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Development of Student Worksheets (LKPD) With a Green Industry Perspective in Science Learning for Grade 4 SDN 12 Kalideres Pagi

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Abstract

This study aims to develop a digital Green Industry-based Student Worksheet (LKPD) for the IPAS subject on Biodiversity material for grade IV elementary school students. The background of this study is the low student learning motivation and outcomes caused by the use of teaching materials that are insufficiently innovative, creative, and contextual. Unlike previous LKPD studies, which generally applied STEAM or PBL approaches without integrating industrial sustainability issues, this study offers novelty by integrating a Green Industry perspective into a digital LKPD for the IPAS subject, systematically developed through the ADDIE model. This study employed the Research and Development (R&D) method with the ADDIE development model. The research subjects consisted of 18 grade IV students and one classroom teacher at SDN 12 Kalideres Pagi. Data collection techniques included observation, in-depth interviews, questionnaires, and documentation. The research instruments consisted of validation sheets from material experts, language experts, and education experts, as well as teacher and student response questionnaires. The validation results showed that the LKPD obtained feasibility scores of 85% from the material expert, 100% from the education expert, and 92.5% from the language expert. At the implementation stage, the small-scale trial (6 students) obtained a mean score of 3.73 with a validity percentage of 94%, while the medium-scale trial (9 students) obtained a mean score of 3.93 with a validity percentage of 98%. Based on all these results, the Green Industry-based IPAS LKPD was declared highly feasible, valid, and effective. This product proved capable of increasing student learning motivation, strengthening understanding of biodiversity material, and fostering environmental awareness in students from an early age.
Keywords: LKPD; Green Industry; Science Learning; Digital Learning.

Abstrak

Penelitian ini bertujuan untuk mengembangkan Lembar Kerja Peserta Didik (LKPD) digital berbasis Green Industry pada mata pelajaran IPAS materi Keanekaragaman Hayati untuk siswa kelas IV Sekolah Dasar. Latar belakang penelitian ini adalah rendahnya motivasi dan hasil belajar siswa yang disebabkan oleh penggunaan bahan ajar yang kurang inovatif, kurang kreatif, dan tidak kontekstual. Berbeda dari penelitian LKPD terdahulu yang

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umumnya menggunakan pendekatan STEAM atau PBL tanpa mengintegrasikan isu keberlanjutan industri, penelitian ini menawarkan kebaruan berupa integrasi perspektif Green Industry ke dalam LKPD digital mata pelajaran IPAS, yang dikembangkan secara sistematis melalui model ADDIE. Penelitian ini menggunakan metode Research and Development (R&D) dengan model pengembangan ADDIE. Subjek penelitian terdiri dari 18 siswa kelas IV dan satu guru kelas di SDN 12 Kalideres Pagi. Teknik pengumpulan data meliputi observasi, wawancara mendalam, angket, dan dokumentasi. Instrumen penelitian terdiri dari lembar validasi ahli materi, ahli bahasa, dan ahli pendidikan, serta angket respons guru dan siswa. Hasil validasi menunjukkan bahwa LKPD memperoleh skor kelayakan sebesar 85% dari ahli materi, 100% dari ahli pendidikan, dan 92,5% dari ahli bahasa. Pada tahap implementasi, uji coba skala kecil (6 siswa) memperoleh rerata skor 3,73 dengan persentase kevalidan sebesar 94%, sedangkan uji coba skala sedang (9 siswa) memperoleh rerata skor 3,93 dengan persentase kevalidan sebesar 98%. Berdasarkan seluruh hasil tersebut, LKPD IPAS berbasis Green Industry dinyatakan sangat layak, valid, dan efektif. Produk ini terbukti mampu meningkatkan motivasi belajar siswa, memperkuat pemahaman terhadap materi keanekaragaman hayati, serta menumbuhkan karakter peduli lingkungan pada siswa sejak dini.
Kata kunci: *LKPD; Green Industry; Pembelajaran IPAS.*

INTRODUCTION

Education plays a crucial role in life; through education, one can develop personal qualities such as logical, creative, and critical thinking. In this context (Khoiri & Peterianus, 2021). Learning activities are not merely limited to training and instruction, but also encompass the development of problem-solving skills. Thus, learning that aims to sharpen problem-solving skills requires effective and innovative teaching materials (Eka Liana, 2018).

