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Design and Development of Tangram-Based Educational Games to Enhance Creativity in Early Childhood

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Abstract

This study aimed to develop a tangram-based educational game designed to stimulate creativity and introduce geometric concepts among early childhood learners. The study employed a Research and Development (R&D) approach using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model. Data were collected through observation, interviews, questionnaires, documentation, and tests. Validity, practicality, and effectiveness were assessed using structured questionnaires administered to content and media experts, as well as end-users. Validation results demonstrated that the educational game met the validity criteria, with a content expert score of 93.3% and a media expert score of 89.41%. The practicality assessment yielded an average score of 91%, indicating that the game is feasible for classroom implementation. The effectiveness evaluation resulted in a score of 93%, confirming that the game significantly supported children's learning outcomes. These findings suggest that the tangram-based educational game is valid, practical, and effective as an instructional tool for early childhood education. The study contributes to the growing body of literature on game-based learning and hands-on instructional media in early childhood settings.

INTRODUCTION

Early childhood represents a critical period of rapid growth and development across multiple developmental domains, including cognitive, social, emotional, and creative capacities. Creativity, defined as the ability to generate novel ideas or produce original works that differ meaningfully (Aslindah, 2018; Permatasari, 2014; Wahyuni et al., 2016) from existing ones, is recognized as a fundamental competency that must be nurtured from an early age (Nofrizal et al., 2025). In the context of twenty-first-century education, creativity has been widely identified as a core skill essential for children's future success and adaptability in an increasingly complex world (Behnamnia et al., 2020; Rahimi & Shute, 2021).

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Optimal creativity development in young children requires deliberate guidance from both educators and parents. Educators serve as the primary agents in fostering creativity within early childhood education settings (O'Connor, 2016). To support this role, teachers must cultivate stimulating environments that encourage creative expression and ensure access to appropriate instructional resources and materials (Cremin et al., 2006) . Research has consistently shown that when educators intentionally design play-rich and resource-abundant environments, children demonstrate significantly higher levels of creative output and engagement (Fleer & Quinones, 2022; Hirsh-Pasek et al., 2021).

Play-based approaches have been widely recognized as effective strategies for stimulating creativity in early childhood (Wen et al., 2020). Play provides a meaningful context through which children can develop holistically , (Watson & Yang, 2016), offering opportunities to imagine, explore, and express their creative capacities freely (Rohmah, 2016). Contemporary research further emphasizes that structured play, when intentionally designed with learning objectives, yields greater developmental benefits compared to unstructured play alone (Hirsh-Pasek et al., 2021; Toub et al., 2022). Spatial play in particular — including puzzle-solving and shape manipulation — has been shown to significantly predict later mathematical achievement and creative reasoning (Hawes et al., 2022; Verdine et al., 2022).

Among various educational tools, tangram has emerged as a promising medium that integrates play with learning. Tangram enables children to construct diverse forms and express creativity through spatial manipulation of geometric pieces (Domino, 1980). As a physical medium typically crafted from cork, plywood, or wood, tangram is also durable and suitable for repeated classroom use (Sedighian & Klawe, 1996). Furthermore, tangram-based activities have been shown to increase children's engagement with geometry by transforming abstract concepts into enjoyable, hands-on experiences, allowing children to externalize ideas through the arrangement of shapes such as triangles, squares, and parallelograms into representations of animals, plants, and human figures ((Itawari et al., 2017 ; Irawan et al., 2020)).Recent studies further confirm that tangram and similar geometric puzzle tools effectively develop spatial reasoning and creative problem-solving among young learners (Lowrie et al., 2020; Santos et al., 2024; Shumway et al., 2021).

In parallel, advances in educational technology have expanded the possibilities for developing interactive learning media. Game-based learning, particularly computer-assisted and mobile educational games, has gained increasing attention as an engaging instructional approach (Mirawati & Nugraha, 2017; Plass et al., 2020). Systematic reviews and meta-analyses confirm that game-based learning in early childhood settings promotes cognitive, social, and emotional development while sustaining children's intrinsic motivation (Alotaibi, 2024; Wouters & Oostendorp, 2021). Educational games are designed with enjoyment as a central element, reducing the likelihood of disengagement and sustaining children's motivation throughout the learning process (Nikiforidou, 2018; Ott & Pozzi, 2012). Gamification elements embedded in educational games have also been shown to increase learner engagement and learning persistence (Hamari et al., 2021; Toda et al., 2021).

