

Development of Problem-Based Learning-Based Digital Teaching Materials on Biodiversity

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ABSTRACT

This study was motivated by the fact that teachers have not been fully effective in developing technology-based teaching materials and have not incorporated audiovisual aids into their biodiversity lessons, resulting in low learning outcomes. This study aims to describe the development design and test the feasibility and effectiveness of PBL-based e-learning materials to improve learning outcomes in flora and fauna biodiversity among fifth-grade students at SDN Ngaliyan 05. This study employs an R&D approach using the ADDIE model (Analysis, Design, Development, Implementation, & Evaluation). The research subjects consisted of 27 fifth-grade students. Data collection techniques included non-test methods (observation, interviews, questionnaires, and documentation) and test methods (pre-test and post-test). Data analysis techniques utilized normality tests, t-tests, and N-Gain tests. This study used Canva and Heyzine to design an integrated PBL-based e-learning material starting with a video stimulus. The feasibility of the e-learning material was demonstrated by a media validation result of 93.75% and a content validation result of 90%, supported by the analysis of teacher and student responses, which categorized it as highly feasible. The effectiveness of the PBL-based e-learning materials was demonstrated by a 30% increase in pre-test and post-test scores; the t-test showed a significance level of 0.000, and the N-Gain was 0.5218, falling into the moderate category. The conclusion of this study is that PBL-based e-learning materials on the subject of flora and fauna biodiversity have been successfully developed, are highly suitable, and are effective in improving the learning outcomes of fifth-grade students at SDN Ngaliyan 05 in Semarang City.

Keywords: Digital Learning Materials; Problem-Based Learning; Learning Outcomes

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INTRODUCTION

Education plays a vital role in shaping the quality of human resources through the development of knowledge, skills, attitudes, and values, thereby driving a nation's progress in various aspects of life—social, economic, and cultural. Education is one of the main pillars in shaping social change (Marnawati et al., 2023). This is in accordance with Government Regulation No. 4 of 2022 (Peraturan Pemerintah, 2022) according to the Indonesian National Education Standards, education is a conscious and planned effort to create a learning environment and learning process that enables students to actively develop their potential so that they may possess religious and spiritual strength, self-control, a well-rounded personality, intelligence, noble character, and the skills required by themselves, society, the nation, and the state.

IPAS learning consists of two main elements: IPAS comprehension (science and social studies) and process skills (Kementerian Pendidikan, Kebudayaan, 2024). Understanding of IPAS encompasses an understanding of concepts, facts, principles, theories, and models. The goal of IPAS understanding is to explain and predict phenomena and apply concepts in new situations. Process skills include the scientific method of inquiry, namely observing, questioning, planning an investigation, processing and analyzing data, evaluating, reflecting, and communicating results. Process skills aim to develop critical, creative, and collaborative thinking skills in problem-solving. Science education involves several aspects: products, processes, attitudes, and technology. These four elements constitute the complete characteristics of Natural Sciences (IPA), which are, in fact, inseparable from one another (Arief, 2021).

The Natural and Social Sciences (IPAS) subject covers a variety of concepts and learning objects, some of which are difficult to present directly in the learning process. This situation is evident in the material on the characteristics of terrestrial and aquatic reptiles and mammals for fifth-grade students in Phase C of elementary

school, which requires learning representations so that the concepts being studied can be fully understood. The presence of teaching materials in learning activities allows teachers to act more as facilitators for students rather than mere conveyors of subject matter (Magdalena et al., 2020). The right teaching materials not only help students understand the subject matter more easily, but also boost their overall motivation to learn (Nurnaningsih et al., 2023). Instructional materials assist students in the learning process and serve as a medium that supports teachers in delivering content. One such example is technology-based instructional materials that integrate various media, known as Problem-Based Learning (PBL)-based E-Learning Materials.

Teachers have a role and responsibility in developing strategies for learning activities. They need to employ a variety of appropriate teaching methods or models to apply to the discussion of a subject. According to Azizah dalam (Siregar & Rhamayanti, 2025) A learning model is a pattern of interaction between students and teachers in the classroom that involves the approaches, strategies, methods, and techniques applied in the teaching and learning process. Problem-Based Learning is a contextual, problem-based learning model designed to encourage students to think critically, work collaboratively, and discover solutions through independent and collaborative inquiry (Isna Hany Nizam Kholilah et al., 2025). The strategies used in problem-based learning include orienting students toward problems, organizing students for learning, guiding individual and group investigations, developing and presenting work, and analyzing and evaluating the problem-solving process (Nilam et al., 2023). The digital learning materials on each slide include PBL content accompanied by video stimuli and questions.