Teaching materials are the most important component in the implementation of the learning process. Through teaching materials, teachers are assisted in implementing the learning process, and students find learning more accessible and effective. Teaching materials can also be adapted to the needs and characteristics of students and the material to be delivered (Djamila Paputungan et al., 2024). Teaching materials are closely related to the content of every subject and must be adapted to the learning objectives, learning strategies, and student characteristics. Teaching materials contain information provided in physical and electronic forms, used by students to achieve learning objectives. So that the learning process runs well in accordance with its objectives, teaching materials should be compiled not only as a collection of information, but also as a guide for students, providing relevant tasks and supporting the achievement of learning outcomes (Nur Amalia Ramadhani et al., 2024).

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LKPD, or Student Worksheet, a pedagogical tool used by teachers and students throughout the learning process, incorporating various elements designed to enhance student engagement and facilitate meaningful learning experiences. LKPD is defined as printed teaching materials in the form of sheets containing learning tasks completed by students in reference to the Basic Competencies (KD) to be achieved (Sulasriani et al., 2023). One of the subjects that plays an important role in developing logical and critical thinking skills is IPAS (Integrated Science and Social Studies) lessons (Darniyanti et al., 2023). The implementation of the Independent Curriculum (Kurikulum Merdeka) in elementary schools, including in IPAS learning, requires the support of innovative and contextual teaching materials to achieve learning objectives optimally (Alimuddin, 2023).

A number of previous studies have proven the effectiveness of Student Worksheet (LKPD) development in various learning contexts (Novitasari et al (2023) developed a STEAM-based LKPD on the theme of environmental conservation for grade V elementary school students, which showed highly valid, very practical, and effective results based on improvements in students' pretest and posttest scores. Research by Esa Fitriana Khoirun Nisak & Endang Susantini (2023) also demonstrated that a PBL-based E-LKPD on the topic of environmental change was highly effective in improving students' problem-solving abilities, with an achievement rate of 99–100%. However, neither study integrated a green industry perspective into IPAS content for grade IV, nor used the ADDIE model to systematically develop such material this is the gap that distinguishes the present study. Building on these previous studies, the researchers therefore developed an LKPD with a green industry perspective for IPAS learning in grade IV at SDN 12 Kalideres Pagi, as a more current, contextual, and relevant solution to the needs of today's students.

Based on observations conducted at SDN 12 Kalideres Pagi, most all teachers across lower and upper grade levels already use Student Worksheets (LKPD) in the learning process; however, most of them still rely on LKPDs provided by the school . This means not all teachers have yet developed their own LKPDs that can help students express their ideas actively, creatively, and innovatively heir ideas. As a result, students are lack sufficient learning motivation, which in turn negatively affects their learning outcomes. Low student learning motivation is one of the main problems that needs to be addressed through updated strategies and teaching materials in elementary schools (Suparman & Junaidin, 2023). Therefore, the development of LKPD is needed to improve student learning outcomes (Sajudin, 2025).

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Based on this background, the present study aims to (1) analyze the need for an LKPD with a green industry perspective in grade IV IPAS learning, (2) design and develop such an LKPD using the ADDIE model, and (3) evaluate the validity, practicality, and effectiveness of the developed LKPD when implemented at SDN 12 Kalideres Pagi.

RESEARCH METHODS

Research Design

This study employed the Research and Development (R&D) method because it aims to produce a product in the form of a Student Worksheet (LKPD) with a green industry perspective that is valid, practical and effective for use in IPAS learning for grade IV elementary school (Okpatrioka, 2023). The R&D method was chosen because it is consistent with the research objectives, which are not only to produce a new product, but also to systematically test its feasibility and effectiveness through a series of structured stages. This approach focuses on a development process grounded in empirical data that has been validated through a series of systematic stages (Ade Rahayu, 2025).

