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Innovation of Interactive Science Teaching Materials Based on Problem Based Learning Model through Learning Management System in Elementary School

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Abstract: This research aims to develop science teaching materials integrated with Learning Management System (LMS) based on Problem Based Learning (PBL) in elementary schools. The method used is the 4D development model which includes the Define, Design, Develop, and Disseminate stages. The research subjects were fifth grade students in one of the elementary schools, with data collected through observations, interviews, questionnaires, and learning outcomes tests. Data analysis was done descriptively quantitative and qualitative. The results showed that the teaching materials developed were highly valid, practical, and effective in improving students' science learning outcomes. This study recommends wider use of these teaching materials and further development for various topics and levels of education.

Keywords: Learning Management System; Problem Based Learning; Science Teaching Materials

Introduction

Natural Science Education in elementary school has an important role in shaping the basis of knowledge and character of students. As one of the branches of science that underlies the understanding of the surrounding world, science education aims to develop the ability to think critically, logically, and systematically in students from an early age (Agustiana et al., 2021; Hardiansyah et al., 2022; Mustikaningrum et al., 2021). This is very important because understanding of the basic concepts of science will be the foundation for further learning in higher education and further learning at higher education levels and also in everyday life (Matere et al., 2021; Sari et al., 2023; Sharif et al., 2021).

An effective science teaching and learning process in elementary schools is not only about conveying information, but also actively involving students in exploration, experimentation, and problem-solving activities (Amin et al., 2021; Damayanti & Putra, 2021). Interactive and contextualized science learning can arouse students' natural curiosity, encourage them to ask questions, and seek answers through observation and investigation. Such learning methods will help students develop scientific thinking skills and understand the practical application of science concepts in real life so that it has a significant impact on student learning outcomes (Duong et al., 2022; Nurgaliyeva et al., 2022; Saija et al., 2022).

However, the results of science learning in schools are still far from the Criteria for Achieving Learning Objectives (Kurniawan & Fitria, 2023; Nisa et al., 2022; Prafitasari et al., 2021). One of the causes is the perception of students who think that science learning only contains memorization, so many students are not motivated to learn more deeply. In addition, based on the results of the 2018 Programme for International

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Student Assessment (PISA) in collaboration with the Organization for Economic Co-operation and Development (OECD), 35% of Indonesian students are still at a low level of competence in science. This competency level measures students' ability to use general and procedural knowledge to understand or explain simple scientific phenomena (Hassan et al., 2022; Martawijaya et al., 2023; Walid et al., 2023).

Researchers found low student learning outcomes when conducting preliminary studies at SDN 14 Ulakan Tapakis on Saturday, August 5, 2023; at SDN 14 Nan Sabaris on Saturday, August 26, 2023; and at SDN 05 Ulakan Tapakis on Tuesday, August 29, 2023. From the results of the needs analysis conducted, several important points were found. First, teachers have not utilized digital platforms in the learning process. The use of digital platforms can help design creative teaching materials, monitor student progress, and provide access to a variety of online learning tools, allowing teachers to personalize teaching to student needs and deliver materials more easily (Adnyani & Wibawa, 2021; Dewi & Fatkhiyani, 2021; Khotimah & Hidayat, 2022).

Second, teachers use visual media such as pictures and learning videos, but this is still not in accordance with the demands of the independent curriculum which encourages the use of technology in teaching. Third, the school has sufficient facilities and infrastructure and good internet access, but it is not optimally utilized. Observations show that students score less than 60% in the science assessment according to the KKTP, which is largely due to the lack of activity and feedback from students in the classroom, due to boring traditional learning methods.

Fourth, the teaching materials used tend to focus on school books that are less interesting and limited. One-way learning, where teachers explain more than actively involve students, shows a lack of application of differentiated learning and the concept of learning styles. Fifth, teachers need to adapt the learning model to the characteristics and learning styles of students. Teaching materials such as teaching modules are often downloaded from the internet without utilizing digital media and the internet as interesting and up-to-date additional references.

