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Lumio media development to improve motivation and critical thinking abilities in elementary school students

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Abstract. Science learning in elementary schools is faced with the challenge of conventional media, which results in low motivation and critical thinking skills of students. This study aims to develop Lumio by SMART media through the STEAM approach on the metamorphosis of living things material in elementary schools. This study uses an R&D approach with the MDLC development model. Participants in this study included teachers and 18 third-grade students of SDN Sudo. Data collection methods included observation, interviews, questionnaires, pre-tests, and post-tests. Data were analyzed qualitatively and quantitatively to assess the feasibility of the product. The results of the validity test from the media validator obtained scores of 94% and 98% with a very valid category. The validity test of the material obtained results of 94% and 96%, in the very valid category. The results of the student and teacher questionnaires also showed positive results, namely 94% and 91% with a very good category, thus indicating that this media is feasible and effective to use. The results of the paired sample T-test, with N-Gain values of 0.86 and 0.68, respectively, showed differences and improvements in student learning outcomes. As a follow-up, Lumio by Smart Media is expected to be used to enhance students' learning experiences. Lumio by SMART Media, with its STEAM approach, is recommended for continuous implementation in elementary school science curricula as a concrete solution to improve educational quality, student motivation, and critical thinking skills. It also serves as a reference for teachers and schools in optimizing the use of innovative learning technologies.

Introduction

Natural Sciences and Social Sciences (*IPAS*) is a combined subject of science and social sciences taught in elementary schools since the Independent Curriculum (Dyaning et al., 2023; Purnadewi &Widana, 2023). Science and Natural Sciences reflect a holistic and comprehensive approach in viewing reality, where science and social science are not separated, in accordance with the way of thinking of elementary school students who are still concrete and not detailed (Sa'adah et al., n.d.). The goal is to equip students with a complete understanding of the natural and social environment, including the relationship between natural and social phenomena in everyday life (Zakarina et al., 2024). Given the importance of Science and Natural Sciences, an effective learning design is needed to achieve learning objectives (Zulfa & Bektiningsih, 2024). An effective learning design must be supported by adequate facilities, namely learning media.

Etymologically, media comes from the Latin word meaning "intermediary" (*medium*), whose primary function is to convey information from educators to students (Mulyani, 2022). Therefore, learning media is an essential and integral tool in the teaching and learning process (Haptanti et al., 2024; Wahdian & Arifah, 2025). The role of media is crucial because it can bridge communication, attract students' attention (Angely et al., 2023), and facilitate the understanding of abstract concepts that are difficult to explain verbally alone. In the context of the latest technological innovation, Lumio by SMART (formerly Smart Learning Suite Online) presents an innovative, collaborative, and flexible ICT-based solution (Osipova, 2022). Lumio is designed to support active interaction and load various media formats, such as images, audio, video, animations, and formative quizzes, making the learning process more dynamic and engaging (Janah, 2023). The use of interactive, technology-based media is intended to address key aspects of student success.

The use of Lumio interactive media is specifically aimed at supporting increased student motivation and critical thinking skills. Learning motivation is a vital internal drive, defined as a student's cognitive tendency to engage actively in meaningful academic activities. Motivated students will demonstrate enthusiasm and seriousness in their studies to achieve behavioral changes and optimal learning outcomes (Oktaviani & Dewi, 2021). Furthermore, this media also serves to hone critical thinking skills, one of the higher-order thinking skills essential in all aspects of life (Safitri & Mediatati, 2021). Critical thinking encompasses the in-depth intellectual process of systematically and specifically analyzing problems, developing concepts, and evaluating information as a basis for decision-making (Anggraini, 2022). Therefore, the integration of Lumio by SMART as an interactive media is expected to be an effective means of boosting student motivation while facilitating the development of their critical thinking skills in science learning.

The implementation of science and science learning in the field faces quite serious obstacles, especially the use of technology that is not optimal (Nurlaila et al., 2024). Teachers often still rely on conventional media and methods such as lectures and textbooks, which make learning monotonous and less interactive. This condition has a direct impact on low learning motivation and lack of active student involvement. In fact, technology is an effective means of presenting abstract science and science material in an interactive, interesting, and fun way, which is important to increase students' learning motivation and critical thinking (Dewi & Setyasto, 2024). The development of learning video media is very important to increase motivation and learning outcomes (Buchori & Kholifah, 2022).

