Jurnal Pijar MIPA
https://jurnalfkip.unram.ac.id/index.php/JPM

ISSN 1907-1744 (Print)
ISSN 2460-1500 (Online)

Development of an E-Worksheet Based on Problem-Based Learning to Improve Concept Understanding

Linda Yudha Az'zahra*, Aldina Eka Andriani

Elementary School Teacher Education, Faculty of Education and Psychology, Universitas Negeri Semarang, Semarang, Indonesia
*e-mail: lindayudhaazzahra@students.unnes.ac.id

Received: February 25, 2026. Accepted: March 9, 2026. Published: April 13, 2026

Abstract: Science learning in elementary schools still faces challenges in the form of low student conceptual understanding, caused by the lack of digital interactive student worksheets that can facilitate concept visualization and encourage active student involvement in the learning process. This study aimed to design, validate, and examine the effectiveness of E-Worksheet based on Problem-Based Learning to improve sixth-grade students' understanding of Earth's rotation and revolution at SDN Kalibanteng Kidul 03, Semarang City. This research employed a Research & Development (R&D) approach using the ADDIE model, comprising analysis, design, development, implementation, and evaluation. The participants were 22 sixth-grade students. Data were collected through interviews, observations, questionnaires, documentation, and pretest–posttest instruments. Data analysis included normality testing, the Wilcoxon Signed Rank Test, and the N-Gain test. The E-Worksheet was developed using Canva, delivered through the Liveworksheet platform, and integrated with Solar System Scope as a virtual laboratory to enhance visualization. E-Worksheet-based Problem-Based Learning consists of a cover page, identity, general information, learning activities, learning activities arranged in stages based on aspects of conceptual understanding and in line with PBL syntax, and developer profiles. Validation results from material and media experts reached 93%, indicating a very feasible category. The Wilcoxon Signed Rank Test showed a significant difference between pretest and posttest scores (Asymp. Sig. = 0.046 < 0.05). The N-Gain score of 0.30 indicates a moderate improvement in students' conceptual understanding. These findings demonstrate that the E-Worksheet based on Problem-Based Learning is successfully developed, feasible, and moderately effective in improving students' understanding of Earth's rotation and revolution. This study contributes a systematic worksheet that integrates PBL syntax with digital simulations and explicit conceptual understanding, serving as a model for developing interactive problem-based digital science materials and as a reference for other science subjects.

Keywords: Conceptual Understanding; Earth's Rotation and Revolution; E-Worksheet; Problem-Based Learning.

Introduction

The ideal science learning in elementary schools is one that not only emphasizes mastery of facts, but also develops students' critical, analytical, and reflective thinking skills through active involvement in the learning process [1]. Learning is carried out in an integrative manner by linking scientific and social concepts in real-life contexts. Effective science learning integrates conceptual understanding and process skills, enabling students to understand concepts while observing, analyzing, concluding, and communicating findings [2].

Modern developments demand that science and science learning continue to be developed innovatively to align with the demands of 21st-century competencies. In the Independent Curriculum, one of the competencies emphasized is information and communication technology literacy (ICT literacy) [3]. One form of technological innovation in learning is the use of digital-based student worksheets, such as Liveworksheet. The use of this technology has proven effective in improving the quality of learning in schools [4].

A worksheet in science learning functions as a learning guide that encourages active student involvement, both individually and in groups [5]. Optimizing worksheets requires teachers' pedagogical skills in applying appropriate models, such as problem solving or scientific approaches, to enhance critical thinking and conceptual understanding [6] [7]. Virtual laboratories provide practical experiences while enhancing students' science process skills [8]. The integration of technology, such as the PhET Simulation virtual laboratory and Web Olabs in E-Worksheet, facilitates the development of science process skills in an integrated manner [9] [10].

A student worksheet is a learning resource containing materials, summaries, and instructions for assignments, both theoretical and practical, designed to help students achieve basic competencies [11]. The ideal Worksheet contains several components, including a title, learning instructions, the competencies to be achieved, supporting information, steps for activities or tasks, and assessment procedures [12]. The worksheet can be adapted to technological advances, from being printed to digital or electronic (E-Worksheet).

An e-Worksheet, or electronic student worksheet, is a student worksheet in digital format that can be accessed anytime, anywhere via electronic devices connected to the internet [13]. E-Worksheet is equipped with interactive features, such as select, single-choice, checkboxes, drag &

How to Cite:
L. Y. Azzahra and A. E. Andriani, "Development of an E-Worksheet Based on Problem-Based Learning to Improve Concept Understanding", *J. Pijar.MIPA*, vol. 21, no. 2, pp. 325–335, Apr. 2026. https://doi.org/10.29303/jpm.v21i2.11683

drop, and other features, and is integrated with multimedia, providing flexible access to support a more meaningful and enjoyable learning experience [4].

Integrating Problem-Based Learning into E-Worksheets encourages students to solve problems, thereby helping them develop critical thinking skills, increasing learning independence, and improving conceptual understanding. [11] [14]. Problem-Based Learning has five syntaxes, namely, 1) orienting students to the problem, 2) organizing students to learn, 3) guiding group/individual investigations, 4) presenting results, 5) analyzing and evaluating the problem-solving process [15].

Conceptual understanding is an important aspect in the success of science learning. Bloom's Taxonomy states that conceptual understanding is the result of a thinking process that is formed through generalization and abstraction from facts, events, and experiences, and continues to develop as learning experience increases, both through reading and direct experience [16].

According to anderson and Krathwohl, conceptual understanding consists of seven aspects, namely explaining (describing concepts sequentially with logical cause-effect relationships), interpreting (changing information into another form to make it easier to understand), classifying (grouping based on similar characteristics), exemplifying (giving examples that match the concept), comparing (finding similarities and differences systematically), concluding (drawing general conclusions from patterns or relationships in information), and summarizing (representing information briefly by including the main points) [17].

Based on an interview with a teacher and observations of the learning process in class VI at SDN Kalibanteng Kidul 03, Semarang City, the researchers identified several problems in science learning. The teacher has not compiled student worksheets that meet the completeness of the components systematically and utilize technology. This finding is supported by the teacher needs questionnaire, which indicates that although worksheets are regularly used, they meet only 25% of the six essential components. In addition, teachers have not compiled problem-based student worksheets. The compiled student worksheets contain only the questions students must answer. Problem-based worksheets should present real-life scenarios that guide students through identifying problems, analyzing information, and drawing conclusions [18].

The implementation of Problem-Based Learning in science learning remains suboptimal, particularly at the first syntax, problem orientation. Questionnaire results indicate that although Problem-Based Learning has been introduced, its application is not yet systematic. A 50% disagreement rate on the contextual problem presentation indicator highlights problem orientation as a key challenge. Problem-based learning requires diverse learning resources and adequate access to information to support effective problem solving [19]. This condition highlights the need to improve planning, learning resources, and implementation to ensure the optimal application of Problem-Based Learning syntax.

Based on the cognitive diagnostic analysis, students' conceptual understanding remains relatively low. This is evidenced by the average score of sixth-grade students on the Earth's rotation and revolution material of 67. Students are not yet able to accurately explain, interpret, classify, compare, or draw conclusions about concepts. The abstract nature of the material makes it difficult for students to visualize and relate Earth’s motion to everyday phenomena. Scientific terms such as rotation, revolution, period, axis, and orbit remain unfamiliar to students. This condition highlights the need for integrated media that provide concrete visual representations. Interactive web technologies such as Solar System Scope enhance students’ interest and understanding through 3D visualization and simulation [20].

