5. Exploration

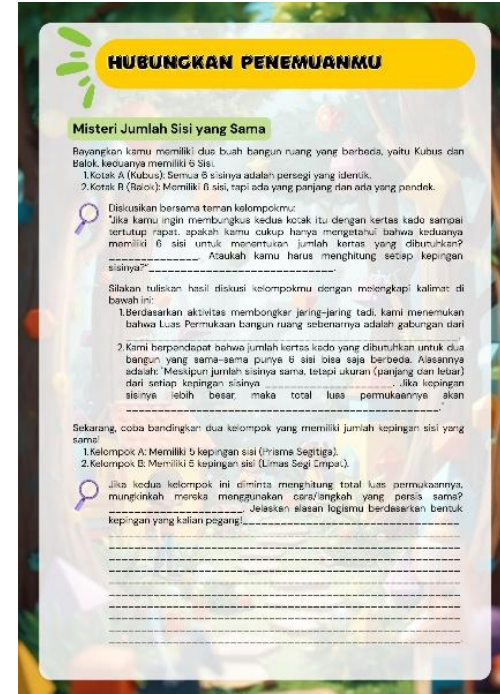


Image 6. Elaboration

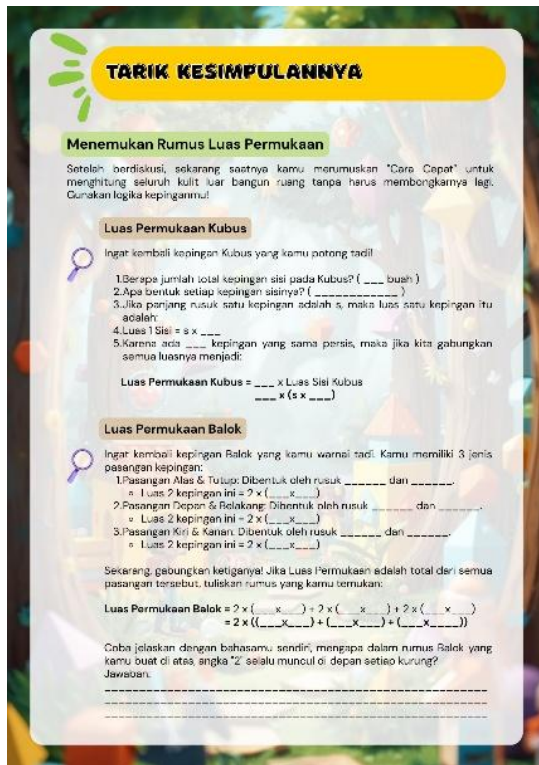


Image 7. Concept Formation



Image 8. Application

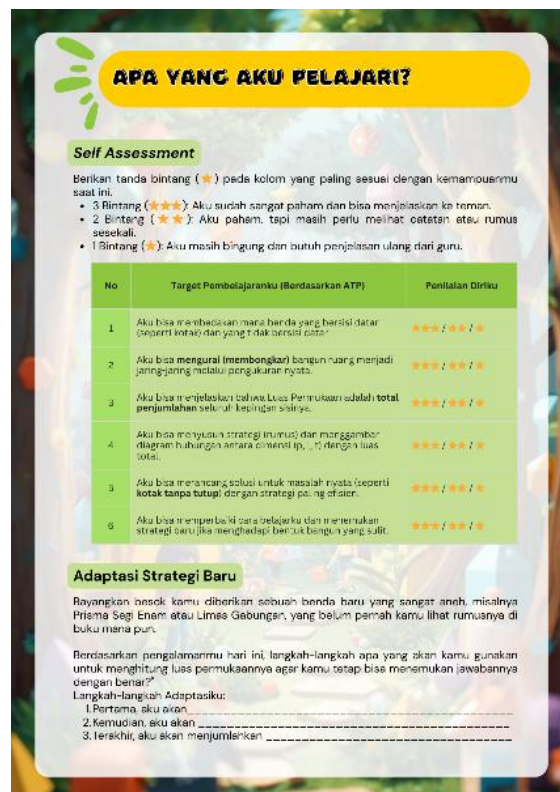


Image 9. Reflection

The constructivism-based LKPD prototype was tested through three main procedures: expert validation, a trial limited to 21 grade VI students, and an analysis of improved learning outcomes through tests before and after the use of LKPD.

Product Validity (Expert Validation)

Three expert validators assessed the LKPD using a 4-point Likert scale. The Aiken V scale determined product eligibility.

