The Effect of Lumi Education-Based Interactive Multimedia on Learning Outcomes: Exploring the Compatibility of Content Types with Student Learning Styles

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***Abstract*—The rapid development of digital technology has transformed students' learning patterns, requiring teachers to provide more innovative and interactive learning approaches. However, conventional instruction still dominates in schools and often neglects individuals' different learning styles, resulting in low learning outcomes. The urgency of this study lies in the need for digital learning media that are not only engaging but also adaptive to students' visual, auditory, and kinesthetic learning preferences. Therefore, this study aims to analyze the effect of Lumi Education-based interactive multimedia on students' learning outcomes and examine the compatibility between different content types and students' learning styles. This research employed a quantitative approach with a one-shot case study design involving 90 fifth-grade students from five elementary schools in District X. Students' learning styles were identified using a validated Quantum Learning questionnaire, while learning outcomes were measured through post-tests. Data were analyzed using Structural Equation Modeling–Partial Least Squares (SEM-PLS) version 4. The results revealed that Lumi Education had a significant effect on students' learning outcomes, with the highest contribution from game content (0.263), followed by material summaries (0.262), videos (0.259), and music (0.241). Each content type showed distinct compatibility with specific learning styles. These findings highlight that multimedia design aligned with learning styles can enhance elementary students' motivation, conceptual understanding, and equity in science learning.**

***Keywords*—interactive multimedia, Lumi education, learning outcomes, learning styles, science learning, Structural Equation Modeling–Partial Least Squares (SEM-PLS)**

I. Introduction

The increasing intensity of technology use among students has become a growing concern for schools, particularly for teachers. Nowadays, many students spend significant time on online activities such as messaging, interacting with others on social media, streaming digital content, and reading online news—behaviors contributing to a decline in physical outdoor activities. This shift is supported by a survey of Australian teenagers, which found that only 13% of their time was spent outdoors [1, 2]. These behavioral changes reflect a broader transformation in how students access and interact with information, highlighting the need to reassess existing teaching approaches. Over the past two decades, technological advancements have rapidly reshaped the educational landscape, requiring teachers to adapt and innovate through the integration of digital learning methods [3–5]. In this context, teachers play a vital role in designing instructional media that align with the subject matter's characteristics and the intended learning outcomes [6]. In addition, students' cognitive learning outcomes indicate learning objective achievement, reflecting the knowledge and intellectual skills mastered [7].

Low average assessment scores and the continued use of conventional teaching methods notably impact student learning outcomes. This issue is illustrated by the average daily test scores for the human respiratory system-related learning materials (Phase B) in elementary schools across District X, which reached only 66.54, and is below the minimum passing standard of 70. Various factors shape student learning outcomes, including internal factors such as health condition, intelligence, learning styles, and motivation, as well as external factors related to school environment, family background, community influence, and the instructional approach employed by teachers [8–11].

Among these factors, the choice of instructional approach plays a particularly crucial role. Conventional teaching methods, which tend to be teacher-centered, often emphasize rote learning rather than active understanding. Such approaches limit students' opportunities to explore concepts, engage in discussions, and apply knowledge in meaningful contexts [11]. As a result, students may struggle to develop higher-order thinking skills, leading to lower learning outcomes after they finish learning the materials [12]. Therefore, examining the effectiveness of different teaching methods becomes essential to improve student learning outcomes.

This study focuses on learning approach factors, particularly the teaching methods employed by teachers, as one of the most influential determinants of student learning outcomes. Effective teaching methods not only facilitate the transfer of knowledge but also foster students' engagement, motivation, and cognitive development. In this context, interactive learning multimedia emerges as a promising pedagogical innovation that integrates visual, auditory, and kinesthetic modalities to enhance conceptual understanding. Through interactive multimedia, abstract scientific concepts can be visualized. This can enable students to connect theory with real-life applications and encourage active participation in the learning process. Previous studies have shown that multimedia-based learning environments can significantly improve students' comprehension and retention compared to traditional methods [13]. Therefore, optimizing instructional strategies through interactive multimedia allows teachers to align pedagogical practices with students' diverse learning styles as an internal factor, ultimately leading to improved learning outcomes and a more meaningful educational experience.

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In line with this pedagogical shift, it is also essential to acknowledge that rapid technological advancement and the pervasive influence of digital culture have fundamentally transformed students' learning behaviors and preferences. The current generation of learners, often referred to as digital natives, interacts with information in dynamic, multimodal, and non-linear ways that differ markedly from traditional learning patterns. Exposure to diverse digital platforms and social media has fostered a tendency toward visual and experiential learning, shorter attention spans, and a preference for interactive, self-directed learning environments. Consequently, instructional approaches that fail to adapt to these evolving digital learning characteristics risk diminishing student engagement and reducing learn.

Along with technological developments in the digital era, students have also experienced changes in learning methods due to the abundance of information obtained through social media [14]. Each individual has a different learning style consisting of visual, kinesthetic, and auditory, and this can influence learning outcomes [15]. Visual learning emphasizes learning through sight, kinesthetic learning emphasizes touch, movement, and experience, while auditory learning relies more on hearing to obtain information. Previous studies have also stated that using a single instructional approach is effective when applied to a class with diverse learning styles [16, 17]. Therefore, there is a need to implement interactive multimedia to address and support all students' learning styles. While numerous studies have explored the effectiveness of interactive multimedia in enhancing learning outcomes, they have largely focused on general Science, Technology, Engineering and Math (STEM) topics rather than specific content, such as the human respiratory system at the elementary school [18–25].

