



## A human-centered development of local wisdom-based puzzle learning media for early childhood cognitive development

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### Abstract

**Background:** Early childhood is a critical period for cognitive development, during which children rapidly develop thinking, problem-solving, and symbolic abilities. Learning media play an important role in facilitating cognitive stimulation through play-based and concrete learning experiences. However, many educational puzzle media used in early childhood classrooms lack durability, cultural relevance, and human-centered design considerations. Integrating local wisdom into learning media offers opportunities to contextualize learning while strengthening children's cultural identity.

**Aims:** This study aims to develop and validate a local wisdom-based puzzle learning media designed to support cognitive development in early childhood, with a focus on media feasibility, teacher usability, and children's engagement as key human factor indicators.

**Method:** This study employed a Research and Development approach using the ADDIE model, consisting of analysis, design, development, implementation, and evaluation stages. The learning media were developed in the form of an acrylic-based puzzle integrating Lampung local wisdom. Data were collected through expert validation sheets, teacher response questionnaires, and observations of children aged 5-6 years during small-scale and large-scale trials. Data were analyzed using descriptive quantitative analysis with a percentage-based approach.

**Results:** The findings show that the developed puzzle media achieved very high validity scores from both media and subject-matter experts. Teacher responses indicated that the media were very attractive, easy to use, and appropriate for early childhood learning. Children demonstrated high levels of engagement, concentration, and cognitive interaction during both trial stages.

**Conclusion:** Local wisdom-based puzzle learning media developed through a human-centered approach are feasible and attractive for early childhood cognitive learning. The integration of cultural content, durable materials, and user-oriented design enhances learning relevance and engagement.

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## INTRODUCTION

Early childhood represents a critical developmental period in which foundational cognitive, social, emotional, and motor abilities are rapidly formed. Developmental psychologists describe early childhood as a phase characterized by accelerated growth in thinking, language, and problem solving abilities, typically occurring between the ages of 2.5 and 6 years, while broader international frameworks extend this range to birth through eight years of age (Kurniawan et al., 2023; Tadjuddin, 2014). Educational theorists emphasize that this stage constitutes a decisive

foundation for later learning trajectories, as children demonstrate innate potential for creativity, curiosity, and exploration (Susanto, 2017). Educational interventions implemented during this period therefore exert long-term influence on children's academic readiness and adaptive capacities.

Early childhood education aims to support holistic development through structured stimulation that addresses multiple developmental domains. National and international early childhood standards consistently highlight the importance of fostering physical motor skills, language, cognitive development, social emotional competence, moral values, and artistic expression within integrated learning environments (Permendikbud No. 137/2014). Cognitive development occupies a central position within these domains because it underpins children's abilities to reason, solve problems, classify objects, and adapt to everyday challenges. Cognitive competence in early childhood is widely associated with later academic success and lifelong learning readiness (Khadijah, 2023; Santrock, 2018).

Learning media play a crucial role in facilitating cognitive stimulation in early childhood settings. Educational research has consistently shown that children learn most effectively through active engagement with concrete, manipulative, and visually rich materials that allow them to explore concepts through play (Windayana, 2014). Educational game tools or alat permainan edukatif function as instructional media that integrate play and learning, enabling children to acquire new knowledge while maintaining intrinsic motivation. Well designed educational game tools support experiential learning, promote sustained attention, and encourage creative exploration when aligned with children's developmental characteristics (Mahardikha et al., 2019; Mursid, 2017).

Among various forms of educational media, puzzle based learning tools have received considerable attention in early childhood research. Puzzle activities are widely recognized for their capacity to stimulate cognitive processes such as visual perception, memory, logical reasoning, and problem solving. Studies indicate that puzzle play enhances children's motivation to persist in solving challenges and supports conceptual understanding related to color, shape, size, and quantity (Srianis et al., 2014; Rahmani & Suryana, 2022). Age appropriate puzzle complexity has been shown to influence engagement and learning outcomes, with gradual increases in the number of pieces corresponding to children's developmental stages (Trimantara et al., 2019; Harmila et al., 2023).

