JPPIPA 12(1) (2026)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Development of RBL–STEM Learning Materials to Foster Students' Creativity in Eco-Friendly Technological Innovation: Transforming Used Cardboard into an Electric Broom

Aning Setianingsih[1,2], Rina Sugiarti Dwi Gita[1*], Eges Triwahyuni[1]

[1] Departement of Learning Technology, Universitas PGRI Argopuro Jember, Jember, Indonesia.
[2] SDN Kepatihan 01 Jember, Jember, Indonesia.

Received: November 17, 2025
Revised: December 26, 2025
Accepted: January 25, 2026
Published: January 31, 2026

Corresponding Author:
Rina Sugiarti Dwi Gita
gitarina16@gmail.com

DOI: 10.29303/jppipa.v12i1.13950

Open Access

© 2026 The Authors. This article is distributed under a (CC-BY License)

Abstract: This study focuses on the development of RBL–STEM learning materials that integrate research-based learning and STEM principles to foster students' creativity through an eco-friendly technological innovation project, specifically the transformation of used cardboard into a functional electric broom. The development used the ADDIE development model, which consists of the stages of Analysis, Design, Development, Implementation, and Evaluation, and this study produced a set of comprehensive learning materials, including instructional modules, student worksheets, project media, and creativity assessment instruments. Expert validation confirmed that the developed materials were valid, while responses from teachers and students indicated a high level of practicality. Empirical implementation demonstrated a moderate improvement in students' learning outcomes, as reflected by an average N-gain score of 0.5617, and evidenced the students' ability to generate creative and functional electric broom prototypes. These findings contribute to the field of science education by providing an empirically validated RBL–STEM learning framework that promotes creativity through sustainable technological innovation at the elementary school level. The significance of the study is reflected in its contribution to enhancing students' creativity, strengthening their understanding of scientific concepts, and fostering environmental awareness through research- and engineering-oriented learning experiences. The developed RBL–STEM learning materials were empirically demonstrated to be feasible and effective in supporting innovative science instruction at the elementary school level.

Keywords: Eco friendly technology; Learning materials; RBL–STEM; Student creativity

Introduction

In recent years, issues related to environmental sustainability have increasingly dominated global media coverage in both developed and developing countries. Growing public awareness of the importance of environmental services and their preservation has positioned environmental sustainability as a widely discussed global concern. However, economic development, which remains a primary objective for most countries worldwide, has often progressed in contradiction to environmental quality. In practice, economic development activities tend to exert more detrimental impacts on the environment than beneficial ones. One significant negative consequence of such development is the continuous accumulation of consumer waste. When waste accumulates without adequate management, it can generate additional social and environmental problems within communities. According to data reported by ISPN, the total volume of waste generation reaches 36,847,005,210 tons per year, of which only approximately 32.36% is properly managed, while the remaining 67.64% is left untreated and continues to accumulate (BPS, 2024).

How to Cite:
Setianingsih, A., Gita, R. S. D., & Triwahyuni, E. Development of RBL–STEM Learning Materials to Foster Students' Creativity in Eco-Friendly Technological Innovation: Transforming Used Cardboard into an Electric Broom. *Jurnal Penelitian Pendidikan IPA*, *12*(1), 324-336. https://doi.org/10.29303/jppipa.v12i1.13950

Such conditions highlight the relevance of environmental issues as an important context within educational discourse. In educational settings, numerous learning topics are closely related to concrete environmental issues, especially in science education, which examines natural phenomena and their interactions with the surrounding environment. The learning process therefore requires well designed learning materials that serve as essential references for effective teaching and learning activities (Pratiwi et al., 2021). In the context of elementary education, where students require concrete examples to understand conceptual problems, teachers are expected to carefully select appropriate learning models and instructional methods that align with students' developmental characteristics and the intended learning objectives.

Issues related to waste problems in the surrounding environment, when examined within the context of elementary science education, offer substantial potential to be integrated as contextual learning materials. This perspective provides an initial foundation for positioning environmental problems, particularly waste accumulation, as meaningful learning contexts in schools through the application of appropriate instructional design. To effectively transform these real-world environmental challenges into structured learning experiences, science instruction requires learning materials that integrate research activities and engineering processes, enabling students to explore problems systematically and develop creative solutions. Consequently, the development of RBL–STEM learning materials becomes a relevant pedagogical approach to support innovative and context-based science learning at the elementary school level.

The RBL–STEM instructional design represents an effective integration of learning models and methods for implementing environment based learning in both elementary and secondary education. Liufvanni (2025) reported that STEM is a suitable instructional approach for practicum-oriented learning activities across elementary and secondary school levels. The study further indicated that learning experiences grounded in environmental and natural contexts have a significant influence on the development of students' creative and critical thinking skills. Similarly, Kristiana et al. (2024) demonstrated that instruction employing an RBL–STEM design positively impacts students' thinking skills. Their findings also suggest that creative thinking skills play a crucial role in enabling students to generate practical and solution-oriented responses to environmental problems encountered in their surroundings.

An analysis of the available data indicates that the area surrounding SDN 01 Kepatihan Jember is experiencing several environmental challenges, particularly the inadequate management of accumulated cardboard waste. At the same time, the elementary science curriculum implemented at SDN 01 Kepatihan includes learning outcomes that address waste processing and environmental management. These conditions highlight a convergence between existing environmental problems and curricular demands, creating a meaningful context for educational intervention. In response to this situation, the present study was conducted to develop RBL–STEM learning materials aimed at fostering students' creativity through eco-friendly technological innovation, specifically through the transformation of used cardboard into an electric broom.

Method

This research adopted a research and development methodology by applying the ADDIE framework, encompassing the phases of Analysis, Design, Development, Implementation, and Evaluation, with the objective of producing RBL–STEM learning materials that meet the criteria of validity, practicality, and effectiveness (Arikunto, 2019).

The effectiveness test employed a quasi-experimental method with a pretest–posttest control group design, consisting of an experimental group, in which students were taught using RBL–STEM learning materials, and a control group, in which students received conventional instruction.

The research site was SDN Kepatihan 01 Jember. Participants in the limited trial consisted of one fourth-grade class. Participants in the large-scale trial consisted of two fourth-grade classes, comprising an experimental group and a control group. The sampling technique employed was purposive sampling, based on criteria including the relevance of instructional content, teacher readiness, and the conditions required for STEM-oriented learning.