Other studies have explored using various interactive multimedia learning tools to improve learning outcomes by considering learning styles at the secondary and university levels. Previous research found that integrating Lumi Education and H5P effectively improved distance learning and provided insights into how technology can enhance students' learning experiences [26]. Additionally, a study using a quantitative descriptive approach found that applying interactive videos based on Lumi Education can increase students' interest in learning chemistry [27]. Meanwhile, through an implementation of the ADDIE method on senior high school students found that interactive multimedia based on sound waves using Lumi, which is based on project-based learning, was deemed feasible by validators [28].

While numerous studies have explored the effectiveness of interactive multimedia in enhancing learning outcomes, most have primarily focused on general STEM topics rather than specific content areas such as the human respiratory system at the elementary school level [16–23]. Moreover, there remains a notable lack of research on the use of Lumi Education-based interactive multimedia in elementary education, particularly in science instruction. This gap highlights the need to further investigate how such technology-driven learning tools can be optimized to address diverse learning styles and improve students' conceptual understanding of scientific phenomena. Despite the growing body of literature on multimedia learning, empirical evidence on how Lumi Education-based multimedia can be effectively applied to support different learning styles and improve conceptual understanding in specific scientific topics at the elementary level remains limited.

Therefore, this study aims to address these issues by (1) examining the effect of Lumi Education-based interactive learning multimedia on elementary students' learning outcomes, and (2) exploring the compatibility between different multimedia content types (summaries, videos, games, and music) and students' learning styles (visual, auditory, and kinesthetic). The outcomes of this study can assist teachers in designing inclusive and adaptive instructional strategies that align with students' individual learning preferences. Furthermore, the findings can provide empirical evidence to support education policymakers in promoting the integration of interactive multimedia as a means to enhance learning quality and equity in elementary schools.

II. Literature Review

A. Interactive Learning Multimedia

Interactive multimedia refers to digital-based learning materials that combine various media elements, such as audio, texts, animations, videos, and images. These materials include interactive features that allow students to engage actively with the content, stimulating their senses and cognitive processes, thereby enhancing understanding of the learning materials [3]. Over the past two decades, technological developments in education have produced various platforms, such as Lumi Education, which enable teachers to create interactive learning processes without requiring advanced programming skills. These platforms offer features such as integrated quizzes, games, scenarios, and multimedia annotations that are appropriate and flexible for diverse learning contexts [21].

Previous research has consistently demonstrated that interactive multimedia learning can improve learning outcomes, especially for elementary school students, as concrete visualization is needed to enhance student motivation, engagement, and understanding [19, 22]. Interactive multimedia learning makes learning student-centered and dynamic, whereas conventional learning has not integrated multimedia elements, thus failing to support students' diverse learning preferences.

B. Learning Styles

Learning styles refer to individuals' preferences in terms of the way they understand, process, and retain information. Learning styles are generally categorized into three types: visual, auditory, and kinesthetic [15]. Students with visual learning styles understand information better through pictures and diagrams. Students with auditory learning styles prefer to learn by listening to verbal explanations. Kinesthetic learners learn well through movement and physical experiences. Significant differences in how students interact with learning materials or learn can significantly affect motivation and academic performance [13]. Therefore, teachers must recognize students' learning styles to apply learning strategies that suit their needs [16]. However, the challenge in implementing this approach, especially in large, heterogeneous classrooms, is that teachers must balance diverse learning styles simultaneously.

The integration of multimedia content into learning has been scientifically proven. Multimedia enables the simultaneous presentation for all student learning styles in a single lesson. Its flexible nature makes interactive multimedia learning effective in improving student learning outcomes, especially in elementary schools with multisensory engagement [17].

C. Learning Outcomes

Learning outcomes are indicators of student achievement. In digital education, learning outcomes generally focus on students' cognitive, affective, and psychomotor development, emphasizing cognitive improvement such as knowledge mastery, understanding, and problem-solving skills [7]. If teachers utilize effective learning media, it can directly contribute to improved learning outcomes.

Many studies have shown that interactive multimedia learning can enhance attention, strengthen understanding, and provide individually tailored learning pathways [20, 24, 25]. When multimedia content is designed to accommodate visual, auditory, and kinesthetic learning styles, students are more likely to engage actively according to their preferences and improve learning outcomes [16, 17].

As explained above, Lumi Education is a flexible and accessible application that teachers can use to develop interactive learning content. Lumi Education is built on H5P technology, integrating quizzes, games, videos, and audio into a single platform without requiring advanced programming skills [26]. In Indonesia, studies have shown increased students' interest in chemistry through Lumi-based video content [27]. Additionally, Lumi-based multimedia content on sound waves is pedagogically appropriate and engaging for secondary school students [28]. However, previous research has not explored the extent to which the type of multimedia content in Lumi Education design aligns with students' learning styles, particularly in the subject of the human respiratory system for elementary school students.

This effectiveness can be explained by the Cognitive Theory of Multimedia Learning (CTML), which states that students process information more deeply when lesson material is delivered through visual and auditory channels. CTML is based on three main assumptions: dual-channel processing (visual and auditory processing), limited capacity (each channel has a limited processing capacity), and active processing (learning occurs when learners actively interact with the materials). Multimedia learning that accommodates different learning styles, such as videos for visual learners, narration for auditory learners, and games for kinesthetic learners, can support more effective encoding and retention of information [29].