Despite the documented benefits of puzzle based learning, several limitations remain evident in existing educational media designs. While many commercially available puzzles rely on fragile materials, research on play materials, such as loose parts and manipulatives that highlights their impact on engagement and cognitive development, suggesting the need for durable and flexible materials in early learning environments (Cankaya, Martin, & Haugen, 2025). Prior research has largely emphasized functional outcomes of puzzle use while giving limited attention to material innovation, media durability, and usability from the perspective of teachers and learners as end users (Ramilo et al., 2022; Ochogboju & Díez-Palomar, 2025; Gnawali, 2025). Moreover, most puzzle designs focus on generic themes such as animals, fruits, or vehicles, offering limited cultural relevance to children's local contexts (Veronica, 2018).

The integration of local wisdom into educational media has emerged as a promising approach to contextualize learning and strengthen children's cultural identity. Local wisdom embodies values, symbols, and traditions that reflect a community's worldview and social practices (Priyatna, 2017; Pingge, 2017). In early childhood education, culturally responsive media can enhance learning relevance and foster emotional connections between children and their learning environments. Research on cultural integration in early childhood learning has

predominantly employed narrative texts or visual representations, with limited exploration of interactive media that combine cultural content with hands on cognitive activities (Arkas & Suryana, 2022; Rizkiyani & Sari, 2022).

From a media technology perspective, educational game tools should be understood not merely as play objects but as learning media designed through intentional instructional design processes. Contemporary learning media research emphasizes usability, material innovation, and user experience as critical factors influencing instructional effectiveness (Plass et al., 2015; Dede, 2014; Mayer, 2020). Human factor considerations such as teacher perceptions, ease of use, learner engagement, and age appropriateness play a decisive role in determining whether a learning medium can be effectively implemented in classroom practice. However, empirical studies that explicitly integrate human factor analysis into early childhood media development remain limited, particularly in culturally grounded learning contexts.

A review of existing international literature reveals several gaps. First, limited studies examine puzzle based educational media that integrate local cultural elements as core design features rather than supplementary visuals. Second, material durability and sustainability of early childhood learning media receive minimal scholarly attention despite their practical importance in educational settings. Third, human factor dimensions including teacher usability perceptions and learner engagement are often treated as secondary outcomes rather than central evaluative criteria. Fourth, interactive design innovations that extend beyond conventional puzzle assembly, such as multimodal visual interaction, remain underexplored in early childhood media development research. Fifth, few studies adopt a comprehensive research and development framework that simultaneously addresses instructional design, media technology, cultural relevance, and user validation in early childhood contexts (Hirsh-Pasek et al., 2015; Papadakis et al., 2021; Mardell et al., 2019).

To address these gaps, this study aims to develop and validate a local wisdom based educational puzzle as a learning media for early childhood education. The study focuses on the design and development of a culturally grounded puzzle made from durable acrylic material, incorporating interactive visual elements and multiple modes of play. The research specifically aims to evaluate the validity of the developed media, examine teacher responses as primary human factor indicators, and assess learner engagement as reflected in children's interest and interaction with the media.

This study contributes to early childhood education research in several ways. First, it extends media technology scholarship by demonstrating how material innovation and instructional design principles can be integrated into early childhood learning media. Second, it advances human factor perspectives by positioning teacher usability and learner engagement as central evaluative dimensions in media development. Third, it enriches childhood education literature by embedding local cultural wisdom within interactive learning media, thereby strengthening contextualized learning approaches. Finally, the study provides empirical evidence to inform educators and curriculum designers about the development of durable, culturally responsive, and user oriented educational game tools for early childhood learning environments.

## **METHOD**

This study employed a Research and Development (R&D) approach using the ADDIE development model, which consists of the stages of analysis, design, development, implementation, and evaluation (Branch, 2009; Molenda, 2015). This model was selected because it provides a systematic framework for designing and developing learning media that are oriented

toward user needs and allows for continuous evaluation at each stage of development (Dick, Carey, & Carey, 2015).