Based on preliminary research data obtained through observations, interviews, questionnaires, and documentation conducted at SD Negeri Ngaliyan 05 in Semarang, several issues were identified in the science learning process in fifth grade. The first issue is that teachers have not been fully effective in developing technology-based teaching materials, as these materials are not yet systematically organized and do not incorporate audiovisual elements. The teaching materials do not yet incorporate audiovisual elements; this is because there are no instructional videos, which causes students to become bored and drowsy during lessons. The second issue is that teaching materials still rely heavily on the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) textbook, as the content and images are solely sourced from that book. The third problem is that learning outcomes on biodiversity are low because students have difficulty classifying reptiles, mammals, and aquatic animals. Student engagement is also influenced by the use of teaching materials. The function of teaching materials is to serve as a guide in the learning process and as a tool for evaluating learning outcomes (Magdalena et al., 2020).

Teachers have not yet fully implemented the Problem-Based Learning model in Syntax 1, 2, and 3. The stimuli provided in Syntax 1 have not been varied, as teachers have relied solely on questions and images. In line with the research (Maraqonitatillah & Ixfina, 2024) variety in stimuli is essential for fostering enthusiasm and motivation to succeed in the learning process. Variety is necessary in learning activities so that students do not become bored with the learning process (Oktafiani et al., 2020). In the second scenario, the teacher divided the students into several groups but did not do so based on their level of understanding; this is evidenced by the fact that the teacher divided the groups solely based on whether students were seated in the front or back rows. In the third syntax, students worked on the worksheets in groups while the teacher provided guidance; however, some students were unfocused because they were joking around with friends while working on the worksheets. In syntax 4, students developed and presented their work, and in syntax 5, they analyzed and evaluated the problem-solving process.

Based on the above analysis, this learning process requires the development of technology-based instructional materials to make abstract science concepts more concrete. Technology enables more interactive learning, in which students can participate directly in understanding the concepts being taught (Sarianti et al., 2026). Therefore, there is a need for technology-based teaching materials that are appropriate for the learning process and can present the material in a way that is easy to understand. Such teaching materials can help students take their first steps toward improving their learning outcomes (Zulfi Idayanti & Muh. Asharif Suleman, 2024). When students are interested in the learning materials, it can motivate them to engage in independent learning outside of the school setting. Technology-based learning materials that meet these criteria include e-learning materials based on Problem-Based Learning.

The study supporting this research (Lutfiani & Andriani, 2025) "Development of Interactive E-Books Based on Problem-Based Learning on the Material of the Earth's Surface Layers" concludes that interactive e-

books based on problem-based learning have been successfully developed, are highly feasible, and are effective in improving the science learning outcomes of fifth-grade students. The effectiveness of the e-book is demonstrated by a 15.25 point increase in pretest and posttest scores, supported by a t-test result of 0.001 and an N-Gain score of 0.50, which falls into the moderate category. The novelty of this study lies in the development of an interactive e-book that integrates the PBL model and includes educational games to facilitate conceptual understanding. A limitation of this study is that it focused more on validating and assessing the feasibility of the product rather than testing its effectiveness; consequently, the generalizability of the research findings remains limited.

The novelty of this study lies in the development of e-learning materials that integrate the Problem-Based Learning (PBL) approach, which includes stimuli. Before beginning the lesson, a stimulus is always presented to facilitate higher-order understanding. The audiovisual stimulus, in the form of a video, is accompanied by prompt questions that serve as a bridge between new material and prior knowledge. Stimuli play a crucial role in learning because they can spark students' interest, engagement, and understanding of the material being taught. (Maraqonitatillah & Ixfina, 2024). In addition, there is a WordWall quiz that serves as a review at the end of the lesson. Evaluation results are displayed in real time, allowing teachers to immediately identify students or groups who need additional learning support (Aisyah & Syafe, 2026).

Based on the background described above, the researcher will conduct a development study titled "Development of Problem-Based Learning-Based E-Learning Materials to Improve Student Learning Outcomes in the Subject of Flora and Fauna Biodiversity for Fifth-Grade Students at SDN Ngaliyan 05 in Semarang City."

