

The Development Of A Stem-Based Electronic Student Worksheet (E-Lkpd) For Natural And Social Sciences To Enhance The Critical Thinking Skills Of Fifth-Grade Elementary School Students On The Topic Of The Human Digestive System

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Abstract

This research is motivated by students' low critical thinking skills in Natural and Social Sciences (IPAS) learning, which is indicated by the prevalent use of conventional instructional materials and the suboptimal utilization of digital resources integrating the Science, Technology, Engineering, and Mathematics (STEM) approach. This study aims to produce a valid, practical, and effective STEM-based Electronic Student Worksheet (E-LKPD) for IPAS to enhance the critical thinking skills of fifth-grade elementary school students specifically on the topic of the Human Digestive System. The study employed a Research and Development (R&D) methodology utilizing the ADDIE development model, which encompasses the Analysis, Design, Development, Implementation, and Evaluation phases. The research was conducted at SD Negeri 112330 Tubiran, involving subject matter experts, design experts, linguists, teachers, and fifth-grade students as research subjects. Data were collected through observations, interviews, questionnaires, and critical thinking skills tests. The data were subsequently analyzed using quantitative descriptive techniques to determine the percentages of validity and practicality, as well as inferential statistics utilizing the N-Gain test and Independent Samples t-test. The results indicated that the developed STEM-based IPAS E-LKPD was deemed highly feasible, achieving

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validation scores of 95% from subject matter experts, 95% from design experts, 82% from linguists, and 96% from test instrument experts. The practicality test demonstrated that the E-LKPD fell into the highly practical category, with a student response rate of 98.33% and a teacher response rate of 92.81%. Furthermore, the effectiveness test revealed that the average N-Gain for students' critical thinking skills in the experimental class was 0.550 (moderate category), which was higher than that of the control class at 0.289 (low category). The Independent Samples t-test yielded a Sig. (2-tailed) value of $0.000 < 0.05$, indicating a significant difference in critical thinking skills between students in the experimental class utilizing the STEM-based IPAS E-LKPD and those in the control class using conventional worksheets.

Keywords: E-LKPD, STEM, IPAS, Critical Thinking, ADDIE.

INTRODUCTION

Primary education serves a strategic function in establishing the foundational knowledge, attitudes, and skills required for students to navigate the complexities of scientific and technological advancements (Muliastirni, 2020). Within this educational tier, Natural and Social Sciences (IPAS) emerges as a pivotal subject. IPAS transcends mere conceptual mastery; it necessitates that students employ logical, critical, and systematic thinking to comprehend natural phenomena and their practical implications in daily life. Furthermore, the Kurikulum Merdeka (Independent Curriculum) mandates that IPAS instruction be structured to cultivate 21st-century competencies, with a particular emphasis on critical thinking, problem-solving, creativity, and collaboration (Irawan, 2023).

Critical thinking is an indispensable skill that warrants cultivation beginning at the elementary education level (Relisa & Alwi, 2024). Students equipped with proficient critical thinking abilities can effectively analyze information, evaluate empirical evidence, deduce logical conclusions, and formulate informed decisions grounded in data and factual evidence. Nevertheless, current observational data and empirical research highlight a pervasive deficiency in the critical thinking skills of elementary school students (Winarti et al., 2022). Current pedagogical practices remain predominantly reliant on conventional lecture methods, textbook dependency, and assignments centered on rote memorization. Consequently, students are inadequately engaged in the active processes of knowledge discovery and cognitive construction.



The topic of the human digestive system in fifth-grade elementary school science constitutes an abstract and complex subject matter that necessitates a robust conceptual understanding (Manisa et al., 2025). This material requires students to comprehend the structure and function of digestive organs, the process of food digestion, and their correlation with healthy lifestyle habits. In the absence of appropriate instructional media and learning materials, students frequently encounter difficulties in acquiring an in-depth understanding of these concepts. Consequently, this limitation adversely affects students' proficiency in analyzing problems, contextualizing concepts within real-world scenarios, and cultivating critical thinking skills.