The conditions observed in the field are consistent with the findings at Sudo Public Elementary School. The analysis revealed serious problems in science learning: 11 of 18 students (61.1%) did not achieve the KKTP (competency standards), indicating low motivation and weak critical thinking skills. This is reinforced by the observation that students tend to be passive and less enthusiastic in tasks that require analysis and problem-solving, a behavior that indicates low motivation and critical thinking skills in science (Darling-Hammond et al., 2020). To overcome this problem, teachers need to utilize interactive technology that is interesting and actively involves students. The use of interactive learning media is very important because it can increase student motivation by presenting material in a more interesting and easy-to-understand way (Kardina Usman et al., 2025), as well as making students more interactive and adaptive to technological developments (Buchori & Kholifah, 2022).

Efforts to improve students' motivation and critical thinking skills can be achieved through the use of interactive learning media Lumio by SMART, an ICT-based digital platform from SMART Technologies Canada that can be accessed via the web without installation (Ajeng Margareta Sari et al., 2025). Therefore, this study proposes the integration of this platform with the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach. The STEAM approach is an

integrated learning framework that encourages inquiry, creativity, and project-based problem solving (Septia Devega & Buchori, 2024; Widana & Ratnaya, 2021) and is a multidisciplinary learning model aligned with the objectives of the Independent Curriculum (Rusmini et al., 2023). Nationally, STEAM has been confirmed to be able to foster and improve critical thinking skills at the elementary school level (Hardani et al., 2022). The superiority of disciplinary integration in STEAM is very much in line with the holistic spirit of science subjects. The novelty of this research lies in the development and validation of Lumio media with SMART, specifically designed and implemented through the STEAM framework for science and natural science materials, which is expected to produce a valid, practical, and effective learning model in addressing learning problems in elementary schools.

Interviews with third-grade students at Sudo Elementary School revealed that science subjects are considered complex and boring, especially those discussing abstract biological processes. This is because abstract biological processes cannot be directly observed and require a high level of imagination (Ratna & Sitepu, 2022). Therefore, teachers need to innovate to increase student motivation and facilitate understanding (Suhardita et al., 2024). This innovation can take the form of utilizing technology or interactive teaching aids. In this context, Lumio by SMART is considered an effective solution because it can visualize abstract concepts, making them easier for students to understand.

This research focuses on three main problem formulations: (1) What are the validity criteria for the Lumio by SMART learning media with the STEAM approach on the Metamorphosis of Living Things material for third grade elementary school students? (2) What is the level of practicality of the media based on field trials? and (3) What is the level of effectiveness of the Lumio by SMART media with the STEAM approach in increasing students' motivation and critical thinking skills? In line with these problem formulations, the objectives of this research are to produce valid media, determine the level of practicality of the media, and analyze the level of effectiveness of the media in increasing the motivation and critical thinking skills of third-grade elementary school students. By considering the need for effective learning planning (Zulfa & Bektiningsih, 2024) and empirical evidence from recent research, the hypothesis of this research is that the media developed has a high level of validity, practicality, and effectiveness in overcoming the problem of low motivation and critical thinking skills of students.

Method

This research uses a quantitative approach with the type of R&D because the goal is to produce a specific product, namely interactive learning media based on STEAM Lumio by SMART, while also testing the feasibility and effectiveness of the product (Sugiyono, 2020). The development model used is MDLC (Multimedia Development Life Cycle), which is a systematic approach to designing and developing interactive multimedia products. MDLC is widely used in the development of learning media, educational applications, and educational games, because it is able to integrate various multimedia elements such as text, images, audio, video, and animation effectively (Ridha et al., 2021). This model was developed by Luther and refined by Sutopo, which consists of six stages, namely: Concept, Design, Material Collection, Creation, Testing, and Distribution. Each stage plays a crucial role in ensuring that the media developed is not only visually appealing but also effective in conveying learning materials (Kasri et al., 2021).