The interactive integration of content, such as games in Lumi Education, aligns with Edgar Dale's Cone of Learning Theory, which shows that students can better gain information through direct practical experience than passive methods. According to Dale, such activities can result in up to 75% retention rates because they involve multiple senses. Lumi's ability to provide immersive, multisensory, and interactive learning supports strong conceptual understanding [30–32].

Based on existing literature reviews, interactive learning multimedia has been widely used to improve learning outcomes at various levels of education. However, most existing studies focus on STEM content in general and pay little attention to basic topics such as the human respiratory system. Additionally, few studies have specifically explored how content types, such as videos, games, music, and summaries designed within interactive learning multimedia platforms like Lumi Education, align with learning styles (visual, auditory, and kinesthetic) to enhance learning outcomes.

Furthermore, although Lumi Education is recognized as a promising tool for multimedia instruction, research applying SEM-PLS to analyze the contribution of each multimedia component related to learning styles and student performance remains limited. This deficiency hinders the development of more tailored instructional strategies to meet diverse learning needs at the basic level.

III. Materials and Methods

A. Research Design

This study employed a quantitative approach with a one-shot case study design, a research design in which data is collected at a single point after an intervention or event occurs [33]. This design is often used to evaluate the direct effects of an intervention without using pre-intervention tests or control groups for comparison. Students were given treatment in the form of learning using Lumi Education-based interactive multimedia, and then learning outcomes were measured through a post-test. This design was used to determine the effect of interactive learning multimedia "Lumi Education" on student learning outcomes, with learning style as a moderating factor.

B. Sampling and Data Collection

This study was conducted in January 2025. The subjects in this study were not randomly selected to be involved in the experimental and control groups. The experimental group received an intervention in the form of a learning method using interactive learning multimedia, "Lumi Education", while the control group used a conventional method. The sample in this study consisted of 90 students from 5 elementary schools in District X.

The "Lumi Education" design consists of an initial interface, learning identity, intended learning outcomes (CP), and learning objective flow (ATP), learning videos, a summary of learning materials, pictures of respiratory organs, music of the human respiratory system, assessments, a discussion room, and references. The content included in the menu is based on the CP and learning objectives (TP) for the human respiratory system material. Learning in the experimental and control groups was conducted by classroom teachers over three sessions through pre-tests and post-tests. Students' learning styles were identified using a questionnaire adopted and modified from the book Quantum Learning by Bobbi Deporter and Mike Hernacki, which explains the characteristics of visual, kinesthetic, and auditory learning styles [15]. Each learning style questionnaire consisted of 10 questions, and the type of learning style was determined based on the highest score among the three learning styles. The components of visual, kinesthetic, and auditory learning styles consisted of appearance, speaking, reading, understanding, and hobbies, with the following indicators in Table 1.

Table 2 presents the indicators of student learning outcomes, consisting of 25 questions for each learning style.

Table 1. Types of learning style questionnaire indicators

No.	Learning Styles	Indicators	Question Numbers	Number of Questions
1.	Visual	1.1 Neat and orderly	1, 3	2
		2.1 Speaking quickly	2, 9	2
		3.1 Preferring reading alone quickly and diligently	4, 10	2
		4.2 More likely to remember what is seen than what is heard	6, 7	2
		5.1 Preferring art over music	5, 8	2
		Total		**10**
2.	Kinesthetic	1.1 Unable to sit still for a long time	11, 12	2
		2.1 Standing close together when speaking softly	13,14	2
		3.1 Using fingers or mirroring actions in reading	15, 16	2
		4.1 Learning through practice and group work	17, 18	2
		5.1 Taking time to exercise and engage in other physical activities	19, 20	2
		Total		**10**
3.	Auditorial	1.1 Easy to get along with	22, 25	2
		2.1 A good and fluent speaker	21, 27	2
		3.1 Reading aloud, moving lips/pronouncing words	23, 24	2
		4.1 Learning by listening and discussing	26, 28	2
		5.1 Preferring music over painting	29, 30	2
		Total		**10**
		Number of Questionnaire Items		**30**

