



## Development of Interactive Learning Media Based on Differentiated Learning Styles to Improve Literacy and Numeracy in Early Childhood

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**Abstract:** This study aims to develop, validate, and evaluate the practicality and effectiveness of differentiated interactive learning media based on learning styles to improve early literacy and numeracy. The research applied an R&D method following the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The participants were 30 children aged 5–6 years, divided into experimental and control groups. Instruments included literacy and numeracy tests, expert validation sheets, and practicality questionnaires for teachers and children. Data were analyzed using normality and homogeneity tests and MANOVA with SPSS 26. The findings showed that the media was highly valid (Aiken's  $V > 0.90$ ), very practical (teacher response 95.56% and children's response 91.48%), and effective in improving literacy ( $F = 20.711$ ;  $p < 0.001$ ;  $R^2 = 0.425$ ) and numeracy ( $F = 63.439$ ;  $p < 0.001$ ;  $R^2 = 0.694$ ). The more substantial effect on numeracy reflected the role of concrete and kinesthetic activities, while audio-visual features supported literacy gains. These results confirm that the differentiated interactive learning media is a pedagogically relevant tool to support literacy and numeracy achievement within the Merdeka Curriculum.

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## Introduction

Early childhood is a critical period for developing foundational literacy and numeracy skills that shape later academic success and life opportunities. Yet, many education systems worldwide continue to report low proficiency in these basic skills (Parker et al., 2022). Results from the Programme for International Student Assessment (PISA) 2022 showed a decline in mathematics performance, with Indonesia's average score decreasing from 379 in 2018 to 366 in 2022. Moreover, only 18% of Indonesian students reached at least Level 2 proficiency in mathematics, a figure far below the OECD average of 69% (OECD, 2023). Over the past decade, roughly 70% of 15-year-olds have failed to reach minimum competency in literacy and numeracy (Kartika, 2024). These alarming outcomes underscore the urgent need for innovations in early education to strengthen literacy and numeracy from the ground up.

In response, the Indonesian government introduced the Merdeka Curriculum in 2022 as a major reform aimed at improving foundational learning outcomes (Kartika, 2024). This new curriculum emphasizes flexible, student-centered pedagogy and seeks to address entrenched disparities in educational quality across regions and socio-economic groups. Teachers are now encouraged, and in some cases mandated, to adopt differentiated and engaging instructional approaches, including the integration of digital technologies, to



optimize content delivery and better meet students' individual learning needs (Siswanti & Daud, 2024).

However, transforming these policy aspirations into classroom practice remains challenging. Many early childhood educators lack the training, confidence, or resources to effectively integrate technology in their teaching, resulting in continued reliance on conventional one-size-fits-all methods (Ogegbo & Aina, 2022). Even when educators recognize the value of technology for young children's learning, barriers such as limited ICT access, insufficient support, and lack of developmentally appropriate digital content often hinder implementation (Ogegbo & Aina, 2020). As a result, preschool and early primary classrooms frequently miss opportunities to leverage interactive media and differentiated strategies that could make learning more accessible and enjoyable for every child. This gap between the Merdeka Curriculum's innovative vision and the reality of current practice highlights the need for research-informed solutions and capacity-building in early childhood settings.

Another critical consideration is the diversity of learning preferences and modalities among young children. Research shows that children construct knowledge through multiple modes, visual, auditory, verbal, and kinesthetic, especially when learning early literacy and numeracy concepts (Muguwe et al., 2024). Indeed, Ningsi & Hartono (2025) and Dermitzaki (2025) observe that young learners require more than verbal explanations or textbook exercises to fully grasp new concepts and stay motivated. Similarly, Hidayat et al. (2023) note that simply relying on teachers is no longer sufficient in today's classrooms; teachers are expected to create learning environments that are enjoyable, creative, and dialogical to capture children's interest.

Observations revealed that teaching practices and learning media remain monotonous and fail to accommodate children's diverse learning preferences. Teachers reported that children often struggled to grasp basic literacy and numeracy concepts, while school leaders highlighted that students entering primary school also faced persistent challenges. These findings emphasize that the low performance in literacy and numeracy is not solely due to children's abilities, but also the lack of adaptive media tailored to their learning needs. Consequently, there is a pressing need for innovative instructional media to provide engaging, compelling, and differentiated learning experiences for early childhood education. (Oya et al., 2024).