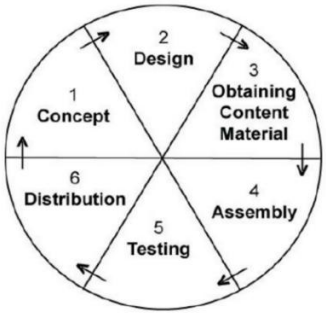

Image 1. MDLC Development Model Scheme

The main instruments used in this study included observation, interviews, documentation, and questionnaires. The questionnaires were administered to validators (media experts, subject matter experts, and practitioners/teachers) to test their feasibility, and to students to measure their responses and learning motivation. To measure the variables, the learning motivation questionnaire was adapted from the Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich & De Groot. (1990) while critical thinking skills were measured using a test referring to critical thinking indicators (Ennis, 1993).

Table 1. Motivation Indicator Table

Motivation Indicators	Questionnaire Items	Likert Scale
Intrinsic goal orientation	I feel personally motivated to study the Metamorphosis of Living Things material, mainly because I am interested in the learning method using Lumio by Smart Media.	1–4 (STS–SS)
Self-efficacy in learning	I believe that I can understand the material on Metamorphosis of Living Things well when using Lumio by Smart Media.	1–4 (STS–SS)
Assignment grades	I feel that the material on the Metamorphosis of Living Things has important and interesting value to be studied with the help of Lumio by Smart Media.	1–4 (STS–SS)
Intrinsic goal orientation	I feel that the process of learning about the Metamorphosis of Living Things is more fun and not boring because of the use of Lumio by Smart Media.	1–4 (STS–SS)
Confidence in learning control	If I do not understand a lesson, I feel no need to ask because I feel like I won't understand anyway.	1–4 (STS–SS)
Anxiety in facing exams	When faced with a difficult question, I felt unsure I could solve it correctly, so I chose not to answer.	1–4 (STS–SS)
Self-efficacy in learning	When I have difficulty studying, I feel unsure about my ability to understand the material.	1–4 (STS–SS)
Confidence in learning control	I believe that my efforts in completing the assignments given by the teacher can help me understand the material better.	1–4 (STS–SS)
Extrinsic goal orientation	I am motivated to complete assignments on time because I want to get good learning results.	1–4 (STS–SS)

Score Description:
STS = Strongly Disagree (1)
TS = Disagree (2)

N = Neutral (3)
S = Agree (4)

Score Range **:**
31-36 (Highly Motivated)
21-30 (Motivated)
11-20 (Moderately Motivated)
≤ 10 (Less Motivated)

In educational research methodology, critical thinking skills are measured quantitatively through standardized test instruments, which are generally administered as pre-tests and post-tests. Post-tests play a crucial role as a final measuring tool to determine the extent of change or improvement in students' abilities after receiving learning interventions, in this case through Lumio by SMART media with a STEAM approach (Sugiyono, 2020). It is important to emphasize that the tests used must be specifically designed to assess indicators of critical thinking (such as analysis, inference, and evaluation), not simply memorizing facts. Various studies use tests in essay or structured description formats, such as the standardized *Cornell Critical Thinking Test* (Ennis, 2013), to ensure that students' higher-order cognitive abilities are truly measured. The results of the pre-test and post-test scores are then analyzed using the N-Gain (Normalized Gain) calculation to measure the effectiveness of the improvement in ability.

The improvement in critical thinking skills, as measured by post-tests, shows a strong, often significant correlation with improvements in students' overall cognitive learning outcomes. Critical thinking skills are not a separate goal, but rather a key factor that influences and contributes to students' success in achieving a deep understanding *of* the subject matter. Several studies have shown a significant positive relationship between critical thinking skills and learning outcomes. A positive correlation coefficient indicates that any improvement in students' critical thinking skills will be directly proportional to improvements in their learning outcomes. This occurs because critical thinking skills encourage students to be more thorough in solving problems, analyzing information, and constructing logical arguments, all processes that directly improve mastery of concepts and subject matter in science. Therefore, *post-tests* designed to measure critical thinking also indirectly validate the quality of the cognitive learning outcomes achieved.