To answer these problems, an E-Worksheet based on Problem-Based Learning was developed on the Liveworksheet platform, ensuring complete components, alignment with Problem-Based Learning syntax, and integration of Solar System Scope to support visualization and enhance sixth-grade students’ understanding of Earth’s rotation and revolution. E-Worksheet was developed to promote active, independent learning through problem solving, thereby enhancing critical thinking and conceptual understanding [21].

Previous studies show that E-Workshops based on Problem-Based Learning are valid, practical, and effective, and can improve students’ critical thinking skills. Observations indicate high student engagement with the E-Worksheet based on Problem-Based Learning, and their ability to apply learned concepts. [22]. Other studies show that an interactive worksheet based on Liveworksheet significantly enhances students’ motivation and participation through engaging and accessible activities [23].

Liveworksheet is an online platform that allows teachers to convert traditional worksheets into PDF, JPG, or other document formats, turning them into interactive worksheets [24]. Available features include text box, drag-and-drop, single-choice, and link insertion, which greatly support interactive learning and make it easier for students to work on and submit assignments directly. The link insertion feature can be integrated with virtual laboratories, so that abstract material can be visualized in a more concrete and understandable way.

Previous studies have demonstrated that integrating simulations such as PhET into Liveworksheet improves students’ understanding of physics concepts [25]. However, these studies primarily focused on conceptual mastery in general physics topics rather than the development of spatial ability. This study addresses that gap by integrating Solar System Scope as a virtual laboratory within Liveworksheet to simulate Earth’s rotation and revolution through interactive 3D visualization, aiming to support students’ spatial ability and deeper conceptual understanding.

Solar System Scope is an educational website based on interactive 3D solar system modeling that displays the positions of planets, satellites, and celestial bodies in real-time. This website provides visual representations of abstract concepts such as the solar system, rotation and revolution of celestial bodies, and planetary characteristics [26]. Previous research shows that integrating Solar System Scope enhances the practicality, interactivity, and meaningfulness of learning [27]. However, this research does not explicitly align digital simulation features with a structured pedagogical worksheet or specific conceptual understanding aspects.

This study differs by systematically integrating Solar System Scope within a Problem-Based Learning delivered through Liveworksheet. The integration is not merely technological but also pedagogically structured, linking

Problem-Based Learning syntax with measurable conceptual understanding of Earth's rotation and revolution. This research offers a coherent worksheet that connects digital interactivity, pedagogical processes, and targeted conceptual outcomes in elementary science learning.

Research Methods

Type of Research

This research is a type of Research & Development (R&D) study aimed at developing a product, with its feasibility and effectiveness tested. This research model is based on the ADDIE model.

Research Procedure

This research model consists of 5 stages which include the stage analysis, design, development, implementation, and evaluation [28].

This research was conducted based on the following stages: 1) Analyze, researchers identified learning needs, characteristics of sixth grade students, and problems that occurred in science learning, especially in the material on Earth's rotation and revolution: 2) Design, researchers developed an E-Worksheet worksheet based on Problem-Based Learning from the aspects of conceptual understanding, visual appearance, language, content selection, and multimedia integration, researchers also created an In-Depth Learning Implementation Plan: 3) Development, researchers create E-Worksheet products based on Problem-Based Learning based on the previously prepared design, process product validation, and make product revisions if necessary: 4) Implementation, researchers conducted small-scale and large-scale product trials. 5) Evaluation, researchers assess the effectiveness of the product.

Research Subject

The subjects of this study were 22 students from class VI A of SDN Kalibanteng Kidul 03, Semarang City, comprising a small sample of 6 and a large sample of 16. The participants were selected using purposive sampling because the class had previously demonstrated low conceptual understanding of the targeted topic.

Research Instrument

The validity of the test instruments was examined through expert judgment. Teacher and student response questionnaires were used to assess the product's practicality. The reliability analysis using Cronbach's Alpha yielded a coefficient of 0.633, which indicates reliability. Pretest and posttest questions were used to measure students' conceptual understanding, which was operationally defined based on aspects, explaining, interpreting, classifying, exemplifying, comparing, concluding, and summarizing. The pretest and posttest included 20 multiple-choice items aligned with conceptual understanding and learning objectives. Each correct answer was scored 1 point.

Data Analysis Technique

Data analysis was used to answer the problem formulation. The data analysis in this study included design development analysis, feasibility analysis, and product effectiveness analysis using the N-Gain test.

Results and Discussion

Development of an E-Worksheet Based on Problem-Based Learning

The development of an E-Worksheet based on Problem-Based Learning has been implemented through the ADDIE model. Stages analyzes the initial stage of development that aims to identify learning needs, student characteristics, and problems that occur in learning as a basis for designing products to suit the needs in the field [29]. Based on the results of interviews with teachers and observations of the learning process in class VI at SDN Kalibanteng Kidul 03 Semarang City, it can be seen that, 1) teacher has not compiled student worksheets that meet the completeness of the components systematically and utilize technology: 2) teacher has not implemented the learning model Problem-Based Learning optimally, especially in the first syntax, namely problem orientation: 3) the average results of the cognitive diagnostic assessment class on the material of the earth's rotation and revolution are classified as low, namely 67: 4) students' understanding of the concept of the earth's rotation and revolution is still low. This is evidenced by students' low learning outcomes.

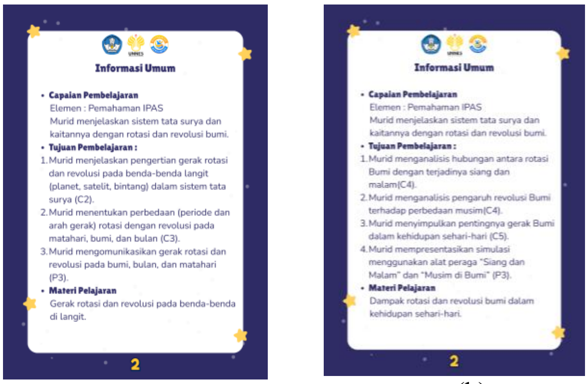
Stage design is the second stage, which aims to design a prototype Product [30]. The design begins with determining learning outcomes and learning objectives. The learning material is then organized sequentially, starting from the basic concepts of rotation and revolution to their impact on everyday life. Learning activities are structured based on aspects of conceptual understanding. In addition, learning activities are structured around syntax. Problem-Based Learning. Design using the Canva app for visual design and content creation. The completed design is then realized through the platform. Liveworksheet to integrate various interactive features. These features include various question types, such as drag & drop, select, checkboxes, and text boxes, as well as multimedia insertions, such as Solar System Scope, which allows students to explore Earth's motion simulation in a more concrete way. The following is a design for the E-Worksheet display based on Problem-Based Learning.

Figure 1 shows the cover page of the E-Worksheet based on Problem-Based Learning. Figure (a) shows the cover page for Lesson 1, while Figure (b) shows the cover page for Lesson 2. The cover page contains information, such as the title of the Learning-Based E-Worksheet. Problem-Based Learning, learning materials, supporting illustrations, class descriptions, and the curriculum used. The illustrations on the cover page provide an overview of the material students will study [31].