Development Procedure (ADDIE Model)

Analysis

This stage includes analysis of instructional needs for RBL and STEM based learning, analysis of the characteristics of fourth grade students, curriculum analysis focusing on science and mathematics learning outcomes, a review of relevant literature on RBL, STEM, creativity, and environmentally friendly innovation, and aanalysis of the potential use of recycled cardboard as a medium for innovation-based projects.

Design

This stage encompasses the formulation of learning objectives, RBL and STEM activity sequences, and creativity indicators based on Guilford's framework.

The design of instructional components includes teaching modules, RBL and STEM worksheets, instructional materials, creativity rubrics, test instruments, and observation sheets. The design of a project transforming recycled cardboard into an electric broom was aligned with STEM elements and the engineering design process.

Development

Development of draft RBL and STEM based learning materials. Expert validation involving subject matter experts, instructional design experts, and educational practitioners. First-stage revisions conducted until the learning materials were declared feasible and valid

Implementation

Limited scale trial to examine implementation feasibility and initial student responses. Large scale trial (experimental phase) involving the application of the learning materials in the experimental class. Data collection procedures include creativity pretest and posttest, observation of learning activities, and student and teacher response questionnaires.

Evaluation

Formative evaluation conducted at each stage of the ADDIE model. Summative evaluation aimed at assessing the effectiveness of the developed learning materials. Final revisions undertaken to produce a finalized set of learning materials ready for dissemination

Research Instruments

Assessment of content validity, construct validity, and linguistic clarity. Developed based on Guilford's creativity indicators: fluency, flexibility, originality, and elaboration. Observation of student learning activities during RBL and STEM based instruction. Observation of instructional implementation fidelity.

Response questionnaires, collection of student and teacher responses toward the learning materials. Electric broom product assessment rubric, evaluation criteria encompassing creativity, innovation, functionality, and technological feasibility.

Data Collection Techniques

Expert validation to determine the validity of the developed learning materials. Observation of student activities and instructional implementation during the learning process. Pretest and posttest assessments measure creativity and learning outcomes. Student and teacher response questionnaires. Documentation of the electric broom development process (Sugiyono, 2019).

Data Analysis Techniques

Validity Analysis

The learning materials were considered valid when the average score assigned by the validators met the criterion: Va ≥ 3.25.

Practicality Analysis

Practicality was evaluated based on observation of instructional implementation. Teacher and student responses. The learning materials were considered practical when the response score met the criterion: 90% ≤ SR ≤ 100%.

Effectiveness Analysis

Learning outcomes and creativity Effectiveness was measured using the normalized gain (N-Gain) with the criteria as shown in Table 1.

Table 1. Research category of effectiveness

Category	N-Gain Value
High	≥ 0.70
Medium	0.30–0.70
Low	≤ 0.30

Classical mastery was achieved when at least 90% of students reached the established competency criteria. Student activity was considered effective when the activity level ranged between 90% and 100%. Student responses were categorized as effective when the average response score exceeded > 90%.

Qualitative Analysis

Qualitative data analysis followed the Miles and Huberman framework, encompassing data reduction, data display, and conclusion drawing or verification. This analysis was applied to examine: the implementation process of RBL and STEM based learning, students' creativity throughout the project activities, and the quality of the electric broom products developed by the students (Sudjana, 2016).

Results and Discussion

Result

The Analysis stage aimed to identify learning requirements and contextual issues to guide the development of RBL–STEM learning materials. Findings indicate that fourth-grade science instruction primarily emphasizes cognitive skills, offering limited opportunities to develop students' creativity and research abilities. At the same time, the school environment faces an accumulation of cardboard waste that remains unused. Curriculum review showed that topics on waste management and basic engineering are highly suitable for integration with a STEM approach,

while students' preference for hands-on activities supports the implementation of project-based learning. Moreover, students' creativity, assessed through fluency, flexibility, originality, and elaboration, remains underdeveloped, highlighting the need for instructional materials that facilitate idea exploration and innovative product creation. With the availability of simple resources such as recycled cardboard, DC motors, and basic tools, the Transformation of Recycled Cardboard into an Electric Broom project offers a relevant and meaningful context for applying RBL–STEM-based learning.

Table 1. Summary of Findings from the Analysis Stage

Analyzed Aspect	Key Findings	Implications for the Development of RBL and STEM Learning Materials
Learning Needs Analysis	Elementary science instruction remains predominantly cognitive oriented and insufficiently promotes creativity and innovation.	Learning materials should integrate RBL and STEM through research oriented and product-based learning activities.
Environmental Context Analysis	Cardboard waste accumulation is prevalent in both school and home environments and is rarely utilized for educational innovation.	The transformation of recycled cardboard into an electric broom provides a contextual basis for environmentally oriented learning.
Curriculum Alignment Analysis	Grade IV science emphasizes waste management and resource utilization, while mathematics addresses measurement, design, and basic computation.	RBL and STEM learning materials must align with integrated science and mathematics learning outcomes.
Student Characteristics Analysis	Fourth grade students demonstrate a preference for concrete, hands-on, and collaborative learning, while creative abilities remain underdeveloped.	Instructional modules and worksheets should prioritize practical activities, visual supports, and structured opportunities for creativity.
Facilities and Material Potential Analysis	Recyclable materials and simple technological components are readily available and suitable for project-based learning.	Learning materials should utilize accessible resources and include safe, age-appropriate practicum guidelines.
Creativity Competency Analysis (Guilford)	Indicators of fluency, flexibility, originality, and elaboration have not been optimally facilitated in prior instruction.	Creativity assessment instruments should incorporate all Guilford indicators within the project context.
Review of Prior Studies	Empirical studies integrating RBL and STEM with environmentally friendly technological innovation using cardboard waste remain limited.	Learning materials should integrate complete RBL syntax with the engineering design process to support authentic innovation.

The Design stage focused on developing RBL-STEM learning materials aimed at enhancing students' creativity through the *"Transformation of Recycled Cardboard into an Electric Broom"* project. In this stage, learning objectives were established based on Grade IV science learning outcomes, and the RBL-STEM syntax was structured to encompass scientific investigation and the engineering design process. Worksheets were designed to guide exploration, brainstorming idea, sketching, and prototype evaluation. Teaching modules were prepared as comprehensive teacher guides, including supporting materials, observation sheets, and creativity rubric based on Guilford's indicators. Additionally, the project product, media, tools, and required materials were planned, along with research instruments such as validation sheets, creativity tests, questionnaires, and product assessment rubrics. This design ensures that the developed learning materials provide a clear, relevant, and structured learning framework capable of facilitating research activities, technological innovation, and the development of creativity effectively.