Interactive learning media offer a promising avenue to address these challenges and align teaching practices with both children's needs and policy mandates. Broadly defined, interactive learning media include digital and physical educational tools (such as multimedia apps, e-books, educational games, and interactive storytelling materials) that actively involve learners through touch, movement, sound, and visual stimuli (Adawiyah et al., 2024). Prior studies have shown that such media can serve as a bridge between abstract academic concepts and young children's concrete understanding (Irmaningrum et al., 2023). Likewise, Hossain (2024) reports that well-designed educational media can clarify difficult content, enrich children's vocabulary, and "bring lessons to life" through multi-sensory engagement. In early childhood contexts, integrating interactive media into lessons has been associated with increased student attention, participation, and enjoyment of learning. Thus, a critical need exists for developing and testing innovative instructional media that are not only pedagogically effective but also feasible and user-friendly for teachers in real-world early childhood settings.



One innovative framework that can guide the design of such media is the VARK learning style model (Visual, Auditory, Read/Write, Kinesthetic). The VARK model provides a simple yet practical way to categorize learners' preferred modes of information intake, and it encourages educators to deliver content in multiple formats to reach all learners. While debates persist about the rigidity of "learning styles," there is consensus that a multimodal approach can enrich learning experiences, particularly for young children, who benefit from engaging as many senses as possible during instruction (Viet Quynh, 2024). The VARK model has been widely applied in various educational contexts because of its intuitiveness and ease of use in classroom planning. By ensuring that teaching materials incorporate visual elements, auditory elements (spoken words, music, sound effects), reading/writing elements (text, letters, labels), and kinesthetic elements (hands-on activities, interactive touch or movement), educators can cater to a broad spectrum of learning preferences in one cohesive learning experience (Lee, 2019).

Recent studies demonstrate the effectiveness of integrating VARK-based strategies with modern technology. For instance, Lee (2019) implemented a technology-mediated multimodal approach using digital audio-visual materials, and found that 100% of students agreed this approach helped them learn more effectively. In another study, Irmaningrum et al. (2023) developed a learning medium for elementary students based on the VARK model, embedding illustrated stories (visual), narration (auditory), on-screen text (reading), and interactive tasks (kinesthetic). It was rated highly valid (96% validity) by experts and, when tested in classrooms, led to notable gains in student understanding of the material.

Despite these advances, there remains a clear gap in the literature and practice regarding early childhood education. Few studies to date have applied a VARK-integrated interactive media approach specifically to bolster early literacy and numeracy in the preschool or early primary years. Early childhood learners have unique developmental needs and shorter attention spans, requiring that any digital or interactive intervention be carefully tailored to be age-appropriate, engaging, and aligned with foundational skill-building goals. The novelty of the present study lies in addressing this gap by combining the well-established VARK multi-modal framework with interactive learning media designed explicitly for young children's literacy and numeracy development.

In doing so, our approach responds directly to the Merdeka Curriculum's call for differentiated, engaging instructional innovations supported by digital technologies in early education. Moreover, this approach is significant in the Indonesian context, where teachers are striving to fulfil new curriculum mandates but often lack practical examples of effective, technology-enhanced activities for young learners. By developing and evaluating a VARK-based interactive learning medium for early childhood, this study aims to demonstrate a proof of concept for how such innovations can enhance early literacy and numeracy outcomes while aligning with national education reforms. It also seeks to contribute to the broader knowledge base by illuminating how multimodal learning theories can be operationalized in real classrooms to support foundational skills.

## **Research Method**

This study applied a research and development (R&D) method to create, validate, and test a differentiated interactive learning medium based on children's learning styles to improve early literacy and numeracy skills. The development process followed the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) (Made et al., 2015). In the Implementation phase, the intervention was conducted in early childhood



classrooms over four consecutive weeks, with sessions held three times per week for about 30–35 minutes each. This schedule was designed to match young children’s limited attention spans while ensuring consistent reinforcement of literacy and numeracy concepts, as recommended in early childhood education research that emphasizes short, repeated, and engaging learning activities for optimal retention and participation (Pyle & Danniels, 2017; Wasik & Hindman, 2020).