Digital educational games specifically designed for preschool-aged children have demonstrated significant effects on creative thinking development. Behnamnia et al. (2022) identified key components of creativity — including fluency, originality, and elaboration — that are effectively nurtured through digital game-based learning environments. Chen and Wu (2022) further found that digital educational games significantly improved divergent and convergent thinking among preschool children compared to traditional instructional methods. By integrating tangram principles into a digital game format, children are encouraged to actively solve problems using their

imagination and spatial reasoning skills, thereby supporting both geometric understanding and creative development (Mayer & Fiorella, 2021; Papadakis et al., 2021).

Despite the recognized potential of tangram-based educational games, empirical studies examining their systematic development, validation, and effectiveness in early childhood settings remain limited, particularly in Indonesian contexts. Moreover, few studies have applied structured instructional design frameworks such as ADDIE to the development of tangram-based digital games for early childhood learners. Therefore, this study aims to develop and evaluate a tangram-based educational game as an instructional medium to stimulate creativity and geometric concept recognition among early childhood learners, assessed through validity, practicality, and effectiveness indicators.

METHODS

This study employed a Research and Development (R&D) design, which is a systematic research approach aimed at producing a specific product and empirically evaluating its effectiveness (Sugiyono, 2019). R&D is widely used in educational research to design, develop, and validate instructional products in a systematic manner (Meredith D. Gall, Joyce P. Gall, 2003). The development process was guided by the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) as proposed by Branch (2009), which provides a structured and iterative framework for instructional media development.

The ADDIE model was implemented across five sequential phases. In the *Analysis* phase, learner characteristics, curriculum requirements, and instructional needs were identified to establish the foundation for game development (Branch, 2009) The *Design* phase involved the planning of game structure, content, and learning objectives aligned with early childhood creativity indicators. During the *Development* phase, the tangram-based educational game was constructed and refined based on expert feedback (Molenda, 2003). The *Implementation* phase involved the trial of the game in an early childhood education setting, while the *Evaluation* phase assessed the overall quality and impact of the developed product (Reiser & Dempsey, 2012).

Data were collected through multiple techniques, including interviews, observations, documentation, questionnaires, and tests (Creswell, 2012). Questionnaires were administered to content experts, media experts, and end-users (teachers and children) to evaluate the validity and practicality of the game. The use of expert validation through structured questionnaires is a well-established approach in educational product development (Nieveen, 1999; Plomp & Nieveen, 2013). Tests were conducted to measure the effectiveness of the game in supporting children's learning outcomes related to creativity and geometric concept recognition.

Data analysis was conducted quantitatively using percentage scoring to determine three key quality indicators: validity, practicality, and effectiveness (Akbar, 2013). Validity was assessed based on evaluations from content and media experts, practicality was measured through teacher and user responses, and effectiveness was determined by analyzing children's learning outcomes following game implementation. The scoring criteria used to interpret each indicator were based on established classification scales adapted from Sugiyono (2019). This three-indicator framework — validity, practicality, and effectiveness — is consistent with quality standards widely adopted in instructional design research.

RESULT AND DISCUSSION

This study successfully developed a tangram-based educational game aimed at stimulating creativity development among early childhood learners. The development

process followed the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) and resulted in a validated instructional product. The study assessed three key quality indicators throughout the development process: validity, practicality, and effectiveness. The tangram-based educational game was implemented with children aged 5–6 years in Class B2 at PAUD Melati Batang Merangin. The use of a structured instructional design model such as ADDIE ensures that the developed product is systematically aligned with learner needs, curriculum standards, and measurable learning outcomes (Dewi et al., 2022; Spatioti et al., 2022).

The first phase of the ADDIE model involved a comprehensive analysis of the learning environment, curriculum, and instructional needs. Need analysis in instructional development refers to the systematic examination of tasks and their context in order to identify the appropriate product to be developed (Rusdi, 2018). Based on field observations and curriculum review, several core competencies had not yet been optimally achieved by the learners, including: (1) understanding and applying creative problem-solving strategies in everyday situations (Competencies 3.5 and 4.5); and (2) recognizing and producing various forms of artistic expression using diverse media (Competencies 3.15 and 4.15).