In this study, the product developed is an IPAS LKPD for grade IV elementary school. The development model used is the ADDIE model designed by Robert Maribe Branch. The purpose This model was chosen to produce a new product through 5 stages: analysis, design, development, implementation, and evaluation. The ADDIE model was selected because its stages are clear and its development procedures are structured, making it the most relevant model (Zamsiswaya et al., 2024).

Research Setting and Participants

This study was conducted at SDN 12 Kalideres Pagi, West Jakarta, over the period of September 2025 to May 2026. The research subjects and data sources consisted of:

- One fourth-grade classroom teacher (Mrs. Putri Elisa, S.Pd.), who served as a practitioner respondent providing input on the practicality of the developed LKPD.
- 18 fourth-grade students, who served as the end-users of the product and provided response data at both medium- and Small-scale trial phases.

In addition, the study involved expert validators namely a subject matter expert, and a language expert who assessed the feasibility of the product prior to field trials.

Product Development Procedure

The development procedure followed the five stages of the ADDIE model, adapted to the context of this study:

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Edisi : Vol. 10, No. 2, Juni/2026, hlm. 499-516

- Analysis: A needs analysis (Training Needs Analysis/TNA-based approach) was conducted to identify curriculum requirements, characteristics of grade IV students, and the gap between existing teaching materials and the green industry perspective intended to be integrated into IPAS learning.
- Design: Based on the analysis findings, the LKPD framework was designed, including learning objectives, content structure, activity types, and the integration of green industry themes into the IPAS syllabus for grade IV.
- Development: The initial LKPD draft was developed and then validated by subject matter, and language experts. Revisions were made iteratively based on validators' qualitative feedback (suggestions and criticism) and quantitative scores.
- Implementation: The revised LKPD was tested in the classroom setting through medium-scale and Small -scale trials involving the fourth-grade students and their teacher, to observe practicality and usability in an authentic learning environment.
- Evaluation: Both formative evaluation (conducted throughout each stage) and summative evaluation (conducted after implementation) were carried out to assess the overall validity, practicality, and effectiveness of the final product.

Instruments

Data were collected using the following instruments:

- Expert validation questionnaires: separate instruments for subject matter, and language experts, used to assess content accuracy, visual/design quality, and language appropriateness of the LKPD.
- Teacher response questionnaire: used to capture the practicality of the LKPD from the teacher's perspective.
- Student response questionnaires: administered at both medium-scale and Small-scale trial phases to measure product practicality and student engagement.
- Observation guidelines: used during classroom implementation to record student interaction with the LKPD.
- Interview guidelines: used in semi-structured interviews with the teacher to obtain qualitative insights on classroom needs and product feasibility.
- Documentation: photographs and records of learning activities during implementation, used as supporting evidence.

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These techniques and instruments align with recommended data collection procedures for LKPD development research, which typically combine observation, interviews, questionnaires, and documentation

Data Analysis

Data in this study were analyzed using two approaches, corresponding to the qualitative and quantitative data types collected:

- Qualitative data (suggestions, criticism, and input from validators and the teacher) were analyzed descriptively to inform revisions at each stage of product development.
- Quantitative data (eligibility scores from expert validation sheets and student response questionnaires) were analyzed using a validity percentage formula, with results interpreted according to standardized eligibility criteria for educational textbooks/materials at the MI/SD level, as presented in Table 1.

Table 1. Eligibility Criteria for the Proportion of Educational Textbooks in MI/SD

Level of Achievement (%)	*Qualification*	*Notes*
86 – 100	*Very decent*	*No Revision Needed*
71 – 85	*Worth it*	*No Revision Needed*
56 – 70	*Enough*	*worth Revision*
41 – 55	*Less*	*worth Revision*
0 – 40	*Very Unworthy*	*Total Revision*

Data Collection Techniques and Instruments

The data collection techniques used in this study included observation, in-depth interviews with teachers, questionnaire distribution, and activity documentation. The research instruments used consisted of validation questionnaires from subject matter experts, media experts, and language experts, teacher response questionnaires, and medium- and large-scale student response questionnaires (Edhie Rachmad et al., 2024).