The study was conducted at Sudo State Elementary School and Pragu State Elementary School, Sulang District, Rembang Regency, with third-grade students as the trial subjects. The study was conducted from August to September 2025. Data analysis was conducted descriptively and quantitatively. Quantitative data analysis was conducted to determine three product quality criteria: validity, practicality, and effectiveness. Product effectiveness testing was conducted using a quasi-experimental design with a nonequivalent control group design. This design was chosen because the research subjects, namely third-grade students of Sudo State Elementary School and Pragu State Elementary School, could not be perfectly randomized into experimental and control groups. The research subjects consisted of third-grade students of Sudo State Elementary School (18 students) as the experimental group, and fourth-grade students of Pragu State Elementary School (12 students) as the control group. Although there were differences in sample sizes between groups, this can be justified in the context of the quasi-experimental school environment (Amaliyah et al., 2023).The difference in school locations (Sudo State Elementary School and Pragu State Elementary School) was deliberately chosen to minimize the risk of contamination or spread of interventions between groups, thereby strengthening the internal validity of the study (Hasan et al., 2021). The research subjects in both schools were considered equivalent in terms of curriculum and basic skill level before treatment.

The experimental group was given Lumio treatment through SMART media with a STEAM approach, while the control group used conventional learning (lectures and worksheets). The research location at SDN Sudo was chosen based on the results of a needs analysis that showed low motivation and achievement of students' critical thinking skills on the material of the metamorphosis of living things. The research subjects were divided into two groups to compare improvements measured through pretests and posttests (Amaliyah et al., 2023). The selection of a quasi-experimental design was considered the most realistic for research conducted in a school context (Khairani & Prodjosantoso, 2024). Primary data collection was carried out through three main instruments: Expert Validation Sheets, Practicality Questionnaires, and Tests.

Validation sheets were completed by subject matter experts, media experts, and practitioners to assess the suitability of the content and the accuracy of the question construction, thus ensuring the validity of the media content and construction. A practicality questionnaire, administered to teachers and students, was used to measure ease of use, time efficiency, and level of engagement in learning (Nadilah et al., 2025). The data obtained were analyzed using three different techniques. First, expert validity data were analyzed quantitatively using Aiken's V formula to determine the level of consensus among experts, with a minimum threshold that must be met for the media to be declared valid. Second, practicality data from teacher and student questionnaires were analyzed using descriptive percentage statistics to determine how easy and efficient the media was to implement in the classroom. Third, effectiveness data from the pretest and posttest were analyzed using the N-Gain Score test to assess the increase in students' KPM, followed by an Independent Sample T-test to compare significant differences between the experimental and control groups. Prerequisite tests, such as normality and homogeneity, were conducted first to ensure the suitability of the t-test.

Qualitative data were analyzed based on comments, suggestions, and expert validation obtained from questionnaire respondents. Quantitative data were then analyzed using a Likert scale. This scale is used to assess perceptions by measuring the level of agreement or disagreement with a particular subject or object (Sugiyono, 2020). Meanwhile, to determine media suitability, the following percentage formula can be used:

$$p = \frac{\Sigma x}{\Sigma x1}\ x\ 100\%$$

Information:
P = Percentage
X = Total number of answers from all respondents
X1 = Total ideal score
100% = Constant

Validity test data calculations can be performed using the formula above, so that quantitative data will be obtained, which is then accumulated into the form (%). To determine the validity of the product that has been developed, please see the following criteria table:

Table 2. Product Validity Percentage Scale

Percentage	Qualification	Information
75-100%	Very Valid	No revisions
51-74%	Legitimate	No revisions
25-50%	Less valid	Revision
0-24%	Invalid	Revision

To determine students' and teachers' responses to product use, data were collected via a questionnaire. The questionnaire analysis criteria are shown in the following table:

Table 3. Percentage Scale of Student Responses

Percentage	Qualification	Category
75-100%	Very Positive	Very practical
51-74%	Positive	Practical
25-50%	Less positive	Less practical
0-24%	Not positive	Not practical

The categorization of N-Gain scores can be seen in the following table:

Table 4. Distribution of N-Gain Scores

N-Gain Score Value	Criteria
(g) > 0.7	Tall
0.3 ≤ (g) ≤ 0.7	At the moment
(g) < 0.3	Low

Results and Discussion

The use of technology, such as interactive learning media, is very important because it can present material in an interesting way and facilitate understanding (Kardina Usman et al., 2025), and allows students to adapt to technological advances (Buchori & Kholifah, 2022). This is important considering that low learning outcomes and passive student behavior reflect deficits in critical thinking skills (Darling-Hammond et al., 2020). Learning motivation also plays an important role in student success (Agustina & Wisnumurti, 2019). The integration of STEAM into Lumio by SMART media, with the MDLC development model, is a solution to address students' complaints that science is complicated and boring, especially biological processes that are abstract and difficult to visualize (Ratna & Sitepu, n.d.). This pedagogical innovation aims to change passive student behavior into more active and enthusiastic behavior (Susilo, 2020), in line with the demands of technological developments in the digital era (Farhati & Supriadi, 2020).