One approach that is getting more attention is the use of Learning Management System (LMS) in the learning process. LMS is a digital platform that enables the management, delivery and measurement of teaching and learning activities in a more structured and efficient manner. With LMS, teachers can upload teaching materials, assignments, and tests, and provide direct feedback to students (Amida et al., 2024; Kadek et al., 2021; Sudarma & Sukmana, 2022). The LMS also allows students to access learning materials anytime and anywhere, increasing learning flexibility. Features such as discussion forums, interactive quizzes, and student learning performance analysis can also be integrated to support a more dynamic and personalized learning process (Ertikanto & Hardini, 2023; Hikmawati & Syahidi, 2022; Setiawan et al., 2023).

In addition, the problem-based learning (PBL) model has been proven effective in improving students' critical thinking and problem-solving skills. PBL emphasizes on a student-centered learning process by exposing them to real problem situations that are relevant to everyday life (Barbara & Bayu, 2022; I. P. Sari & Fathoni, 2022; Sipayung et al., 2021). In PBL, students are invited to work in groups, identify problems, search for relevant information, and find solutions based on their analysis. This process not only improves students' knowledge of the subject matter, but also develops collaboration, communication and self-directed learning skills (Pangestu, 2021; Sabil et al., 2021; Sekarwangi et al., 2021).

The development of LMS-based interactive teaching materials that integrate the PBL model in grade V elementary school is a promising innovation in improving the quality of learning. Through interactive teaching materials, students can be more actively involved in the learning process, utilize technology as a learning tool, and develop critical thinking and problem-solving skills. Interactivity in teaching materials can be in the form of learning videos, simulations, interactive quizzes and collaborative projects designed to challenge students and encourage their active engagement (Amida et al., 2024; Ana, 2020; Zainal et al., 2020).

In addition, the use of an LMS allows teachers to manage and monitor students' learning progress more effectively. Teachers can track students' learning progress through data collected by the LMS, such as time spent studying, quiz results, and participation in discussions. This data helps teachers to understand students' individual needs and provide the right intervention at the right time. Thus, the LMS not only serves as a tool for delivering teaching materials, but also as a tool for evaluation and continuous improvement of learning quality. The integration of LMS and PBL in grade V primary school creates a learning environment that is more adaptive, responsive and relevant to the needs of today's students. This innovation is expected to bring positive changes in the education system, making the teaching and learning process more interesting, effective, and oriented towards developing 21st century competencies (Sangsawang, 2020; Utama et al., 2023; Wulandari & Abadi, 2021).

Relevant research shows that the development of a Learning Management System (LMS) has various benefits and applications that are successfully implemented in an educational context. The developed

a Smartphone Learning Management System (S-LMS) as a medium for learning mathematics in high school, and the results showed that the LMS was feasible to apply to students and effective to use as a companion for mathematics learning in a blended learning scheme. The development of LMS in higher education based on Permendikbud No. 3 of 2020, and testing using black box unit testing showed that 100% of the LMS features functioned properly.

The developed Problem Based Learning (PBL) teaching materials for online learning using the Edmodo platform, and the results showed that the use of these teaching materials received a positive response from students. The developed PBL-based interactive teaching materials to improve students' science literacy skills, and the results showed that the interactive teaching materials were suitable for use in the learning process in class IX Mts Loppe Luwu Regency. These studies support that the development of LMS and PBL-based interactive teaching materials can improve the quality of learning and get positive responses from students, so it is relevant to be adopted in various educational contexts.

Science education in elementary school is very important in forming the basis of knowledge and character of students. Science learning aims to develop the ability to think critically, logically and systematically from an early age, which is the basis for further learning and daily life. An effective science teaching and learning process not only conveys information, but also involves students in exploration, experimentation, and problem solving. However, the results of science learning are still below the Minimum Completeness Criteria (KKM), with many students who are less motivated and think that science only contains memorization.