Table 2. Summary of findings from the design stage

Design Component	Findings from the Design Stage	Implications for RBL-STEM Learning Materials
Learning Objectives Formulation	Objectives were developed based on Grade IV science learning outcomes covering waste utilization, simple energy, and environmentally friendly technology design.	Ensures the learning materials achieve knowledge competencies, scientific process skills, and creativity.
RBL-STEM Syntax Design	The syntax includes problem identification → research question formulation → data	Provides a structured learning process that supports inquiry, problem solving, and the engineering design process.

Design Component	Findings from the Design Stage	Implications for RBL-STEM Learning Materials
	collection → experimentation → analysis → prototype design → evaluation → revision.	
RBL-STEM Worksheet Design	Worksheets guide investigation steps, concept exploration, brainstorming for the electric broom, design sketches, testing, and reflection.	Serves as the main guide for students to conduct research and product engineering.
Teaching Module Design	Modules contain learning sequences, objectives, supporting materials, investigation guides, creativity indicators, assessment rubrics, and activity observation sheets.	Facilitates systematic implementation of RBL-STEM learning by teachers.
Creativity Assessment Design	Creativity rubric developed based on Guilford indicators: fluency, flexibility, originality, and elaboration.	Standardized assessment captures students' idea development and creative growth.
Project Product Design	Designed product: Electric Broom from recycled cardboard, using a DC motor, battery, cardboard frame, and simple tools.	Provides authentic engineering experience while utilizing environmentally friendly materials.
Research Instrument Design	Instruments include expert validation sheets, practicality questionnaires, creativity pretest–posttest, observation sheets, and product rubric.	Supports evaluation of validity, practicality, and effectiveness of the learning materials.
Media and Material Planning	Main media: design illustrations, step-by-step videos, and assembly tools from recycled materials.	Ensures the project can be conducted safely and cost effectively.

The Development stage focused on producing the complete set of RBL-STEM learning materials designed in the previous phase, including teaching modules, worksheets, project media, and instruments for assessing creativity, practicality, and effectiveness. These materials underwent validation by subject matter experts, instructional design specialists, and educational practitioners to assess content accuracy, language quality, presentation, and conformity with the RBL-STEM framework. The validation results confirmed the materials as valid, with minor adjustments recommended, such as language refinement, simplification of project procedures, clarification of tool components, and improvement of the creativity rubric based on Guilford's indicators. All suggested revisions were implemented, enhancing clarity, safety for student use, and ease of implementation for teachers. At the conclusion of this stage, the learning materials were considered fully prepared for both limited and extended trials in the Implementation phase.

Table 3. Summary of findings from the development stage

Developed Component	Development Activities	Key Findings	Implications
RBL-STEM Teaching Module	Compiled based on RBL-STEM syntax, Grade IV science learning outcomes, and instructional design principles.	Module includes objectives, learning sequence, conceptual materials, project guidelines, assessment rubrics, and observation sheets.	Ready for trial and serves as a comprehensive teacher guide for implementation.
RBL-STEM Worksheet	Developed to include investigation, concept exploration, design, experimentation, evaluation, and reflection steps.	Worksheet is practical, user-friendly, and supports research activities and electric broom construction.	Enhances student engagement and learning activity.
Project Media and Guides	Created design guides, step-by-step illustrations, and supporting videos for the electric broom project.	Media are simple, cost-effective, and suitable for project-based learning.	Facilitates student understanding of procedures and minimizes technical errors.
Assessment Instruments	Developed creativity tests, expert validation sheets, practicality questionnaires, observation sheets, and product rubrics.	Instruments incorporate Guilford indicators and align with research objectives.	Supports evaluation of validity, practicality, and effectiveness of the learning materials.

Developed Component	Development Activities	Key Findings	Implications
Expert Validation	Conducted by instructional design experts, subject matter experts, and educational practitioners.	Materials were rated "Valid" with minor revisions suggested (language, layout, activity flow).	Confirms materials are suitable for subsequent trial implementation.
Material Revision	Adjustments based on expert feedback: language improvement, tool safety instructions, simplification of project steps, and refinement of creativity rubrics.	Materials are clearer, safer, and more accessible to teachers and students.	Learning materials are ready for the Implementation stage (limited and extended trials).

The validation results of the RBL-STEM learning materials indicate that all components including the teaching module, worksheets, project media and guides, assessment instruments, language and presentation, as well as alignment with RBL-STEM syntax and curriculum learning outcomes, received an overall rating in the valid category. Evaluations from the three validators confirmed that the materials meet content accuracy, clarity of presentation, appropriateness of instructional steps, and alignment with the objectives of fostering creativity and environmentally friendly technological innovation. The overall average score of 3.50 suggests that the materials are suitable for instructional use, requiring only minor revisions as recommended by the experts to improve instructional clarity and presentation quality. Therefore, the developed learning materials are considered ready for implementation in both limited and extended trials.

Table 4. Validation results of RBL-STEM learning materials

Assessed Component	Validators			Average	Category
	1	2	3		
Teaching Module	3.6	3.4	3.5	3.5	Valid
RBL-STEM Worksheet	3.5	3.3	3.6	3.47	Valid
Project Media and Guides	3.4	3.5	3.3	3.4	Valid
Assessment Instruments	3.7	3.5	3.4	3.53	Valid
Language and Presentation	3.5	3.4	3.5	3.47	Valid
Alignment with RBL-STEM Syntax	3.6	3.5	3.5	3.53	Valid
Curriculum Alignment (CP/TP)	3.7	3.5	3.6	3.6	Highly Valid
Overall Average				3.50	Valid

The results of the Implementation stage indicate that the RBL-STEM learning materials effectively enhanced students' learning outcomes and creativity. Descriptive analysis showed an average N-Gain score of 0.5617, ranging from 0.41 to 0.71, indicating a medium to high level of improvement. This suggests that following the application of research and engineering based learning materials, students demonstrated increased conceptual understanding, critical thinking skills, and creativity in problem solving through the electric broom project using recycled cardboard. The variation in N-Gain scores also reveals that some students achieved substantial gains, highlighting the effectiveness of the materials in accommodating diverse learning needs.

