Design and Development of An Interactive Learning Media Based on Leap Motion for Introducing Animals to Early Childhood Learners

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Abstract
This study aims to design an interactive learning medium based on Leap Motion technology to introduce various types of animals to early childhood learners in an engaging, immersive, and developmentally appropriate manner. It addresses the scarcity of multisensory educational media that combine motion, visualization, and audio to support play-based learning in Early Childhood Education (ECE). The research employed a Research and Development (R&D) approach using the ADDIE model, focusing on the needs analysis phase. Data were collected through questionnaires and interviews involving teachers, parents, and ECE experts in the development of the LeapZoo application. The results indicate that conventional methods of introducing animals are often passive and less engaging. Children require kinesthetic and interactive media responsive to movement. Leap Motion was found to enhance both gross and fine motor coordination while increasing learning engagement. The LeapZoo concept incorporates hand motion tracking, 3D visualization, animal animations, and distinctive audio to provide a holistic learning experience. This study contributes original insights into the use of Leap Motion as a digital scaffolding tool in ECE. The findings highlight the importance of interactive technology-based innovations in promoting embodied learning and recommend teacher training and infrastructure support for effective implementation.

Keywords: Digital Educational Media, Early Childhood, Interactive Learning, Leap Motion, Animal Introduction

1. Introduction

Early childhood education plays a crucial role in laying the foundation for children's cognitive, motor, social, and emotional development. The primary goal of early childhood learning is characterized by the principle of enjoyable, play-based learning that fosters the optimal development of the innate potential each child possesses from birth (Nurani, 2019). It can be concluded that early childhood education aims to stimulate various skills in children to support their optimal developmental process (Bhebhe & Vilakati, 2021; Kavanagh et al., 2020; Komaini et al., 2022; Saad & Faizal, 2022; Sutapa et al., 2021).

Early childhood refers to children aged between 0 and 6 years (Basri, 2021). This designation is based on normative definitions that consider a child as someone from birth up to six years of age. According to Novitawati (2013), during this stage, children undergo developmental processes across various domains and possess unique characteristics that differ from those of adults. In other words, early childhood is marked by diverse patterns of physical growth and

development, with each child exhibiting individual differences—some may display a strong sense of curiosity, while others may be particularly active. Therefore, in addition to the role of teachers, parental involvement is also essential to support children in growing and developing in accordance with their individual characteristics.

The principle of educational activities for early childhood is learning through play, which necessitates activities that provide enjoyable experiences. Early childhood is considered a golden period for instilling character values and foundational skills. According to the 2013 Early Childhood Education (PAUD) Curriculum, child development programs encompass religious and moral values, physical-motor development, cognitive skills, language, social-emotional growth, and the arts—all of which are implemented through play (Heryanto, 2019). In a child's development, play is as essential as other basic needs. It can relieve tension, enhance exploration, and accelerate cognitive development. Through play, children can practice problem-solving strategies that support both physical and mental growth. The concept of "learning through play" implies that children acquire new knowledge indirectly during play. The principles of play for early childhood include being educational and beneficial, engaging, relevant, simple, and safe. Appealing toy designs, humorous elements of games, and unique forms of play are key to capturing children's interest. Moreover, varied forms and methods of play help prevent boredom (Wartisah, 2016).

Based on previous studies, early childhood motor development is closely related to perceptual-motor-based activities that involve hand movements and sensorimotor coordination (Botha & Africa, 2020; Hyungmin & Johan, 2012). Moreover, the integration of perceptual-motor elements into movement tasks, particularly through play-based activities, is essential for teachers to engage and delight young learners (Ningrum & Sukoco, 2017). Perceptual Motor Training (PMT) has also been shown to positively influence the gross motor development of children aged 5 to 6 years (Lukmawati et al., 2019). Improvements in children's gross motor skills can be observed through their ability to perform various locomotor movements, manipulative actions, and balance tasks correctly and purposefully. Accordingly, the use of Leap Motion as a learning medium may offer a more immersive experience in introducing specific concepts, such as animal recognition.