This study found that the low learning outcomes of science are caused by the lack of utilization of digital platforms, unoptimal use of visual media, and one-way learning. LMS (Learning Management System) and problem-based learning (PBL) model can be a solution to this problem. LMS allows the management and delivery of materials in a more structured and efficient manner, while PBL emphasizes student-centered learning through real problem situations.

This research develops science teaching materials based on LMS and PBL for fifth grade students. The novelty of this research is the combination of LMS and PBL specifically applied to basic education, in contrast to previous studies that focus more on secondary and higher education. This research is important to improve the quality of science learning and students' critical thinking skills in elementary schools.

This research has a novelty with a unique focus on combining LMS technology and PBL learning approaches specifically for grade V students. In contrast to previous studies that focused more on secondary education levels such as high school and college, this research makes a new contribution in the context of basic education with the development of more interactive and structured teaching materials. By combining LMS technology with a student-centered learning approach, this research aims to improve the quality of learning and critical thinking skills of students at the primary school level. This makes this research important in efforts to improve the effectiveness of learning at the basic education level.

Method

This research uses the R&D method, or Research and Development, with the 4-D development model, namely define, design, develop, and disseminate (Daryono et al., 2021; Maulida et al., 2020; Yusuf, 2023). The subjects of the trial and application were fifth grade students of SDN 05 Ulakan Tapakis (10 students), fifth grade students of SDN 14 Ulakan Tapakis (16 students), and fifth grade students of SDN 14 Nan Sabaris (15 students). The research was motivated by the condition of students in accordance with the needs of the research, the support of the school environment, the ability of teachers, and positive responses from the school. The description of the research flow using the 4D development model is as follows Figure 1.

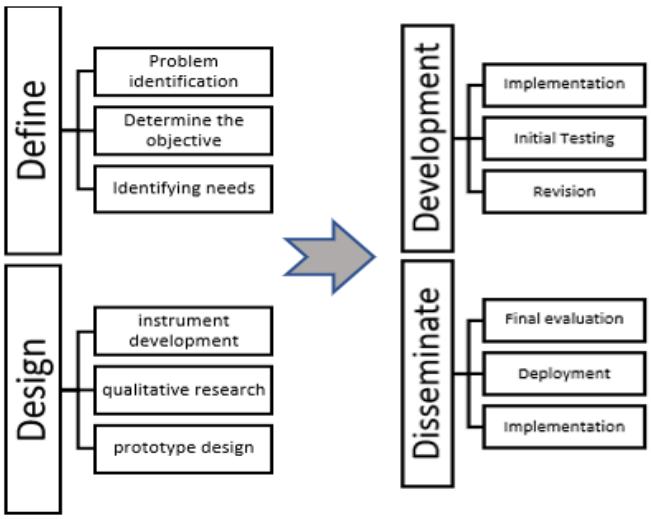

Figure 1. Flow of the 4D Development Model

The 4D stream in Research begins with the Define stage. At this stage, preliminary studies are carried out through classroom observations, interviews with teachers, and analysis of the needs of teachers and students. The objective of this preliminary study is to understand the current context of IPA learning, identify obstacles encountered, and understand the specific needs of students and teachers. The identification of problems is done by revealing key problems in IPA

learning in primary schools, such as problems of student motivation, less interactive teaching methods, and lack of use of technology in the teaching learning process.

The next phase is the Design phase. In this phase, IAP material is designed that is integrated with the Learning Management System (LMS) and is based on Problem Based Learning (PBL). The plan includes the structure of the material, interactive formats, and content that matches the curriculum and student needs. In addition, a validation sheet is compiled that will be used by experts to evaluate the quality of the materials developed, as well as a lifting instrument to measure the response of teachers and students to the material.