Further analysis revealed that children's creativity development had not progressed optimally. This finding was corroborated through interviews with the principal of PAUD Melati Batang Merangin, which indicated that children's creative capacities remained underdeveloped. Existing instructional approaches relied primarily on conventional materials such as textbooks, student worksheets, and drawing books. Teachers also reported challenges in developing engaging digital content, including videos and interactive games, to enhance the quality and attractiveness of the learning process. This is consistent with previous research suggesting that children's engagement with game-based media can effectively stimulate cognitive development and sustain intrinsic motivation for learning (Behnamnia et al., 2020; Setiawan, 2019). The integration of digital tools in early childhood settings has been found to support collaborative learning, innovation, and digital literacy when implemented with clear pedagogical goals (Lai, 2020; Resnick & Rusk, 2020).

The design stage is the phase after analyzing problems in the field. According to (Arofah, 2019), design refers to several development plans involved in product development activities. The design stage begins with planning appropriate learning objectives to develop products that are relevant to the problems found in the field, as well as designing materials based on theory and curriculum by determining Core Competencies (KI), Basic Competencies (KD), and indicators in accordance with curriculum analysis and needs analysis.

The design phase followed the findings obtained during the analysis stage. In the context of instructional product development, design refers to the systematic planning of activities involved in creating an educational product (Arofah, 2019). This phase began with the formulation of appropriate learning objectives directly aligned with the problems identified in the field. Subsequently, instructional materials were structured based on relevant theoretical frameworks and curriculum requirements, including the identification of Core Competencies (KI), Basic Competencies (KD), and learning indicators derived from both the curriculum analysis and needs assessment conducted in the preceding phase. This alignment between learning objectives and curriculum standards is considered essential in ensuring the instructional relevance and pedagogical appropriateness of the developed product (Branch, 2009; Dick et al., 2015). The design of game elements was also guided by principles of multimedia learning to ensure age-appropriate visual complexity and cognitive load management (Putri & Eliza, 2021).

Fig. 1. Tangram Educational Game

The implementation stage was carried out in one school, namely PAUD Melati Batang Merangin. According to (Borman & Idayanti, 2018; Falahah & Irrahali, 2019) implementation is the process of applying the product to a large group. This stage involves developing procedures for training facilitators and students. During the implementation stage, a practicality test of the game was conducted through assessments by teachers, as well as an effectiveness test on the development of children's creativity abilities.

The final phase of the ADDIE model involved a comprehensive evaluation of the developed product. Evaluation is conducted to determine the extent to which learning objectives have been achieved and whether the identified problems have been adequately addressed (Mustaji, 2013). Evaluation data were gathered through assessment sheets completed by expert lecturers and classroom teachers based on their direct experience with the educational game. This multi-source evaluation approach strengthens the credibility of the findings and is consistent with design-based research methodology (Spatioti et al., 2022).

Material validation was conducted prior to field testing to ensure the quality and instructional appropriateness of the developed media. The validated materials encompassed learning content patterns and visually engaging media elements suitable for early childhood learners (Febliza, 2015). Assessment of the content, language, and presentation dimensions indicated that all items met the required validity criteria. The content expert validation yielded a score of 93.3%, placing the material in the *highly valid* category.

Table 1. Material Validity Assessment Results

Dimension	Max Score	Score Obtained	Percentage (%)
Content / Material Accuracy	48	45.2	94.2
Language & Communication	32	29.5	92.1
Curriculum Alignment	20	18.7	93.7
Overall	100	93.3	93.3 (Highly Valid)

Note. Classification criteria adapted from Akbar (2013).

Media validation yielded an average score of 89.41%, also classified as highly valid. Table 2 presents results across the evaluated media dimensions.

Table 2. Media Validity Assessment Results

Dimension	Max Score	Score Obtained	Percentage (%)
Visual Design & Aesthetics	32	28.6	89.4
Usability & Navigation	28	25.1	89.6
Interactivity & Feedback	24	21.4	89.2
Technical Performance	16	14.3	89.4
Overall	100	89.4	89.41 (Highly Valid)

Note. Classification criteria adapted from Akbar (2013).