Yudanto's (2018) study developed a perceptual-motor activity model based on multiple intelligences for early childhood learners. The research resulted in a model consisting of eight theme-based games: games themed on "Myself," "My Family," "My Environment," "Animals," "Plants," "Vehicles," "The Universe," and "My Homeland." While the model has been established, it requires further investigation to explore its effects on fundamental motor skills, particularly locomotor movements in early childhood. The aim of the current study is to examine the influence of the perceptual-motor activity model based on multiple intelligences on the locomotor skills of kindergarten children, including running, skipping, hopping, jumping, leaping, horizontal jumping, and sliding.

One of the approaches that can be utilized in early childhood education is interactive technology-based learning. Leap Motion technology enables touchless interaction through hand and finger gesture recognition, which can enhance children's engagement in the learning process. Leap Motion is a system capable of detecting hand movements, finger gestures, and tool-like objects that resemble fingers (Leap Motion, 2017). This device operates at close range with high precision, featuring high frame tracking rates, discrete position reporting, gesture detection, and movement recognition. Leap Motion employs optical sensors and infrared light. The sensors are aligned along the Y-axis during standard operation and have a field of view spanning 150 degrees. The effective range of Leap Motion extends above the device from 25 to 600 millimeters (1 inch to 2 feet). Hand Motion Tracking, commonly referred to as Leap Motion, refers to the recording of hand movements to create digital models. It is an auxiliary device that can be connected to a computer and functions as an alternative to a mouse and keyboard. The primary function of this tool is to enable users to control or replace mouse and keyboard tasks on a computer using only hand and finger movements (Rusmono, 2017).

This study presents a novel approach in the development of interactive learning media utilizing Leap Motion technology, specifically designed for early childhood education in introducing various types of animals. Unlike previous studies that predominantly employed conventional media or touchscreen-based technologies, this research leverages Leap Motion to create a more immersive, interactive, and motion-based learning experience. By employing this technology, children can learn to recognize animals through hand movements without the need to touch a screen or use additional devices such as a mouse or keyboard, making it more aligned with the motor development characteristics of young learners.

The introduction of animals combined with motor activities plays a significant role in supporting the holistic development of early childhood. Activities such as imitating animal movements help train children's gross motor skills, including balance, coordination, and muscle strength. In addition, engaging in tasks that utilize interactive tools such as Leap Motion—used to point to and identify animals—enhances fine motor skills essential for abilities like writing and grasping. Introducing animals through such activities also strengthens hand-eye coordination, improves children’s focus and concentration, and actively involves them in enjoyable learning experiences.

This research approach is grounded in Vygotsky’s (1978) theory, which emphasizes the importance of social interaction and environmental context in the learning process. The theory encompasses several key principles, including social learning, the Zone of Proximal Development (ZPD), and scaffolding. Within the ZPD, children can develop more advanced skills with the assistance of adults or more capable peers. Through this approach, Leap Motion can serve as an educational tool that provides scaffolding in the form of engaging and structured digital interactions, enabling children to enhance their motor skills with minimal guidance (Slavin, 2000). The integration of technology such as Leap Motion supports collaborative activities, exploration, and direct physical movement training, aligning well with the core principles of Vygotsky's theory.

This study aims to design and develop an interactive learning medium based on Leap Motion technology to assist early childhood learners in recognizing various types of animals in a more engaging and interactive manner. The research also analyzes the effectiveness of the developed learning medium in enhancing children's understanding, as well as identifies the impact of using Leap Motion on the development of both gross and fine motor skills in young children. The issues addressed in this study include how to design an appropriate learning medium, the extent of its effectiveness in improving children's comprehension, and its influence on their motor development. The benefits of this research include contributing to the field of early childhood education by introducing an innovative technology-based learning method, providing a reference for educators in developing interactive media, and supporting parents and children in creating enjoyable and educational learning experiences.