The next stage is Develop. At this stage, interactive teaching materials are developed based on designs that have been compiled. This teaching material includes learning videos, simulations, interactive quizzes, and collaborative projects. After development, the material is validated by the expert using a validation sheet with the Likert scale to ensure that the material meets the validity standards and is suitable for use in learning. Based on the validation results, revisions are carried out to correct the deficiencies and improve the quality of the material according to the input from the experts.

The last stage is Disseminate. In this phase, the revised teaching materials were tested in three primary schools: SDN 05 Ulakan Tapakis, SDN 14 UlakanTapakis and SDN14 Nan Sabaris. This test aims to see how the material is implemented and accepted by students and teachers. The data is collected through responsive lifts from teachers and students as well as student skills tests before and after using interactive teaching materials. The lifts are used to measure the response to the practicality and effectiveness of the teaching material, while the tests are used for measuring the improvement in student learning outcomes. The collected data is analyzed to assess the validity, practicality, and effectiveness of interactive teaching materials. Validation is analyzed based on expert validation scores, practicality is analysed based on teacher and student responses, and effectiveness is measured through improved student learning outcomes using the N-Gain Score test.

Data collection techniques include preliminary studies, validation sheets, questionnaires, and tests. The preliminary study was conducted through observation analysis, teacher interviews, and analysis of the needs of teachers and students to find out the problems that occur in the field. The validation sheet is used to obtain data on the results of expert validation of the developed product. Questionnaires were used to collect teachers' and learners' responses to the interactive teaching materials developed. The test instrument is used to measure the ability of students to master science material before and after using interactive teaching materials.

Data analysis techniques include analyzing the validity of teaching materials, the practicality of interactive teaching materials, and the effectiveness of interactive teaching materials. The validity of teaching materials is analyzed using a Likert scale from expert validators, while the practicality of interactive teaching materials is assessed based on the final score from the analysis of the response questionnaire of teachers and students.

Table 1. Categories of Validation and Practicality Results

Percentage (%)	Category	Description
81-100	Very Valid	Very valid, no revision needed
61-80	Valid	Valid needs minor revision
41-60	Moderately	Valid can be used with moderate revision
21-40	Invalid	Needs major revision
1-20	Very Invalid	Cannot be used

The effectiveness of interactive teaching materials is measured through learner activity test sheets and tests. The effectiveness analysis involved calculating the percentage of learners involved in the activity as well as assessing the effectiveness based on certain criteria with the N-Gain Score test (Sumarni & Kadarwati, 2020; Yustina. & Vebrianto, 2020).

Result and Discussion

This research was conducted using the R&D (Research and Development) method and the 4-D development model. The stages in this model include Define, Design, Develop, and Disseminate. The following are the research results from each stage:

This research began with the Define stage, where researchers conducted a needs analysis. The analysis was conducted on the curriculum, learners, and teachers. The results of the curriculum analysis showed that the school uses two types of curriculum, namely the independent curriculum and the 2013 curriculum. The majority of learners do not understand the material well, which also affects their learning outcomes. The results of the needs analysis of teachers and learners show their interest in interactive teaching materials that use interesting images, games, and learning videos.

However, the use of technology-based interactive teaching materials is still minimal in schools. Teachers also face difficulties in designing interactive teaching materials that are in line with the demands of the times and technology. By considering these findings, the researcher designed the development of interactive teaching materials using the PBL model in grade V

elementary school to improve the quality of learning. The Design stage involves creating interactive teaching materials using the PBL model for grade V primary school in the science subject. This involved using tools such as Canva, Wordwall, and Google Classroom.

The process included the creation of teaching materials with Canva, where the researcher downloaded templates and designs from the internet for chapter 6 science materials, as well as the creation of standardized tests according to the learning objectives. In addition, the teaching materials were developed according to the PBL model and uploaded to Google Drive to be connected to Linktree and Google Classroom. The process of working on teaching materials includes several steps, including making cover pages, information pages, teaching modules, teaching materials with learning videos, audio, and learning videos, LKPD, games, and evaluations. All of these are designed to make learning more interactive and engaging for learners.