Figure 2 displays the general information page. This page contains learning outcomes, learning objectives, and the subject matter students will study. This page provides an initial overview of the learning direction and targets so that students understand the competencies to be achieved and the scope of the material to be studied. Clearly formulated, specific, and measurable learning objectives are the main foundation for designing effective learning plans [32].

(a) (b)

Figure 1. Cover Page



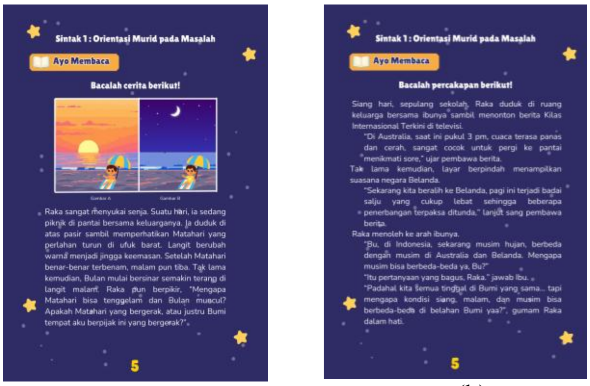
(a) (b)

Figure 2. General Information Page

(a) (b)

Figure 3. Learning Activity Instructions Page

Figure 3 displays the learning activity instructions page. Figure (a) displays activities consisting of "Let's Read," "Let's Try," "Let's Discuss," "New Vocabulary," and "Did You Know?" Meanwhile, figure (b) displays the activities "Let's Read," "Let's Try," "Let's Discuss," "Let's Make," and "New Vocabulary." This page provides clear directions to students for the learning activities to be undertaken. Learning activities are a series of activities designed and delivered by the teacher during the learning process [33].



(a) (b)

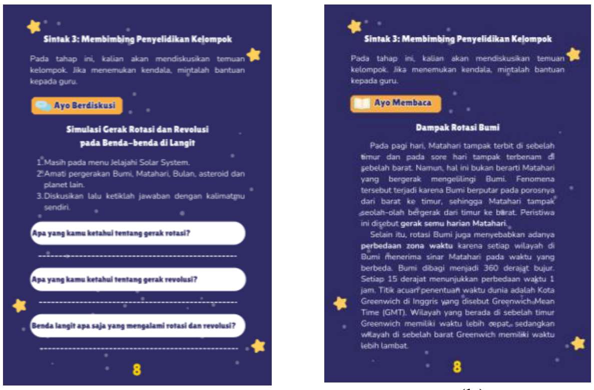
Figure 4. Syntax Learning Activity Page 1

Figure 4 shows the learning activity page in the first syntax. Problem-Based Learning, namely, the student's orientation to the problem. This syntax includes aspects of understanding the concept of explaining and interpreting. In image (a), the problem is presented through a stimulus in the form of an image, while in image (b), it is presented through a short narrative. The stimulus aims to raise the problem and encourage student curiosity as the beginning of learning activities [34]. The stimulus can be in the form of images, videos, narrative text, contextual phenomena, provocative questions, or the results of simple demonstrations related to the learning material.

(a) (b)

Figure 5. Syntax Learning Activity Page 2

Figure 5 shows the learning activity page in the second syntax. Problem-Based Learning, namely organizing students to learn. Students are grouped heterogeneously based on high, medium, and low ability levels. Heterogeneous grouping has been shown to have a significant positive impact on improving student learning outcomes and achievement motivation [35]. The second syntax includes aspects of understanding the concept of interpreting and explaining. In Figure (a), the Let's Try activity is carried out through web exploration. Solar System Scope, then continues with a discussion of the results of the observations. This activity uses the Liveworksheet feature, namely, select and text box. In picture (b), the Let’s Try activity is done by making simple props about day and night events, then continuing with a discussion using the features box on the Liveworksheet to write down the observation results.



(a) (b)

Figure 6. Syntax Learning Activity Page 3

Figure 6 shows the learning activity page in the third syntax. Problem-Based Learning, namely, guiding group investigations. Investigations can be carried out in various ways, such as reading books, conducting demonstrations, utilizing learning media, using the latest software, or utilizing concrete demonstration tools [36]. The third syntax includes aspects of conceptual understanding, namely classifying, exemplifying, comparing, concluding, and summarizing. In figure (a), the activities consist of Let's Discuss, Did You Know, Let's Read, and Let's Try by utilizing the Liveworksheet feature in the form of text boxes, checkboxes, a link to a drive, and drag & drop. In image (b), the activities include Let's Read, Let's Discuss, Let's Make, and Let's Try using the features text box, select, single choice, and link to drive. These interactive activities aim to create challenging and enjoyable learning experiences.

(a) (b)

Figure 7. Syntax Learning Activity Page 4

Figure 7 shows the learning activity page in the fourth syntax. Problem-Based Learning, namely, developing and presenting results. Image (a) contains aspects of conceptual understanding summarizing using the Liveworksheet feature. text box. Image (b) contains aspects of understanding the concept of concluding and summarising by utilising the features selected to conclude and a text box to summarize in the form of a concept map. Concept maps help students summarize information more systematically [37]. This activity aims to train students to organize their thoughts and strengthen their understanding of the concepts they have learned.

(a) (b)

Figure 8. Syntax Learning Activity Page 5

Figure 8 shows the learning activity page in the fifth syntax. Problem-Based Learning, namely analyzing and evaluating the problem-solving process. At this stage, students can access additional references through the Liveworksheet feature to enrich their knowledge. Figure (a) contains reading material about the rotation and revolution of the Earth. Figure (b) contains reading material about why planets do not collide with each other and gravity in space. This material was chosen to reinforce concepts and to broaden students' horizons. Meanwhile, the teacher plays a role in facilitating students' reflection and evaluation of the problem-solving process, thereby deepening and making understanding more meaningful [38].

Stage development is the third stage, which aims to realise the design plan into an E-Worksheet-based product. Problem-Based Learning includes materials, problem-based activities, and conceptual understanding components, and can be accessed digitally via the website Liveworksheet. The product is then validated by material and media experts to assess the feasibility of the content and design. Based on the validation results, revisions were made to improve the product, making it better prepared for implementation in learning. Preparing evaluation instruments is also carried out at this stage, with attention to validity and reliability to ensure accurate results and the achievement of learning objectives [39].

Stage Implementation is the fourth stage, which aims to implement E-Worksheet products based on Problem-Based Learning, which has been developed into the classroom learning process. The product has been validated and tested at both small and large scales to assess its practicality and effectiveness. The small-scale trial was conducted with a group of 6 students to assess the product's practicality and feasibility under limited conditions. Next, a large-scale trial was conducted on 22 students to determine the practicality and effectiveness of the product in real learning conditions. Researchers can collaborate with schools to create an ideal, conducive learning environment [40].

Stage evaluation is the fifth stage, which assesses the quality of the learning process and its outcomes, both before and after the product is used in learning activities [41]. The evaluation aims to determine the extent to which the E-Worksheet is based on Problem-Based Learning to improve students' conceptual understanding. Data obtained from expert validation, teacher and student questionnaire responses, and pretest and posttest analysis were summarized and analyzed as the basis for determining the product's final feasibility. The evaluation phase also included reflection on the product's strengths and weaknesses, leading to recommendations for improvement and further development.