Table 2. Indicators of learning outcomes questionnaire

Material Indicators	Question Indicators	Question Numbers
Identifying the human respiratory organs	After an image of the human respiratory system is presented, the students can accurately analyze the human respiratory organs.	1
	After a narrative about one of the human respiratory organs is presented, the students can analyze the respiratory organ.	2
	After a narrative about one of the human respiratory organs is presented, the students can analyze the human respiratory organ accurately.	3
	After a narrative of one of the human respiratory organs is presented, the students can analyze the human respiratory organ accurately.	4
	After an image of the human respiratory system is presented, the students can accurately analyze the human respiratory organs.	5
Analyzing the respiratory process in humans	After an image of the human respiratory inspiration process is presented, the students can systematically explain the human inspiration process.	6
	After a list of human respiratory organs is presented, the students can accurately detail the sequence of human respiratory organs.	7
	After a narrative about the process of human respiration is presented, the students can accurately analyze the human respiratory process.	8
	After the types of changes that occur in human respiration are presented, the students can accurately analyze the process of air changes that take place.	9
	After a narrative about daily human activities is presented, the students can accurately correlate the causes of shortness of breath.	10
	After a text about events occurring in human respiration is presented, the students can accurately analyze the events happening in one of the human respiratory organs.	11
Analyzing the function of the respiratory system in humans	After an image of a nose is presented, the students can accurately analyze the function of the human respiratory organs.	12
	After an image of the human respiratory organs is presented, students can analyze the function of the human respiratory system.	13
	After a description of the human respiratory organs is presented, the students can accurately distinguish the function of one of the respiratory organs.	14
	After an image of the human respiratory organs is presented, the students can accurately determine the function of one of the human respiratory organs.	15
	After a narrative about the dangers of a certain gas is presented, the students can accurately conclude the dangers of that type of gas to human respiration.	16
Identifying various disorders of the human respiratory system	After a narrative about respiratory system disorders is presented, the students can accurately diagnose the type of disease related to the human respiratory organs based on its symptoms.	17
	After a narrative about respiratory system disorders is presented, the students can accurately identify the types of affected human respiratory organs.	18
	After a narrative about respiratory system disorders is presented, the students can accurately diagnose the symptoms shown when experiencing respiratory disturbances.	19
	After a brief narrative is presented, the students can correlate respiratory disorders with appropriate ways to address them.	20
Analyzing various ways to prevent respiratory diseases	After a narrative about the characteristics of respiratory disorders is presented, the students can take the right steps to prevent the transmission of respiratory diseases accurately.	21
	After statements about behaviors related to the respiratory system are presented, the students can accurately analyze the appropriate behaviors.	22
	After statements about behaviors related to the respiratory system are presented, the students can accurately analyze the appropriate behaviors.	23
	After images of behaviors that maintain the respiratory system are presented, the students can accurately select the appropriate behaviors.	24
	After a narrative about lung diseases is presented, the students can accurately select efforts to prevent respiratory tract infections.	25

The researchers ensured the equality of questions through descriptive statistical means and obtained a moderate difficulty index in the range of 0.31–0.70 for all questions in each learning style. Expert judgment and questionnaire testing were conducted to validate the learning style and learning outcome instruments.

C. Data Analysis

Data analysis was conducted using a quantitative approach with the Structural Equation Modeling–Partial Least Squares (SEM-PLS) method through the SmartPLS version 4 application. SEM-PLS can test structural and measurement models simultaneously and is suitable for experimental research with small to medium sample sizes.

The analysis procedure includes evaluating the outer model (convergent and discriminant validity, construct reliability through Average Variance Extracted (AVE) and Composite Reliability (CR) and the inner model (testing the relationship between constructs using path coefficients, T-statistics, and *p*-values through bootstrapping techniques). The model fit was tested using the Standard Root Mean Square Residual (SRMR) indicator, while the significance of the relationship between constructs was analyzed by looking at p-values < 0.05.

IV. Result and Discussion

A. The Design of Interactive Learning Multimedia "Lumi Education"

The use of Lumi Education interactive multimedia learning materials includes content such as summaries of materials, videos, games, and music about the human respiratory system, presented as follows:

The content is designed to present material on the human respiratory system in an engaging, interactive manner tailored to students' learning characteristics. Fig. 1 following is a preview of the learning summary content.

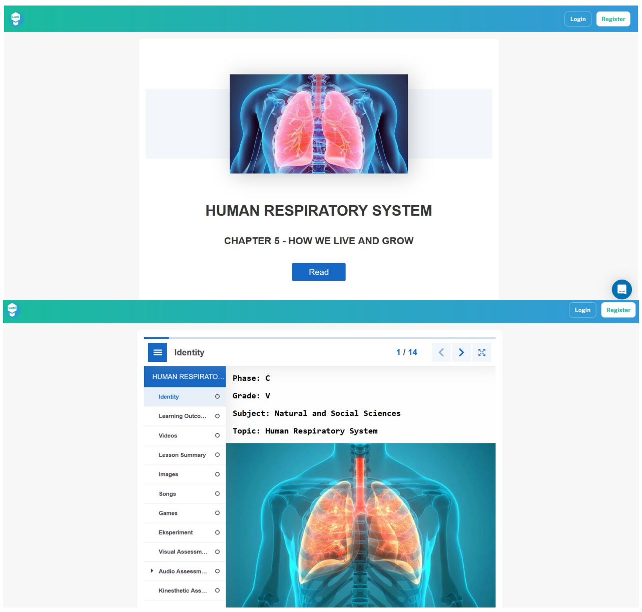

Fig. 1. Display of Lumi education.

Fig. 2 shows a summary of materials in a concise and compact text format of the human respiratory system material. The summary of materials is designed to facilitate students with visual learning styles by systematically presenting the learning material's core concepts. The following is a video of the lesson.

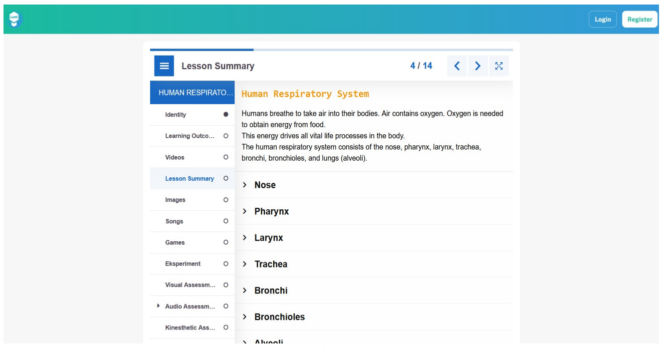

Fig. 2. Display of learning summary.