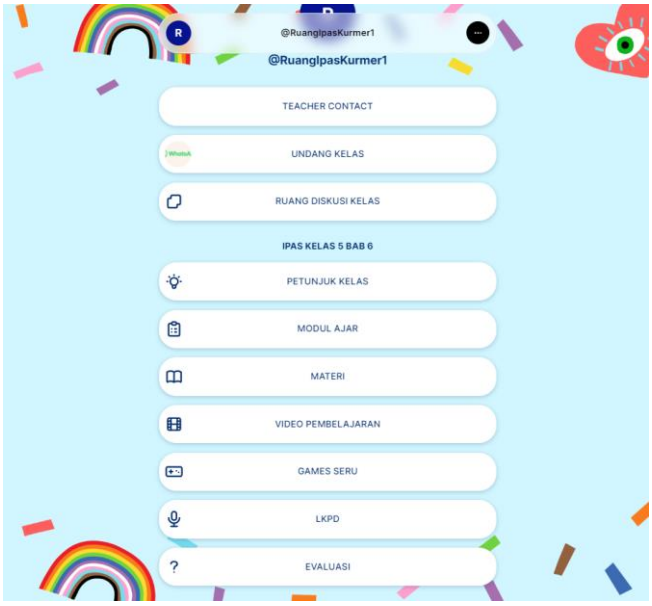

Figure 2. LMS Main View

Figure 3. Teaching Material Display

Figure 4. Learner Worksheet Display

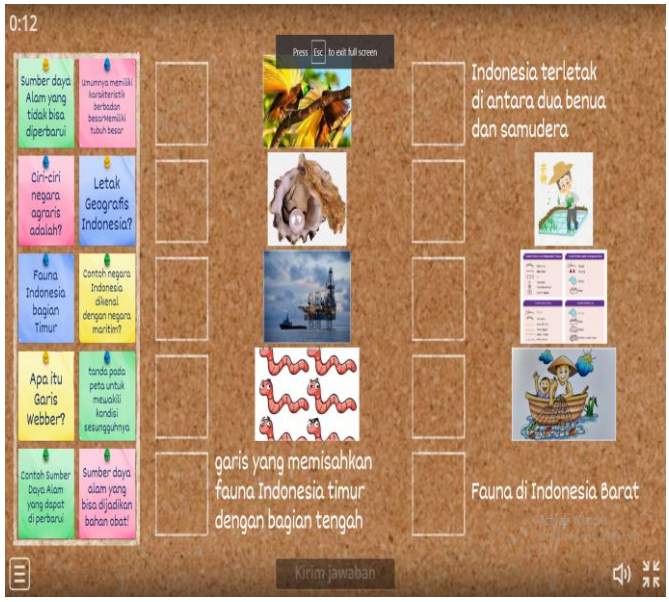

Figure 5. Educational Games Display

The development stage involves validation of teaching materials by expert lecturers, Focus Group Discussion (FGD), and practicality test.

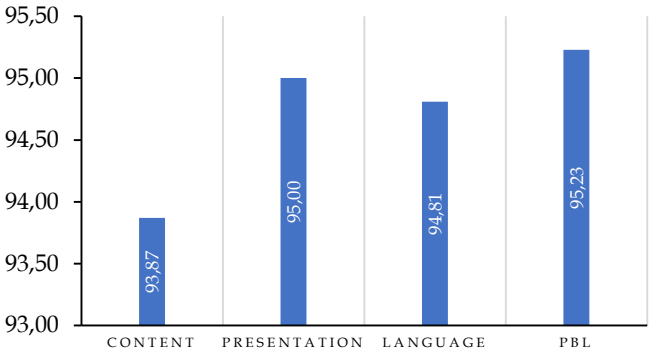

Figure 6. Average Results of Material Validation

The material validation results get an average score of 93.87 which is very valid. Similarly, the presentation validation obtained an average score of 95, and the

language validation received an average score of 94.81, all of which were in the highly valid category. The last validation on the Problem Based Learning (PBL) assessment reached an average value of 95.23, also included in the very valid category. Overall, the average value of the four aspects was 94.72, indicating a very valid category.