METODE

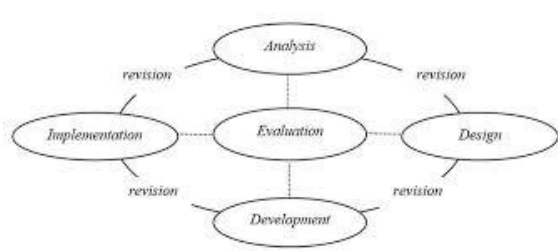


Figure 1. Langkah-langkah R&D Model ADDIE (Sugiyono, 2023)

Figure 1 shows the R&D stages of the ADDIE model developed by Sugiyono. According to (Sugiyono, 2023), The ADDIE development model stands for Analysis, Design, Development, Implementation, and Evaluation. The Analysis phase involves analyzing the environmental context. Design is the process of planning the product to be developed. Development involves testing the product being developed. Implementation is the process of deploying or using the developed product. Evaluation involves assessing the product through analysis and testing.

This development research was conducted during the even semester of the 2025/2026 academic year. The research subjects were 27 fifth-grade students at SDN Ngaliyan 05 in Semarang City; 6 students were selected for the experimental group based on cognitive ability categories (high, moderate, low) in a small group, while 21 students were in the control group. Subject selection was conducted using purposive sampling, a technique for determining a sample based on specific considerations relevant to the research objectives. Data collection was carried out through non-test methods including observation, interviews, questionnaires, and documentation as well as tests, namely pre-tests and post-tests. Data analysis techniques included a normality test to determine whether the data were normally distributed, a t-test to test hypotheses and determine whether there were significant differences between the pretest and posttest scores, and an N-Gain test to measure learning effectiveness by comparing score increases between the pretest and posttest.

RESULTS AND DISCUSSION

Development of Problem-Based Learning-Based E-Learning Materials

The first stage is the analysis stage. The analysis stage includes the students' circumstances, challenges, and learning needs (Maziyah & Zumrotun, 2025). The analysis was conducted to identify the gap between the ideal

conditions and the actual conditions on the ground (Nilam et al., 2023). Based on interviews with teachers and observations of the learning process in Grade 5 at SDN Ngaliyan 05 in Semarang, it can be seen that 1) teachers have not been fully effective in developing technology-based teaching materials because they have not utilized audiovisual aids, 2) teachers have not been fully effective in applying the Problem-Based Learning model in phases 1, 2, and 3, 3) the average results of the class's cognitive diagnostic assessment on the characteristics of terrestrial and aquatic reptiles and mammals were classified as low, at 62, 4) students' understanding of the concepts regarding the characteristics of terrestrial and aquatic reptiles and mammals remains low. This is evidenced by the low results of the cognitive diagnostic assessment.

SDN Ngaliyan 05 possesses various resources that support the learning process, particularly through the availability of fairly comprehensive facilities. The school has projectors or LCD screens in every classroom that can be used during lessons, enabling teachers to present material in a visual and audiovisual manner, making it more engaging. Additionally, the school is equipped with a reliable internet connection and a sound system. Teachers can utilize technology-based teaching materials, one of which is E-Learning Materials. E-Learning Materials are a type of module containing text, images, graphics, animations, and videos that can be accessed anytime and anywhere (Lastri, 2023). Digital learning materials can be accessed anytime and anywhere as long as there is an internet connection or they have been downloaded (Saleh et al., 2021). Digital learning materials often include multimedia elements such as videos, audio, animations, and interactive quizzes that can help clarify concepts (Putri Fitriasisari et al., 2021). According to Lastri, (2023), User-friendly means that the digital learning materials should be user-friendly and accessible to users. One aspect of being user-friendly is that they include instructions for use; in other words, they contain user guides and activity instructions so that students can use them independently without needing to be supervised by a teacher or parent.

The second stage is design; this stage involves creating a blueprint for the product to be developed, complete with product specifications. During this stage, the researcher designs a prototype of the product to be created (Rachma et al., 2023). At this stage, Problem-Based Learning (PBL)-based digital teaching materials are designed by first creating a framework (prototype) and then making them as engaging as possible. The development of technology-based teaching materials requires a design approach that takes into account students' needs and characteristics, as well as diverse learning contexts (Anwar et al., 2024). The results of the questionnaire on the needs of teachers and students were analyzed and used as a reference in the development of e-learning materials based on Problem-Based Learning. The results of the needs analysis also served as the basis for determining the content, features, and presentation of the e-learning materials, ensuring that the developed materials are more contextual and easier for students to understand (Amelia et al., 2024). The digital teaching materials were designed using the Canva app and include WordWall quizzes.