The population consisted of early childhood students aged 5–6 years enrolled in kindergarten level B, while the sample included 30 children selected purposively based on comparable developmental characteristics. The sample was divided into 15 children in the experimental group and 15 in the control group. The experimental group was taught using the differentiated interactive media, whereas the control group received instruction through conventional methods. Both groups were administered a pretest before the intervention and a posttest afterward, allowing for comparative outcomes analysis. The research employed a quasi-experimental design using a nonequivalent control group pretest-posttest structure, as summarized in Table 1.

**Table 1. Research Design**

<b>Group</b>	<b>Pre-test</b>	<b>Treatment</b>	<b>Post-test</b>
EG	O <sub>1</sub>	X <sub>1</sub>	O <sub>3</sub>
CG	O <sub>2</sub>	-	O <sub>4</sub>

(Sugiyono, 2018)

Notes:

- O<sub>1</sub> : Pre-test of the Experimental Group  
O<sub>2</sub> : Pre-test of the Control Group  
O<sub>3</sub> : Post-test of the Experimental Group  
O<sub>4</sub> : Post-test of the Control Group  
X<sub>1</sub> : Differentiated Interactive Learning Media Intervention

Data collection techniques consisted of observations, questionnaires, and tests. Structured observations were conducted to capture children’s engagement with the media and the classroom environment. Questionnaires were administered to gather feedback from teachers, experts, and students, covering aspects of the media’s validity, practicality, and usability. Three types of expert validation were carried out: material validation, media validation, and practitioner validation. Each expert assessed the product using a Likert scale rubric (Nurkhalisa et al., 2025).

In addition, literacy and numeracy tests were administered as pre- and posttests to both groups. These tests were designed to align with the learning indicators of the Merdeka Curriculum and were validated by literacy and numeracy experts. Item validity was tested using Pearson Product-Moment correlation, while reliability was measured using Cronbach’s Alpha to ensure internal consistency. Results indicated high reliability, with alpha values above 0.85 for literacy and numeracy instruments.

**Table 2. Blueprint of Numeracy Test Instrument**

<b>Aspect</b>	<b>Indicator</b>	<b>Items</b>
Algebra	Sorting, grouping, creating patterns, solving problems	1,2,3,4
Numbers	Recognizing numbers, comparing, and ordering numbers	5,6,7
Geometry	Understanding geometric shapes, spatial relationships, position, and 2D/3D objects	8,9,10

Source: Kementerian Pendidikan Kebudayaan Riset dan Teknologi (2022)



**Table 3. Blueprint of Literacy Test Instrument**

Aspect	Indicator	Items
Language Comprehension	Understanding multiple instructions simultaneously	1,2
Language Expression	Answering more complex questions	3
	Naming familiar letter symbols	4,5
Early Literacy	Identifying the initial sound of objects in the environment	6
	Naming groups of pictures with the same initial sound/letter	7,8
	Understanding the meaning of words in a story	9,10

Source: Kementerian Pendidikan Kebudayaan Riset dan Teknologi (2022)

Data were analyzed quantitatively with SPSS version 26. Prerequisite tests included normality testing using the Shapiro-Wilk method, homogeneity testing with Levene's Test, and multicollinearity testing to ensure independence between dependent variables. Hypothesis testing was conducted using Multivariate Analysis of Variance (MANOVA) to determine both interactive media's simultaneous and partial effects on literacy and numeracy skills. Significance levels of  $p < 0.05$ , supported by Wilks' Lambda and related multivariate statistics, were used as decision criteria to conclude the effectiveness of the intervention.

## **Results and Discussion**

### **Development of Differentiated Interactive Learning Media**

The development stage produced an interactive learning medium to accommodate diverse learning styles (visual, auditory, and kinesthetic) by integrating digital features such as images, audio narration, animations, and interactive exercises. The product was designed using the Flutter–Firebase platform to ensure flexible deployment across devices, providing children with a multisensory learning experience that aligns with the principles of differentiated instruction. This design of Gall, Borg choice was based on the recognition that early childhood learners require multimodal input to strengthen cognitive processing and sustain engagement (Gustiani, 2019). The media structure was organized into two domains (literacy and numeracy) with content mapped to the national early childhood curriculum indicators to ensure contextual and developmental relevance.