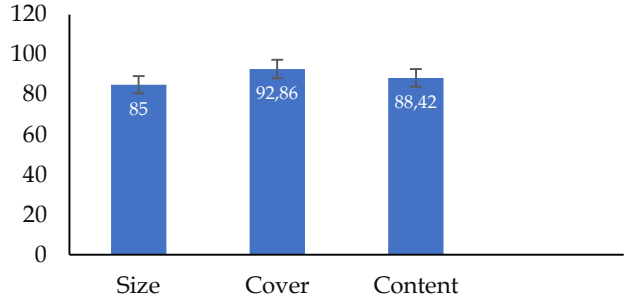

Figure 7. Average Results of Media Validation

The validation results for the cover content received an average score of 92.86, which is very valid. As for the design of the content, the average value is 88.42, also included in the very valid category. The validation test results for these three aspects gave an average score of 88.76, which indicates a very valid category.

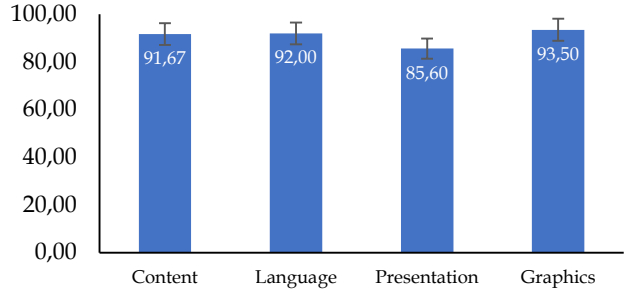

Figure 8. FGD Validity Recapitulation

The recapitulation results of the validation of teaching materials filled in by teachers in focus group discussions (FGD) show that the average feasibility of material content is 91.67. The grammar aspect scored 92, while the presentation aspect had an average of 85.6. Finally, for the graphic aspect, the value obtained was 93.5. Thus, the average total validation score for all aspects in the focus group discussion was 90.69.

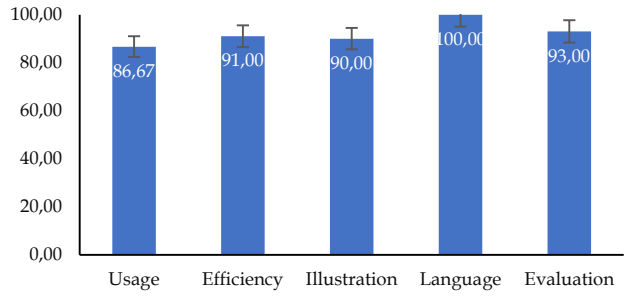

Figure 9. Teacher Practicality Test Average

From the recapitulation of the practicality test by teachers, it was found that the use of interactive teaching materials scored 86.67% in the practicality aspect, with a very practical category. Furthermore, the time efficiency aspect scored 91%, also in the very practical category. Then, for the suitability of illustrations, a score of 90% was obtained, also in the very practical category. The language aspect scored 100%, remaining in the very practical category. Finally, the evaluation aspect scored 93%, with a very practical category. The average score of all aspects for the results of practicality by teachers is 92.13%, with a very practical category.