Fig. 3 shows a learning video that contains dynamic explanations of the human respiratory process, the anatomy of the respiratory organs, and simulations of air movement within the body. This media is designed to dynamically accommodate students with auditory and visual learning styles, as it combines sound, animated images, and narration. The following is a music display.

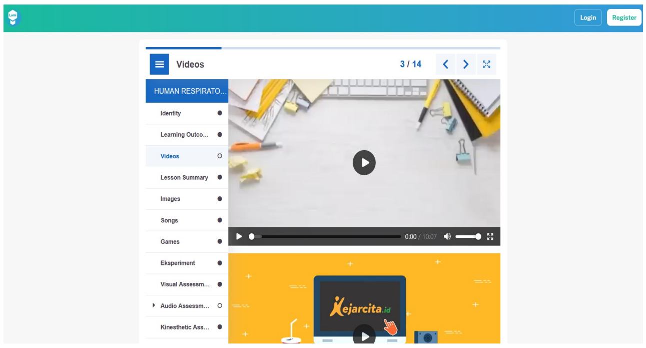

Fig. 3. Display of learning video.

Fig. 4 shows an educational song about the human respiratory system. The music is accompanied by lyrics and illustrations, which aim to strengthen students' memory through rhythm and repetition. This media accommodates auditory learning styles and can increase students' enthusiasm and emotional engagement in learning. The following is an interactive game display.

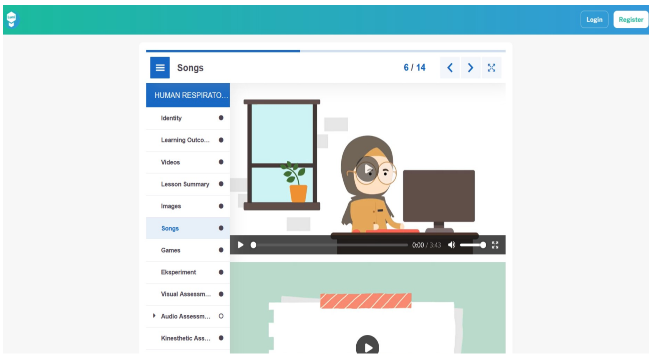

Fig. 4. Display of educational music.

Fig. 5 shows the content of an educational game where students can answer questions about the respiratory system while playing. This game motivates learning through challenges and positive reinforcement and is ideal for students with a kinesthetic learning style.

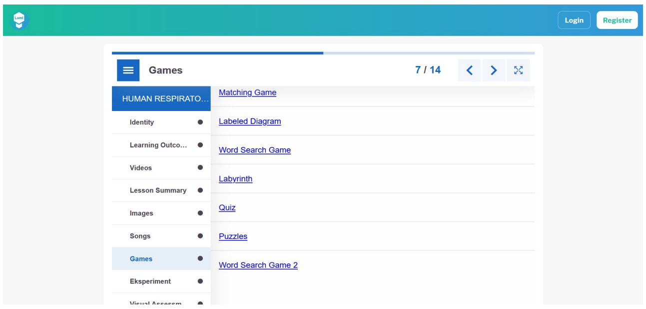

Fig. 5. Display of an educational game.

B. Construct Reliability and Validity

The following are the results of internal consistency reliability using Cronbach's Alpha (α), rho_A, and CR indicators, as well as convergent validity using AVE.

Table 3. The results of the construct reliability test

Construct	α	Rho_A	CR	AVE
ILM Lumi Education	0.941	0.943	0.960	0.822
Learning Outcome Based on Learning Styles	0.834	0.887	0.925	0.892

Table 3 above shows that all constructs have excellent reliability, above 0.70 [34]. The indicators in the Interactive Learning Multimedia (ILM) "Lumi Education" construct consistently measure variables. Learning outcomes based on learning styles also demonstrate high reliability, meaning that learning outcomes measured based on the content of the Lumi Education for each learning style are consistently measured by their respective indicators. Table 3 also shows AVE values above 0.50, indicating that all constructs meet the criteria for convergent validity. Therefore, all constructs are deemed reliable and suitable for further structural analysis.

C. Discriminant Validity

The following are the results of the cross-loading test for discriminant validity.

The results of the cross-loading test for discriminant validity are considered acceptable if the indicator has the highest loading value in the construct where it should be located compared to the loading values in other constructs [35]. Table 4 shows that the indicators in each construct have higher loading values than other constructs, so all constructs are considered valid.

Table 4. The results of the discriminant validity test based on cross-loadings

Indicators	Learning Outcome Based on Learning Styles	ILM
HBGameA	**0.996**	0.918
HBGameK	**0.989**	0.966
HBGameV	**0.996**	0.929
HBMusA	**0.995**	0.963
HBMusK	**0.988**	0.914
HBMusV	**0.989**	0.957
HBRMA	**0.994**	0.568
HBRMK	**0.988**	0.909
HBRMV	**0.987**	0.944
HBVidA	**0.956**	0.890
HBVidK	**0.925**	0.914
HBVidV	**0.997**	0.946
MA	0.770	**0.792**
MK	0.838	**0.924**
MV	0.863	**0.906**
RMA	0.484	**0.938**
RMK	0.864	**0.925**
RMV	0.880	**0.841**
VA	0.777	**0.915**
VK	0.820	**0.845**
VV	0.919	**0.936**
GA	0.836	**0.934**
GK	0.875	**0.853**
GV	0.823	**0.924**

D. Model Fit Evaluation

The following are the results of the model fit test to assess how well the model reflects the actual data shows that the SRMR value of the saturated model is 0.069, and the estimated model is 0.071, both below 0.10. This means that the model and data are suitable for analyzing the influence of the existing variables. The significant results can be seen in the internal model test to determine the influence of exogenous variables on endogenous variables [36]. The criteria used to determine the impact of the model are p-value <0.05.