RESULTS AND DISCUSSION

This study produced a final product in the form of a Digital IPAS LKPD with a *Green Industry* on Biodiversity material for Grade IV. The product development process was carried out systematically following the ADDIE model stages:

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1. **Analysis** (*Analyze):* At this stage, the researchers analyzed the need for teaching materials used at SDN 12 Kalideres Pagi (Putri Sholihah et al., 2024). Based on the needs analysis, students lacked interactive teaching materials, making it difficult for them to understand biodiversity material. Teachers needed alternative digital teaching materials for learning switch from use paper to friendly electronic media environment (Fitria Hidayat & Muhammad Nizar, 2021).
2. **Design**: After the problem is identified , the next step *is* was to design and create a digital-based or paperless LKPD. The design and creation of this LKPD is based on the results of the researcher's observations and analysis. (Tri Rosdianah & Sofwan, 2024). At this stage, the researcher developed the LKPD framework by compiling *cover,* work instructions, learning objectives, materials, practice questions, evaluation, and assessment rubrics (Putri & Badeni, 2026). After that, the researchers compiled the research instrument design, namely questionnaires for, material experts, language experts, teachers, and students (Zajirah et al., 2026).
3. **Development**: At *this* stage, the researcher conducted a validation process to assess whether the media developed was feasible and effective. In this study, validation was carrid out by 3 expert validators that is, expert material, expert language and experts education (Marisa et al., 2023). After that, the researcher tallied the questionnaire results and began revising the media based on suggestions and input from the experts before tested try it to students at school (Imelda & Syafi, 2025).

Material Expert Validation Results Data

Subject matter experts assessed the materials used in developing the LKPD. The validator, who served as a subject matter expert, was Ferry Perdiansyah, M.Pd., a lecturer in Natural Sciences (IPA) at Muhammadiyah University of Tangerang. Complete data presented in Table 2:

Table 2. Validation by Material Experts

No.	Indicator	Score	Criteria
1.	Suitability of Material with Basic Competencies (KD) and Indicators	3	Good
2.	The material in the LKPD is in accordance with the applicable curriculum	4	Very good

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Universitas Ibn Khaldun Bogor
Edisi : Vol. 10, No. 2, Juni/2026, hlm. 499-516

3.	The images/illustrations on the cover and contents are interesting and relevant to the theme.	4	Very good
4.	Presentation of material in a coherent and systematic manner	4	Very good
5.	LKPD increases students' learning motivation and independence	3	Good
6.	Material according to students' ability level	4	Very good
7.	Clear and systematic material	3	Good
8.	The material used is in accordance with the IPAS sub-theme	3	Good
9.	Clarity of the material presented in the LKPD	3	Good
10.	The accuracy and effectiveness of the sentences presented	3	Good
	Total Score / Average	**34/3.4**	**Good**

If seen from the classification table, the research results from the material experts are "Good", at this stage of the assessment in the quantitative data conversion table are included in the interval >3.25 - 4.00, that the level of validity of the data obtained by the research results of the material experts, which is 85%. Therefore, the conclusion of the research results from the material experts developed has been VALID for testing. Based on the provisions of the LKPD development product is said to be suitable for use with improvements.

Language Expert Validation Results Data

Evaluation was conducted by Asih Rosnaningsih, M.Pd. (UMT Language Lecturer), who gave an average score of 3.7 (Very Good), indicating that the grammar, sentences standard and readability instructions in LKPD has in accordance with developments cognitive elementary school students.