A viable strategy to mitigate these challenges involves the development of innovative and interactive instructional materials, such as the Electronic Student Worksheet (E-LKPD) (Umaroh et al., 2022). The E-LKPD serves as a digital educational resource designed to facilitate both independent and collaborative student learning activities through technological integration. The implementation of E-LKPD enables the delivery of educational content via diverse modalities including text, imagery, video, animation, and interactive exercises thereby enhancing student interest and engagement in the learning process.

The efficacy of E-LKPD development can be further optimized by integrating it with pedagogical approaches aligned with 21st-century educational demands, notably the STEM (Science, Technology, Engineering, and Mathematics) framework (Hendri et al., 2022). The STEM approach amalgamates scientific, technological, engineering, and mathematical concepts into a cohesive, contextual, and problem-based learning paradigm (Muttapiin, 2023). Through STEM-based instruction, students are systematically trained to observe natural phenomena, formulate solutions, conduct fundamental experiments, and critically analyze empirical outcomes. This pedagogical strategy is widely recognized for its capacity to elevate critical thinking skills by directly immersing students in higher-order cognitive processes.

Activities within the STEM approach such as designing solutions, analyzing data, evaluating experimental results, and systematically drawing conclusions align with the indicators of critical thinking skills proposed by Ennis (as cited in Aziz & Haris, 2025). These indicators encompass providing elementary clarification, building basic support, inferring, providing advanced clarification, and executing strategies and tactics. This theoretical integration demonstrates that the STEM approach is conceptually relevant for cultivating the critical thinking skills of elementary school students.



Preliminary observations conducted in a fifth-grade classroom at SD Negeri 112330 Tubiran, specifically during a Natural and Social Sciences (IPAS) lesson on the human digestive system, revealed that the pedagogical process remains predominantly teacher-centered. The instructor delivered the educational material utilizing the standard textbook as the primary resource, subsequently assigning tasks or written exercises from the available printed student worksheets (LKPD). Consequently, student engagement during the lesson primarily consisted of passive listening, taking notes, and answering direct questions. Opportunities for collaborative discussion, contextual problem-solving, and exploratory activities were observed to be significantly limited. Furthermore, the worksheets utilized in the classroom were conventional printed formats containing brief material summaries and standard written exercises. The questions posed were generally factual in nature, such as identifying digestive organs and their respective functions. There was a conspicuous absence of instructional activities designed to guide students in analyzing cause-and-effect relationships, correlating theoretical concepts with daily life, or formulating solutions to practical digestive health problems.

To substantiate the observational findings, a preliminary assessment of critical thinking skills concerning the human digestive system was administered. The results of this initial evaluation revealed that among 24 fifth-grade students, only 8 individuals (33.3%) attained the institutional Learning Objective Attainment Criteria (KKTP) threshold of 75. Consequently, 16 students (66.6%) failed to achieve the required level of mastery. These empirical data demonstrate that the majority of students continue to experience substantial difficulties in comprehending and analyzing the subject matter related to the human digestive system.

Furthermore, the low percentage of academic mastery suggests that the existing instructional process has not sufficiently supported students in cultivating critical thinking skills, specifically in their capacity to analyze information, integrate concepts, and draw valid conclusions. Additionally, the educator indicated a lack of digital teaching materials or instructional tools explicitly designed to enhance students' critical thinking capabilities. Given that current pedagogical practices remain conventional, there is an evident need for more stimulating and interactive instructional resources. Such materials are essential to actively engage students in the learning process, thereby facilitating the improvement of their critical thinking competencies.

The development of a STEM-based Electronic Student Worksheet (E-LKPD) for Natural and Social Sciences (IPAS) serves as a relevant alternative solution to address these issues. Through



the E-LKPD, students can be guided to engage in various learning activities, such as observing phenomena related to the human digestive system specifically its organs and functions, balanced nutrition, and digestive disorders designing simple solutions, and formulating conclusions based on the acquired data and information. The integration of the STEM approach within the E-LKPD enables students to correlate scientific concepts with technological applications, fundamental engineering processes, and the contextual utilization of mathematical principles.