A critical scientific finding in this phase was that differentiated learning media can reduce the limitations of one-size-fits-all teaching practices, which often overlook individual learning needs. By incorporating the VARK learning styles into the media design, children could explore letters, words, and numbers through modes that matched their preferences, fostering intrinsic motivation and deeper understanding. This aligns with the theoretical basis that differentiated media enhances children's readiness by providing multiple entry points into the duplicate content (Setiawan et al., 2024). In particular, the visual features supported recognition of letters and numbers, the auditory narration aided phonological awareness, and the kinesthetic tasks promoted active exploration of numeracy concepts (Nugraha & Budiyo, 2022).

Another important outcome was that the design of the media allowed for interactive scaffolding. Each learning activity followed a structured flow: an introductory segment, an exploratory task, and a reflective mini-assessment. For instance, literacy modules introduced letters with audio-visual cues, followed by drag-and-drop matching exercises, and concluded with short quizzes to reinforce comprehension. This iterative flow ensured that children were not passive recipients but active constructors of knowledge. Such an approach is consistent with constructivist learning principles, which emphasize meaningful engagement and scaffolding in early childhood education (Chalik & Cahyani, 2024).





**Figure 1. Differentiated Interactive Media Interface**

The development process also demonstrated that technology-supported differentiation provides opportunities for hybrid learning, where children can continue practicing at home with parental guidance. This expands the learning context beyond the classroom, fostering collaboration between schools and families. Compared with previous studies that relied on traditional printed media or single-mode digital tools, the integration of multimodal features within a single platform represents a novel contribution of this research (Astawan & Bayu, 2025). Earlier findings highlighted the importance of media in supporting children's literacy and numeracy but did not sufficiently address how differentiated learning styles could be systematically embedded in media design (Muawannah et al., 2023). This study advances the discourse by showing that interactive differentiation supports learning outcomes and creates a more engaging and equitable learning environment for diverse learners.

### Expert Validation of the Media and Instruments

**Table 4. Expert validation result**

Expert Appraisal Category	Average Percentage	Qualification
Material Experts	89%	Valid
Media Experts	91%	Valid
Design Experts	90%	Valid

Assessment adapted from (Alamanda & Zainil, 2024)

**Table 5. Expert instrument validation result**

Instrument validation	Aiken's V	Qualification
Literacy Instrument	0,97	Very Valid
Numeracy Instrument	0,95	Very Valid

Assessment adapted from (Retnawati, 2016)

Results from the validation process indicated that the media was highly valid across all categories (Table 4 and 5). Specifically, material experts highlighted that the literacy and numeracy content corresponded with indicators of the Merdeka Curriculum, while also integrating differentiated learning strategies that supported visual, auditory, and kinesthetic modalities. Media experts emphasized that the interface design was intuitive and user-friendly, with clear visual and auditory cues to accommodate early childhood learners. Practitioner validation confirmed that the media could be easily applied in classroom practice without requiring extensive teacher training, thus ensuring practicality in real teaching settings.

The scientific interpretation of these results suggests that the high validity levels were not incidental but rooted in the systematic design process that followed the ADDIE framework. The consistency of high scores indicates that the product met theoretical and practical standards for early childhood media. In addition, the use of validated literacy and



numeracy instruments ensured that learning outcomes could be measured accurately. These instruments, which were also validated using Aiken's V, showed that each item reliably represented the intended learning constructs, reinforcing their pedagogical relevance (Sugiyono, 2018).

Similar research has shown that media validated through expert judgment and statistical indices provides higher reliability and effectiveness in classroom application (Fadila et al., 2024; Wahyuni et al., 2024). Moreover, studies on early childhood media development emphasize that expert involvement at the validation stage is essential to ensure that instructional products are both engaging and instructionally sound (Dirgantoro et al., 2024). In line with these studies, the present research demonstrates that differentiated interactive media can achieve high content validity, design appropriateness, and classroom applicability, positioning it as a credible tool to support literacy and numeracy development in early childhood education.