Previous research has proven that Lumio by SMART is effective in learning (Ajeng Margareta Sari et al., 2025). In "Development of Learning Media Using Lumio by SMART in ICT Subjects for Grade VII Junior High School Students," it was concluded that Lumio by SMART media was declared very feasible to use, with a high average value obtained from all validators. This study (Suryandani & Asih, 2024) also found that the media was effective in increasing learning motivation. Riyanti et al., 2024in his research also showed a significant effect of the use of Lumio by SMART media on creative thinking skills and student learning outcomes. This result is evidenced by the value of the Independent Sample T-test (Sig (2-tailed)) of the experimental class which is smaller than 0.005. Thus, previous research also proves that the use of Lumio by SMART media is feasible to use in learning. Although there has been research on Lumio, motivation, and critical thinking separately or in pairs, what is new from this study is the development of a more holistic instrument by developing a valid and reliable critical thinking or motivation assessment instrument, which is in line with the characteristics of STEAM learning and Lumio's interactive features. For example, students' critical thinking is measured through their responses to Lumio's collaborative features, rather than just paper-based pre- and post-tests. Lumio's interactive media prototype/template is designed to explicitly integrate all STEAM elements into the metamorphosis activity.

This research offers significant novelty compared to previous research. The main differences lie in the approach, target audience, and focus of instrument development.

Table 5. Differences in media novelty with previous research

Aspect	Previous research	This research
Main approach	Generally, using a conventional approach or media development without a particular approach focus	Using the STEAM Approach explicitly in Lumio media development.
Student targets	Junior High School Students of Grade VII (Margareta Sari et al.).	Elementary School (SD) Grade 3 students (require different material adjustments and interactions).
Focus on media development.	Effective or viable Lumio media without explicit integration of STEAM elements in the prototype.	Development of an interactive Lumio prototype that explicitly integrates all STEAM elements into learning activities
Measurement focus	Motivation or creative thinking/learning outcomes.	Holistic: seeks to improve motivation and critical thinking skills simultaneously.

MDLC stages

The initial stage in the MDLC development method cycle is concept development based on the results of the needs analysis. At this stage, a review of the needs analysis instruments derived from interviews with homeroom teachers was conducted, with the aim of classifying and identifying key features to be implemented in the application. The needs analysis identified significant problems in learning in grade III at SD N Sudo, where learning remains conventional, dominated by lecture methods, and dependent on static textbooks. This condition causes students to be passive, easily bored, and have low learning motivation. To address these problems, an urgent need was identified to transform teaching methods into more interactive, visual, dynamic, and student-centered approaches. Teachers were also identified as needing training in digital pedagogy practices, not just an introduction to teaching aids. The leading recommended solution was the development of interactive digital learning media to increase student engagement, while also training them how to integrate these media effectively into learning modules.

The second stage is the design stage, where researchers develop concepts for media flow, media architecture, media display, and media materials. At this stage, the concept and structure of the module and teaching materials are designed in detail, including what will be taught and how to teach it, but the content is not finalized. Activities related to the creation of teaching materials at this stage include instructional design, such as determining learning objectives, basic competencies, and achievement indicators, and breaking down the primary material (for example, complete and incomplete metamorphosis) into smaller, more logical subtopics. In addition, researchers also design question types, answer formats, and interaction scenarios for activities on the media page, as well as questions on the Student Worksheet and evaluation questions.

The third stage, namely design, is a crucial phase in the multimedia development life cycle that is carried out after the conceptual and structural design is completed. At this stage, the researcher's main focus is to collect all digital and non-digital assets that will become components of the Lumio by SMART interactive teaching module, which are classified according to the five pillars of the STEAM approach to ensure holistic integration. This collection process is carried out systematically, guided by the storyboard and flowchart that have been prepared in the design stage, to ensure that each collected material is relevant, accurate, and aligned with the research objectives,

namely to increase the motivation and critical thinking skills of third-grade students through the STEAM approach on the material of metamorphosis of living things.