Feasibility of E-Worksheet Based on Problem-Based Learning

The eligibility of the E-Worksheet based on Problem-Based Learning will be reviewed by validators, material experts, and media experts. The assessment by material experts covers four aspects: the suitability of the material for learning, the suitability of the E-Worksheet to the syntax of Problem-Based Learning, the suitability for the level of understanding of sixth-grade students, and the suitability for aspects of conceptual understanding. The assessment by media experts covers five aspects: the E-Worksheet component, E-Worksheet design, E-Worksheet content, implementation of conceptual understanding, and interactivity. The practicality of the E-Worksheet is based on Problem-Based Learning, as evidenced by the results of the teacher and student response questionnaires.

Table 1. Product Feasibility Results

Validator	Percentage	Criteria
Material	93%	Very feasible
Media	93%	Very feasible

Based on Table 4, the material feasibility achieved 93%, with the criteria very feasible, earning a score of 71 out of a maximum of 79. The material expert validator questionnaire focused on four aspects, namely: 1) the aspect of the suitability of the material with learning, 2) the suitability of the E-Worksheet with PBL syntax, 3) the aspect of suitability with the level of understanding of grade VI students, and 4) the suitability with aspects of conceptual understanding. Meanwhile, the suitability of the media obtained 93%, with the criteria very feasible, earning a score of 101 out of a maximum of 108. The media expert validator questionnaire focused on five aspects, namely: 1) E-Worksheet components, 2) E-Worksheet design, 3) E-Worksheet content, 4) implementation of conceptual understanding, and 5) interactivity. The results of the validity of the media and materials are in line with previous research, which shows that the development of the E-Worksheet based on Problem-Based Learning obtained an average score of 90.1% with very valid criteria based on aspects of appropriateness of content, language, graphics, questions, and teaching modules [42].

Table 2 Product Practicality Results

Response	Percentage	Criteria
Teacher	100%	Very practical
Student	93%	Very practical

Based on Table 5, the practicality assessment results indicate that the teacher response was 100% very practical. Meanwhile, the student response was 93% with the criteria of very practical. In line with previous research, which found that teacher and student responses to Liveworksheet-based E-Worksheet were very positive, with scores above 75% [43].

It is concluded that the E-Worksheet is based on Problem-Based Learning. It is very feasible and very practical to use to improve the conceptual understanding of the rotation and revolution of the Earth in class VI of SDN Kalibanteng Kidul 03, Semarang City. These results are supported by previous research, which shows that an interactive E-Worksheet based on Problem-Based Learning has very good validity and practicality in science learning [44].

Effectiveness of E-Worksheet Based on Problem-Based Learning

The effectiveness of the E-Worksheet based on Problem-Based Learning was analyzed by comparing pretest and posttest results on a large scale regarding conceptual understanding. Data on conceptual understanding scores were obtained from the analysis of test items compiled into categories of conceptual understanding. The scores for each aspect were then summed, and the average was calculated to provide a general overview of students' conceptual understanding before and after learning using the E-Worksheet based on Problem-Based Learning.

Table 3 Normality Test

Mark	Sig.	Information
Pretest	.699	Normally distributed
Posttest	.035	Not normally distributed

The normality test for pretest and posttest data was conducted using the One-Sample Shapiro–Wilk test to determine whether the data are normally distributed and as a prerequisite for further analysis. A Sig. A value greater than 0.05 indicates that the data are normally distributed [45]. Based on the results of the normality test, the pretest significance value was 0.699 (>0.05), indicating the data are normally distributed, while the posttest significance value was 0.035 (<0.05), indicating the data are not normally distributed. Therefore, the data do not meet the normality assumption, so hypothesis testing was carried out using the Wilcoxon Signed Rank Test.

Table 4. Wilcoxon Nonparametric Test

Wilcoxon	Posttest-Pretest	Information
Asymptotic. (2-tailed)	.046	Significant

The nonparametric Wilcoxon test is used to assess differences between pretest and posttest results in large-scale trials. The nonparametric test is used because the data are not normally distributed; the Wilcoxon test is used as an alternative to the paired-sample t-test [46]. Based on the results of the Wilcoxon non-parametric test, the Asymp. Sig. (2-tailed) value is 0.046, which is smaller than the significance level of 0.05. There is a significant difference between the pretest and posttest values. This shows that the implementation of E-Worksheet is based on Problem-Based Learning's statistically significant effect on improving students' conceptual understanding. Previous research obtained an Asymp. Sig. (2-tailed) value of 0.028 < 0.05 in the Wilcoxon test, indicating a significant difference between the pretest and posttest results. Thus, the application of the model Problem-Based Learning proved effective in improving students' conceptual understanding [47].

Table 5 N-Gain

Mark	Mean	Improvem	N-Gain	Criteria
Pretest	56	10	.300	Moderat
Posttest	66			

The level of improvement was analyzed using the N-Gain calculation to quantitatively determine the learning effectiveness. The analysis results showed an average N-Gain value of 0.30, which is in the moderate category. This category indicates that the increase in conceptual understanding was sufficiently effective, meaning that learning using the E-Worksheet based on Problem-Based Learning significantly improved student learning outcomes, although it did not yet reach the high category. Previous research has shown that the use of innovative learning media can improve elementary school students' understanding of science concepts. The results of this study showed an N-Gain value of 0.54 after treatment, indicating a significant increase in conceptual understanding [47].

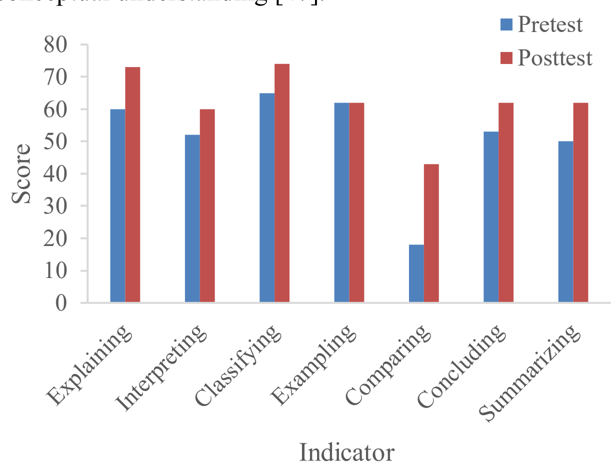


Figure 9. Bar Chart of Concept Understanding Values from Pretest and Posttest Results

Based on Figure 9, posttest scores tended to be higher than pretest scores across most aspects of conceptual understanding. This indicates an increase in students' conceptual understanding after the learning process.

The explaining aspect increased from 60 to 73, indicating that students were able to re-explain concepts in their own words logically and coherently. This improvement was influenced by the implementation of syntax 1 (problem orientation), which encouraged students to express their initial understanding, and syntax 3 (guiding individual and group investigations), which provided space for students to process and present discussion results. Group discussion activities in the model Problem-Based Learning provide students with an opportunity to exchange ideas and support one another in understanding the material [48]. In addition, Liveworksheet features such as text boxes encourage students to systematically record their thoughts, while features linked to drive integrated reading materials help students gain a deeper understanding before developing explanations. This has a positive impact on students' scientific communication skills.