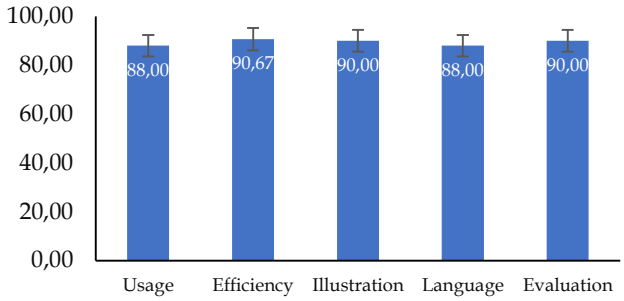

Figure 10. Student Practicality Test Average

The practicality aspect of using interactive teaching materials scored 88, a very practical category. Then, time efficiency scored 90.67, also in the very practical category. Furthermore, the suitability of illustrations scored 90, a very practical category. In the language aspect, the score is 88, with a very practical category, and finally, in the evaluation aspect, it gets a score of 90, also in the very practical category. The average result of the total validation score from all aspects of the assessment is 89.33, with a very practical description. Thus, the practicality response from teachers and students shows that the development of interactive teaching materials for science learning in grade V elementary schools on the material of chapter 6 My Indonesia is Rich in Richness is classified as very practical.

Disseminate (Effectiveness Test) involves three stages. The first stage is giving pretests at SDN 14 Ulakan Tapakis and SDN 14 Nan Sabaris. The second stage is the learning process using interactive teaching materials in the science lesson chapter 6, "Indonesiaku Kaya Raya".

Table 2. Recapitulation of Pretest-Posttest Score

School Name	Totals Student	KKTP	Pre-test	Post-test
SDN 14 Ulakan Tapakis	16	75	46.38	94.38
SDN 14 Nan Sabaris	23	75	49.39	84.70
Amount	39		95.77	179.07
Average		75	47.88	89.54

Before using the problem-based learning (PBL) model in grade V elementary school, the average student learning outcomes were 47.88%. However, after applying the development of interactive teaching materials with PBL in learning science chapter 6, learning outcomes increased to an average of 89.54%.

From the results of the N-Gain Score evaluation carried out by researchers, in the pretest test at SDN 14 Ulakan Tapakis, the score was 46.38 and the posttest was 94.38.The N-Gain Score value is 0.90, which is in the high category with an N-Gain Score percentage of 90.22, which is effective. For SDN 14 Nan Sabaris, the pretest was 49.39 and the posttest was 84.70, with an N-Gain Score of 0.69, falling into the medium category. The percentage of N-Gain Score is 69.16, which is quite effective. With an average N-Gain Score percentage of 79.69, which is effective, it can be concluded that the development of interactive teaching materials using the Problem Based Learning (PBL) model was successfully applied and improved the learning outcomes of students in grade V elementary schools in learning science.

This study aims to develop interactive teaching materials using the Problem Based Learning (PBL) model for learning Natural and Social Sciences in the Chapter with the topic "My Indonesia is Rich" in grade V elementary school. The development stages use the D development model, which includes define, design, develop, and disseminate. The results of the validation of interactive teaching materials using the PBL model show that the product has been considered valid. This validity is obtained through several stages of validation by material experts, media experts, and Focus Group Discussions (FGDs) with teachers.

The results of the validation of interactive teaching materials using the PBL model show that the product has been considered valid. This validity is obtained through several stages of validation by material experts, media experts, and Focus Group Discussions (FGDs) with teachers. The results of validation by material experts show a very valid category with an average score, which is in accordance with the competencies to be achieved in the learning material. Furthermore, validation by media and language experts also received a very valid category with an average score. This shows that the media and language design in the teaching materials are in accordance with the recommended principles.

Validation through FGDs also resulted in a total score that fell into the very valid category, indicating that this teaching material received a positive response from teachers, which could help in operationalizing the media.The practicality trial of interactive teaching materials showed that this product was very practical to use by users, both by teachers and students.High practicality scores from both groups indicate that this teaching material meets the needs and can be easily accessed.Integration with digital platforms such as Linktree and Google Classroom facilitates access and use of these teaching materials, providing flexibility in learning anywhere and anytime.