Based on these theoretical reviews and empirical conditions, it can be concluded that a discrepancy remains between curricular demands and the actual pedagogical practices of IPAS in elementary schools, particularly concerning the cultivation of students' critical thinking skills. This discrepancy underscores the necessity for innovative teaching materials that are not solely oriented toward conceptual mastery, but are also systematically designed to exercise the indicators of students' critical thinking. Consequently, there is a requisite for developmental research aimed at producing a valid, practical, and effective STEM-based IPAS E-LKPD focusing on the human digestive system for fifth-grade elementary school students.

This research is anticipated to provide a theoretical contribution to the development of STEM-based digital teaching material models at the elementary school level, specifically in reinforcing critical thinking skills within IPAS instruction. In practical terms, this study is expected to assist educators in designing more innovative and interactive learning experiences. From a policy perspective, the findings of this research can support the implementation of instructional practices that align with the demands of 21st-century competencies, as emphasized in national education policies. Accordingly, this research is entitled "The Development of a STEM-Based IPAS E-LKPD to Enhance Students' Critical Thinking Skills Regarding the Human Digestive System in the Fifth Grade of Elementary School.

METHOD

The research design employed in the development of this STEM-based Electronic Student Worksheet (E-LKPD) utilizes the Research and Development (R&D) method. The R&D methodology is fundamentally applied for the purpose of product development. According to Sugiyono (2015), Research and Development is a scientific approach used to produce a specific product and systematically test its operational effectiveness. This developmental research aims to yield an effective educational product designed to facilitate students in comprehending and assimilating Natural and Social Sciences (IPAS) learning materials.



Furthermore, this study employs specific instruments to assess the validity, practicality, and effectiveness of the STEM-based E-LKPD within a fifth-grade elementary school context. The research procedure is adapted from the ADDIE instructional design model, which encompasses five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. This framework signifies that the research is inherently product-oriented, ensuring that the entire developmental process is articulated with meticulous detail and precision.

This research will be conducted at SD Negeri 112330 Tubiran, located in Marbau Subdistrict, North Labuhanbatu Regency. The selection of this research site is predicated on preliminary observations indicating a necessity for the development of innovative Student Worksheets (LKPD) for Natural and Social Sciences (IPAS) instruction at the institution. Furthermore, no prior studies regarding the development of STEM-based Electronic Student Worksheets (E-LKPD) for IPAS have been executed at this school. The study is scheduled to take place from April to June during the even semester of the 2025/2026 academic year.

The subjects of this study comprise individuals directly participating in the development and empirical testing phases of the STEM-based IPAS E-LKPD. Specifically, the subjects encompass 48 fifth-grade students from SD Negeri 112330 Tubiran, divided into a control group ($n=24$) and an experimental group ($n=24$). These students will serve as trial subjects to evaluate the practicality and effectiveness of the product in enhancing critical thinking skills concerning the human digestive system. Additionally, the fifth-grade teacher will participate as a product user and evaluator to assess the practicality of the STEM-based IPAS E-LKPD during instruction. Expert validators comprising subject matter experts, instructional design experts, and linguistic experts will also serve as subjects to evaluate the feasibility and validity of the developed E-LKPD. The objects of this research are the STEM-based IPAS E-LKPD product focused on the human digestive system for fifth-grade elementary students, alongside the students' critical thinking skills.

The data collection methods employed in this study comprised observations, interviews, questionnaires, and tests. Observations were utilized to monitor the implementation of the instructional process and the students' responses to the STEM-based E-LKPD. Interviews were conducted to acquire in-depth information from educators regarding instructional needs and their perspectives on the developed E-LKPD. Questionnaires were administered to gather data concerning the validity and practicality of the product; these were distributed to subject matter experts, design experts, linguists, teachers, and students. Tests were administered to assess students' critical thinking skills, consisting of both a pretest and a posttest. Prior to



administration, the test instruments were evaluated for validity, reliability, difficulty index, and discriminating power.

The data analysis techniques employed in this research included both quantitative descriptive and inferential analyses. Quantitative descriptive analysis was utilized to process the data pertaining to product validation and practicality using percentage calculations. The criteria for establishing validity and practicality were based on predetermined categorical scales. Inferential analysis was conducted to evaluate the product's effectiveness. An N-Gain test was applied to ascertain the magnitude of improvement in students' critical thinking skills pre- and post-instruction. A normality test was performed as a prerequisite for parametric statistical analysis. Subsequently, an Independent Samples t-test was utilized to determine whether a significant difference existed in the critical thinking skills between students in the experimental and control groups. Hypothesis testing was executed at a significance level of $\alpha = 0.05$. To ensure data integrity, the instruments were subjected to expert validation and empirical testing, thereby confirming their validity and reliability.