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Edisi : Vol. 10, No. 2, Juni/2026, hlm. 499-516

Table 3. Validation by Linguists

No.	Indicator	Score	Criteria
1.	Use sentences in accordance with good and correct Indonesian language rules	3	Good
2.	Use of terms, vocabulary and spelling according to KBBI	4	Very good
3.	Correct use of capital letters and punctuation	4	Very good
4.	The language used is easy for students to understand	4	Very good
5.	The sentences used do not have double meanings (ambiguity)	4	Very good
6.	The sentences used are communicative and encourage student interaction.	3	Good
7.	Language according to the level of cognitive development of students	4	Very good
8.	The language used in sentences is effective and efficient	4	Very good
9.	The language used is standard	3	Good
10.	The instructions are clear and not confusing.	4	Very good
	Total Score / Average	**37/3.7**	**Good**

Based on the classification table, the results of the linguist's research are "Good." The quantitative data conversion table at this stage shows the data range >3.25 - 4.00, indicating that the validity level of the data obtained by the linguist's research is 92.5%. Therefore, the conclusion of the linguist's research is that the developed product is VALID for testing. Based on these provisions, the LKPD development product is considered suitable for use with improvements.

Education Expert Validation (Teacher Response)

Education expert validation was conducted by the grade IV teacher at SDN 12 Kalideres Pagi, namely Putri Elisa, S.Pd., which consisted of 10 statements. Her suggestions and input will be used by the researchers as reference revision. The following For table results validation expert education or teacher:

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Universitas Ibn Khaldun Bogor
Edisi : Vol. 10, No. 2, Juni/2026, hlm. 499-516

Table 4. Education Expert Validation

No.	Indicator	Score	Criteria
1.	Suitability of material with curriculum	4	Very good
2.	The material is arranged in an easy to understand manner	4	Very good
3.	Suitability of material to students' level of thinking	4	Very good
4.	Presentation of material that students remember	4	Very good
5.	Attractive cover design	4	Very good
6.	The size and shape of the letters are easy to understand.	4	Very good
7.	Attractive content design	4	Very good
8.	Clarity of instructions on each worksheet	4	Very good
9.	Make it easier for teachers to implement learning	4	Very good
10.	This LKPD makes teachers and students feel actively engaged in the learning process	4	Very good
	Total Score / Average	**40/4**	**Very Good**

Based on the classification results, the education expert evaluation yielded a rating of "Very Good," falling within the interval of >3.25–4.00 in the quantitative data conversion table. The validity percentage from the education expert's assessment is 100%. Therefore, the LKPD product is declared VALID for testing and is considered suitable for use without revisions.

4. Implementation

After the LKPD developed by the researchers was declared feasible by, material, and language experts, the product was implemented in actual learning activities. The results of this trial served as the basis for further revising the materials developed by

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UIKA Universitas Ibn Khaldun Bogor
Edisi : Vol. 10, No. 2, Juni/2026, hlm. 499-516

the researchers (Sri Rahayu et al., 2025). The product trial was conducted at SDN 12 Kalideres Pagi, with grade IV students as the research subjects. The one-to-one trial, involving 3 students, was conducted on May 6, 2026, the small-scale trial, involving 6 students, was conducted on May 8, 2026 and the medium-scale trial, involving 9 students, was conducted on May 12, 2026. In the first stage, the one-to-one trial involving 3 students, the results of the student response questionnaire indicated several shortcomings in the product developed by the researcher. These results are presented in the assessment table below:

Table 5. One-to-One Trial Assessment Scores

Name	Statement										ST	SM	HS	KL
	1	2	3	4	5	6	7	8	9	10				
1. Aqil	4	3	4	4	3	4	3	3	4	4	36	40	3.6	SB
2.Rva	3	3	4	4	3	3	2	2	4	3	31	40	3.1	B
3.Ndri	3	2	3	4	4	3	4	4	4	4	35	40	3.5	SB
AMOUNT											102	120		

The mean score calculation yielded a result of 3.4. Referring to the classification table, the overall student response questionnaire results indicate that the developed product falls into the Good category for use in the learning process. At this one-to-one trial stage, students generally agreed or rated the product favorably, with an average score of 3.4. The researchers therefore revised the initial product in order to achieve a "Very Good" classification.