E. Structural Model and Hypothesis Testing

Table 5. The structural model fit test (model fit) SEM-PLS

Structural Path (SP)	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistik (|O/STDEV|)	*p*-values
G → ILM	0.263	0.262	0.005	52.755	0.000
M → ILM	0.241	0.241	0.005	50.963	0.000
RM → ILM	0.262	0.262	0.004	64.236	0.000
V → ILM	0.259	0.259	0.004	60.831	0.000
HBGameA → G	0.251	0.263	0.074	3.408	0.001
HBGameK → G	0.626	0.624	0.054	11.503	0.000
HBGameV → G	**0.132**	**0.122**	**0.091**	**1.446**	**0.148**
HBMusA → M	0.640	0.653	0.106	6.042	0.000
HBMusK → M	0.144	0.143	0.089	1.625	**0.104**
HBMusV → M	0.198	0.186	0.140	1.416	**0.157**
HBRMA → RM	0.016	0.014	0.043	0.387	**0.699**
HBRMK → RM	0.456	0.454	0.077	5.894	0.000
HBRMV → RM	0.507	0.512	0.071	7.186	0.000
HBVidA → V	0.345	0.373	0.108	3.195	0.001
HBVidK → V	0.183	0.152	0.148	1.236	**0.216**
HBVidV → V	0.465	0.469	0.078	5.961	0.000

Table 5 shows that there are several insignificant relationships, namely learning outcomes in the use of games for visual learning styles (HBGameV), with a p-value of 0.148 (>0.05), indicating that visual learning styles are less able to learn optimally with game media. Learning outcomes in the use of music for the kinesthetic learning style (HBMusK) with a p-value of 0.104 (>0.05) indicate that the kinesthetic learning style is less effective in achieving optimal learning outcomes through music as a medium. Learning outcomes in the use of music for visual learning style (HBMusV) with a p-value of 0.157 (>0.05) indicate that visual learning style is less effective in achieving optimal learning outcomes through music. Learning outcomes in the use of material summaries for auditory learning style (HBRMA) with a p-value of 0.699 (>0.05) indicate that auditory learning style is less effective in achieving optimal learning outcomes through material summaries. Learning outcomes in the use of videos for kinesthetic learning styles (HBVidK) with a p-value of 0.216 (>0.05) indicate that kinesthetic learning styles are less effective in achieving optimal learning outcomes through video media. The following are the results of the structural model using SEM-PLS.

Fig. 6 shows the results of the structural model analysis using the SEM-PLS method that path coefficient values indicate the direction and strong relationships between latent constructs. The ILM variable directly contributes to four forms of learning multimedia, namely: Summary of Material (RM) of 0.262, Video (V) of 0.259, Game (G) of 0.263, and Music (M) of 0.241. This indicates that the four media play an essential role in shaping perceptions of interactive learning multimedia in a relatively balanced manner.

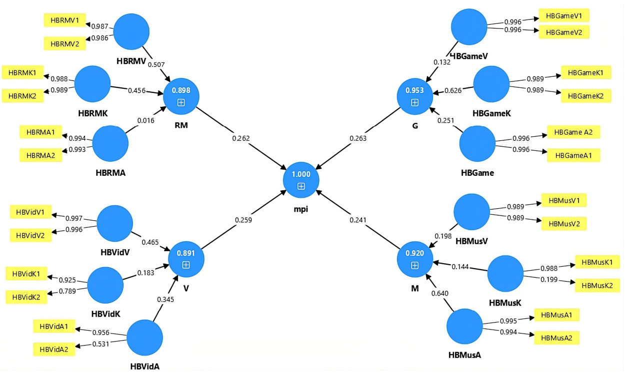

Fig. 6. The structural model using SEM-PLS.

Each media type influences student learning outcomes differently based on their learning styles (visual, kinesthetic, and auditory). RM has the most significant impact on the learning outcomes of visual learners (HBRMV) with a coefficient of 0.507, followed by kinesthetic learners (HBRMK) at 0.456, and the lowest influence on auditory learners (HBRMA) at 0.016. This indicates that summaries are more effective for students with visual and kinesthetic learning styles. Video media has a dominant influence on the learning outcomes of visual students (HBVidV) at 0.465, followed by auditory students (HBVidA) at 0.345, and the lowest on kinesthetic students (HBVidK) at 0.183. Meanwhile, game media is the most effective for kinesthetic learners (HBGameK) with an influence coefficient of 0.626, followed by auditory learners (HBGameA) at 0.251 and visual learners (HBGameV) at 0.132. Music media had the most significant effect on auditory learners (HBMusA) with a coefficient of 0.640, followed by visual learners (HBMusV) at 0.198, and the lowest on kinesthetic learners (HBMusK) at 0.144.