RESULTS AND DISCUSSION

Development of the STEM-Based IPAS E-LKPD

The development of a STEM-based Electronic Student Worksheet (E-LKPD) for Natural and Social Sciences (IPAS) focusing on the Human Digestive System was initiated based on the instructional needs of fifth-grade students at SD Negeri 112330 Tubiran. Prior to product development, a preliminary needs analysis was conducted through classroom observations and interviews with the fifth-grade teacher. The interview results indicated that IPAS instruction remains predominantly teacher-centered, with students primarily engaged in passive learning activities such as listening, note-taking, and answering questions. Furthermore, the existing instructional materials are limited to printed worksheets that are heavily oriented toward rote task completion and theoretical mastery. Consequently, students are afforded limited opportunities to observe problems, analyze information, conduct investigations, articulate reasoning, and formulate solutions (Wahono et al., 2022).

This situation underscores the necessity for instructional materials that not only deliver content but also foster active student participation in the educational process. The implementation of an E-LKPD serves as a viable alternative, as electronic instructional materials facilitate a more structured presentation of subject matter, visual aids, activities, and exercises,



thereby effectively guiding students' learning trajectories. This approach aligns with the research conducted by Wahono et al. (2022), who developed an E-LKPD to enhance the critical thinking skills of elementary school students. Their findings demonstrated that an E-LKPD can be effectively utilized as a pedagogical tool to support student engagement in comprehending and resolving complex learning challenges.

Preliminary analyses indicate that students encounter difficulties when confronted with analytical problems, particularly those pertaining to the Human Digestive System. Consequently, there is a critical need for instructional materials designed to guide students beyond mere rote memorization. Such materials should enable them to analyze problems, identify relevant information, construct logical reasoning, formulate solutions, and draw valid conclusions. This necessity serves as the foundational rationale for the development of the STEM-based IPAS E-LKPD in this study (Zuryanty et al., 2020).

Furthermore, in addition to observational and interview data, baseline measurements of critical thinking skills informed the product development process. The pretest results revealed a mean critical thinking score of 51.38 for the control group and 52.29 for the experimental group. These findings demonstrate that the baseline proficiencies of both cohorts were relatively comparable. These initial conditions were strategically considered during the design of the E-LKPD to ensure that the pedagogical activities provide a more meaningful learning experience and effectively cultivate students' critical thinking skills.

The development of the E-LKPD was conducted utilizing the ADDIE model, which comprises the Analysis, Design, Development, Implementation, and Evaluation stages (Sugiyono, 2017). The selection of the ADDIE model was predicated on its systematic developmental phases, ranging from comprehensive needs analysis to the evaluation of the implemented product. The application of the ADDIE framework is also consistent with the research conducted by Oktavianto and Aghni (2022), who developed a STEM-based E-LKPD employing the Analysis, Design, Development, Implementation, and Evaluation stages. The findings of their study indicated that the ADDIE model can be systematically applied in the development of a STEM-based E-LKPD, as well as in assessing its feasibility and the enhancement of student learning outcomes.

During the Analysis stage, the researchers examined the instructional needs, student characteristics, curriculum, learning materials, and the educational environment. The results of this analysis served as the foundational basis for determining the content and characteristics of the E-LKPD. In the Design stage, the researchers formulated the structural framework of the E-



LKPD, learning objectives, instructional materials, STEM activities, tasks designed to cultivate critical thinking skills, and evaluation instruments. Throughout the Development stage, this conceptual design was actualized into a STEM-based Natural and Social Sciences (IPAS) E-LKPD. The E-LKPD was designed to encompass instructional material on the Human Digestive System, which includes the organs and their functions, balanced nutrition, and digestive disorders. These materials were contextualized with issues proximal to the students' daily lives, ensuring that students do not merely memorize concepts but can also correlate them with real-world circumstances (Prastowo, 2019).