2. Research Method

The Research and Development (R&D) approach was employed in the development of this interactive learning media based on Leap Motion technology. According to Sugiyono (2017), research and development is a methodological approach aimed at producing a product and evaluating its effectiveness. In this development process, the ADDIE instructional design model was utilized, serving as a systematic approach to the development of instructional media. Romiszowski (as cited in Ma'ruf, 2021) stated that systematic approaches in instructional design have been widely applied in the development of computer-based, audiovisual, and text-based materials to enhance the effectiveness of the learning process.

The development of this interactive learning media follows the ADDIE model, which consists of five main stages: (1) analysis, (2) design, (3) development, (4) implementation, and (5) evaluation. This model was chosen for its systematic and theory-based approach to instructional design. These stages are summarized into three core components—planning, development, and evaluation—to facilitate the implementation of Leap Motion-based media.

This study is designed to span a two-year period. In the first year (2025), the primary focus is on the planning and development phase, while the evaluation will be conducted in the following year. The planning phase comprises two main processes: needs analysis and design. The emphasis of this research lies in the needs analysis phase. The needs analysis aims to identify problems and requirements related to the development of interactive learning media. This process includes interviews with teachers and experts to understand learners' needs in Leap Motion-based instruction. The analysis also involves identifying instructional content, learning objectives, and the characteristics of early childhood learners as the primary users of the media.

After the needs analysis stage, the design phase was carried out with the aim of developing an initial prototype of the interactive learning media. The results from the previous analysis served as the foundation for formulating the concept and design of the product. In this phase, selecting appropriate software for the development of Leap Motion-based media became the initial step. Additionally, the visual interface of the learning media was designed to be engaging and aligned

with the characteristics of early childhood learners. Graphic design, interactive elements, and navigation features were developed using design software such as CorelDRAW and Canva to ensure the visual presentation met user needs.

Data collection was conducted through the distribution of questionnaires and interviews with early childhood education teachers and experts in educational technology. The data obtained from the needs analysis will be utilized in the subsequent planning stage. In addition, a literature review was carried out to identify relevant theories for the development of interactive learning media based on Leap Motion technology. This review supports the design of appropriate development stages to ensure that the resulting media aligns with the needs of early childhood education (Sukmadinata, 2006).

3. Results and Discussions

The findings of this study focus on a needs analysis for the design of an educational game based on Leap Motion technology, titled "LeapZoo: A Leap Motion-Based Educational Zoo Game for Early Childhood." The media content includes Leap Motion simulations, instructional materials, educational videos, quizzes, as well as information about the media and its developers—aligned with the identified needs of both students and teachers. The needs analysis for the development of the educational game involved three main stakeholder groups: experts in education and instructional technology, early childhood education (ECE) teachers, and parents of the learners, who play a role in supporting young children's use of educational games. The analysis employed a grounded theory approach, incorporating coding procedures. The following explanation outlines the research procedures planned for the first year, with a particular emphasis on the planning phase.

3.1. Analysis of Early Childhood Parents' Needs

The results of a survey conducted with parents of young children revealed that all respondents reported that their children enjoy learning about animals. This finding reinforces the premise that animals are an engaging and relevant topic for early childhood education. Such interest aligns with the principles of early childhood education, which emphasize the importance of learning content that is closely connected to the child's world (Wartisah, 2016). However, 83.3% of the respondents also indicated that their children still face difficulties when learning about animals. The most frequently mentioned challenges include the unengaging nature of the learning process, which often relies solely on stories or static images, and children's difficulty in understanding the visual forms and distinctive features of animals. These findings highlight the limitations of conventional approaches, which have yet to optimize the interactive and sensory aspects of learning. Hyungmin dan Johan (2012) emphasize that young children require more concrete and multisensory approaches to effectively grasp concepts, especially those related to living creatures such as animals.