### **Practicality of the Media in the Classroom Use**

The practicality of the differentiated interactive media was assessed through teacher evaluations and small-group trials with children during classroom implementation. Teachers reported that the media was easy to operate, required minimal technical guidance, and could be integrated smoothly into daily lesson plans. The interface design, including clear navigation buttons, child-friendly icons, and interactive tasks, enabled teachers and children to use the media easily. Children demonstrated enthusiasm when interacting with the media, showing high levels of participation and minimal hesitation in navigating activities. These responses illustrate that the media successfully met the practicality criteria of being accessible, intuitive, and engaging in real classroom settings.

Quantitatively, the results of practicality testing showed strong positive responses, with teacher practicality scores reaching above 95% and child responses exceeding 91%. These scores fall into the "very practical" category, indicating that the media was accepted and perceived as valuable and efficient for teaching and learning. Such outcomes reflect the ability of the media to reduce instructional complexity for teachers while supporting children's independent engagement. The practicality results, therefore, confirm that the product does not impose additional workload on educators but rather enhances the efficiency of instructional delivery.

The scientific interpretation of these findings is that practicality is achieved because the media incorporates multimodal features in a way that aligns with children's natural learning tendencies (Khoirunnisa et al., 2023). Children in early childhood respond positively to interactive, visually appealing, and responsive media, which explains their active engagement and favorable evaluations (Hayes, 2025). Teachers also perceived the media as practical because it provided ready-to-use content aligned with curriculum goals, allowing them to focus more on facilitation rather than preparation. These findings are consistent with prior studies emphasizing usability as a critical determinant of media adoption in early childhood classrooms. Research has shown that digital learning tools designed with intuitive interfaces and playful elements are more likely to be considered practical and sustainable in classroom application (Siswanti & Daud, 2024).

### **Effectiveness of the Media on Literacy and Numeracy**

The effectiveness of the differentiated interactive learning media was evaluated through pretest–posttest comparisons, supported by statistical analyses of normality,



homogeneity, multicollinearity, and MANOVA. Preliminary tests confirmed that the data met statistical assumptions: the Shapiro-Wilk test indicated normal distribution for both literacy and numeracy gains ( $p > 0.05$ ), and Levene's Test showed homogeneity of variance across groups ( $p > 0.05$ ). Multicollinearity testing revealed tolerance values above 0.10 and VIF values below 10, confirming that literacy and numeracy functioned as independent yet related constructs suitable for simultaneous analysis. These conditions provided a robust foundation for multivariate testing of the media's effectiveness.

The MANOVA results simultaneously demonstrated a significant overall effect of the intervention on literacy and numeracy outcomes, with Wilks' Lambda = 0.247,  $F = 41.256$ , and  $p < 0.001$ . This indicates that the experimental group exposed to the differentiated media improved significantly more than the control group. The simultaneous effect highlights the strength of multimodal learning strategies in enhancing both domains together, consistent with constructivist and differentiated learning theories which emphasize multiple entry points to knowledge acquisition (Taş & Minaz, 2024).

**Table 6. Results of Hypothesis Testing for Literacy and Numeracy**

Dependent Variable	F	Sig.	R <sup>2</sup>	Interpretation
Numeracy	63,439	0,000	0,694	Significant, strong effect
Literacy	20,711	0,000	0,425	Significant, moderate effect

Source: Statistical analyses SPSS 26

Following the significant MANOVA results, univariate ANOVAs were conducted separately for each dependent variable to explore their individual contributions. The results (Table 6) indicate that the intervention significantly improved both numeracy and literacy, with stronger effects observed for numeracy. Numeracy gains yielded  $F = 63.439$ ,  $p < 0.001$ , with  $R^2 = 0.694$ , suggesting that the media explained nearly 70% of the variance in numeracy outcomes. Literacy gains produced  $F = 20.711$ ,  $p < 0.001$ , with  $R^2 = 0.425$ , indicating a substantial though comparatively lower effect. These findings suggest that interactive tasks emphasising visual and kinesthetic modalities, such as counting, patterning, and classification, contributed more directly to numeracy improvement, while literacy, though also enhanced, benefited primarily from auditory and symbolic reinforcement embedded in the media (Wahyuni et al., 2024; Davidse et al., 2014).

The interpretation of these results underscores that both the media and the assessment instruments were aligned with competencies expected at this developmental stage. The strong effects reflect a methodological commitment to ensuring that media development addressed not only technical feasibility but also pedagogical and evaluative validity, consistent with the ADDIE model (Pakaja et al., 2024). These findings also resonate with Arsyad's (2016) emphasis that instructional media should concretize abstract concepts, while Richard (2009) highlights that the storyboard and interface design followed multimedia learning principles such as coherence, signaling, and modality. By providing multimodal entry points, the media reduced cognitive load and supported symbolic representation in ways developmentally suited to early learners.