The STEM approach was integrated into the E-LKPD activities through the elements of Science, Technology, Engineering, and Mathematics. The Science component was utilized to facilitate the comprehension of digestive system concepts and physiological processes within the body. The Technology element was applied through the adoption of the E-LKPD as an electronic instructional medium. The Engineering component was implemented via activities that required students to determine or design solutions to specific problems. Meanwhile, the Mathematics element was incorporated into activities involving quantitative data or information presented during the learning process. This STEM integration provides students with the opportunity to learn through problem-based scenarios and problem-solving methodologies. Zuryanty et al. (2020) elucidate that STEM education in elementary schools integrates science, technology, engineering, and mathematics through problems relevant to everyday life. Such an approach can stimulate students to think critically, conduct analyses, and resolve complex problems.

Furthermore, the integration of STEM was aligned with the indicators of critical thinking skills. Students were directed to comprehend problems, provide explanations, seek relevant information, analyze data, draw conclusions, and formulate resolution strategies. Consequently, the developed E-LKPD functions not only as a digital instructional resource but also as a medium to provide a learning experience that actively supports the cultivation of critical thinking skills.

During the Implementation stage, the E-LKPD was tested progressively through one-on-one trials, small group trials, and field trials. The outcomes of these trials were utilized to ascertain the readability, usability, clarity of instructions, and user responses to the E-LKPD. Subsequently, the Evaluation stage was executed by analyzing the validation results, teacher and student feedback, as well as the pretest and posttest scores. The evaluation results also encompassed an N-Gain analysis and a two-tailed t-test to determine the improvement and variances in critical thinking skills. Ultimately, the development of the E-LKPD in this study



originated from empirical needs identified through observations and interviews, was systematically developed using the ADDIE model, and was purposefully directed toward integrating STEM and enhancing students' critical thinking skills.

The Validity of the STEM-Based IPAS E-LKPD

The validity of the STEM-based IPAS (Natural and Social Sciences) E-LKPD (Electronic Student Worksheet) was established through a comprehensive validation process conducted by subject matter, media, language, and instructional experts. This validation aimed to evaluate the product's alignment with learning objectives, IPAS content, fifth-grade student characteristics, STEM principles, critical thinking skills, linguistic elements, as well as the visual and functional aspects of the E-LKPD (Rizkika et al., 2022).

The material expert validation yielded a score of 95.00%, indicating that the content presented in the E-LKPD aligns with the targeted learning outcomes, objectives, and the specific topic of the Human Digestive System. The material is systematically structured and contextualized within the students' daily lives. This contextualization is crucial, as the digestive system must be understood not merely as a theoretical concept, but also in relation to eating habits, balanced nutrition, and digestive disorders commonly encountered by students.

The design expert validation resulted in a score of 95.00%, demonstrating that the visual and design elements of the E-LKPD meet the requisite feasibility criteria. The layout, imagery, typography, page presentation, and navigation were specifically engineered to facilitate student utilization of the platform. Furthermore, the electronic format provides a more interactive alternative to the traditional printed worksheets commonly utilized in schools (Arsyad, 2019).

The language expert validation achieved a score of 82.00%, signifying that the linguistic components of the E-LKPD are appropriately tailored to the cognitive characteristics of fifth-grade students. Activity instructions are articulated clearly utilizing accessible language. Linguistic clarity is essential to ensure that students fully comprehend the activity guidelines and can successfully execute the instructional stages.

Based on the conducted assessments, the material expert awarded a score of 95.00%, the design expert 95.00%, and the language expert 82.00%. According to the established evaluation criteria, all three results fall within the "highly valid" category. Subsequently, the test instrument expert validation indicated that the E-LKPD is highly congruent with the designated learning objectives and instructional activities. The activities embedded within the E-LKPD effectively



integrate STEM principles and provide students with vital opportunities to cultivate their critical thinking skills.