The interpretation aspect increased from 52 to 60. This shows that students are beginning to transform the information they obtain into other forms, such as re-explaining the phenomena of Earth's rotation and revolution in their own language, based on image stimuli, narratives, and observation results via the web-based Solar System Scope. This improvement is influenced by the presentation of contextual problems in syntax 1 (student orientation to the problem), which helps students understand the material by relating it to everyday situations and experiences [49]. Furthermore, syntax 2 (students are organized to learn in groups through an E-Worksheet based on Problem-Based Learning makes students active in discussions and problem solving. In addition, Liveworksheet features such as text boxes and single-choice support students in interpreting images into simple explanations and selecting appropriate information based on observations.

The classifying aspect increased from 65 to 74. This improvement indicates that students can group information based on specific characteristics, such as distinguishing between events resulting from the Earth's rotation and those resulting from its revolution. This aspect is presented in syntax 3 (guiding individual and group investigations). After conducting observations on the Solar System Scope website, students group concepts. Interactive activities, such as drag and drop, Liveworksheet, support improved classification skills. These results align with Piaget's theory, which states that cognitive structures are strengthened through the process of grouping new information to make it easier to understand and organize systematically [50].

The exemplification aspect did not improve (62 to 62). This indicates that students' ability to provide concrete examples of a concept has not developed significantly. Although Liveworksheet features, such as a link to Drive, have facilitated access to reading materials and a select-and-text box, while students are given the opportunity to choose and write down answers, the exercises provided may not sufficiently require students to independently generate new examples. Furthermore, variations in questions that do not align with the reading material's context can make it difficult for students to transfer their understanding to other situations. As a result, students' ability to distinguish between examples and non-examples of the material they have learned has not developed optimally [51]. Students still rely on the information provided in the reading, rather than constructing their own understanding.

The comparison aspect experienced the most significant increase, from 18 to 43. Although the final score was not high, this jump indicates students' developing ability to identify similarities and differences between concepts. This aspect emerged in syntax 3 (guiding individual and group investigations). This was influenced by exploration activities using the web-based Solar System Scope, which allows students to visually observe the differences in Earth's rotation and revolution. Liveworksheet features, such as select and checkbox options, help students choose appropriate statements and mark similarities and differences based on the analysis results. This finding aligns with previous research, which found that using web simulations such as PhET improves the ability to compare phenomena presented in the simulations [52].

The concluding aspect increased from 53 to 62. This indicates that students are beginning to draw conclusions from observations and discussions. This aspect is highlighted in syntax 4 (developing and presenting work). Previous research has shown that students' ability to draw conclusions improves after implementing the Problem-Based Learning model [40]. Liveworksheet features, such as links to help students strengthen their understanding, then students draw conclusions in the features' text box. Previous research found that students' ability to draw conclusions increased after applying the model. Problem-Based Learning [53].

The summarizing aspect increased from 50 to 62. This increase indicates that students are starting to be able to briefly restate the core material in the form of concept maps. The summarizing aspect appears in syntax 4 (developing and presenting work results), when students create concept maps as a form of presenting the results of their understanding. The concept maps presented have embedded features.text box on Liveworksheet so students can immediately write down the main ideas or important information in the provided space. Concept maps help students organize and summarize information more systematically so that it is easier to understand and remember [37].

The research results show an increase in students' conceptual understanding in the moderate category. This indicates that the implemented learning has had a positive impact, but still requires reinforcement to achieve more optimal results. Learning that facilitates conceptual understanding needs to be systematically designed from the outset, starting with the determination of learning objectives that explicitly lead to the development of higher-order thinking skills. Learning planning should combine a comprehensive understanding of HOTS with the development of students' digital skills and collaborative skills [54].

Learning activities that consistently facilitate higher-order thinking skills, such as conceptual understanding, cannot produce instant impact. These skills develop through practice in each learning activity, including students' practice of explaining, comparing, concluding, and relating concepts to real-world situations. Learning that provides opportunities for repeated practice and reflection also helps students recall previously learned material, reducing the likelihood of forgetting and making understanding more permanent [55].

The improvement in conceptual understanding, which remains moderate, can be influenced by several factors. One of these is the heterogeneity of students' abilities and learning speeds in understanding the material. Diverse levels of understanding lead to differences in how information is received and processed. Some students can answer questions, solve problems, and find solutions quickly, while others require more time and additional guidance to achieve the same level of understanding. This difference results in uneven improvement across indicators of conceptual understanding [56].

The next factor is the suboptimal level of student activity during the activity. Some students still show limited participation in discussions, are less willing to express opinions, and tend to be passive when asked to answer questions. This condition can hinder the process of maximizing knowledge construction. Students who are actively involved in the learning process tend to have a better, deeper understanding, while passive learning often results in a shallow, less lasting understanding [57]. Low student participation is often associated with underdeveloped self-confidence, leading students to be reluctant to appear or be actively involved in learning [58].

Another factor influencing improved conceptual understanding is students' level of concentration. During the learning process, it was found that some students easily become bored, leading to suboptimal attention to the material and to problem-solving activities. This condition results in suboptimal information processing and conceptual understanding. This low conceptual understanding ability is greatly influenced by students' concentration during the learning process [59].

Conclusion

Development of an E-Worksheet based on Problem-Based Learning using a type of Research & Development (R&D) with the ADDIE model. E-Worksheet based on Problem-Based Learning designed with Canva, implemented on the Liveworksheet platform, and integrated with Solar System Scope as a virtual laboratory. E-Worksheet-based Problem-Based Learning consists of a cover page, identity, general information, learning activities, learning activities arranged in stages based on aspects of conceptual understanding and in line with PBL syntax, and developer profiles. The feasibility of the E-Worksheet based on Problem-Based Learning received a very suitable rating, with validation percentages of 93% from material experts and media experts, thus fulfilling the suitability criteria for content, language, design, and interactivity. Wilcoxon Signed Rank Test shows a significant difference between the pretest and posttest scores (Asymp. Sig. = 0.046 < 0.05), with an N-Gain value of 0.30 in the moderate category. It can be concluded that the E-Worksheet based on Problem-Based Learning was successfully developed, highly feasible, and effective in improving sixth-grade students' understanding of Earth’s rotation and revolution at SDN Kalibanteng Kidul 03, Semarang City. This study contributes theoretically by presenting a structured integration model linking Problem-Based Learning syntax, digital interactivity, and conceptual understanding, and by providing a worksheet for developing interactive science learning materials. Practically, it offers elementary science teachers a feasible and interactive tool to engage students actively, facilitate visualization of abstract concepts, and support problem-solving skills. However, the study has limitations, including a small sample size, absence of a control group, and moderate effectiveness, suggesting that conceptual understanding could be further enhanced. Future research is recommended to include experimental comparison designs, larger and more diverse samples, and longitudinal evaluation of learning outcomes to strengthen the evidence of effectiveness and refine the integration of digital teaching materials based on Problem-Based Learning.

Author’s Contribution

L.Y. Az'zahra: contributed to product development, conducted research, and wrote the research results. A.E. Andriani: contributed to drafting, monitoring, and revising the research process.