In practical terms, the medium-to-high N-Gain values also reinforced the statistical results. Numeracy achieved an N-Gain of 0.68 and literacy 0.62, which according to Hake's (2000) classification fall into the medium ( $0.3 \leq g < 0.7$ ) to high ( $g \geq 0.7$ ) category. These values demonstrate that the media was effective statistically and meaningful in practical classroom application, allowing children to build measurable gains in foundational competencies. The more substantial effect on numeracy may be explained by the concrete



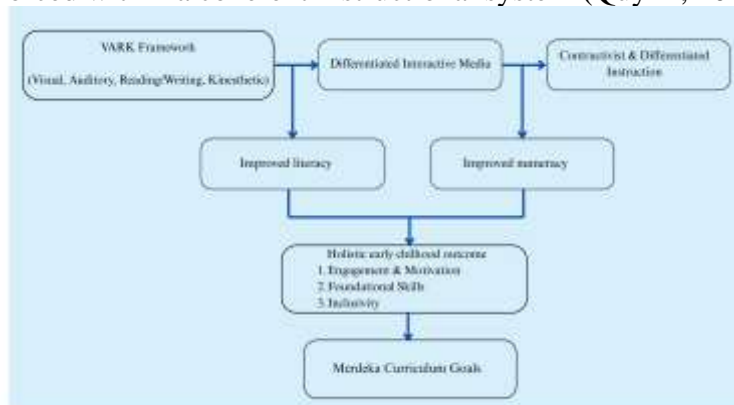


and playful nature of the activities, which aligned with children's natural tendencies to explore through manipulation, classification, and sequencing (Wahyuni et al., 2024). Although slightly lower, literacy gains were still substantial, particularly in letter recognition, auditory comprehension, and symbolic understanding.

These results align with prior research emphasizing that multimodal, differentiated media strengthen learning engagement and outcomes. Studies such as Suci et al. (2024) and Jazriyah & Yuliantina (2025) interactive, visually appealing media enhanced comprehension and motivation in early childhood contexts. Likewise, Kewalramani et al. (2024) highlighted that multimodal digital resources foster inclusive early STEM engagement, while Kasman (2025) demonstrated that visual-interactive designs support logical reasoning and mathematical thinking. The current findings extend these insights by showing that differentiated interactive media can systematically combine these principles to produce statistically significant and practically meaningful improvements in literacy and numeracy.

### **Integrated Impact on Early Childhood Learning**

The integrated improvement across both domains can be explained through constructivist and differentiated instruction theories. Constructivist perspectives argue that children build knowledge actively through interaction with meaningful stimuli, while differentiated instruction emphasizes adapting learning experiences to individual readiness, interest, and learning profiles (Marantika et al., 2023). The media developed in this study aligned with these principles by offering multimodal tasks designed to engage children with varied entry points, enabling them to construct an understanding of letters, sounds, numbers, and patterns through exploration and play. This alignment explains why both literacy and numeracy improved simultaneously, as children's symbolic, auditory, and kinesthetic experiences were reinforced within a coherent instructional system (Quynh, 2024).



**Figure 2. Integrated Impact Model of Differentiated Interactive Media on Early Childhood Literacy and Numeracy**

The VARK framework (Visual, Auditory, Reading/Writing, and Kinesthetic) was central to these outcomes. By integrating visual animations, auditory narration, interactive quizzes, and kinesthetic tasks, the media provided multiple pathways for processing information, thereby reducing cognitive load and increasing retention. Studies in early childhood education emphasize that multimodal designs not only improve engagement but also foster inclusivity by accommodating diverse learning preferences (Taş & Minaz, 2024). This aligns with Aloni et al. (2024), who demonstrated that students strongly favored visual and sensorimotor modalities in learning, while auditory preferences correlated positively with higher academic achievement. Such findings reinforce that VARK-based interventions offer



dual benefits: they respect children's natural inclinations toward hands-on and visual exploration and strengthen verbal and auditory comprehension crucial for literacy development.