The researchers then proceeded to the second stage, the small-scale trial, involving 6 students who provided responses through a questionnaire. Based on the questionnaire results, the researchers concluded that the developed product was highly appealing, making students enjoy the learning process; students were also highly enthusiastic in completing the LKPD. The following is the table of results from the small-scale trial:

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Universitas Ibn Khaldun Bogor
Edisi : Vol. 10, No. 2, Juni/2026, hlm. 499-516

Table 6. Small-Scale Trial Assessment Scores

Name	Statement										ST	SM	HS	KL
	1	2	3	4	5	6	7	8	9	10				
1.Hkl	3	4	4	3	4	4	4	4	4	4	38	40	3.8	SB
2.Sbr	4	3	4	4	4	3	4	4	4	4	38	40	3.8	SB
3.Rsyd	3	4	3	4	4	4	4	4	3	4	37	40	3.7	SB
4. Abzr	3	4	4	4	3	4	4	4	4	4	38	40	3.8	SB
5. Af	4	4	4	4	4	4	4	3	4	4	39	40	3.9	SB
6. Avn	3	4	4	4	4	3	4	4	3	4	37	40	3.7	SB
AMOUNT											227	240		

The mean score calculation yielded a result of 3.73. Referring to the classification table, the overall student response questionnaire results place the developed product into the Very Good category for use in the learning process. The validity score was calculated as 227/240 × 100% = 94%. Based on this result, the small-scale trial group's developed product was declared VALID. The questionnaire results from the small-scale trial also indicated that students were highly interested in the developed product, and that the product met the very good, or strongly agree, criteria, indicating that it can be regarded as highly practical for use. The following is the table of results from the third stage, the medium-scale trial:

Table 7. Medium-Scale Trial Assessment Scores

NR	Statement to										ST	SM	HS	KL
	1	2	3	4	5	6	7	8	9	10				
1. Iva	4	4	4	4	4	4	4	4	4	4	40	40	4	SB
2.Fdl	4	3	4	4	4	4	4	4	4	4	39	40	3.9	SB
3. Ark	4	4	4	4	4	4	4	4	4	4	40	40	4	SB
4.bla	4	4	4	3	4	4	4	4	3	4	38	40	3.8	SB
5.Ctk	4	4	3	4	4	3	4	4	4	4	38	40	3.8	SB
6. Tri	4	4	4	4	4	4	4	4	4	4	40	40	4	SB

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Universitas Ibn Khaldun Bogor
Edisi : Vol. 10, No. 2, Juni/2026, hlm. 499-516

7.Lbn	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**40**	**40**	**4**	**SB**
8. Ndn	4	4	4	4	4	4	4	4	4	4	**40**	**40**	**4**	**SB**
9. Ezl	4	4	4	4	4	4	3	4	4	4	**39**	**40**	**3.9**	**SB**
AMOUNT											**354**	**360**		

The mean score calculation yielded a result of 3.93. Referring to the classification table, the overall student response questionnaire results place the developed product into the Very Good category for use in the learning process. The validity score was calculated as 354/360 × 100% = 98%. Based on this result, the medium-scale trial group's developed product was declared VALID. The questionnaire results from the medium-scale trial likewise indicated that students were highly interested in the product, and that it met the very good, or strongly agree, criteria, confirming that it can be regarded as highly practical for classroom use.

5. Evaluation

The evaluation stage is the final stage of the ADDIE model. This stage includes final revisions to the product developed by the researcher based on suggestions and input from experts and student responses (Sugihartini & Yudiana, 2018).

a. Validity Quality

The validity quality was calculated at the development stage. Validity was assessed by language experts and material experts. According to the language expert, Mrs. Asih Rosnaningsih, M.Pd., the language of the developed LKPD reached an average score of 3.7, categorized as Good. According to the material expert, Mr. Ferry Perdiansyah, M.Pd., the material reached an average score of 3.4, also categorized as Good.

b. Quality of Effectiveness

The quality of effectiveness was also evaluated during the development and implementation stages. This effectiveness assessment was carried out by an education expert, namely the fourth-grade class teacher at SDN 12 Kalideres Pagi, Mrs. Putri Elisa, S.Pd. Based on the education expert's assessment, the LKPD developed by the researchers for the trial reached an average score of 4, meaning strongly agree or very effective. The student response effectiveness assessment based on the medium-scale trial (9 students) also reached an average of 3.93, meaning strongly agree or very effective.