The design of Problem-Based Learning (PBL)-based e-learning materials on the characteristics of terrestrial and aquatic reptiles and mammals consists of 1) the main page/cover, 2) a preface, 3) a table of contents, 4) instructions for use, 5) activity guidelines, 6) learning outcomes, 7) a concept map, 8) scenario 1, 9) Syntax 2, 10) Syntax 3, 11) Syntax 4, 12) Syntax 5, 13) Quiz, 14) Conclusion, 15) Reflection, 16) Evaluation Questions, 17) Answer Key, 18) Glossary, 19) Bibliography, 20) Developer Profile, and 21) End Page. Problem-Based Learning (PBL)-based e-learning materials facilitate students in improving their learning outcomes through the provision of content, instructional videos, and quizzes, which serve as tools for students to deepen their understanding of the characteristics of terrestrial and aquatic reptiles and mammals (Nathasya, 2024).

The next stage is the development stage, during which the Problem-Based Learning (PBL)-based digital learning materials are realized in their final form through the development process. The materials are validated by a team of validators consisting of media experts and subject matter experts. Expert validation sheets are used to assess the suitability of the developed media, both in terms of content and presentation. The purpose of validation is to measure the level of suitability and success of the product. The purpose of the content expert validation process is to measure and assess the degree of validity of the developed content, specifically the characteristics of terrestrial and aquatic reptiles and mammals (Dewi et al., 2021). Media validation aims to assess the suitability of the developed media before it is used in subsequent development stages. A feedback questionnaire is used to determine the practicality of using e-learning materials in the classroom based on feedback from teachers and students (Amellia et al., 2026). Next, a questionnaire was distributed to teachers and students regarding the development product that had been tested in fifth grade; the purpose of this questionnaire

was to compare whether the results of the content and media validation aligned with the teachers' and students' feedback on the development product that had been designed and tested in the classroom.



Figure 2. Syntax 1 and 2: Problem Based Learning

Figure 2 shows Problem-Based Learning-based e-learning materials for Syntax 1 and 2. Syntax 1 contains videos and questions designed to provide an initial stimulus for students. The stimulus is provided by the teacher, while the students' responses can be observed and measured. This initial stimulus is provided to elicit an initial response from students before they begin learning (Anjarsari, P., & Fatmawati, 2020). In Sequence 1 of Lesson 1, a video and questions about the characteristics of terrestrial and aquatic reptiles were presented. In Sequence 1 of Lesson 2, a video and questions about the characteristics of terrestrial and aquatic mammals were presented. After the stimulus was provided, in Sequence 2, the students were divided into 5 groups, each consisting of 4–5 students. The researcher distributed the worksheets to the students, and the students listened to the instructions. In Phase 2 of Lesson 1, students worked on the worksheet on the characteristics of terrestrial and aquatic reptiles, and then in Lesson 2, they worked on the worksheet on the characteristics of terrestrial and aquatic reptiles. At this stage, the teacher explained that students should complete the worksheets in their respective groups. Students were then able to discuss the material according to their individual abilities (Yuliastanti et al., 2024).



Figure 3. Syntax 3, 4 and 5: Problem Based Learning

Figure 3 shows the Problem-Based Learning-based e-learning materials for Syntaxes 3, 4, and 5. In Syntax 3, students complete worksheets, and the researcher guides individual and group activities. The content for Syntax 3 is as follows: in Syntax 3, Lesson 1 covers the characteristics of terrestrial and aquatic reptiles, while Syntax 3, Lesson 2 covers the characteristics of terrestrial and aquatic mammals. During this process, students have already demonstrated their active participation (Yuliastanti et al., 2024). In Session 4, students work with their groups to present their work on the LKM to receive feedback from their teacher and classmates (communicating), and students collaborate with other groups to offer opinions, input, and suggestions regarding the presentations given (Yuliastanti et al., 2024).