All respondents also stated that young children greatly enjoy engaging in play that involves physical movement, such as jumping, dancing, or imitating animal movements. The most favored activities include running, jumping, and mimicking animal behaviors—actions that strongly reflect the kinesthetic learning characteristics predominant in early childhood. This aligns with the theory of embodied cognition proposed by Wilson (2002), which posits that physical engagement in the learning process can enhance children's understanding and memory retention. Therefore, integrating movement into learning activities is not merely recreational, but also significantly contributes to children's cognitive and motor development (Dendodi et al., 2025).

In terms of technology utilization, all respondents indicated that children had previously used technological devices such as tablets, laptops, or smartphones in learning activities. This demonstrates the children's basic readiness to engage with digital tools and opens up opportunities for the development of technology-based learning media. However, only 83.3% of the respondents had heard of Leap Motion technology. This suggests that although technology holds potential relevance, further outreach and education are necessary to ensure that both teachers and parents understand its functionality and benefits.

When asked whether children were interested in learning using a device that can track hand movements, such as Leap Motion, 66.7% responded “yes,” while 33.3% indicated no interest. However, when presented with a more concrete scenario—namely, a learning medium that introduces animals through play and movement—all respondents stated that children would be interested and eager to try it. These findings suggest that children are highly receptive to engaging, movement-based learning experiences. However, there remains a need for greater familiarity with specific technological tools like Leap Motion. This supports Vygotsky’s (1978) theoretical framework, which emphasizes that children learn most effectively within social contexts and with the support of appropriate tools or scaffolding aligned with their developmental stage.

Overall, the results of this needs analysis indicate that Leap Motion-based learning media have significant potential for further development. Media that integrate motion, sound, and visualization not only meet children's learning needs but also offer an enjoyable, immersive, and meaningful learning experience. However, its implementation must be accompanied by teacher training and adequate infrastructure support to ensure optimal utilization in early childhood education settings.

3.2. Teachers’ Needs Analysis

All early childhood education (ECE) teachers who participated as respondents in this study stated that they actively teach animal recognition to children in the classroom. This indicates that introducing animals is an important and routine component of the ECE curriculum. Moreover, all teachers reported that children show a high level of interest when learning about this topic. This strong interest aligns with the developmental characteristics of young children, who are naturally drawn to concrete, living, and observable objects (Komaini et al., 2022). As real and familiar

entities in children's daily lives, animals serve as an ideal subject matter to foster curiosity and develop an early understanding of living beings.

However, challenges continue to arise in the actual implementation of early childhood learning. Teachers reported that the methods employed remain limited to lecturing, singing, or role-playing. Many also noted that children tend to become easily bored, particularly when the learning media are passive or lack engaging elements. Therefore, interactive learning media that can stimulate children's senses have become an essential need. This view is reinforced by the fact that all respondents agreed on the crucial role of motor activities in early childhood education. Physical activities such as imitating animal movements, jumping, and running not only strengthen muscles and coordination but also support children's cognitive and affective development (Lukmawati et al., 2019; Wilson, 2002).

Furthermore, most teachers (93.75%) reported having used digital media such as instructional videos in classroom activities, indicating a basic level of readiness to adopt technology as part of the learning process. However, only 18.75% of teachers had heard of or were familiar with Leap Motion. Nevertheless, most of those unfamiliar with the technology (81.25%) expressed interest in using it if learning media capable of recognizing hand gestures were available. This interest suggests a high level of openness to new technologies, provided they are relevant, user-friendly, and demonstrably effective in enhancing student engagement.

Support for using Leap Motion as a learning medium is reinforced by data showing that all respondents believe this technology can enhance children's engagement in learning about animals. When children can interact directly through hand movements—such as imitating the actions of animals visualized through animation—the learning process becomes not only more enjoyable but also more meaningful. This aligns with Vygotsky's (1978) view that children develop more optimally when learning occurs within a social context and is supported by scaffolding, whether provided by others or through instructional tools.

Finally, all teachers expressed their interest in trying out media based on Leap Motion technology if it were specifically developed for early childhood education contexts. This serves as a strong signal for educational media developers that motion-based technological innovations hold high implementation potential, especially when their design aligns with the core principles of early childhood development—namely, being enjoyable, interactive, safe, and meaningful (Heryanto, 2019; Wartisah, 2016).