The results of this study indicate that Lumi Education ILM significantly influences students' learning outcomes. The results of the analysis using SEM-PLS show that the four multimedia contents: summary, videos, games, and music, contribute to the formation of the ILM construct and have varying but relatively balanced levels of influence. When examined through path coefficients, the game content has the most significant contribution, followed by the materials, music, and video summary.

The findings of this study align with previous research results indicating that ILM can enhance students' learning outcomes [37–40]. Previous studies have also indicated that multimedia-based technology offers various forms of media that can be tailored to individual learning styles, thereby encouraging students to be more active and independent [41–44]. Various types of multimedia, such as interactive animated videos and mobile-based video learning, are preferred by students and influence learning outcomes [45–48]. Thus, interactive learning multimedia content may be adapted based on contextual needs and instructional objectives.

The use of interactive learning multimedia "Lumi Education" is aligned with the CTML, which states that multimedia learning has three assumptions: the dual-channel assumption, the limited capacity assumption, and the active processing assumption [49]. The dual-channel assumption means that humans can process information through two main channels in the brain, so presenting text and images simultaneously can help learners understand better than text or pictures alone. The limited capacity assumption means that each channel in the brain has limitations, so multimedia must be designed in a simplified and focused manner to support learning outcomes. The active processing assumption means that interactive stimuli, such as questions and games, can encourage learners to actively think rather than passively receive material. Mayer also argues that children gain a more profound understanding when they combine words with images rather than words alone [29, 50].

The effectiveness of Lumi Education-based interactive multimedia in improving students' learning outcomes can be explained through several learning theories that emphasize active engagement, multimodal input, and learner-centered experiences. Based on the CTML [51], students learn more effectively when information is presented through both verbal and visual channels, as this dual coding helps optimize working memory and facilitates meaningful learning. Lumi Education's integration of text, images, videos, and sounds allows students to process information through multiple sensory modalities, aligning with this principle. Furthermore, the study reflects Constructivist Learning Theory (Piaget & Vygotsky), stating that learners actively construct their understanding through interaction with media, peers, and contextualized content. The interactive features, such as discussion rooms and assessments, provide scaffolding and social interaction that enhance cognitive development. Additionally, Dunn and Dunn's Learning Style Theory supports the observed findings, emphasizing that students achieve better outcomes when instructional methods match their preferred learning modalities: visual, auditory, or kinesthetic. Lumi Education's varied content types cater to these preferences, enabling personalized learning experiences. Thus, the alignment between multimedia elements, students' learning styles, and established learning theories accounts for the significant improvement in analyzing, identifying, and understanding concepts across all material indicators of the human respiratory system [52].

The findings of this study indicate that the game content is suitable for auditory and kinesthetic learning styles. The effectiveness of interactive learning multimedia "Lumi Education" in accommodating kinesthetic and auditory learning styles is in line with the learning pyramid or cone of learning model developed by Edgar Dale, which states that there are variations in how humans absorb and remember information with different levels of understanding and retention. This model indicates that direct experiences involving multiple senses are more effective in enhancing information retention than abstract or passive experiences [30–32].

Features like educational games that practice direct digital operations are highly suitable for kinesthetic learning styles. These activities fall under the "direct practice" level of the learning pyramid, which theoretically can achieve retention rates of up to 75%. The interactive learning multimedia "Lumi Education" enables kinesthetic learners to receive information passively and actively participate in learning. Thus, interactive learning multimedia-based learning provides visual and auditory stimuli and offers in-depth exploratory opportunities, as conceptualized in the "learning by doing" strategy that underpins the peak of effectiveness in Dale's pyramid.

Game content is less suitable for visual learners, as games often rely on complex visual representations, making it difficult for students to interpret and understand information [53]. This complexity can hinder the learning process of students with visual learning styles. Visual learners may require additional support to understand visual information in games.

Another finding is that music content is suitable for auditory learning styles. Sensory media, including auditory, can create a more interactive and immersive learning experience [54]. This helps students become more engaged and improves their learning performance compared to traditional learning methods [55]. This is also in line with CTML regarding the assumption of dual channels in the two main channels of the brain [49]. Music content is less suitable for visual and kinesthetic learning styles because music is naturally an auditory art form and, therefore, lacks visual content that visual learners can rely on through sight [56]. Although there have been attempts to integrate it with visual content and games, the results have not been optimal due to limitations in visualization and physical interaction.

Video content is suitable for auditory and visual learning styles. Clear and attractive visualizations can help visual learners enjoy videos. Videos can improve understanding of abstract scientific concepts, such as those found in material on the human respiratory system, in line with the video features on Lumi Education and students with visual learning styles [57]. Videos that often combine graphics, animations, and texts help visual learners understand the material better and can increase information retention and student motivation [58, 59]. Interactive videos that combine elements such as quizzes and simulations can help visual learners engage actively and think critically [60]. In addition, video is also suitable for visual learners because it combines visuals with auditory [61].

Auditory narration in videos can help auditory learners understand and remember information well [62]. Video content is less suitable for kinesthetic learners because they tend to learn better through physical activities and direct experiences. Although videos can provide good visuals and auditory, they do not offer physical interaction that kinesthetic learners require [63]. Videos cannot give the immediate feedback that kinesthetic learners often need to improve and optimize their skills. Immediate instructor feedback or interaction with the physical environment is essential for kinesthetic learners.