Using this presentation is expected to better motivate and encourage students to participate, as it creates a sense of obligation that arises naturally namely, the fear of feeling embarrassed in front of other students if

they are unable to present the material, or the student will be compelled to improve their knowledge and ability to address questions posed by other students (Noor, 2021). In Session 5, the worksheets were discussed collectively as a form of feedback, and students received reinforcement regarding the worksheets. A quiz was then administered using WordWall as an assessment tool. The use of WordWall can foster students' creativity because it allows them to learn while playing with their peers, either individually or in groups. Students' creativity is engaged as they work through the games presented on WordWall, which were previously designed by the teacher (Nafian et al., 2024). In Lesson 5, Lessons 1 and 2 are presented in the form of multiple-choice questions related to the characteristics of terrestrial and aquatic reptiles and mammals.

The next step is implementation, which involves piloting the learning materials in a school setting. The pilot test was conducted with a small group of students to gain insight into user response, engagement levels, and the appeal of the developed learning materials (Rembet et al., 2026). The test items, which had been deemed suitable by subject matter experts and media experts, were then tested by students. The experiment was conducted on students one grade level higher than the research subjects. The researcher conducted a pilot test in the sixth-grade class at Ngaliyan 05 Public Elementary School, which had 29 students, by administering 40 test questions that would later be evaluated to ensure validity through validity testing, reliability testing, and tests of item difficulty and discriminative power (Eka et al., 2022). Of the 40 questions tested in sixth grade, 28 were found to be valid and reliable, with difficulty levels ranging from easy to moderate to difficult. Of the 28 valid questions, 20 were selected to be used as pre-test and post-test questions to measure student learning outcomes. The discriminative power of the questions was classified as excellent, good, adequate, and poor.

The next stage is evaluation; the purpose of this stage is to determine the extent to which the e-learning materials, based on Problem-Based Learning, enhance students' conceptual understanding. In this stage, it can be determined whether the developed materials are effective for use in the learning process (Saputra et al., 2026). In this evaluation, the researcher conducted a normality test, a t-test, and an N-Gain test. Before using non-parametric statistics, a normality test was conducted to determine whether the data were normally distributed; a t-test was used to test the hypothesis and determine whether there was a significant difference between the pretest and posttest scores; and an N-Gain test was used to measure learning effectiveness by comparing the increase in scores between the pretest and posttest. Learning outcomes improved due to the contribution of Problem-Based Learning (PBL) strategies incorporated into the digital instructional materials. The increase in posttest scores was attributed to Strategy 1, which involved providing stimuli in the form of videos and prompt questions. Audiovisual media plays a role in enhancing students' concentration during learning. This is because audiovisual media stimulates two senses sight and hearing and stimulating more senses significantly enhances children's concentration during learning (Estiana et al., 2023).

Feasibility of E-Learning Materials Based on Problem-Based Learning

The feasibility assessment of the research findings indicates that the Problem-Based Learning (PBL)-based digital teaching materials for the IPAS subject are based on the topic "Characteristics of Terrestrial and Aquatic Reptiles and Mammals," as determined through a media and content expert validation questionnaire.

Table 1. Results of Material Validation Test and Media Experts

Validation	Presentage	Criteria
Media Experts	93,75%	Highly Feasible
Material Experts	90%	Highly Feasible

Based on Table 1, the validation results show that the product received a "highly satisfactory" rating from both validators. The feasibility study was conducted by distributing validation questionnaires to subject matter experts and media experts (Eriska et al., 2022). The media validation results by experts scored 93.75%, meeting the "highly suitable" criterion. The assessment of media suitability used a research questionnaire based on three aspects: (1) visual design, (2) audiovisual elements, and (3) ease of use. The media validation score indicates that the design of the Problem-Based Learning (PBL)-based e-learning materials is excellent in terms of visual presentation, audiovisual elements, and ease of use. The media validators provided several suggestions: moving the developer's profile section on the title page/cover to the bottom, enlarging the images, and adding a synopsis of the e-learning materials to the final page. A key strength of this e-learning material is that the stimuli help students understand the material, with a score of 4. Therefore, teachers must employ creative and innovative

stimuli when designing learning strategies that effectively cater to all student learning styles—visual, auditory, and psychomotor (Sipayung & Sihotang, 2022).

The results of the expert validation of the material scored 90%, meeting the criteria for “highly suitable.” The assessment of the material’s suitability used a research questionnaire based on four aspects, including: (1) material relevance, (2) content and subject matter, (3) material usefulness, and (4) practicality of use. There were several suggestions to add learning objectives, namely not only to watch the video but also to listen to the material and to include material on the homologous skeletal structures of terrestrial, aquatic, and aerial mammals. The material has also been adapted to the cognitive level of elementary school students, making it easy to understand (Sari & Andriani, 2026).