The analysis stage focused on identifying the characteristics of children aged 5–6 years, learning needs in kindergarten settings, and the limitations of previously used educational puzzle tools. The design stage was directed toward developing a puzzle learning medium based on Lampung local wisdom, taking into account visual aspects, shape, size, materials, and variations of play that align with children’s developmental characteristics (Mursid, 2017). The development stage involved producing an acrylic-based puzzle prototype, which was subsequently validated by subject-matter experts and media experts (Plomp & Nieveen, 2013). The implementation stage was carried out through limited trials and field trials in kindergarten environments. The evaluation stage aimed to assess the feasibility, attractiveness, and user acceptance of the media as a basis for product refinement. To enhance methodological clarity, the stages of the ADDIE development process implemented in this study are visually represented in Figure 1, which illustrates the sequential and iterative flow from analysis to the final learning media product.



**Figure 1.** ADDIE-Based Development Process of the Local Wisdom–Based Puzzle Learning Media

The research subjects involved several groups of participants who served as users and evaluators of the learning media. Subject-matter experts and media experts were involved to assess content validity, material suitability, media design, and technical aspects of the developed educational game tools (Sugiyono, 2019). Kindergarten teachers acted as the primary users of the media and provided evaluations of feasibility, ease of use, and the educational value of the media in learning contexts. Child participants consisted of children aged 5–6 years from Group B at TK Bakti II Arrusydah Bandar Lampung, who were involved in both small-scale and large-scale trials. The small-scale trial involved six children to obtain initial feedback on media use, while the large-scale trial involved twenty-six children to examine attractiveness and children’s engagement more broadly.

Research instruments were developed in accordance with the evaluation objectives at each stage of media development. The main instruments included validation sheets for subject-matter experts and media experts, teacher response questionnaires, as well as observation sheets and child response questionnaires. Expert validation sheets were used to assess content feasibility, material accuracy, technical aspects, and the aesthetic quality of the learning media. Teacher

response questionnaires were used to measure teachers' perceptions of ease of use, attractiveness, suitability of the media to children's characteristics, and the educational value of the media in the learning process. Instruments for children consisted of observation sheets and simple questionnaires used to observe levels of concentration, engagement, hand-eye coordination, and children's ability to recognize shapes and local cultural motifs after using the puzzle media (Sukmadinata, 2017). All instruments were developed based on early childhood developmental indicators and principles of educational game tool design.

Research data were analyzed using descriptive quantitative analysis with a percentage-based approach. Scores obtained from expert validation sheets, teacher response questionnaires, and child response questionnaires were calculated by comparing the actual scores with the maximum possible scores and then converted into percentages (Sugiyono, 2019). The resulting percentages were subsequently interpreted into qualitative categories to determine the levels of validity, feasibility, and attractiveness of the learning media. This analysis technique was used to provide a clear overview of the quality of the learning media and user acceptance of the Lampung local wisdom-based puzzle educational game tool.

## RESULT AND DISCUSSION

The development of the Lampung local wisdom-based educational puzzle (Alat Permainan Edukatif/APE) was carried out through the ADDIE stages and resulted in a learning medium that has been validated and tested through both limited and large-scale trials involving children aged 5–6 years. This section presents the research findings focusing on product feasibility, user responses, and the results of media trials in the context of early childhood learning.



**Figure 2.** Appearance of the Lampung Local Wisdom-Based Puzzle Product

The figure above illustrates the development of the Lampung local wisdom-based puzzle design, starting from a simplified initial design to the final character design. The puzzle features male and female Lampung cartoon characters (*muli* and *meghanai*) wearing traditional attributes such as *tapis* cloth, *siger* crown, *papan jajar* necklace, and *pucuk rebung* motifs. The product is designed in a square shape measuring 24 cm × 24 cm and consists of six puzzle pieces, adjusted to the cognitive developmental characteristics of children aged 5–6 years.

The uniqueness of this learning medium lies in its variety of play methods, including visual puzzle assembly and a shadow play activity using a flashlight to form animal silhouettes. This variation is intended to enhance children's engagement and support multisensory learning experiences.