Table 5. Summary of findings from the implementation stage

Variable	N	Minimum	Maksimum	Mean	Std. Deviation	Category
N-Gain Score	28	0.41	0.71	0.5617	0.08481	Medium to High
N-Gain Percentage (%)	28	40.54	71.43	56.17	8.48	Medium

Furthermore, the average N-Gain percentage of 56.17% falls within the medium category, reinforcing the effectiveness of RBL-STEM learning materials in elementary science and STEM instruction. The range of 40.54% to 71.43% indicates that most students benefited from investigation, concept exploration, design, and

product evaluation activities conducted during the learning process. The implementation of these materials not only enhanced cognitive understanding but also promoted student motivation and engagement through contextual and meaningful project activities. Consequently, the results demonstrate that RBL-STEM materials are suitable as an instructional approach that effectively fosters creativity and measurable improvements in learning outcomes.

Table 6. Summary of results from the evaluation phase

Evaluated Aspect	Evaluation Findings	Conclusion / Implications
Validity Evaluation	The average score from expert validation was 3.50, falling within the valid category. All components are ready for use with minor adjustments.	The learning materials are appropriate for implementation in actual classroom settings.
Practicality Evaluation	Responses from students and teachers indicated a very practical category (≥ 90%). Worksheets are clear, instructions are easy to follow, and project activities are comprehensible.	The materials are easily implemented and well received by both teachers and students.
Effectiveness Evaluation	The average N-Gain Score was 0.5617 (medium category) with an N-Gain Percentage of 56.17%. Students showed notable improvement in creativity and learning outcomes.	The materials effectively support the development of creativity and conceptual understanding.
Learning Process Evaluation	Students exhibited high engagement, enthusiasm, and active participation in investigation, experimentation, and product design activities.	The RBL-STEM learning process was successfully implemented and supports 21st-century competencies.
Student Product Evaluation	Students successfully created electric brooms from cardboard with diverse designs, functional performance, and high creativity.	The project aligns with learning objectives related to engineering skills and environmentally friendly innovation.
Final Revision Evaluation	Adjustments included refining worksheet presentation, simplifying instructions, improving the creativity rubric, and enhancing media.	The materials are ready for broader dissemination and classroom application.
Overall Feasibility	Overall, the materials were valid, practical, and effective.	The learning materials are considered feasible and ready for final deployment.

The evaluate stage was conducted to assess the overall quality of the RBL-STEM learning materials following validation, implementation, and revision processes. The evaluation results indicate that the materials met the criteria for validity, practicality, and effectiveness, as evidenced by an average expert validation score of 3.50 (valid category), highly positive responses from students and teachers, and an improvement in learning outcomes with an average N-Gain of 0.5617, falling within the medium category. The evaluation of the learning process revealed that students actively participated in investigation, experimentation, and product design activities. Furthermore, the evaluation of student products demonstrated that all groups successfully created electric brooms from cardboard, exhibiting both creativity and functional performance. Final revisions were carried out to refine presentation, clarify instructions, and enhance assessment rubrics, resulting in learning materials that are ready for broader application in elementary school science instruction based on RBL-STEM.

Discussion

The RBL-STEM based learning implemented in this study proved to provide a more meaningful learning experience for students, as they not only acquired theoretical concepts but also applied them directly through research and product engineering activities (Gita, Waris, et al., 2023). During the problem identification phase, students were engaged in understanding real environmental issues in their surroundings, specifically the accumulation of cardboard waste that had not been properly utilized (Adrillian et al., 2024). This direct involvement heightened students' environmental awareness and motivated them to develop creative solutions. The integration of research-based learning across problem formulation, data collection, experimentation, and solution testing provided a structured learning process that enabled students to cultivate critical and scientific thinking skills from the outset (Alvin et al., 2025).

The "Transforming Used Cardboard into an Electric Broom" project offered students a practical context to explore the application of STEM concepts in daily life. In the science domain, students gained knowledge of basic electrical energy, motion forces, and material properties (Fikriyah & Sukmawati, 2022). In terms of technology and engineering, students practiced designing, constructing prototypes, and refining their designs based on trial results (Delfianza et al., 2023). The mathematics component was integrated through activities such as measurement, material calculation,

and proportion planning for product design. The holistic engagement of all four STEM elements transformed this project into more than a practical activity; it served as a platform for developing engineering-based problem-solving competencies (Guntur et al., 2025).

The learning process demonstrated a significant development of students' creativity, particularly across the four Guilford indicators, namely fluency, flexibility, originality, and elaboration. Students were able to generate numerous alternative ideas for utilizing cardboard, explore various potential designs and mechanisms for the electric broom, and produce unique and functionally valuable prototypes (Cheng & Bololia, 2024). This enhancement of creativity was facilitated by the RBL-STEM learning materials, which provided opportunities for brainstorming, design exploration, experimenting with new solutions, and revising outcomes based on component testing (Amanda et al., 2024). The use of creativity rubrics and guided support through research-based learning further enabled students to systematically reflect on and refine their ideas (Gita et al., 2024).

Beyond fostering creativity, the implementation of the learning materials significantly enhanced students' engagement and active participation throughout the learning process. Observations indicated that students were more enthusiastic and actively participated in group discussions, material analysis, component assembly, and performance testing of the electric broom. The project- and research-based activities made learning more contextual and enjoyable, enabling students not only to understand concepts but also to develop a sense of ownership over the products they created. Positive responses from both students and teachers further confirmed that the RBL-STEM learning materials are practical and suitable for use in elementary school science instruction (Renita, 2023).

In general, the implementation of RBL-STEM learning materials proved effective in enhancing students' creativity, promoting divergent thinking, and fostering a comprehensive understanding of environmentally friendly technological innovation processes (Gita, Waris, et al., 2023). The electric broom project using used cardboard served not only as a contextual learning medium but also as a means to instill sustainability values through upcycling waste into functional products (Juliastari et al., 2022). These findings reinforce that integrating research-based learning with STEM constitutes a relevant educational strategy for addressing twenty-first century learning demands, particularly in cultivating a generation that is creative, environmentally conscious, and capable of producing simple yet practical technological innovations (Fatah et al., 2025).

The study results indicate that the developed learning materials effectively enhanced students' creativity. Guilford's creativity indicators fluency, flexibility, originality, and elaboration showed notable improvement throughout the design and prototype development process (Ariawan et al., 2023). Students generated various alternative ideas for broom shapes, cardboard arrangements, and modifications to the driving mechanism. They demonstrated greater flexibility in thinking and were more open to revising their designs following trial testing. Brainstorming sessions and design sketches in the student worksheets effectively facilitated creative ideation, while the creativity rubric supported systematic self-evaluation and iterative product improvement (Fauzia et al., 2024).