The effectiveness test of interactive teaching materials shows a significant increase in learning outcomes after the use of these teaching materials. The post-test results showed a striking improvement compared to the pre-test, with the average score increasing from.The N-Gain analysis also showed a high category, confirming that the use of interactive teaching materials with the PBL model effectively improved students' learning outcomes.Although this product has shown validity, practicality, and effectiveness in learning, there are some limitations that need to be considered.

For example, restrictions on product development are only on one subject topic and a certain grade level.Previous research that has been conducted discusses the development of interactive teaching materials and learning management systems (LMS) in the context of education. The development of a Smartphone Learning Management System (S-LMS) for learning mathematics in high school shows that the system is feasible to use as a companion to learning mathematics with a blended learning approach.Furthermore, Nasrulloh & Sutisna (2022) developed an LMS for universities that has passed the test of 100% of its functional features using black box unit testing.

Aeni, Mutaqin, & Setiani's research (2021) highlighted the development of Problem Based Learning (PBL) teaching materials with the Edmodo platform, which received positive responses from students in online learning.Meanwhile, Rafi'y, Irawan, & Harahap's (2023) research focused on developing PBL-based interactive teaching materials to improve the science literacy of students in class IX MTs Loppe Luwu Regency.In this context, recent research that discusses the development of Interactive Teaching Materials Using Learning Management System Based on Problem Based Learning Model in Grade V Elementary School adds an important contribution.

New findings from the study show that the development of interactive teaching materials using the PBL model at the elementary school level can improve the quality of learning. The developed system is feasible to use as an interactive learning support in grade V elementary school, by utilizing PBL approach and integration with Learning Management System (LMS). This opens up new opportunities to improve the effectiveness of learning at the primary level by utilizing technology and innovative learning approaches.

The implication of this study is that the development of interactive teaching materials using the PBL model in grade V elementary school, which has been carried out by researchers, has been proven valid, practical, and effective.The application of these teaching materials after going through trials shows a high level of effectiveness, integrating problem-based learning strategies that allow students to be active, creative, and innovative in developing their abilities.From the educator's point of view, this teaching material helps create enthusiasm and active participation of learners in learning, making the learning process more enjoyable and in accordance with the demands of digital technology in the era of the industrial revolution 4.0 (Agustiana et al., 2021; Pangestu, 2021; Santhi et al., 2020).

In addition, interactive teaching materials using the PBL model developed can also be part of the learning management system, helping to facilitate a more structured and efficient learning process. This teaching material is also able to have a significant impact in various aspects of learning, including the delivery of material and the growth of students' reading literacy, and is proven to be able to improve their learning outcomes as expected.

In addition, limited technology and infrastructure in some schools may affect the use of these teaching materials.Further research involving more subjects and learning environments is needed to generalize the results of this study. Thus, the development of interactive teaching materials using the PBL model is a positive step in improving learning in grade V elementary schools. Taking into account the limitations and recommendations proposed, the use of these teaching materials is expected to make a significant contribution in improving student learning outcomes.

Conclusion

This research successfully developed science teaching materials integrated with Learning Management System (LMS) based on Problem Based Learning (PBL) for grade V elementary school students. These teaching materials are very valid, practical, and effective in improving students' science learning outcomes. The validity of teaching materials is confirmed through positive responses from material and media expert validators, while its practicality can be seen from the responses of teachers and students. The effectiveness of this teaching material is evidenced by a significant increase in student learning outcomes, supported by high gain-score test results. This study recommends wider use of this teaching material and further development for various topics and levels of education.

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Place acknowledgments, including information on grants received, before the references, in a separate section, and not as a footnote on the title page

Author Contributions

Conceptualization, W. S., D., Y. M.; methodology, W. S.; validation, D. and Y. M.; formal analysis, U. R.; investigation, W. S. and D.; resources, Y. M. and U. R.; data curation, W. S.; writing—original draft preparation, D. and Y. M.; writing—review and editing, U. R.; visualization, W. S. and D. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest

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