Table 7. Product Validity

Validity Aspect	Average Score	Category
Contents (Material)	3.65	Highly Valid
Construct (Pedagogy)	3.78	Highly Valid
Media (Display and Design)	3.52	Highly Valid
Total Average	3.65	Highly Valid

The average score of 3.65 indicates high validity, confirming the LKPD is pedagogically appropriate to support conceptual learning. Minor revisions were made to layout and instructions, resulting in Prototype 2 ready for student testing.

Product Practicality

Practicality was measured via student responses (21 students) and teacher observation. Data interpretation followed a modified Likert scale (minimum $\geq 61\%$).

Table 8. Student Response (Practicality Questionnaire)

Measurement Aspects	Percentage	Category
Ease of Use	80.12%	Very Practical
Implementation of Activities	78.50%	Practical
Visual Appeal	85.33%	Very Practical
Total Average	81.32%	Very Practical

Teacher observation indicated 92% learning implementation, confirming practical application of constructivist activities. In class, students were actively manipulating nets and discussing concepts, not just performing calculations.

Product Effectiveness

Effectiveness was measured using pretest–posttest comparisons, N-Gain, and paired t-test.

Table 9. N-Gain Score

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Hours of deviation
N-gain_score	21	0.00	1.00	0.7964	0.30503
N-gain_persen	21	0.00	100.00	79.6429	30.50338
Valid N (listwise)	21				

The average N-Gain 0.7964 (High) shows that LKPD substantially improved conceptual understanding. Most students understood formula derivation from geometric nets.

Paired Sample t-test

Table 10. Difference Test (Paired Sample t-test)

		Paired Differences					Significance			
		Mean	Hours of deviation	Std. Error Mean	95% Confidence Interval of the Difference		T	df	One-Sided p	Two-Sided p
					Lower	Upper				
Pair 1	pre test – post test	-15.47619	7.40013	1.61484	-18.84469	-12.10769	-9.584	20	<0,001	<0,001

The significance value of <0.001 confirms a very significant increase in learning outcomes due to LKPD usage. Overall, the findings from the Develop Stage show that the LKPD is Very Valid ($\bar{x} = 3.65$), Very Practical (81.32%), and Highly Effective based on the N-Gain score (0.7964). These results collectively indicate that the constructivism-based LKPD has successfully achieved its objectives and is ready for dissemination.

Disseminate Stage

The Disseminate stage involved documenting and introducing the final LKPD to both the academic and practitioner communities. The Final Prototype was disseminated through academic publications in Sinta-indexed journals and teacher workshops in Banyuwangi, which focused on the effective implementation of discovery learning. This constructivism-based LKPD bridges the gap between procedural knowledge and conceptual understanding, offering teachers and curriculum developers a model that emphasizes exploration and independent discovery. By aligning teaching materials with students' cognitive development at the concrete operational stage and grounded in constructivism theory, the LKPD effectively addresses the challenges of teaching abstract mathematics concepts at the elementary level.

Discussion

The discussion focuses on how the developed constructivism-based LKPD addresses structural and methodological challenges in elementary mathematics education. The following sections elaborate on theoretical justification, practical classroom application, and empirical validation.

The findings in the Define stage confirmed a significant gap between current classroom practices and the demands of the Independent Curriculum. While the curriculum emphasizes the 8 Dimensions of Graduate Profiles, such as critical reasoning and creativity, classroom observations revealed that teaching still relies heavily on rote memorization. Students often recite formulas such as $L = 6 \times s^2$ without understanding how the formula represents the sum of the surfaces of a cube or other geometric nets. This procedural approach limits their ability to apply mathematical concepts to real-world contexts or novel problems.

The constructivism-based LKPD was designed to bridge this gap by providing a structured, discovery-oriented learning path. For instance, instead of giving students the formula directly, they are asked to manipulate nets, measure sides, and calculate areas individually and in groups. These activities allow students to see the relationship between the flat net and the three-dimensional object, gradually building the conceptual foundation needed for higher-level problem solving. By connecting activities to students' prior experiences and everyday contexts, such as comparing the dimensions of classroom

objects or packaging boxes, LKPD promotes meaningful learning rather than memorization.

Grade VI students are in the Concrete Operational Stage according to Piaget (Nortje, 2023), which means they learn best by manipulating tangible objects and observing direct cause-effect relationships. The LKPD activities are aligned with this stage: during the Exploration cycle, students dismantle geometric nets and calculate individual surfaces. This hands-on process triggers cognitive disequilibrium, prompting students to reconcile inconsistencies between their expectations and observations, thus facilitating accommodation (Wardani, 2022).