Project-based learning implemented through the RBL-STEM learning materials also demonstrated a significant increase in student engagement and motivation. The classroom became more dynamic as students collaborated in groups, engaged in discussions, assembled components, and conducted trials on the performance of the electric broom they created (Alvin et al., 2025). This process fostered collaboration, communication, and a sense of responsibility among group members. Observations indicated that students were more enthusiastic when confronted with real-world challenges that required problem-solving, particularly when they could observe tangible outcomes from their efforts (Jamebozorg et al., 2022). These findings align with the developmental characteristics of elementary school students, who prefer concrete and experiential learning activities (Atsilnaura et al., 2024).

In terms of teacher perspectives, the developed learning materials were considered practical because they provide comprehensive guidance through teaching modules, student worksheets, creativity rubrics, and easily applicable assessment instruments (Christina et al., 2025). Teachers reported that the structured RBL-STEM approach, covering investigation, experimentation, design, and product evaluation, facilitated the teaching process. The standardized materials also enabled teachers to manage time effectively, support group activities, and conduct creativity assessments more objectively (Cheng & Bololia, 2024). Therefore, these learning materials demonstrate strong potential for sustainable implementation in elementary school science education (Hariyantini et al., 2025).

The findings of this study confirm that RBL-STEM learning serves as an effective approach for enhancing students' creativity while fostering sustainability values through environmentally friendly technological innovations. The project of creating an electric broom from used cardboard not only hones students' scientific

and engineering skills but also cultivates awareness of waste management and the reuse of simple materials (Fitri et al., 2025). These findings indicate that well-designed learning materials can positively impact the quality of instruction and the development of twenty-first century competencies (Patras et al., 2024). With the support of teachers and adequate school readiness, RBL-STEM materials hold strong potential for broader implementation in project-based learning at the elementary education level (Miskiyah & Safitri, 2023).

The Development phase represents the core of the RBL-STEM learning material development process, as it transforms the initial designs created during the Design phase into complete, systematic, and ready-to-test instructional materials. The preparation of teaching modules, student worksheets, project media, and assessment instruments was carried out with consideration of elementary students' characteristics and the objectives of science learning, which emphasize research skills and creativity. Each component was aligned with the RBL-STEM framework to ensure a structured learning process from problem identification to the evaluation of the electric broom prototype made from used cardboard (Gita, Waris, et al., 2023).

In general, the Development phase produced well-prepared RBL-STEM learning materials ready for testing in the Implementation stage. Revisions made based on expert feedback enhanced the quality of the materials, ensuring they better met the needs of teachers and students while remaining safe for use in project-based learning (Fidela & Fadilah, 2024). The success of this phase demonstrates that effective instructional material design requires collaboration among theoretical foundations, practical considerations, and expert evaluation (Rachman et al., 2024). With validated materials, the study can proceed to the next stage to assess how these resources contribute to enhancing creativity and environmentally friendly technological innovation skills among elementary school students (Allolinggi et al., 2024).

Expert validation indicated that the developed RBL-STEM learning materials met the criteria for content feasibility, construct, and readability (Nurdiyanti et al., 2022). Each component, including the teaching module, student worksheets, project media, and assessment instruments, aligned with the principles of research and engineering based learning. The overall average score fell within the valid category, demonstrating that the materials possess an appropriate structure, are relevant to the learning objectives, and effectively support investigative activities and environmentally friendly technological innovation (Ubaidah et al., 2025). This evaluation confirms that the materials are suitable for elementary science instruction, which emphasizes concept exploration through hands-on experiences (Maria, 2025).

The validation process also revealed several aspects requiring improvement to enhance usability for both teachers and students. Validator feedback primarily addressed the simplification of language, refinement of visual presentation, and clarification of procedural steps in the cardboard electric broom project. Revisions based on these suggestions were crucial for improving the readability of the materials, providing clearer guidance within the student worksheets, and ensuring that the learning sequence aligns with the developmental capabilities of elementary students. Adjustments to the creativity rubric further strengthened the assessment instruments, making them more measurable and consistent with the indicators of fluency, flexibility, originality, and elaboration.

Overall, the validation process confirmed that the RBL-STEM learning materials are ready for implementation to assess their practicality and effectiveness in real classroom settings (Gita, Waluyo, et al., 2023). The high validity indicates that the materials have been systematically designed, aligned with curriculum requirements, and relevant to the goals of fostering creativity and environmentally friendly technological innovation. With strong theoretical and structural feasibility, these materials have the potential to positively influence students' learning experiences, particularly in developing creative thinking skills and problem-solving abilities through contextual projects involving simple technology (Jamebozorg et al., 2022).

The implementation of the RBL-STEM learning materials demonstrated that the learning process became more structured, meaningful, and challenging for students (Patras et al., 2024). The research-based approach engaged students actively from the outset in identifying problems, collecting data, conducting experiments, and designing technological solutions through the project Transforming Used Cardboard into an Electric Broom. This activity not only emphasized the understanding of science concepts but also fully integrated elements of technology, engineering, and mathematics, making learning relevant to real-life contexts. Such engagement encouraged students to develop higher-order thinking skills and creativity.

The N-Gain Score data from 28 students indicated an average learning gain of 0.5617, falling within the moderate category. The minimum score of 0.41 and the maximum score of 0.71 reflected a range of improvements from moderate to high among the students. These results suggest that the learning materials effectively supported most students in enhancing their conceptual understanding. Although not all students reached the high category, the relatively

even distribution of scores demonstrates that the materials were able to accommodate diverse learning needs (Hake, 1999).

The mean N-Gain percentage of 56.17% provides further evidence that the implemented learning approach positively influenced students' academic achievement and creative performance. The improvement scores, which ranged from 40.54% to 71.43%, suggest that none of the students demonstrated low learning gains, while a proportion achieved high levels of improvement. These findings indicate that the project involving the development of an electric broom made from recycled cardboard served as a meaningful learning experience, fostering higher-order thinking, creative idea development, and a deeper understanding of science concepts related to electrical energy, force, and material characteristics (Juwitasari, 2023).