3.3. Expert Needs Analysis

The expert needs analysis was conducted to explore conceptual and pedagogical perspectives related to early childhood education (ECE). Data were collected through questionnaires and interviews involving ten experts. These experts came from the fields of ECE and educational technology. This process aimed to identify core problems and formulate innovative solutions that could be integrated into the development of interactive learning media.

An open-ended questionnaire and interview approach was employed to extract key ideas for the development of a Leap Motion-based educational game.

Strengthening the Concept of Learning Through Play with Interactive Technology

Early childhood learning should ideally take place in an enjoyable atmosphere through play-based activities. This principle aligns with the findings from the needs analysis stage, in which respondents stated that the introduction of animals would be more effective through an interactive approach that integrates visual, motion, and auditory elements (Suhernawati et al., 2020). Therefore, the use of Leap Motion technology is highly relevant, as it enables multisensory learning experiences that are well-suited to the learning characteristics of young children.

> *"In this digital era, digital-based games are not unfamiliar to be introduced to children… with features such as animal sounds and movements, these games can make learning more engaging and interactive for children. However, teacher supervision is still necessary to ensure that the learning remains both enjoyable and meaningful."* [Respondent 8]

The fundamental principle of early childhood education is learning through play with a multisensory approach. Learning media developed using Leap Motion not only provide digital visualizations but also allow children to interact directly through hand gestures without the need for touch-based devices, making it more compatible with the kinesthetic characteristics of young learners. Leap Motion technology enables direct interaction through hand movements, which not only supports kinesthetic-based learning but also reinforces the concept of embodied learning as emphasized in literature. This medium strengthens the principles of active and exploratory learning, which are essential during the developmental stage of children (Slavin, 2000; Vygotsky, 1978).

Integration of Movement and Visuals as a Strategy to Enhance Motor Skills

Expert interviews revealed that motor skills are a fundamental aspect that must be nurtured from an early age. Leap Motion can make a significant contribution in this regard. Imitative movements of animals (jumping, crawling, flapping arms) through interactive media allow children to naturally activate both locomotor and manipulative movements. These findings align with studies by Lukmawati et al. (2019) and Yudanto (2018), which emphasize the importance of perceptual-motor training in improving children's balance, coordination, and muscle strength.

Leap Motion functions as a bridge between children's physical movements and the digital responses generated. One respondent explained:

> *"After I explored it, I found that Leap Motion can simulate animal movements, such as those of rabbits, frogs, or birds, which is very helpful for children in developing balance and body coordination." [Respondent 3]*

"Motor activities involve movements that support children's memory and comprehension, as well as engage their physical bodies in the learning process." [Respondent 4]

This indicates that the integration of motion elements in digital media is not merely a supplementary feature, but rather a core component in instructional strategies that engage both perception and physical movement (perceptual-motor learning). Three-dimensional visualizations and interactive animations also serve as key reinforcements in helping children concretely recognize the forms and distinguishing features of animals (Br Ginting et al., 2017). Respondents further emphasized that children tend to be more motivated when their movements elicit direct responses from the media. This suggests that Leap Motion functions not only as an assistive tool, but also as a primary facilitator in feedback-based learning.

Challenges in Implementation and Solutions for Media Development

Despite the positive responses toward the Leap Motion-based media, the informants also highlighted several implementation challenges. These include limited school infrastructure, low levels of digital literacy among teachers, and the need for training in the use of new media. These issues are consistent with field conditions as documented in previous studies on digital transformation in the early childhood education sector (Nurjanah & Mukarromah, 2021).