### Product Validation Results by Experts

Product validation was conducted by a media expert and a subject-matter expert to assess the feasibility of the puzzle APE before implementation. A summary of the expert validation results is presented in Table 4.1.

**Table 4.1.** Summary of Expert Validation Results

Validator	Obtained Score	Maximum Score	Percentage	Category
Media Expert	57	60	95%	Very valid
Subject Expert	40	40	100%	Very valid

Based on Table 4.1, the validation results indicate that the Lampung local wisdom-based puzzle APE falls into the *very valid* category. The media expert confirmed that the product meets educational, technical, and aesthetic aspects, while the subject-matter expert stated that the content, scope, and ease of use are fully aligned with early childhood learning objectives. These findings demonstrate that the product is suitable for implementation.

### Teacher Responses to the Puzzle Media

After being declared valid, the puzzle media were tested with classroom teachers as users to determine their attractiveness and feasibility in instructional practice. The results of teacher evaluations are summarized in Table 4.2.

**Table 4.2.** Summary of Teacher Responses to the Puzzle Media

Teacher Respondent	Obtained Score	Maximum Score	Percentage	Category
Teacher I	84	88	95.45%	Very attractive
Teacher II	85	88	96.59%	Very attractive

The teacher assessments indicate that the Lampung local wisdom-based puzzle media are categorized as *very attractive*. Teachers reported that the media are easy to use, aligned with the curriculum, safe for children, and capable of increasing children's engagement and enthusiasm during learning activities. In addition, the visual design and integration of local cultural content were perceived as supporting contextual learning objectives.

### Results of Media Trials with Children

Media trials were conducted through small-scale and large-scale testing to examine children's responses to the use of the puzzle APE. A summary of the trial results is presented in Table 4.3.

**Table 4.3.** Summary of Media Trial Results with Children

Trial Stage	Number of Children	Obtained Score	Maximum Score	Percentage	Category
Small-scale	6	117	12	97.50%	Very attractive
Large-scale	26	503	520	96.73%	Very attractive

Based on Table 4.3, the trial results show that children responded very positively to the puzzle media. Children demonstrated improved concentration, enhanced hand-eye coordination, and better ability to recognize shapes and traditional Lampung clothing motifs after using the media. The consistency of results between the small-scale and large-scale trials indicates that the media are not only effective for limited groups but also stable and effective when applied to larger groups.

The findings of this study demonstrate that the development of a local wisdom based educational puzzle aligns strongly with theoretical perspectives on early childhood cognitive development. As emphasized by developmental psychology, early childhood constitutes a critical period for the formation of foundational cognitive processes, including attention, memory, reasoning, and problem solving (Tadjuddin, 2014; Santrock, 2018). The high levels of learner engagement observed during both small scale and large scale trials suggest that the developed puzzle effectively supported these cognitive processes through play based interaction. This finding reinforces the view that early childhood learning is most effective when children actively engage with concrete and manipulable materials that stimulate exploration and curiosity (Susanto, 2017; Windayana, 2014).

The strong validity ratings obtained from media and material experts further confirm that the developed puzzle meets pedagogical and developmental requirements for early childhood education. The alignment between the puzzle design and curriculum expectations reflects national standards emphasizing integrated stimulation across developmental domains, particularly cognitive development (Permendikbud No. 137/2014). These results support previous studies indicating that well designed educational game tools can function as effective instructional media when they are developmentally appropriate, visually engaging, and pedagogically grounded (Mursid, 2017; Mahardikha et al., 2019). The use of a six piece puzzle configuration is consistent with research highlighting the importance of age appropriate task complexity in sustaining children's engagement and supporting cognitive growth (Trimantara et al., 2019; Harmila et al., 2023).