This finding aligns with the principle that a valid instrument must accurately measure what it is intended to measure, and that valid instruments are a prerequisite for producing reliable research outcomes (Sugiyono, 2019). The high validity score reflects the careful alignment of game content with early childhood curriculum standards and developmental appropriateness indicators, consistent with Van der Berg et al. (2023) who emphasize that content validity is foundational to the quality of educational assessment instruments.

The practicality test was administered by classroom teachers to assess the usability of the developed game in real instructional contexts. Practicality refers to the degree to which the educational game can be effectively utilized as a medium for delivering instructional content to learners (Sujiono, 2013). Assessment instruments were completed by teachers from Class B1, yielding scores of 91% and 95%, respectively. Based on these results, the tangram-based educational game was categorized as *highly practical*, indicating that it can be readily implemented in classroom settings without significant barriers to use. This outcome aligns with Nieveen (1999) and Plomp & Nieveen (2013), who assert that a practically sound educational product must be usable by intended users with minimal support. The high practicality scores also reflect the user-centered design principles applied during the development phase (Lai, 2020; Toda et al., 2021).

The effectiveness test was conducted under teacher supervision, with 15 children participating in the trial using four mobile devices on a rotational basis, with each child engaging with the game for approximately 10–15 minutes. During the initial trial session, children demonstrated limited familiarity with the game interface and required frequent guidance. However, following the introduction of the educational game media, children's engagement in creativity-stimulating activities showed notable improvement across subsequent sessions. This pattern of initial difficulty followed by rapid improvement is well-documented in game-based learning

literature and reflects the motivational affordances of interactive digital media (Alotaibi, 2024; Plass et al., 2020).

The overall effectiveness of the developed game was measured at 93%, confirming that the tangram-based educational game was effective in supporting children's learning outcomes. This result is consistent with the view that effective learning is inseparable from conducive learning conditions, active student engagement, supportive instructional resources, and adequate facilities (Abdullah, 2019). The effectiveness findings are further supported by recent meta-analytic evidence demonstrating that game-based learning interventions consistently produce positive effects on children's cognitive outcomes in early childhood settings (Alotaibi, 2024; Wouters & Oostendorp, 2021). Specifically, digital game-based tools that incorporate spatial reasoning elements — such as tangram-based games — have been shown to significantly enhance children's geometric understanding and creative problem-solving skills (Hawes et al., 2022; Lowrie et al., 2020; Shumway et al., 2021).

Based on the validity, practicality, and effectiveness analyses, the tangram-based educational game developed in this study demonstrated strong overall quality across all three indicators. These findings confirm that the product is valid, practical, and effective as an instructional medium for stimulating creativity development among early childhood learners. This three-indicator quality framework — encompassing validity, practicality, and effectiveness — is widely adopted as a standard for evaluating the quality of instructional products in educational design research (Nieveen, 1999; van den Akker et al., 2006). The results of this study contribute empirical evidence supporting the integration of tangram-based game media in early childhood education, adding to the growing body of literature on game-based learning and hands-on instructional media (Behnamnia et al., 2022).

CONCLUSION

This study successfully developed a tangram-based educational game designed to stimulate creativity development among early childhood learners through the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The developed product provides children with direct, hands-on learning experiences in a playful and engaging environment, facilitating active participation in the learning process. The findings of this study demonstrate that the tangram-based educational game met all three established quality indicators: validity, practicality, and effectiveness, as evidenced by expert validation scores of 93.3% (content) and 89.41% (media), a practicality score of 91%, and an effectiveness score of 93%.

These results suggest that the integration of tangram-based game media into early childhood education settings offers a promising approach to fostering creativity and geometric concept recognition. The findings are consistent with and contribute to the growing body of literature on game-based learning and instructional media development in early childhood education (Ott & Pozzi, 2012; Nikiforidou, 2018; van den Akker et al., 2006).

Future studies are recommended to expand the implementation of tangram-based educational games to broader and more diverse populations, as well as to

explore the long-term effects of game-based learning on creativity development and other cognitive domains in early childhood. Additionally, further research may consider integrating more advanced digital features to enhance interactivity and engagement in line with current technological advancements in educational media.

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