Summary is suitable for visual and kinesthetic learning styles. Summary content combining visual and kinesthetic elements in Lumi Education's interactive learning multimedia can significantly benefit students. Summarized material with colorful illustrations makes concepts easier to understand than long texts [64]. Visual techniques such as diagrams and videos, as well as kinesthetic approaches involving physical activity and direct manipulation, can improve students' overall understanding and engagement. This multimodal approach provides a more comprehensive and practical learning experience. It allows students to see and interact with the material simultaneously. As a result, it can improve students' understanding and retention [65, 66]. Summary of material is less suitable for auditory learners, as they enjoy what they hear, often read aloud, and can judge people by their voices [15, 67, 68]. Therefore, learning methods for auditory learners can include auditory recordings and story-based learning [68].

Beyond learning styles, the practical implications of Lumi Education–based interactive multimedia also extend to pedagogical innovation and classroom engagement. Teachers can leverage the platform's real-time embedded assessments (e.g., quizzes, drag-and-drop interactions, simulated experiments) as formative assessment tools to continuously monitor student understanding. Such use of formative assessment supports the development of students' Self-Regulated Learning (SRL) skills by providing immediate, process-level feedback and prompting metacognitive reflection [69]. In addition, integrating interactive multimedia encourages adaptive pacing and differentiated instruction, as teachers can respond swiftly to misconceptions or lagging students through scaffolded remediation or extension tasks. The platform also facilitates collaborative learning, where students can engage in shared problem-solving using multimedia artifacts (e.g., shared diagrams, annotations, and mini-simulations), thereby promoting deeper understanding through social negotiation of meaning.

For students, Lumi Education offers more than tailored content; it helps cultivate digital literacy and SRL competencies essential in the digital era. Multimedia environments, when designed to encourage planning, monitoring, and reflection, can significantly strengthen students' learning regulation processes [70]. Studies have shown that the use of multimedia resources positively correlates with SRL behaviors such as goal setting, self-monitoring, and reflection, which in turn enhance learning outcomes [71]. Moreover, in technology-enhanced learning environments, students' perceived ease of use and self-efficacy influence how effectively they utilize digital tools for learning gains. Thus, the interactive multimedia offered through Lumi Education functions not only as a content-delivery system but also as a scaffold for metacognitive growth, equipping students to manage their learning more autonomously and effectively.

Therefore, teachers can identify learning styles to recognize students' strengths and weaknesses, thereby creating a pleasant and effective learning environment to achieve optimal learning outcomes over the long term [72–74]. Identifying learning styles is also beneficial for teachers to provide appropriate learning interventions [74, 75].

This study is limited by the absence of a control group and a pretest, the restricted focus on the human respiratory system topic, and the assessment is limited to cognitive outcomes. Future studies are encouraged to use an experimental design with a control group to confirm the effectiveness of the interactive multimedia learning "Lumi Education", apply it to other contextual topics, and include affective and psychomotor domains to provide a more holistic understanding of multimedia-based learning effectiveness.

V. Conclusion

The interactive learning multimedia "Lumi Education," which includes four types of content videos, games, music, and summaries, has a significant and relatively balanced influence on students' learning outcomes. Among these, game content provides the strongest contribution, followed by material summaries, music, and video. In terms of compatibility with students' learning styles, each content type supports different preferences and individual characteristics. For instance, game content is suitable for auditory and kinesthetic learners but less effective for visual learners; music content is ideal for auditory learning styles but less compatible with visual and kinesthetic learners; video content effectively supports auditory and visual learning styles but is less aligned with kinesthetic learning; and material summaries are most suitable for visual and kinesthetic learners but less supportive of auditory learning.

This study advances recent literature on multimedia learning by introducing an integrated analysis of content-specific effectiveness and learning style compatibility within the Lumi Education platform. The significance of this study lies in its contribution to bridging the gap between multimedia design and differentiated learning strategies in elementary education. The findings provide empirical evidence that not all multimedia components have the same pedagogical impact, emphasizing the importance of tailoring instructional materials to accommodate various learning preferences. Theoretically, the study extends the understanding of multimedia learning by highlighting the interaction between content types and learning styles in shaping cognitive engagement and knowledge retention. Practically, the study provides valuable insights for educators and curriculum developers in designing inclusive, student-centered learning environments using Lumi Education. By integrating visual, auditory, and kinesthetic modalities in a balanced way, teachers can enhance motivation, improve comprehension, and achieve more equitable learning outcomes across diverse student populations.

Future research should expand on these findings by incorporating experimental designs with control groups, exploring affective and psychomotor learning outcomes, and applying Lumi Education-based multimedia to other scientific topics beyond the human respiratory system. Moreover, longitudinal studies are recommended to examine the long-term impact of multimedia-based learning on students' critical thinking and problem-solving skills. Investigating the integration of artificial intelligence and adaptive learning systems within Lumi Education could also provide new pathways for personalizing learning experiences and enhancing educational equity in the digital era.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Wahyu Noor Aryfien was responsible for the conceptualization, data collection, formal analysis, and writing of the original draft of the manuscript. Idam Ragil Widianto Atmojo contributed to the conceptualization, provided supervision throughout the research process, and participated in reviewing and editing the manuscript. Matsuri assisted in developing the methodology, supported data management and analysis, and contributed to the review and editing of the final manuscript. All authors have read and approved the final version of the manuscript.

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