Tabel 2. Result of Teacher and Student Responses

Response	Presentage	Criteria
Teacher	95%	Highly Feasible
Students	93,60%	Highly Feasible

Based on Table 2, the results of the teacher feedback questionnaire, with a percentage score of 95%, met the “highly suitable” criterion, and the student feedback questionnaire, with a percentage score of 93.60%, also met the “highly suitable” criterion. The assessment of the teacher response questionnaire’s suitability used three aspects, including: (1) alignment with learning materials; (2) alignment with PBL syntax; (3) presentation. The results of the teacher feedback indicate that the Problem-Based Learning (PBL)-based E-Learning Materials are suitable and aligned with classroom learning needs. The assessment of the student feedback questionnaire’s suitability used three aspects, including: (1) alignment with learning materials; (2) alignment with PBL syntax; (3) presentation. The results of the student feedback indicate that the Problem-Based Learning (PBL)-based E-Learning Materials capture students’ attention, the language used is easy to understand, facilitate students’ learning of the characteristics of terrestrial and aquatic reptiles and mammals, and encourage students to be motivated in their learning (Hotimah, 2020).

Thus, it can be concluded that the Problem-Based Learning-based digital teaching materials are suitable for use in IPAS lessons on the characteristics of terrestrial and aquatic reptiles and mammals for fifth grade students at SDN Ngaliyan 05 in Semarang.

The Effectiveness of Problem-Based Learning-Based E-Learning Materials

The effectiveness of problem-based learning e-learning materials was tested using a normality test, a t-test for dependent samples (paired samples), and an N-Gain test on the pre-test and post-test administered to fifth-grade students at SDN Ngaliyan 05.

Tabel 3. Pre-test and Post-test Result

Aspects	Pre-test	Pos-test	Increase
Minimum Score	30	70	30
Maximum Score	75	95	
Average	52,5	82,5	

Based on Table 3, there was an increase in pretest and posttest scores after using Problem-Based Learning (PBL)-based e-learning materials. The average pretest score was 52.5, while the average posttest score increased to 82.5. Thus, there was a 30-point increase in the average scores between the pretest and posttest. This increase indicates that Problem-Based Learning (PBL)-based E-Learning Materials have a positive impact on student learning outcomes. One factor contributing to this improvement is the inherent nature of PBL itself, as students are immediately engaged in problem-solving skills and the exploration of new information from the very start of the learning process (Sari & Andriani, 2026).

Tabel 4. Normality Test Result

	Shapiro-Wilk	Categori
Pre-test	0.832	Normal
Pos-test	0.076	Normal

Based on Table 4, it is evident that the Sig value for the pre-test Shapiro-Wilk data is 0.832 and for the post-test data is 0.076. The Sig values for both normality test results are greater than 0.05, leading to the conclusion that the pre-test and post-test data are normally distributed. This study used the Shapiro-Wilk normality test because the sample size was less than 50. The first analysis performed was a normality test to determine whether the distribution of the research data was normal or not (Ikhlas et al., 2025).

Tabel 5. Paired Sample t-test Result

Treatment	N	Mean	T	Sign. (2-Tailed)
Pre-test	21	60.95	-9.772	0.000
Pos-test	21	81.90		

Based on Table 5, it can be seen that the average pre-test score was 60.95 and the average post-test score was 81.90, representing an increase of 20.95. Thus, there was an improvement in learning outcomes after using Problem-Based Learning-based e-learning materials. The significance value Sig. (2-tailed) is $0.000 < 0.05$, indicating a significant difference between the two variables (Ayu et al., 2026). Based on the decision criteria, if the significance level is < 0.05 , then H_0 is rejected and H_1 is accepted. Therefore, it can be concluded that there is a significant difference in Grade 5 at SDN Ngaliyan 05 after using Problem-Based Learning-based digital teaching materials.

Tabel 6. N-Gain Test Result

Treatment	Aspect	Mean (N-Gain)	Criteria
Pre-test	60.95	0.5218	Currently
Pos-test	81.90		

Based on Table 6, the N-Gain test results for the large group showed a mean of 0.5218, which falls into the moderate category. The classification of N-Gain test results is as follows: if $N\text{-Gain} > 0.70$, the criterion is high; if $0.30 < N\text{-Gain} < 0.70$, the criterion is moderate; and if $N\text{-Gain} < 0.30$, the criterion is low. Improvements in this criterion are influenced by several supporting factors.