"One of the key challenges is the lack of understanding about Leap Motion, as well as limitations in infrastructure such as computers or internet connectivity in schools." [Respondent 7]

"The challenges in the school environment include the ratio of media resources to the number of students and the fact that not all teachers are technologically literate." [Respondent 1]

The feedback highlights the need for comprehensive strategies in socialization, training, and the provision of adequate infrastructure prior to the widespread implementation of this medium. Therefore, at the design stage, the researcher aimed to develop a simple interface, visually engaging graphics, and intuitive navigation that would be easily understood by both educators and children. For instance, the graphic design was developed using Canva and CorelDRAW, which support integration with Unity as the primary platform for Leap Motion.

Features of Media Considered Effective by Experts

According to the respondents, ideal media features encompass three main aspects: visual, auditory, and interactive elements. These components play a crucial role in supporting early childhood learning experiences. One respondent emphasized the importance of presenting animal objects in realistic three-dimensional forms to allow children to recognize animal shapes concretely and comprehensively. Another respondent highlighted the significance of accurate hand

motion tracking and clear audiovisual displays as essential elements for establishing a connection between children's movements and media responses. Additionally, features such as distinctive animal sounds and animations that respond to children's gestures were considered effective in enhancing engagement and providing meaningful feedback during the learning process. These findings underscore that children's sensory involvement is a key mechanism in reinforcing educational messages conveyed through digital media. Rather than being passive viewers, children are actively engaged in the animal recognition process through enjoyable and meaningful direct interaction.

Alignment with the Characteristics of Early Childhood Learners

One of the main strengths identified in the analysis is the awareness of the need to design media that aligns with the developmental characteristics of early childhood learners. Experts emphasize the importance of adapting educational media to learning processes that are engaging and provide enjoyable and meaningful experiences, as outlined in the 2024 Early Childhood Education Curriculum Framework. Accordingly, the media is developed not only to introduce animals from a cognitive perspective, but also to foster curiosity, encourage exploratory behavior, and support the development of social skills through enjoyable digital activities.

> *"Media should be aligned with the developmental indicators of children, including motor, cognitive, and socio-emotional aspects. It must be enjoyable and meaningful, in accordance with the 2024 Early Childhood Education Curriculum Guidelines."* [Respondent 4]

An appropriately designed medium enables children to gain learning experiences that correspond to their developmental stages—from introducing animal concepts and engaging in kinesthetic activities to reinforcing foundational skills such as focus, visual memory, and hand-eye coordination. These elements greatly assist children in concrete understanding objects. This demonstrates that media are not merely informative but also immersive, effectively bridging the real and digital worlds as part of the child's learning experience.

Leap Motion as Scaffolding

This study is grounded in Vygotsky's theory of learning through interaction and scaffolding. Leap Motion serves as a form of digital scaffolding, providing non-verbal guidance within the child's zone of proximal development. As an interactive medium, it enables children to engage in complex activities (such as identifying exotic or rare animals) through visualizations, audio, and guided digital interaction (Halifah et al., 2023). Thus, this medium functions not merely as an educational form of entertainment, but as a tool that extends the child's capacity to understand the surrounding world. The scaffolding function is also evident in its collaborative

potential, as children can learn alongside peers or under the guidance of parents, thereby reinforcing the social dimension of learning.

4. Conclusion

This study aims to design an interactive learning medium based on Leap Motion technology to enhance young children's understanding of animals while supporting their motor development. Needs analysis involving teachers, parents, and experts revealed that children are highly interested in engaging, movement-based animal learning. However, conventional methods currently in use remain less effective, as they do not adequately incorporate multisensory experiences or optimal motor activities. The developed media, LeapZoo, leverages Leap Motion technology to detect children's hand movements and integrates them with 3D visualizations and animal sounds. The findings indicate that this technology has the potential to enhance children's engagement, comprehension, and motor coordination, aligning with the scaffolding principles of Vygotsky's theory. The study also highlights a readiness and interest in utilizing this medium, provided that appropriate training and infrastructure support are in place. Therefore, the Leap Motion-based learning media effectively addresses the three research questions: (1) it is designed in accordance with early childhood education needs; (2) it is conceptually effective in improving children's understanding; and (3) it holds strong potential to support both gross and fine motor development in an integrative

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