From a media technology perspective, the choice of durable acrylic material addresses a notable limitation identified in prior research. Many existing puzzle based learning tools rely on fragile materials that limit long term classroom use (Veronica, 2018). The high usability scores reported by teachers indicate that material durability and precision cutting not only enhanced the longevity of the media but also improved ease of use and classroom practicality. This finding aligns with contemporary learning media research that emphasizes usability, material innovation, and user experience as critical determinants of instructional effectiveness (Plass et al., 2015; Mayer, 2020). By explicitly incorporating these considerations into the design process, this study responds to calls for greater attention to human factor dimensions in early childhood media development (Dede, 2014).

An important contribution of this study lies in the integration of local wisdom as a core design element rather than a peripheral visual feature. The incorporation of Lampung traditional attire, motifs, and symbols provided cultural relevance that strengthened children's emotional engagement with the learning media. This supports arguments that culturally responsive learning environments enhance meaning making and foster identity development in early childhood (Priyatna, 2017; Pingge, 2017). While previous studies have explored cultural integration primarily through storytelling or visual texts (Arkas & Suryana, 2022; Rizkiyani & Sari, 2022), the present study extends this literature by embedding cultural content within an interactive, hands on cognitive activity. The observed increase in children's ability to recognize cultural motifs suggests that cultural learning and cognitive stimulation can be effectively combined within a single educational medium.

The positive responses from teachers underscore the importance of positioning educators as central evaluators in media development research. Teacher perceptions of attractiveness, usability, and instructional relevance reflect key human factor indicators that determine whether a learning medium can be sustainably implemented in classroom practice. Consistent with human centered design principles, media that align with teachers' instructional needs are more likely to

be adopted and integrated into daily learning activities (Papadakis et al., 2021). The findings therefore reinforce the argument that teacher usability should not be treated as a secondary outcome but as a core evaluative dimension in early childhood media research (Hirsh Pasek et al., 2015; Mardell et al., 2019).

Finally, the interactive design feature allowing multiple modes of play, including puzzle assembly and shadow formation through light projection, represents an innovation beyond conventional puzzle activities. This multimodal interaction supports deeper cognitive engagement by encouraging children to explore visual transformation, spatial reasoning, and cause effect relationships. Such findings respond directly to gaps identified in the literature regarding limited exploration of interactive and multimodal learning designs in early childhood education (Rahmani & Suryana, 2022; Papadakis et al., 2021). Overall, the discussion confirms that integrating instructional design, media technology, cultural relevance, and human factor evaluation within a research and development framework can produce learning media that are not only valid and attractive but also pedagogically meaningful for early childhood learning environments.

## CONCLUSIONS

This study successfully developed a Lampung local wisdom-based Educational Game Tool (Alat Permainan Edukatif/APE) in the form of a puzzle that is feasible and attractive for use as a learning medium to develop the cognitive abilities of children aged 5–6 years. The acrylic-based puzzle, designed with a number of pieces appropriate to children's developmental stages, demonstrated a very high level of validity based on evaluations by media experts and subject-matter experts, and received very positive responses from both teachers and children in small-scale and large-scale trials. The integration of Lampung local wisdom elements into the visual design and puzzle characters not only supports meaningful play activities but also serves as a contextual medium for introducing local culture in early childhood learning.

The implications of these findings indicate that the development of learning media based on local culture can be an effective alternative for improving the quality of early childhood education, particularly in the cognitive domain, while simultaneously fostering appreciation of cultural identity from an early age. However, this study is limited to assessing the feasibility and attractiveness of the media within a single educational context and does not yet examine the long-term impact of APE use on children's cognitive development. Therefore, future research is recommended to test the effectiveness of the media through experimental designs or longitudinal studies, as well as to develop a wider variety of materials and cultural contexts so that the resulting media can be applied more adaptively across diverse early childhood education settings.

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## AUTHOR CONTRIBUTION STATEMENT

KD was responsible for research conceptualization, media design and development and CK was responsible for data collection, data analysis, and manuscript preparation. The author reviewed and approved the final version of the manuscript.

## CONFLICTS OF INTEREST

The authors declares that the development and evaluation of the learning media were conducted independently for academic purposes. No commercial production, financial sponsorship, or institutional interests influenced the design, validation, or interpretation of the research findings.

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