Acknowledgements

Thank you to the PGSD study program FIPP UNNES, Aldina Eka Andriani, S.Pd., M.Pd. as the supervising lecturer who has provided guidance and motivation during the research process, and SDN Kalibanteng Kidul 03 Semarang City who has facilitated the implementation of this research.

References

[1] R. H. Mubarakah, S. A. Putri, A. Wulandari, I. Ikmawati, and K. Kurniawan, "Peran Hakikat Sains dalam Pembelajaran IPA Terhadap Hasil Belajar Siswa," *Journal of Sustainable Transformation*, vol. 4, no. 01, pp. 1–10, 2025.

[2] Kepala Badan Standar, Kurikulum, dan Asesmen Pendidikan, "Keputusan Kepala Badan Standar, Kurikulum, dan Asesmen Pendidikan Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Nomor 046/H/KR/2025 tentang Capaian Pembelajaran pada Pendidikan Anak Usia Dini, Jenjang Pendidikan Dasar, dan Jenjang Pendidikan Menengah pada Kurikulum Merdeka." Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, p. 148, 2025.

[3] N. S. Putri, Hidayatullah, A. A. Audia, Vitara, and M. H. Hibatullah, "Penerapan Literasi Teknologi Informasi dan Komunikasi (ICT) dalam Pembelajaran di SDN 88 Palembang," *Advances In Education Journal* , vol. 2, no. 3, pp. 959–973, Dec. 2025.

[4] N. A. Azis, A. Aminullah, and E. Kining, "Pengembangan Bahan Ajar E – LKPD Interaktif Berbasis Website Liveworksheet untuk Meningkatkan Kemampuan Kognitif Peserta Didik Kelas V pada Mata Pelajaran IPA di UPT SDN 1 Enrekang," *Cokroaminoto Journal of Primary Education*, vol. 8, no. 1, pp. 404–420, Apr. 2025, doi: 10.30605/cjpe.8.1.2025.5600.

[5] A. Nestiadi, A. Safitri, F. Aulia, R. R. Maulidya, and N. Hasanah, "Penggunaan LKPD Untuk Menunjang Keaktifan Peserta Didik Pada Pembelajaran IPA Di SMPN 1 Ciruas.," *Gudang Jurnal Multidisiplin Ilmu*, vol. 2, no. 10, pp. 337–340, 2024.

[6] I. M. N. Fitriyah and M. A. Ghofur, "Pengembangan E-LKPD Berbasis Android dengan Model Pembelajaran Problem Based Learning (PBL) untuk Meningkatkan Berpikir Kritis," *Jurnal Ekonomi dan Pendidikan*, vol. 18, no. 2, pp. 218–229, Apr. 2022, doi: 10.21831/jep.v18i2.41224.

[7] R. H. Hanifah, N. Jumhana, and A. Saefudin, "Rancangan Lembar Kerja Peserta Didik (LKPD) Berbasis Pendekatan Saintifik untuk Meningkatkan Pemahaman Konsep IPA Kelas V di Sekolah Dasar.," *Jurnal Pendidikan Guru Sekolah Dasar*, vol. 8, no. 2, pp. 71–80, 2023.

[8] S. H. Astuti, P. Marianingsih, and R. Survani, "Pengembangan E-LKPD Berbasis Guided Discovery dengan Memanfaatkan OLabs pada Sub Materi Fotosintesis untuk Melatih Keterampilan Proses Sains Siswa," *Bioed: Jurnal Pendidikan Biologi*, vol. 13, no. 2, pp. 135–146, 2025.

[9] R. Putri and T. Ariani, "LKPD Berbantuan PhET Simulation untuk Meningkatkan Pemahaman Konsep Fisika Siswa," *ANTHOR: Education and Learning Journal*, vol. 3, no. 5, Oct. 2024, doi: 10.31004/anthor.v3i5.359.

[10] M. D. Rahayu and Y. S. Rahayu, "Pengembangan E-LKPD Berbasis Guided Discovery dengan Memanfaatkan Web OLabs untuk Meningkatkan Keterampilan Proses Sains Terintegrasi Materi Fotosintesis," *Berkala Ilmiah Pendidikan Biologi (BioEdu)*, vol. 14, no. 3, pp. 699–708, 2025.

[11] W. Saputri and R. Reinita, "Pengembangan E-LKPD Berbasis Canva dalam Pembelajaran Pendidikan Pancasila Elemen Nilai-Nilai Pancasila Kelas IV Sekolah Dasar," *Ideguru: Jurnal Karya Ilmiah Guru*, vol. 10, no. 1, pp. 333–341, Nov. 2024, doi: 10.51169/ideguru.v10i1.1494.

[12] Zhafira and M. Fadilah, "Analisis Komponen Lembar Kerja Peserta Didik (LKPD) Biologi Fase E Pada Materi Ekosistem yang digunakan di SMAN 10 Padang," *Jurnal Pengabdian Masyarakat dan Riset Pendidikan*, vol. 4, no. 2, pp. 8311–8316, 2025.

[13] A. O. Putri and S. W. Ulfa, "Pengembangan E-LKPD Berbasis Problem Based Learning (PBL) Terintegrasi Al-Quran dan Hadis Pada Materi Keanekaragaman Tumbuhan," *Bioscientist : Jurnal Ilmiah Biologi*, vol. 13, no. 2, pp. 772–781, Jun. 2025, doi: 10.33394/bioscientist.v13i2.14900.

[14] N. K. Nazira, S. Idris, W. Widya, N. Novita, and T. Setiawan, "Pengembangan LKPD Fisika Berbasis PBL untuk Meningkatkan Pemahaman Konsep Peserta Didik pada Materi Gerak Lurus," *OPTIKA: Jurnal Pendidikan Fisika*, vol. 8, no. 1, pp. 118–127, Jun. 2024, doi: 10.37478/optika.v8i1.3732.

[15] Dr. A. A. M.Pd Anisya Septiana, M. Pd, *Model Pembelajaran Berkonteks Masalah*. CV. AZKA PUSTAKA, 2024.

[16] R. Ade, A. Z. Nasichah, and A. Mas'ud, "Development of Comics Media to Improve Science Literacy and Concepts Understanding Junior High School Students In Central Halmahera Regency Through Reading Literacy Program," *Jurnal Pijar Mipa*, vol. 20, no. 1, pp. 7–15, Jan. 2025, doi: 10.29303/jpm.v20i1.8327.

[17] Y. S. Novanto, R. Anitra, and F. Wulandari, "Pengaruh Model Pembelajaran Poe Terhadap Kemampuan Pemahaman Konsep IPA Siswa SD," *Orbita: Jurnal Kajian, Inovasi dan Aplikasi Pendidikan Fisika*, vol. 7, no. 1, p. 205, May 2021, doi: 10.31764/orbita.v7i1.4665.

[18] E. F. K. Nisak and E. Susantini, "Pengembangan e-LKPD Perubahan Lingkungan Berbasis Problem Based Learning untuk Meningkatkan Kemampuan Pemecahan Masalah Peserta Didik," *Berkala Ilmiah Pendidikan Biologi (BioEdu)*, vol. 12, no. 3, pp. 683–694, 2023.

[19] K. Dentatama, H. A. Susanti, and Maryoto, "Analisis Kesulitan Penerapan Problem-Based Learning (PBL) pada Mata Pelajaran IPAS Kelas 3 di SDN 3 Randurejo," *Nawasena : Journal of Mathematics, Science and Technology Education*, vol. 1, no. 01, pp. 23–29, Mar. 2025.