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c. Product Revision

The final product developed was a Student Worksheet (LKPD) on biodiversity for elementary school students. The product was validated by experts in the fields of materials, and language. Revisions were made based on input from the language expert, Asih Rosnaningsih, M.Pd. The product underwent changes before and after the revision process (Oktavius Yoseph Tuta Mago et al., 2022).

Discussion

The integration of the green industry concept in the form of an independent digital transition has proven crucial in boosting student learning motivation. By utilizing gadgets to scan barcode-linked learning videos, student activities became more active and focused, and their learning outcomes improved in a significant way significant . The achievement of student learning competence was strongly supported by the innovative and contextual packaging of the electronic teaching materials. In addition, the paperless format successfully reduced paper use within the school environment, demonstrating the compatibility of modern media use with environmental preservation. This is in line with the findings Gusti Ayu Putu Widiastari & Dwi Puspita (2024) which confirmed that the use of digital learning media is consistently effective in improving students' learning motivation, particularly at the elementary school level.

Furthermore, the integration of technology in teaching materials as developed in this study does not merely serve as a learning aid, but also as a means of building environmental awareness in students from an early age. As emphasized, environmental education integrated systematically into learning will form a sustainable ecological awareness in students. A school culture with an environmental perspective, when applied in a planned and integrated manner, has been proven effective in forming environmentally conscious characters in elementary school students (Baiah & Fadiana, 2024) Thus, the development of a digital, green industry-oriented LKPD not only addresses the need for innovative and contextual learning, but also contributes significantly to the formation of a generation that is both technologically literate and environmentally conscious in line with the spirit of the Independent Curriculum (Kurikulum Merdeka), which encourages meaningful, student-centered learning (Alvina Hermawaty & Iwan Wicaksono, 2026).

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CONCLUSION

Based on the results of the research and development conducted, it can be concluded that the Student Worksheet (LKPD) for IPAS with a Green Industry perspective is declared highly feasible, valid, and effective for use in grade IV elementary school learning. The expert validation results show a feasibility level of 100% from the education expert, 85% from the material expert, and 92.5% (mean score 3.7) from the language expert. In terms of practicality and effectiveness, student responses in the small-scale trial (6 students) reached a validity of 94% with a mean score of 3.73, while the medium-scale trial (9 students) reached a validity of 98% with a mean score of 3.93, and the class teacher gave a perfect effectiveness rating of 4.0. The presence of this barcode-based digital LKPD has proven capable of boosting learning motivation, improving students' understanding of biodiversity material, while also pioneering environmentally friendly, paperless alternative teaching materials at the elementary school level. These results are consistent with the principles of developing valid, practical, and effective digital-based teaching materials in improving critical thinking skills and learning motivation among elementary school students (Ni Putu Ayu Pretty Prawati et al., 2026).

For teachers and schools, this digital, barcode-based LKPD offers a practical, ready-to-use alternative to conventional worksheets, supporting more interactive learning while promoting paperless, environmentally friendly practices in line with the Kurikulum Merdeka. However, this study is limited by its relatively small sample (18 students across all trial stages) at a single school and its reliance on response questionnaires rather than a controlled pretest-posttest design, so the findings cannot yet be broadly generalized.

Future research is therefore recommended to test the product on a larger, more diverse sample across multiple schools, employ an experimental design to more rigorously measure learning outcomes, and expand the Green Industry-based LKPD to other IPAS topics or additional digital features to further strengthen student engagement.

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