Drawing upon the comprehensive validation results presented in Chapter IV, the STEM-based IPAS E-LKPD attained a "highly valid" categorization. Consequently, the developed product has fulfilled the feasibility criteria across material, media, linguistic, and instructional dimensions. These findings are corroborated by the research of Rizkika et al. (2022), who similarly developed a STEM-based E-LKPD. Their study reported a validation score of 96.08%, classified as highly valid. Additionally, their practicality results reached 96.39%, accompanied by an N-Gain score of 0.43 (moderate category). Such outcomes demonstrate that a STEM-based E-LKPD not only satisfies feasibility requirements but also significantly supports the enhancement of students' critical thinking capabilities. Ultimately, the validation results of the current study confirm that the STEM-based IPAS E-LKPD aligns with instructional needs and is deemed highly appropriate for application in the implementation phase.

The Practicality of the STEM-Based IPAS E-LKPD

The practicality of the STEM-based IPAS (Natural and Social Sciences) E-LKPD (Electronic Student Worksheet) was evaluated through individual trials, small group trials, field tests (large group), as well as teacher and student feedback. This phased testing approach was implemented to determine the product's usability and applicability within an authentic educational environment (Wahono et al., 2022). During the individual trial, the E-LKPD achieved a score of 96.67%, classifying it as highly practical. This outcome indicates that students can independently navigate the E-LKPD effectively, comprehend the activity guidelines, and interact with the product's interface. Subsequently, the small group trial yielded a score of 96.94%, which is also categorized as highly practical. This demonstrates that the E-LKPD maintains its user-friendliness when administered to multiple students, enabling them to seamlessly follow the provided activities and understand the given instructions.

In the field test, student feedback reached a score of 98.33%, falling into the highly practical category. This significant percentage reflects an overwhelmingly positive student response toward the integration of the E-LKPD in the learning process. It indicates that students are capable of participating in the activities, grasping the subject matter, and utilizing the E-LKPD as a primary instructional resource. Furthermore, teacher evaluations yielded excellent results; research data demonstrated teacher response percentages of 95.38%, 92.30%, and 90.76%.



These figures suggest that the E-LKPD effectively assists educators in facilitating instruction and serves as a viable alternative teaching material to direct student engagement.

The observed practicality is attributed not only to the E-LKPD's electronic format but also to the systematic structuring of its activities. Students are provided with explicit guidance, progressing from problem comprehension to the formulation of conclusions. Consequently, learners can efficiently execute the instructional steps embedded within the E-LKPD. These findings corroborate the research conducted by Rizkika et al. (2022), which reported a practicality rate of 96.39% (highly practical) for a STEM-based E-LKPD, alongside an 87% student response rate (excellent). Such results reinforce the premise that STEM-based E-LKPDs are well-received and effectively utilized by students during educational activities. Additionally, Wahono et al. (2022) demonstrated that E-LKPDs can be developed into instructional materials that fulfill the criteria of validity, practicality, and effectiveness to foster critical thinking skills in elementary school students.

Based on the comprehensive results derived from the individual, small group, and field trials, along with the constructive feedback from teachers, it can be concluded that the STEM-based IPAS E-LKPD is highly practical for instructional use in teaching the Human Digestive System to fifth-grade students at SD Negeri 112330 Tubiran.

The Effectiveness of STEM-Based Electronic Student Worksheets (E-LKPD) in Natural and Social Sciences

The effectiveness of the STEM-based IPAS (Natural and Social Sciences) Electronic Student Worksheet (E-LKPD) was evaluated through the analysis of pretest, posttest, N-Gain, and two-tailed t-test results. Prior to the instructional intervention, students in both the experimental and control groups ($n = 24$ per group) were administered a pretest to assess their baseline critical thinking skills. The pretest results indicated an average score of 51.38 for the control group and 52.29 for the experimental group. The marginal mean difference of 0.91 points suggests that the initial cognitive abilities of both cohorts were relatively comparable.

Following the implementation of the learning modules, both groups demonstrated academic improvement. The posttest average for the control group increased to 67.71 (a gain of 16.33 points), whereas the experimental group's average rose to 79.71 (a gain of 27.42 points). This disparity in growth indicates that students in the experimental group achieved a more substantial improvement after utilizing the STEM-based IPAS E-LKPD. This advancement is



attributed to the specific learning activities integrated into the E-LKPD, which encompass observing problems, gathering information, analyzing data, conducting investigations, designing or determining solutions, and drawing conclusions (Fithri et al., 2021).