First, the application of problem-based learning encourages students to actively solve problems, discuss, and draw conclusions, thereby improving learning outcomes. Syntax 1 is supplemented with stimuli in the form of videos and questions; these stimuli can increase student engagement and improve understanding of the material. By providing stimuli and motivation from the teacher to the students, the learning objectives become effective, fostering spirituality, intelligence, noble character, and behavioral changes in the students (Sipayung & Sihotang, 2022). In Session 2, there is a group discussion involving the completion of worksheets. Completing these worksheets allows students to actively participate in the teaching and learning process (Ayu et al., 2026).

Second, ensuring the instructional materials are complete. These instructional components, which consist of various interconnected and mutually supportive elements in the teaching-learning process, are designed to ensure that educational objectives are achieved effectively and efficiently (Iskandar et al., 2023). The components of the e-learning materials include the Home Page, Preface, Table of Contents, User Guide Menu, Activity Guide Menu, Competencies Achieved Menu, Concept Map Menu, Syntax 1 Menu (Problem Orientation), Syntax Menu 2 (Organizing Students for Learning), Syntax Menu 3 (Guiding Group Inquiry), Syntax Menu 4 (Developing and Presenting Results), Syntax Menu 5 (Analyzing and Evaluating the Problem-Solving Process), Quiz, Conclusion Menu, Reflection Menu, Evaluation Questions Menu, Answer Key Menu, Glossary Menu, Bibliography Menu, Developer Profile Menu.

Third, it meets the characteristics of instructional materials. According to (Yunita, 2024), digital learning materials have the following characteristics: self-instruction (independent), self-contained (comprehensive), stand-alone (self-contained), adaptive (capable of adapting), and user-friendly. In self-instruction, e-learning materials must provide an introduction to the topic at the beginning, usage instructions to guide users in learning independently, and stimuli in the form of videos and questions. Self-contained means that all necessary learning materials are fully included within the e-learning materials. Stand-alone means that students can study, explore, and complete all learning activities using only those e-learning materials. Adaptive: E-learning materials should also be adaptable to various devices (able to be opened on laptops or smartphones with a responsive design) (Eriska, L., 2022). According to (Lastri, 2023), User-friendly means that the e-learning materials should be user-

friendly and intuitive. Problem-Based Learning (PBL)-based e-learning materials come with user guides so that students understand how to use them and can use the PBL-based e-learning materials independently.

Based on the analysis of the average pre-test and post-test score increases, the normality test, the paired t-test, and the N-gain test, the development of Problem-Based Learning-based digital teaching materials was effective in improving the learning outcomes of fifth-grade science students at SDN Ngaliyan 05 in Semarang City.

CONCLUSION

Based on the results of the research and data analysis conducted, the researcher concludes that the Problem-Based Learning (PBL)-based digital teaching materials on the characteristics of terrestrial and aquatic reptiles and mammals were developed using the Canva application. These materials include user instructions, activity guidelines, a PBL framework, and content comprising text, images, animations, and videos, and are supplemented with quizzes (Wordwall). The research results indicate feasibility as assessed by media experts with a score of 93.75% in the “highly feasible” category and by content experts with a score of 90% in the “highly feasible” category. This is supported by a 95% positive response rate from teachers and a 93.60% positive response rate from students. The results of the normality test in the pilot study showed a pre-test significance value of $0.832 > 0.05$, indicating that the data distribution met the assumption of normality. The results of the post-test normality test showed a significance value of $0.076 > 0.05$, indicating that the data distribution met the assumption of normality. Based on the results of the Paired Samples Test, the mean pre-test score for the pilot study was 52.5 and the mean post-test score was 82.5, indicating an increase of 30. The correlation result in the Paired Samples Correlations table is 0.791. Furthermore, the significance level of <0.000 is less than 0.05, indicating a significant difference in learning outcomes before and after using the developed product. The research on the development of Problem-Based Learning (PBL)-based digital teaching materials was successfully completed, and the materials are highly suitable and effective for improving the cognitive learning outcomes in Natural Sciences (IPAS) for fifth-grade students at SDN Ngaliyan 05 in Semarang City.

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