The fourth stage, assembly, is the core phase in which all components designed and assembled in the previous stages are integrated into a complete and functional product. In this study, the assembly stage integrates the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach into the Lumio by SMART platform. All activities in this stage are guided by an instructional design that aims to stimulate motivation and develop critical thinking skills among third-grade elementary school students. In this stage, abstract design concepts and separate media assets are systematically integrated into the selected development environment.

The fifth stage of the MDLC method is testing, a critical phase that evaluates, validates, and refines the completed learning media prototype. At this stage, the product, which was previously tested only internally by researchers, is now subject to external evaluation by experts. The main objective of the testing phase in this study is to ensure that the developed Lumio by SMART learning media has met three important criteria: validity, practicality, and potential effectiveness. Validity refers to the suitability of content and media with scientific principles and instructional design. Practicality refers to the ease of use of media for teachers and students in real learning situations. Meanwhile, potential Effectiveness refers to the extent to which the media can achieve its goals, namely improving the motivation and critical thinking skills of third-grade elementary school students through the STEAM approach.

The sixth stage in the MDLC model is Distribution. This is a crucial phase in which validated and tested media products are taken out of the research environment and implemented in real-world settings with end users (teachers and students). The primary goal of this stage is to ensure the product's widespread, effective, and sustainable use. In the context of developing Lumio media for the Metamorphosis of Living Things material using the STEAM approach, the distribution step does not simply mean sharing access links. This stage encompasses a series of activities, from packaging the media into a ready-to-use format (for example, creating files or links that are easily accessible on the Lumio platform or school LMS), to socialization and brief training for teachers and students. This socialization is important because Lumio media designed with a STEAM approach may require adjustments to teaching strategies, with an emphasis on exploration, design, and artistic creation activities alongside science content.

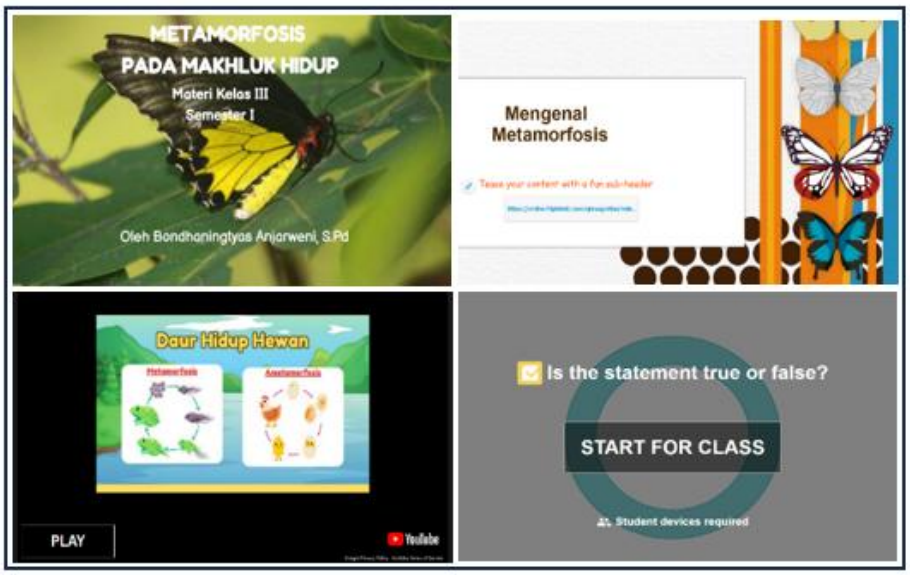

Image 2. Product Design

Product Validation Results (Expert Testing)

The initial stage of this Research and Development (R&D) study was a validation test aimed at ensuring the feasibility of the Lumio by SMART interactive learning media product using the STEAM approach before testing. Validation results from material and media experts showed an average score of 94%, which falls into the "Very Valid" category and meets the minimum validity criteria.

Table 6. Validity Score

Validator	Percentage	Category
Material	95%	Very valid
Media	96%	Very valid
Average	95.5%	Very valid

Product Practicality Test Results (Teacher and Student Trials)

The results of the product's practicality test were measured through teacher and student response questionnaires during classroom implementation. Teacher responses showed a very high level of practicality, with an average score of 91%, categorized as "Very Practical." This practicality was supported by the ease with which teachers operated the Lumio by SMART platform and integrated the STEAM approach into learning scenarios. Meanwhile, student responses also showed high enthusiasm, with a score of 94%, indicating that this interactive game media was engaging and easy to use.