A key factor contributing to the effectiveness of the implementation lies in the instructional design, which is closely aligned with the characteristics of RBL STEM learning. The student worksheets were developed to incorporate systematic stages of investigation, conceptual exploration, prototype design, and tool performance evaluation, providing students with clear guidance throughout the project completion process (Miskiyah & Safitri, 2023). In addition, the teaching modules, supported by detailed instructions and supplementary learning materials, assisted teachers in facilitating instruction in a consistent and structured manner. This strong alignment between the instructional materials and the learning process enabled students to engage in both autonomous learning and collaborative group work (Tamaji et al., 2025).

A substantial increase in student participation was observed during the implementation stage of the learning activities. Learners showed high levels of enthusiasm when conducting measurements, assembling simple components, evaluating the performance of the electric broom, and refining their design prototypes (Fikriyah & Sukmawati, 2022). Such active participation aligns with the core principles of project-based learning, which emphasize experiential processes that allow students to experiment, make mistakes, revise their work, and develop creative solutions (Fidela & Fadilah, 2024). These learning activities contributed meaningfully to the enhancement of students' creativity, which was ultimately reflected in the increased N-Gain scores.

RBL–STEM-based instruction demonstrated higher levels of student motivation and more positive learning responses compared to conventional learning approaches (Adrillian et al., 2024). Students were given autonomy to design products and incorporate personal creative elements, which fostered a strong sense of ownership toward their work (Fidela & Fadilah, 2024). Furthermore, the use of recycled materials such as cardboard contextualized the learning experience within students' everyday lives and aligned it with environmental issues. Consequently, the learning process became not only engaging but also meaningful, as students were able to recognize the real-world relevance and practical value of the projects they developed (Ubaidah et al., 2025).

The implementation of RBL–STEM instructional instruments contributed positively to teachers' pedagogical effectiveness. The availability of structured teaching modules and integrated assessment frameworks enabled teachers to conduct learning activities in a more focused and efficient manner. Moreover, the incorporation of creativity-based rubrics facilitated more systematic and objective evaluation of both students' learning processes and project outputs. Accordingly, these instructional instruments functioned not only as learning supports for students but also as mechanisms for enhancing the overall quality of classroom instruction (Alvin et al., 2025).

In general, the results of the implementation stage demonstrate that RBL-STEM instructional tools are effective in improving students' learning outcomes and creativity. Moderate to high N-Gain values, supported by positive responses from both students and teachers, indicate that these instructional tools are appropriate for wider application across different classes and educational levels (Delfianza et al., 2023). Research- and engineering-oriented learning activities embedded in environmentally friendly technology projects have been shown to facilitate the development of key 21st-century competencies, including creativity, collaboration, problem-solving, and STEM literacy (Cheng & Bololia, 2024). Therefore, these instructional tools exhibit strong potential to serve as an innovative learning model that aligns with current educational needs.

The final evaluation results indicate that the developed RBL-STEM instructional tools have met the required standards in terms of validity, practicality, and effectiveness. An average expert validation score of 3.50 places the instructional tools within the valid category, reflecting adequacy in content quality, alignment of instructional syntax with the RBL STEM approach, and coherence between learning materials and the curriculum's learning outcomes and objectives. This level of validity confirms that the instructional tools were designed in a systematic, logical, and consistent manner, allowing them to function as reliable guides for both classroom instruction and educational research (Alvin et al., 2025). Furthermore, the evaluation verifies that the conceptual framework, project implementation

stages, and assessment instruments satisfy appropriate pedagogical standards for the elementary school level.

Conclusion

This study produced RBL–STEM instructional tools that are valid, practical, and effective in enhancing students' creativity and learning outcomes through an environmentally friendly technological innovation project entitled "Transforming Used Cardboard into an Electric Broom." The development process, guided by the ADDIE model, demonstrated that the resulting instructional tools are well aligned with instructional needs, elementary school students' characteristics, and current curriculum demands. Expert validation results classified the instructional tools as valid, while feedback from both students and teachers indicated that the tools were easy to use and engaging. These findings provide evidence that the developed instructional tools possess both theoretical soundness and practical feasibility to support research- and engineering-based science learning. The application of the developed instructional tools led to a marked enhancement in students' abilities, as reflected in an average N-Gain score of 0.5617 and an N-Gain percentage of 56.17%, both falling within the moderate improvement category, as well as students' ability to produce functional and creatively designed electric broom products. The concluding evaluation indicates that RBL–STEM instructional tools effectively strengthen students' conceptual understanding of science while simultaneously promoting creativity, collaborative competence, and environmental awareness. Consequently, these instructional tools demonstrate strong feasibility for wider adoption as an innovative instructional model to facilitate the development of 21st-century skills in elementary school settings.

Acknowledgments
The authors would like to express their sincere gratitude to the academic supervisors and the Learning Technology Study Program of the Graduate School at Universitas PGRI Argopuro Jember for their guidance and support throughout this study.

Author Contributions
For research articles with several authors, a short paragraph specifying their individual contributions must be provided. Conceptualization and Methodology, A. S.; Validation, and Formal analysis, R. S. D. G. Verification, and Editing, E. T.; All authors have read and agreed to the published version of the manuscript.

Funding
This research received no external funding.

Conflicts of Interest
The authors declare no conflict of interest

References

Adrillian, H., Mariani, S., Prabowo, A., Zaenuri, Z., & Walid, W. (2024). Media Pembelajaran Berbasis Game Edukasi Matematika untuk Meningkatkan Motivasi dan Hasil Belajar Peserta Didik: ystematic Literature Review. *S Jurnal Riset Dan Inovasi Pembelajaran*, *4*(2), 751–767. https://doi.org/10.51574/jrip.v4i2.1444

Allolinggi, L. R., Tangkearung, S. S., Pasauran, S. A., Alexander, F., & Allo, M. R. (2024). Strategi Guru Dalam Implementasi Proyek Penguatan Profil Pelajar Pancasila (P5) Berbasis Kearifan Lokal Di Sekolah Dasar. *Jurnal Onoma: Pendidikan, Bahasa, Dan Sastra*, *10*(4), 4596–4605. Retrieved from https://shorturl.asia/k9BQ8

Alvin, A., Robet, R., & Tarigan, F. A. (2025). Implementasi Chatbot Otomatis Akademik Berbasis Web Menggunakan Llm Dan Rule-Based System Studi Kasus: STMIK Time. *Jiko (Jurnal Informatika dan Komputer)*, *9*(3), 651–665. https://doi.org/10.26798/jiko.v9i3.2209

Amanda, S., Jumadi, J., & Sufyadi, S. (2024). Pemanfaatan Aplikasi Canva Sebagai Media Pembuatan Poster Digital Untuk Meningkatkan Kreativitas Siswa Kelas Viii Pada Mata Pelajaran Seni Budaya Di Smp Negeri 24 Banjarmasin. *Eduinovasi: Journal Of Basic Educational Studies*, *4*(1), 598–607. https://doi.org/10.47467/edui.v4i1.5541

Ariawan, I. K. R., Adi, I. P. P., & Suwiwa, I. G. (2023). Media Pembelajaran Berbasis Video Tutorial Menggunakan Model Addie Pada Materi Passing Control Sepak Bola. *Jurnal Ilmu Keolahragaan Undiksha*, *11*(3), 245–251. https://doi.org/10.23887/jiku.v11i3.66639

Arikunto, S. (2019). *Prosedur penelitian: Suatu pendekatan praktik*. Jakarta: Rineka Cipta.