Moreover, integrating VARK principles in early childhood reflects constructivist pedagogy, where learning is scaffolded through active exploration and multiple sensory channels. Research has shown that when learners are given opportunities to engage with multimodal representations, they not only retain content more effectively but also develop deeper conceptual understanding (DeStefano & LeFevre, 2004; Freeman et al., 2014). This is particularly vital for early children, as their cognitive flexibility allows them to shift between modalities, making differentiated instruction more impactful. Thus, embedding VARK in digital media is a cognitively grounded and developmentally appropriate approach to strengthening literacy and numeracy in early years.

The broader implication of these findings is significant for implementing the *Merdeka Curriculum*. By prioritizing literacy and numeracy as foundational competencies, the curriculum encourages flexible and contextualized approaches to teaching that respect children's diverse learning needs. The results of this study provide empirical evidence that differentiated, multimodal digital media can serve as an effective tool for achieving these goals, while also cultivating the attributes of the *Profil Pelajar Pancasila* such as curiosity, critical thinking, and collaboration. Furthermore, the alignment with experiential learning theory (Kolb) and sociocultural theory (Vygotsky's ZPD) strengthens the case for adopting such media as part of everyday classroom practice. Interactive tasks support individual exploration and facilitate collaborative learning between peers and teacher scaffolding, reinforcing the *Merdeka Curriculum*'s holistic vision (Rigopouli et al., 2025; Zhang, 2023). In sum, the integrated impact of this study demonstrates that differentiated interactive media can effectively improve literacy and numeracy in tandem by blending VARK principles with constructivist and differentiated instruction approaches. Beyond measurable statistical gains, the results suggest a practical pathway for embedding digital multimodal resources into early childhood classrooms as a core strategy for delivering the *Merdeka Curriculum*.

## Conclusion

This study concludes that differentiated interactive learning media based on the VARK framework is valid, practical, and effective in improving early literacy and numeracy. Expert validation confirmed high content and design validity, while classroom trials demonstrated ease of use and strong child engagement. Statistical analyses showed significant improvements in both domains, with numeracy achieving stronger effects due to concrete and kinesthetic tasks, and literacy improving through integrated audio-visual support. Overall, the media provides a scientifically grounded and pedagogically relevant innovation that supports the *Merdeka Curriculum* in strengthening foundational skills for early childhood learners.

The findings of this study carry significant conceptual implications for early childhood education research. By integrating the VARK learning style model into interactive media, the study extends constructivist and differentiated instruction theories with empirical evidence from early literacy and numeracy contexts. The results demonstrate how multimodal entry points (visual, auditory, reading/writing, and kinesthetic) reduce cognitive load, foster inclusivity, and support symbolic representation in developmentally appropriate ways. This contributes to the broader discourse on multimodal pedagogy by providing a validated framework that operationalizes theoretical constructs into a coherent instructional design for early learners.



In practical terms, the study highlights how differentiated interactive media can be seamlessly integrated into early childhood classrooms under the Merdeka Curriculum. The high practicality scores from both teachers and children indicate that the media is user-friendly, requires minimal technical training, and reduces teacher workload while enhancing student engagement. The ability of the media to be used flexibly at school and at home also demonstrates its relevance for teacher-parent collaboration, supporting continuity of learning beyond formal settings. These practical implications reinforce the potential of this innovation as a scalable and sustainable solution to strengthen foundational literacy and numeracy in Indonesian early childhood education.

### Recommendation

Based on the findings and considering the study's limitations, several recommendations can be made. When using the differentiated interactive media, young learners should be accompanied by teachers or parents, since children aged 5–6 years still require guidance to explore according to their individual learning styles while maintaining motivation. Teachers are encouraged to act not only as users but also as facilitators who adapt media use to each child's literacy and numeracy levels, supported by continuous training in digital pedagogy and differentiated instruction. Schools and foundations must provide infrastructure, flexible scheduling, and collaborative opportunities with media developers and academics to ensure sustainable implementation. Future researchers may expand the scope to larger and more diverse populations across different regions, conduct longitudinal studies to evaluate retention and transfer of learning, and integrate broader developmental dimensions such as socio-emotional growth, creativity, and communication to enrich the holistic impact of differentiated digital media in early childhood education.

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