These findings are further substantiated by the N-Gain analysis. The control group recorded an N-Gain of 0.289, which is classified within the low category, while the experimental group achieved an N-Gain of 0.575, falling into the moderate category. The superior N-Gain value of the experimental group indicates that the STEM-based IPAS E-LKPD facilitates a learning experience that more effectively fosters the development of critical thinking skills. Rather than merely memorizing concepts related to the digestive system, students are prompted to apply these concepts to comprehend complex problems and formulate solutions. This outcome is consistent with the findings of Rizkika et al. (2022), who demonstrated that a STEM-based E-LKPD can significantly enhance students' critical thinking capabilities, noting an N-Gain score of 0.43 (moderate category) in their study. Furthermore, these results are supported by Zalsa et al., whose review of 20 studies on STEM application in primary education concluded that the STEM approach positively contributes to the elevation of critical thinking skills among elementary school students. Additionally, research by Wahono et al. (2022) on the development of E-LKPDs emphasized that such digital worksheets serve as viable alternative teaching materials capable of supporting critical thinking in IPAS instruction.

Subsequent statistical evaluation using a two-tailed t-test yielded a Sig. (2-tailed) value of 0.000. Given that $p < 0.05$, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. This confirms a statistically significant difference in critical thinking skills between the experimental and control groups. These statistical findings reinforce both the descriptive and N-Gain analyses. Descriptively, the experimental group's posttest mean (79.71) surpassed that of the control group (67.71), with a corresponding higher point increase (27.42 vs. 16.33). Analytically, the experimental group's N-Gain (0.575, moderate) outperformed the control group's N-Gain (0.289, low). Statistically, the two-tailed t-test confirmed significance (Sig. = 0.000 < 0.05).

In conclusion, all analytical metrics demonstrate a consistent trajectory, establishing that the experimental group achieved superior outcomes compared to the control group. Therefore, the implementation of the STEM-based IPAS E-LKPD is proven to be effective in enhancing the critical thinking skills of fifth-grade students at SD Negeri 112330 Tubiran, specifically concerning the subject matter of the Human Digestive System.



CONCLUSION

The STEM-based Electronic Student Worksheet (E-LKPD) for Natural and Social Sciences (IPAS) has been successfully developed utilizing the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) instructional design model. This developmental innovation was predicated upon a needs analysis, which indicated that the pedagogical process remained predominantly reliant on conventional methods and printed worksheets. Consequently, alternative instructional materials were engineered, specifically formulated to stimulate students' active engagement in problem analysis and the construction of critical thinking skills. The developed E-LKPD product demonstrated exceptional validity and feasibility. This is substantiated by the final validation scores, which achieved 95.00% from subject matter experts, 95.00% from instructional design experts, and 82.00% from linguistic experts. Attaining the "highly valid" criterion confirms that the E-LKPD instrument comprehensively satisfies the feasibility standards across content substance, presentation, design, visual elements, linguistics, and functionality.

Furthermore, the STEM-based IPAS E-LKPD was determined to be highly practical in its application. Evaluation outcomes registered percentages of 96.67% during the one-to-one trial, 96.94% in the small group trial, and 98.33% in the field trial. This degree of practicality was further corroborated by educator feedback across the respective testing phases, yielding scores of 95.38%, 92.30%, and 90.76%. These findings indicate that the E-LKPD possesses substantial accessibility and effectively facilitates the continuity of the instructional process. The application of the STEM-based IPAS E-LKPD also proved efficacious in elevating students' critical thinking skills. Empirical data indicated an average pretest score of 51.38 for the control group and 52.29 for the experimental group. Following the posttest evaluation, the mean scores progressed to 67.71 for the control group (an increment of 16.33) and 79.71 for the experimental group (an increment of 27.42). The N-Gain analysis elucidated that the improvement within the control group fell into the low category (0.289), whereas the experimental group achieved a moderate category (0.550). Finally, hypothesis testing via a two-tailed t-test yielded a Sig. (2-tailed) value of $0.000 < 0.05$, thereby leading to the rejection of the null hypothesis (H_0) and the acceptance of the alternative hypothesis (H_1).



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