Atsilnaura, S. S., Trisiana, A., & Prihastari, E. B. (2024). Analisis Kemampuan Literasi Numerasi pada Mata Pelajaran Matematika Siswa Kelas I SD N 3 Punung Tahun Ajaran 2022/2023. *Jurnal Pendidikan Tambusai*, *8*, 12290–12295. Retrieved from https://shorturl.asia/VAcZa

BPS, B. P. S. (2024). *Statistik Lingkungan Hidup Indonesia 2024*. Retrieved from https://www.bps.go.id/id/publication/2024/11/29/f24c83748852c605dd2c73cb/statistik-lingkungan-hidup-indonesia-2024

Cheng, Y., & Bololia, L. (2024). The Effects of Augmented Reality On Social Skills In Children with an Autism Diagnosis: A Preliminary Systematic Review.

Journal of Autism and Developmental Disorders, *54*(4), 1317–1331. https://doi.org/10.1007/s10803-022-05878-4

Christina, E. T., Harahap, R. K., Kristyawati, D., Situmeang, A., & Jamilah, J. (2025). Pelatihan Pemanfaatan Simulator Elektronika Online Untuk Perangkat Keras IoT Bagi Siswa Smk Yadika 13 Tambun. *Jurnal Pengabdian Masyarakat Bangsa*, *2*(11), 5401–5407. https://doi.org/10.59837/jpmba.v2i11.1981

Delfianza, E., Mawardi, M., & Suryani, O. (2023). Development of Flipped Classroom Based Guided Inquiry Learning System with Digital Literacy Using Discord Application on Thermochemistry. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 5228–5235. https://doi.org/10.29303/jppipa.v9i7.4245

Fatah, A. N., Gumilar, R., & Sartika, S. H. (2025). Peran Self-Directed Learning Dan Kecerdasan Buatan (Ai) Dalam Meningkatkan Motivasi Belajar Mahasiswa: The Role Of Self-Directed Learning And Artificial Intelligence (Ai) In Improving Student Motivation To Learn. *Cosmos: Jurnal Ilmu Pendidikan, Ekonomi Dan Teknologi*, *2*(3), 463–471. Retrieved from https://cosmos.iaisambas.ac.id/index.php/cms/article/view/250

Fauzia, A., Prastiwi, R., & Anjarwati, A. (2024). Penerapan Model Pembelajaran Radec Untuk Meningkatkan Kreativitas Ilmiah Siswa Kelas V Sdn Jati 01 Kota Probolinggo. *Jurnal Review Pendidikan Dan Pengajaran*, *7*(2), 4291–4297. Retrieved from https://shorturl.asia/8Iu7D

Fidela, W., & Fadilah, M. (2024). Literature Review: Penerapan Model Project Based Learning (Pjbl) Untuk Meningkatkan Hasil Belajar Dan Kemampuan Berpikir Kreatif Siswa Sma. *Jurnal Pendidikan Dan Pembelajaran Indonesia (JPPI)*, *4*(4), 1498–1511. https://doi.org/10.53299/jppi.v4i4.745

Fikriyah, A. N., & Sukmawati, W. (2022). Pengembangan Media Pembelajaran Learning Management System (LMS) Berbasis Moodle pada Materi Perubahan Energi. *Ideas: Jurnal Pendidikan, Sosial, Dan Budaya*, *8*(3), 799. https://doi.org/10.32884/Ideas.V8i3.869

Fitri, H. M., Khaerunnisa, P., Setiawan, E., & Wardoyo, S. (2025). Peningkatan Keterampilan Pra-Vokasional Siswa Smk Melalui Project-Based Learning (Pjbl): Studi Literatur. *Jurnal Pendidikan Dan Pembelajaran Indonesia (JPPI)*, *5*(1), 307–318. https://doi.org/10.53299/jppi.v5i1.996

Gita, R. S. D., Adhim, F., Jayawardana, H. B. A., & Hariyanto, F. (2024). Development Of Android-Based E-Learning Platform With Rbl - Stem Approach To Improve Digital Literacy. *Jurnal Penelitian Pendidikan IPA*, *10*(10), 7597–7605. https://doi.org/10.29303/Jppipa.V10i10.8901

Gita, R. S. D., Waluyo, J., Dafik, & Indrawati. (2023). The Analysis of The Implementation Of RBL-STEM In Improving Students Creative Thinking Skills In Solving The Use Of Chitosan As An Antibacterial For Processed Meat. *European Journal of Education and Pedagogy*, *4*(2), 36–47. https://doi.org/10.24018/Ejedu.2023.4.2.524

Gita, R. S. D., Waris, & Jayawardana, H. B. A. (2023). RBL-STEM Model Learning Activity Framework: Vco (Virgin Coconut Oil) Development Analysis Using Artificial Neural Network To Improve Student Metacognition. In I. H. Agustin (Ed.), *Proceedings Of The 1st International Conference On Neural Networks And Machine Learning 2022 (Iconnsmal 2022)* (pp. 157–173). https://doi.org/10.2991/978-94-6463-174-6_14

Guntur, M., Salsabilla, A., Sahronih, S., & Sholeha, H. H. (2025). Efektivitas Model Problem Based Learning Berbasis Artificial Intelligence-Slidesgo Untuk Meningkatkan Kemampuan Pemecahan Masalah Matematis Siswa Sekolah Dasar. *Prima Magistra: Jurnal Ilmiah Kependidikan*, *6*(1), 1–11. https://doi.org/10.37478/jpm.v6i1.4958