Concrete examples illustrate this change: in one activity, students initially assume that the area of a net can be calculated by multiplying side lengths without summing individual faces. Through cutting, folding, and counting each face, students realize their initial assumption is incorrect and adjust their reasoning to arrive at the correct formula. Another example occurs during group discussions in the Elaboration stage, where students must justify their reasoning to peers. These interactions encourage reflection, evaluation, and synthesis, moving them from simple procedural knowledge to deeper conceptual understanding (Bloom's C5–C6).

Beyond the immediate classroom, the constructivism-based LKPD provides students with transferable problem-solving skills. By engaging in hands-on manipulation of geometric nets, students not only understand the surface area of cubes and prisms but also develop spatial reasoning applicable to real-life scenarios, such as packaging design, furniture layout, and architectural considerations. This aligns with the Independent Curriculum's emphasis on the 8-Dimensional Graduate Profile, particularly critical reasoning, creativity, and problem-solving, thus fostering both domain-specific knowledge and generic competencies that support lifelong learning.

Teachers play a crucial role in ensuring the effectiveness of the LKPD. Beyond following procedural steps, they must observe students' reasoning processes, provide timely scaffolding, and encourage peer discussion to address misconceptions. The LKPD allows teachers to implement formative assessment through observation and reflection activities embedded in each cycle, which helps in adjusting instruction in real time. This practical implication is particularly relevant for Phase C students, whose cognitive development benefits from continuous guidance during exploratory and collaborative tasks.

The LKPD's effectiveness is confirmed by a high N-Gain score (0.7964) and statistically significant paired t-test results ($p < 0.001$). In practical terms, this means that most students significantly improved their understanding of geometric surface areas after using LKPD. Instead of simply applying formulas mechanically, students could explain why the formulas work, predict surface areas of new objects, and adapt strategies to solve unfamiliar problems.

Comparing LKPD with traditional worksheets further highlights its advantages. Traditional worksheets often ask students to fill in numbers without encouraging reasoning, discussion, or exploration. In contrast, LKPD fosters active engagement, collaboration, and metacognition. Teacher observations during implementation showed students were more curious, asked questions, and corrected misconceptions in real time, indicating a deeper understanding rather than rote performance. The general benefits of constructivism and hands-on objects, this study offers operational detail in the form of a structured LKPD. The six-cycle design explicitly aligns with Piaget's stages, Bloom's cognitive levels, and Gagné's instructional events. The approach demonstrates

measurable improvement in conceptual learning outcomes, showing that the LKPD is not only theoretically sound but practically superior to conventional worksheets.

Teachers reported that the LKPD allowed them to monitor student progress more effectively. Activities were observable, discussions were richer, and misconceptions were easier to detect. Moreover, the LKPD serves as a replicable model for other topics in mathematics, providing a framework for constructivist learning aligned with curriculum standards. The hands-on and exploratory nature encourages students to become independent problem-solvers, supporting lifelong learning competencies emphasized in the Independent Curriculum.

CONCLUSION

Based on the 4D Model procedures, this study successfully developed constructivism-based Student Worksheets (LKPD) for Building Surface Area for Grade VI students, addressing the gap between procedural memorization and conceptual understanding identified in classroom practice. Data from the Develop stage confirm that the LKPD meets criteria for validity, practicality, and effectiveness: it is Very Valid (3.65), aligning with Piaget's concrete operational stage and targeting high-level cognitive skills (C4–C6); Very Practical, with 81.32% student satisfaction and 92% teacher implementation; and Highly Effective, with a High-category N-Gain score of 0.7964 and a paired t-test ($p < 0.001$), indicating that most students substantially improved their conceptual understanding and were able to explain formulas from geometric nets rather than merely memorize them. For example, students successfully calculated the surface area of unfamiliar shapes by manipulating nets and reasoning systematically. While the study demonstrates strong outcomes, limitations include the small sample size and focus on a single grade and material. Future research could adapt the LKPD for other grades, topics, or contexts. Consequently, this validated and practical teaching medium is ready for dissemination as a reference for inquiry-based learning aligned with the Independent Curriculum, and can inform further innovations in mathematics education.

While this study demonstrates the efficacy of constructivism-based LKPD in improving conceptual understanding of surface area, limitations include the relatively small sample size and the focus on a single school context. Future studies could expand the scope to multiple schools, include longitudinal follow-up to assess knowledge retention, and adapt the LKPD for other geometric topics, such as volume, angles, or composite solids. Moreover, integrating digital tools or augmented reality could further enhance students' interactive exploration, providing a richer multimodal experience aligned with 21st-century learning competencies.

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