Table 7. Practicality Score

Respondents	Percentage	Category
Teacher	91%	Very practical
Student	94%	Very practical
Average	92.5%	Very practical

Before testing the effectiveness of the Independent Sample T-Test, researchers are required to conduct prerequisite tests for normality and homogeneity of post-test data to ensure the validity of the statistical results (Amaliyah et al., 2023).The results of the Shapiro-Wilk normality test in the experimental and control groups showed significance values of 0.457 and 0.372, respectively ($p > 0.05$). These results confirm that the post-test data for both groups were normally distributed, thus fulfilling one of the main requirements of parametric analysis.

Table 8. Normality Test

Group	Shapiro-Wilk Test (Sig.)	Category
Experimental	0.457	Normal
Control	0.372	Normal

Furthermore, the homogeneity of variance test using Levene's test showed a significance value of 0.06 ($p > 0.05$). This figure indicates that the variance in the KPM data between the experimental and control groups is homogeneous. By meeting both prerequisites (normality and homogeneity), further statistical analysis, namely the t-test, can be performed, and the results are valid for concluding significant differences between groups (Khairani & Prodjosantoso, 2024).

Effectiveness Test Results (T-Test and N-Gain)

Based on the results of the T-test conducted, the learning motivation variable shows a Sig. (2-tailed) value of 0.000. Because $0.000 < 0.05$, then H0 (null hypothesis) is rejected and H1 (alternative hypothesis) is accepted. This statistically proves that there is a significant difference (influence) on student learning motivation as a result of the application of learning media. Likewise, the results of the T-test for the critical thinking ability variable also show a Sig. (2-tailed) A value of 0.000

indicates that this result also meets the requirements for accepting the second hypothesis (H2). Because 0.000 < 0.05, then H0 is rejected and H2 is accepted. This confirms that there is a significant difference (influence) on students' critical thinking abilities after using the developed learning media.

Table 9. T-Test Results

Variables	Signature. (2 tails)	Significance Level (α)
Motivation	0.000	0.05
Critical Thinking Skills	0.000	0.05

The N-Gain calculation shows that learning media has a significant positive impact on both variables. The increase in learning motivation was rated at 0.86. Based on the interpretation criteria, this score falls into the "High" category. This indicates that the use of learning media is highly effective in fostering student learning motivation. A value of 0.86 indicates that the intervention successfully facilitated 86% of the remaining potential increase, thereby pushing student learning motivation from the initial level to an approach to the ideal maximum score.

Furthermore, the critical thinking ability variable produced a score of 0.68. This score is categorized as "Moderate." This proves that the learning media is also effective in honing students' critical thinking skills. Although not included in the "High" category, an increase with an N-Gain of 0.68 still shows a substantial and meaningful impact. Effectiveness in the "Moderate" category is considered reasonable, considering that critical thinking ability is a higher-order cognitive skill (HOTS) whose development tends to be more complex and requires a gradual process. Overall, these two N-Gain results confirm that the implemented learning media intervention has proven successful and effective, with a very strong impact on the affective domain (motivation) and a good impact on the cognitive domain (critical thinking).

Table 10. N-Gain Test Results

Variables	Signature. (2 tails)	Category
Motivation	0.86	Tall
Critical Thinking Skills	0.68	At the moment

Conclusion

Based on the research results and discussion presented, three main conclusions can be drawn. The research on Lumio's development by SMART media, using a STEAM approach, for the Metamorphosis of Living Things material confirms that the resulting product is a feasible and beneficial learning solution for elementary school students. Qualitatively, the main interactive media developed has been shown to meet high validity criteria in expert reviews, indicating that its content and technical design are well-suited for use in science learning. In addition, this media offers an extraordinary level of practicality, as confirmed by the very positive responses from teachers and students in the field, which indicate that it is easy to implement, engaging, and helps eliminate boredom. Most importantly, pedagogically, this media shows real effectiveness in improving students' internal abilities. The implementation of Lumio by SMART STEAM-based media has significantly increased student learning motivation and sharpened their critical thinking skills, demonstrating that the integration of technology and an interdisciplinary approach is the key to overcoming the problems of conventional science learning at the elementary school level.

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