Hake, R. R. (1999). Analyzing Change/Gain Scores. In *Indiana University* (pp. 1–4). Dept of Physics Indiana University. https://doi.org/10.24036/ekj.v1.i1.a10

Hariyantini, M. R., Suwindia, I. G., & Winangun, I. M. A. (2025). Penerapan Model Pembelajaran Discovery Learning Dalam Meningkatkan Literasi Membaca Siswa Sekolah Dasar. *Jurnal Educatio FKIP UNMA*, *11*(1). Retrieved from https://shorturl.asia/zH5qa

Jamebozorg, Z., Sarkeshikiyan, S. M., & Sadat Sarkeshikiyan, M. (2022). The Developing Pedagogical And Psychological Trends and Moocs: A Systematic Review. *Journal of Pharmaceutical Negative Results*, *13*(3), 401–414. Retrieved from https://shorturl.asia/UTP50

Juliastari, J., Artayasa, I. P., & Merta, I. W. (2022). Pengaruh Pembelajaran Berbasis Proyek Dengan Pendekatan Sains Teknologi Masyarakat Terhadap Kreativitas Ilmiah Siswa. *Jurnal Ilmiah Profesi Pendidikan*, *7*(2), 337–343. https://doi.org/10.29303/jipp.v7i2.444

Juwitasari, N. T. (2023). *Meningkatkan Hasil Belajar Siswa Pada Mata Pelajaran IPA Materi Penguasaan Konsep Tekanan Melalui Metode Discovery Learning di Kelas VIII SMP Negeri 2 Kota Bogor* (Vol. 3, Issue 1). https://doi.org/10.33751/jssah.v3i1.7425

Kristiana, A. I., Ridlo, Z. R., Dafik, D., Thoyibah, F., Yanuarsih, E., Murtini, M., & Safrida, L. N. (2024). Pelatihan Literasi Lingkungan Siswa Melalui Rbl-

Stem Pada Guru Dalam Meningkatkan Ketrampilan Berpikir Kreatif'. *Jurnal Pengabdian Masyarakat Khatulistiwa*, *7*(2), 174–180. https://doi.org/10.31932/Jpmk.V7i2.3996

Liufvanni, F. (2025). Pengaruh Metode Pembelajaran Praktikum Berbantuan Stem Terhadap Kemampuan Berpikir Kritis Peserta Didik Kelas X Pada Sub Bab Materi Perubahan Lingkungan di SMA Negeri Darussholah Singojuruh. *Jurnal Penelitian Nusantara*, *1*(9), 108–115. https://doi.org/10.59435/Menulis.V1i10.666

Maria, Q. (2025). *Pengembangan Media Pembelajaran Wordwall untuk Meningkatkan Kegiatan Belajar Peserta Didik pada Mata Pelajaran Ipas Kelas Iv Di SD/MI* [Thesis: UIN Raden Intan Lampung]. Retrieved from https://repository.radenintan.ac.id/37251/

Miskiyah, Z., & Safitri, N. L. (2023). Pengaruh Penggunaan Media Kartu Pintar Terhadap Motivasi Dan Hasil Belajar Siswa Sma Materi Ekosistem. *Al Kawnu: Science And Local Wisdom Journal*, *2*(2). http://jurnal.uin-antasari.ac.id/index.php/alkawnu/article/view/7444

Nurdiyanti, N., Wajdi, M., & Fadhilah, N. (2022). Validitas Dan Kepraktisan Modul Digital Berbasis Socio Scientific Issue. *Jurnal IPA & Pembelajaran IPA*, *6*(1), 33–44. https://doi.org/10.24815/Jipi.V6i1.23461

Patras, Y. E., Yolanita, C., Wildan, D. A., & Fajrudin, L. (2024). Pembelajaran Berbasis STEM di Sekolah Dasar Guna Meningkatkan Kemampuan Berpikir Kritis Dalam Rangka Menyongsong Pencapaian Kompetensi Siswa Abad 21. *Kalam Cendekia: Jurnal Ilmiah Kependidikan*, *12*(2). https://doi.org/10.20961/jkc.v12i2.87662

Pratiwi, A. K., Makhrus, M., Zuhdi, & M. (2021). Pengembangan Perangkat Pembelajaran Berbasis Model Inkuiri Terbimbing Untuk Meningkatkan Kemampuan Literasi Sains Dan Sikap Ilmiah Peserta Didik'. *Jurnal Ilmiah Profesi Pendidikan*, *6*(3), 290–295. https://doi.org/10.29303/Jipp.V6i3.240

Rachman, A., Putro, H. Y. S., Rusandi, M. A., & Situmorang, D. D. B. (2024). The Development And Validation Of The" Kuesioner Tema Proyek Penguatan Profil Pelajar Pancasila"(Kt P5): A New Tool For Strengthening The Pancasila Student Profile In Indonesian Pioneer Schools. *Heliyon*, *10*(16). Retrieved from https://www.cell.com/heliyon/fulltext/S2405-8440(24)11943-3

Renita, L. (2023). *Pengaruh Model Pembelajaran Project Based Learning (PjBL) Berbasis Stem Terhadap Hasil Belajar Peserta Didik Pada Pembelajaran IPA Kelas Iv Di Mis Darul Huda Campang Jaya Kecamatan Sukabumi Bandar Lampung* [Thesis: UIN Raden Intan Lampung]. Retrieved from https://repository.radenintan.ac.id/29225/

Sudjana, N. (2016). *Penilaian Hasil Proses Belajar Mengajar*. Jakarta: Remaja Rosdakarya Offset.

Sugiyono. (2019). *Metode Penelitian Kuantitatif Kualitatif dan R & D*. Bandung: Alfabeta.

Tamaji, T., Dhaniswara, E., & Paramitha, M. (2025). Inovasi Modul Embedded-IoT Sebagai Media Pembelajaran STEM di SMK: Studi Kasus di SMK Siang dan SMK Kawung 1 Surabaya. *Jurnal Abdikarya: Jurnal Karya Pengabdian Dosen Dan Mahasiswa*. Retrieved from https://shorturl.asia/O7Mwq

Ubaidah, N. A. M., Prihaswati, M., & Suprayitno, I. J. (2025). Penerapan Project Based Learning Berbasis Lingkungan Untuk Meningkatkan Keaktifan Siswa. *Edusaintek: Jurnal Pendidikan, Sains, Dan Teknologi*, *12*(1), 404–414. https://doi.org/10.47668/edusaintek.v12i1.1552