[20] F. S. Widyaningtyas, F. Santoso, G. T. Wibowo, R. Susilowati, and V. Agustin, "Interactive Physics Learning Innovation Using Solar System Scope to Understand Solar System Material," *Jurnal Literasi Pendidikan Fisika (JLPF)*, vol. 6, no. 1, pp. 67–74, Apr. 2025, doi: 10.30872/jlpf.v6i1.4674.

[21] T. Apmiyanti and Y. Yerimadesi, "Validitas dan Praktikalitas E-LKPD Interaktif Berbasis Guided Discovery Learning Berbantuan Liveworksheet pada

Materi Hidrokarbon untuk Fase F SMA," *SCIENCE : Jurnal Inovasi Pendidikan Matematika dan IPA*, vol. 4, no. 4, pp. 431–438, Nov. 2024, doi: 10.51878/science.v4i4.3492.

[22] I. U. Masruroh and R. Raharjo, "Pengembangan E-LLKPD Berbasis Problem Based Learning (PBL) untuk Meningkatkan Keterampilan Berpikir Kritis Peserta Didik pada Sub Materi Zat Makanan," *Berkala Ilmiah Pendidikan Biologi (BioEdu),* vol. 13, no. 2, pp. 370–382, 2024.

[23] D. A. Dwi, M. Z. Afas, Indra Irawan, and Rifkan Haidorizal, "Pengaruh Media LKPD Interaktif Berbasis Liveworksheet Terhadap motivasi dan Hasil belajar Bahasa Inggris siswa kelas VII MTs Nurul Huda," *Titian Ilmu: Jurnal Ilmiah Multi Sciences*, vol. 16, no. 2, pp. 79–86, Jul. 2024, doi: 10.30599/jti.v16i2.3350.

[24] R. Sugiarni, D. Mulya, V. Putri, and G. Z. Shofa, "Pengembangan Lembar Kerja Peserta Didik (LKPD) Interaktif Berbasis Live Worksheet Pada Materi Eksponen," *SIGMA DIDAKTIKA: Jurnal Pendidikan Matematika*, vol. 11, no. 2, pp. 117–127, 2023.

[25] D. P. Jullyantama, L. A. Tanjung, and E. Nursulistiyo, "Meningkatkan Pemahaman Konsep Fisika Melalui Simulasi Berbasis Web di Live Worksheets," *Jurnal Praktik Baik Pembelajaran Sekolah dan Pesantren*, vol. 3, no. 01, pp. 37–46, Mar. 2024, doi: 10.56741/pbpsp.v3i01.479.

[26] A. A. Fauzi, H. A. C. Wibowo, and F. Hasyim, "Efektivitas Model Pembelajaran Inkuiri Terbimbing Berbantuan Software Solar System Scope untuk Meningkatkan Hasil Belajar Peserta Didik SMP," *Jurnal Phi Jurnal Pendidikan Fisika dan Fisika Terapan*, vol. 4, no. 2, Aug. 2023, doi: 10.22373/p-jpft.v4i2.19022.

[27] M. A. Saputra, Suratmi, and E. Susiloningsih, "Developing AI-Based Teaching Materials with Solar System Scope for Elementary Education," *IJE : Interdisciplinary Journal of Education*, vol. 3, no. 2, pp. 100–112, Jul. 2024, doi: 10.61277/ije.v3i2.209.

[28] Yudi Hari Rayanto and Sugianti, *Penelitian Pengembangan Model Addie Dan R2D2: Teori & Praktek*. Lembaga Academic & Research Institute.

[29] T. Siregar and Y. Rhamayanti, "Implementasi pengembangan model ADDIE pada dunia pendidikan. Jurnal Hasil Penelitian dan Pengembangan," *JHPP*, vol. 3, no. 2, pp. 85–100, 2025.

[30] A. Rachma, Tuti Iriani, and S. S. Handoyo, "Penerapan Model ADDIE Dalam Pengembangan Media Pembelajaran Berbasis Video Simulasi Mengajar Keterampilan Memberikan Reinforcement," *Jurnal Pendidikan West Science*, vol. 1, no. 08, pp. 506–516, Aug. 2023, doi: 10.58812/jpdws.v1i08.554.

[31] O. Y. T. Mago, A. Yati, and Y. N. Bunga, "Pengembangan Lembar Kerja Peserta Didik (LKPD) Berbasis Discovery Learning pada Materi Sistem Pernapasan Manusia Kelas VII SMP," *JURNAL PENDIDIKAN MIPA*, vol. 12, no. 2, pp. 233–240, Jun. 2022, doi: 10.37630/jpm.v12i2.575.

[32] M. Albina and K. B. Pratama, "Peran Tujuan Pembelajaran dalam Perencanaan Pembelajaran : Dasar untuk Pembelajaran yang Efektif," *Harmoni Pendidikan : Jurnal Ilmu Pendidikan*, vol. 2, no. 2, pp. 55–61, Jan. 2025, doi: 10.62383/hardik.v2i2.1233.

[33] E. Suryani and Z. R. Rini, "Pengembangan E-LKPD Berbasis SETS Untuk Meningkatkan Aktivitas Belajar Siswa Sekolah Dasar," *Scholaria: Jurnal Pendidikan dan Kebudayaan*, no. 2, pp. 158–167, May 2023, doi: 10.24246/j.js.2023.v13.i2.p158-167.

[34] E. Adnadiwantari, L. I. Saktiari, and N. Kristiono, "Upaya Meningkatkan Rasa Ingin Tahu Peserta Didik Melalui Strategi Inquiring Minds Want to Know Pada Kelas VII B Mata Pelajaran IPS SMP Negeri 14 Semarang," *Prosiding Webinar Penguatan Calon Guru Profesional*, pp. 621–626, 2024.

[35] N. Zaen, S. H. Wijoyo, and U. Hariyanti, "Perbandingan Pembentukan Kelompok Heterogen dengan Kelompok Homogen Dalam Model Problem Based Learning Terhadap Hasil Belajar dan Motivasi Berprestasi Siswa di SMAN 3 Malang," *Jurnal Pengembangan Teknologi Informasi Dan Ilmu Komputer*, vol. 9, no. 4, 2025.

[36] Darmadi, B. Budiono, and N. Nartini, "Analisis Penerapan Model Pembelajaran Berbasis Masalah (PBL) di Sekolah," *MARAS: Jurnal Penelitian Multidisiplin*, vol. 2, no. 1, pp. 130–137, Jan. 2024, doi: 10.60126/maras.v2i1.148.

[37] S. Asmah, "Efektivitas Penggunaan Peta Konsep Terhadap Hasil Belajar Siswa Kelas VII SMP Negeri 2 Ponre Kecamatan Ponre Kabupaten Bone.," *Jurnal Ilmiah Mandala Education*, vol. 7, no. 3, Aug. 2021, doi: 10.36312/jime.v7i3.2306.

[38] I N. B. Pramartha and N. P. Y. Parwati, "Analisis Penerapan Sintaks Model Pembelajaran Problem Based Learning Pada Mata Pelajaran Sejarah Materi Kelas XI Proklamasi Kemerdekaan Indonesia," *Nirwasita: Jurnal Pendidikan Sejarah dan Ilmu Sosial*, vol. 6, no. 1, pp. 69–74, Mar. 2025, doi: 10.59672/nirwasita.v6i1.4596.

[39] I. W. Widiana, I. K. Gading, I. M. Tegeh, and P. A. Antara, *Validasi Penyusunan Instrumen Penelitian Pendidikan*. PT. RajaGrafindo Persada - Rajawali Pers, 2023.

[40] Sugiyono, *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta, 2023.

[41] Y. H. Rayanto, *Penelitian pengembangan model addie dan r2d2: teori & praktek.* . Lembaga Academic & Research Institute, 2020.

[42] F. Kharisna, N. Wulandari, and Y. Darniyanti, "Pengembangan E-LKPD Berbasis Model Problem Based Learning Pada Mata Pelajaran IPAS Kelas V Di SDN 08 Timpeh.," *Didaktik: Jurnal Ilmiah PGSD STKIP Subang*, vol. 11, no. 2, pp. 252–260, 2025.

[43] N. R. T. Ghaisani and N. Setyasto, "Development of Liveworksheets-Based Electronic Student Worksheets (E-LKPD) to Improve Science Learning Outcomes," *Jurnal Penelitian Pendidikan IPA*, vol. 9, no. 8, pp. 6147–6156, Aug. 2023, doi: 10.29303/jppipa.v9i8.4571.

[44] D. I. Novianti, I. G. Astawan, and G. A. P. Sukma Trisna, "Pengembangan E-LKPD Interaktif Berbasis Problem Based Learning Materi Gaya Muatan IPA pada Siswa Kelas IV SD," *Didaktik : Jurnal Ilmiah PGSD STKIP Subang*, vol. 9, no. 2, pp. 5398–5411, Jul. 2023, doi: 10.36989/didaktik.v9i2.1099.

[45] S. N. Cholifah and D. Novita, "Pengembangan E-LKPD Guided Inquiry-Liveworksheet untuk

Meningkatkan Literasi Sains pada Submateri Faktor Laju Reaksi," *Chemistry Education Practice*, vol. 5, no. 1, pp. 23–34, May 2022, doi: 10.29303/cep.v5i1.3280.

[46] N. Putri, R. S. Putri, C. W. Fauziah, D. O. Nusantari, and I. Zurkarnain, "Analisis Komparatif Berbasis Statistik untuk Mengevaluasi Penerapan Metode Pembelajaran Ditinjau dari Hasil Belajar Siswa," *Himpunan: Jurnal Ilmiah Mahasiswa Pendidikan Matematika*, vol. 5, no. 2, pp. 195–202, 2025.

[47] N. Maulidah and F. Wulandari, "Literature Study: Improving Understanding of Science Concepts Using Science Comics for Elementary School Students," *Jurnal Penelitian Pendidikan IPA*, vol. 7, no. 1, pp. 80–86, Jan. 2021, doi: 10.29303/jppipa.v7i1.509.

[48] S. E. Apriyanti, A. Mariono, A. Kristanto, and K. Khotimah, "Analisis Kebutuhan Pengembangan Model Problem Base Learning (PBL) Berbasis Kontekstual untuk Meningkatkan Kemampuan Siswa dalam Menganalisis Konsep," *Jurnal Studi Guru dan Pembelajaran*, vol. 7, no. 3, pp. 1409–1420, Dec. 2024, doi: 10.30605/jsgp.7.3.2024.4998.

[49] N. Aprilia, E. T. Wahyuni, and L. Listyowati, "Optimalisasi Model Problem-Based Learning (PBL) Berbasis Kontekstual untuk Meningkatkan Pemahaman Konsep Siswa," *Journal of Lesson Study in Teacher Education*, vol. 3, no. 2, pp. 63–71, Jan. 2025, doi: 10.51402/jlste.v3i2.146.

[50] Handriadi *et al.*, *Konsep Dasar Teori Belajar*. Jombang: Aksara Sastra, 2025.

[51] T. N. A. Azizah, S. Arifin, and I. Puspitasari, "Penerapan Media Pembelajaran Wordwall dalam Menunjang Pemahaman Konsep Siswa," *JIIP - Jurnal Ilmiah Ilmu Pendidikan*, vol. 6, no. 5, pp. 3168–3175, May 2023, doi: 10.54371/jiip.v6i5.1655.

[52] A. Munif, "Penggunaan media PhET untuk meningkatkan kemampuan berpikir kritis dan literasi sains siswa pada materi energi dan perubahannya," *Jurnal Pendidikan dan Konseling*, vol. 4, no. 2, pp. 17–25, 2022, doi: 10.31004/jpdk.v4i2.3815.

[53] Ibefati Zai, Novelina Andriani Zega, Hardikupatu Gulo, and Agnes Renostini Harefa, "Pengaruh Model Pembelajaran Problem Based Learning (PBL) Terhadap Kemampuan Pemahaman Konsep IPA di SMP," *Emasains : Jurnal Edukasi Matematika dan Sains*, vol. 14, no. 2, pp. 39–54, Sep. 2025, doi: 10.59672/emasains.v14i2.5353.

[54] A. Riswanto, *Higher Order Thinking Skills (Hots): Fondasi Kepemimpinan di Era Digital*. PT. Sonpedia Publishing Indonesia., 2025.

[55] M. Anggara and A. Samsudin, "Application of Project Based Learning Models to Know The Description of Understanding Concepts of Summary in Class 1 Elementary School Students: project based learning model, understanding the concept of addition, 1st grade elementary school students," *Sebelas April Elementary Education*, vol. 2, no. 1, pp. 62–71, Feb. 2023.

[56] B. Cahyanto, N. Luthfiyah Srihayuningsih, **S.** Aulia Nikmah, and A. Habsia, "Implementasi Model Pembelajaran Problem Based Learning (PBL) Berbantuan LKPD untuk Meningkatkan Literasi Sains Siswa," *Ibriez Jurnal Kependidikan Dasar Islam Berbasis Sains*, vol. 9, no. 2, pp. 263–278, Dec. 2024, doi: 10.21154/ibriez.v9i2.664.

[57] A. M. Amin *et al.*, "The efficacy of Pj4CS (integrated project-based and 4C-scaffolding) on higher-order thinking skills," *JPBI (Jurnal Pendidikan Biologi Indonesia)*, vol. 11, no. 1, pp. 1–9, Mar. 2025, doi: 10.22219/jpbi.v11i1.37574.

[58] Y. Nuraeni, N. Qanitah, L. E. Nawafil, W. A. K. Nurulfadhil, and M. Luthfi, "Implementasi Problem Based Learning di Sekolah Dasar : Tantangan dan Strategi Mengatasi Siswa Pasif dalam Pembelajaran," *Jurnal Pendidikan Sosial dan Humaniora*, vol. 4, no. 3, pp. 6130–6139, Jul. 2025.

[59] K. Cahani, K. N. S. Effendi, and D. R. Munandar, "Kemampuan pemahaman konsep matematika siswa ditinjau dari konsentrasi belajar pada materi statistika dasar," *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, vol. 4, no. 1, pp. 215–224, 2021, doi: 10.22460/jpmi.v4i1.215-224.