Design of Interactive Augmented Reality Learning Media Using the VAKT Approach for Early Childhood Vegetable Recognition

Wahyu Kurnia Dewanto[1], Zilvanhisna Emka Fitri[1], Achmad Amreza Alfarit[1], Arizal Mujibtamala Nanda Imron[2], Reski Yulina Widiastuti[2], Ery Setiyawan Jullev Atmadji[1], Fatimatuzzahra[1]
[1]Politeknik Negeri Jember, Jember, Indonesia
[2]Universitas Jember, Jember, Indonesia

Article Info

Article History:

Received, 20-04-2026
Revised, 18-05-2026
Accepted, 29-05-2026

Keywords:

Augmented Reality;
Early Childhood;
Interactive Media;
VAKT.

ABSTRACT

Early childhood education requires adaptive media to facilitate cognitive and linguistic development. This study aims to evaluate the integration of the Visual-Auditory-Kinesthetic-Tactile (VAKT) framework into an Augmented Reality (AR) application for vegetable recognition, balancing technical engineering with user-centric design paradigms. This research used a method developed with Unity and the Vuforia SDK; the application architecture incorporates real-time marker tracking, a dual-language localization database, and automated dynamic scoring algorithms. Usability was quantitatively measured with 12 respondents using the Technology Acceptance Model (TAM) and the System Usability Scale (SUS) frameworks. The results of this research yielded a high TAM utility score of 80.63% and an ”Excellent” (B+) SUS rating. Technically, the system effectively maps software constraints onto cognitive stimuli, utilizing single-story sans-serif typography and high-saturation color rendering to sustain attention and support emergent literacy. While nearly 90% of respondents affirmed the application's learning efficacy, empirical logs exposed a critical friction point: asynchronous background audio caused sensory overstimulation for 41.67% of users. These findings support the Split-Attention Effect theory, suggesting that in AR environments, multi-sensory inputs must be hierarchically ordered to prevent cognitive overload. This study concludes that a synchronous multimodal hierarchy is essential for successful interactive multimedia environments.

Correspondence Author:

Wahyu Kurnia Dewanto,
Department of Information Technology,
Politeknik Negeri Jember,
Email: wahyu@polije.ac.id

How to Cite:
W. K. Dewanto, Z. E. Fitri, A. A. Alfarit, A. M. N. Imron, R. Y. Widiastuti, E. S. J. Atmadji, & F. Fatimatuzzahra, "Design of Interactive Augmented Reality Learning Media Using the VAKT Approach for Early Childhood Vegetable Recognition," *Jurnal SASAK: Desain Visual dan Komunikasi*, vol. 8, no. 1, pp. 59–70, May 2026. DOI: 10.30812/sasak.v8i1.6317.

1. INTRODUCTION

Childhood, defined as the period from birth to 6 years of age, is a time of rapid growth and development in multiple domains, including social-emotional, physical, motor, language, cognitive, creative, and artistic abilities. This period is often referred to as the ”golden age” of development, signifying its significance and importance in the life of a child [1, 2]. Child development is a critical process dependent on the provision of appropriate stimuli to ensure optimal generation [3]. The cognitive and linguistic development of children aged four to five years is facilitated by the introduction of objects such as fruits, vegetables, animals, numbers, the alphabet, and environmental objects. Furthermore, children aged 5-6 years are capable of recognizing, imitating, and naming objects in their environment, as well as understanding the relationship between the shape and sound of an object's name [4]. However, capturing abstract cognitive concepts and dual-language vocabulary at this developmental stage often creates a high cognitive load if relying solely on passive, single-sensory delivery. To mitigate this educational barrier and maximize sensory retention, an immersive, multisensory pedagogical approach is essential. Consequently, the learning process in this study uses the Visual-Auditory-Kinesthetic-Tactile (VAKT) method, presenting learning materials in visual, auditory, movement, and touch-based forms. A combination of auditory and visual approaches can facilitate children's understanding and improve their language skills in both Indonesian and English [5]. This method necessitates the integration of media and technology to facilitate learning activities [6], which have been shown to promote a passion for learning, enhance interaction between students and their environment, and provide students with the opportunity to learn independently based on their abilities and interests [7]. The integration of media and technology, often referred to as multimedia, can enhance the efficacy of the learning process. The phenomenon can be explained by children's limited capacity to concentrate for extended periods. Their attention can be readily drawn to competing stimuli, rendering educational materials such as books or flash cards ineffective when used repeatedly [8]. Therefore, alternative learning media such as augmented reality (AR) can be employed to create real 3D synthetic images and interactive experiences in real time [9]. According to [10], AR technology in games has the potential to enhance motivation, attention, and cognitive engagement by providing interactive real-world simulations. AR applications require markers with specific characteristics to track and identify items with precision and accuracy. These markers facilitate the processing of images of objects stored on the devices [11]. This technology has the potential to enhance learning experiences by creating interactive and stimulating learning media, thereby increasing children's interest in education.

The integration of Mobile Augmented Reality (MAR) in the educational sector represents a novel innovation in learning media, facilitating the creation of 3D images of real-world objects. These images enhance learning activities, ensuring ease of use, efficiency, and comprehension of critical concepts. This technology finds application in a variety of fields, including health, agriculture, industry, and education. Some examples of the utilization of AR media as learning media in the health sector include the BARA application (Brain Anatomy Embedding Application) for young medical graduates [12] and the Spinovate application to assist physiotherapy in slipped disc patients [13]. The agricultural sector encompasses a variety of disciplines, including nutrition informatics on packaged food labels [14], food safety [15], food production and precision agriculture [11]. However, AR utilization is frequently implemented in education, such as nutritional education and food sustainability [10] and learning the Tribal Bodo language [16]. Traditionally, early childhood education has relied on flashcards, posters, and textbooks, which, in their printed form, have not been accompanied by interactive technology. Consequently, these educational materials have been found to be uninteresting and to rapidly induce boredom for children. The integration of technology, such as augmented reality (AR), has been found to enhance cognitive development across both the sensorimotor phase, in which knowledge is acquired through physical interaction, and the preoperational phase, characterized by the use of symbols to represent the surrounding environment. Furthermore, the employment of augmented reality (AR) technology as an effective, creative, and educational learning media, especially in the context of thematic instruction, is noteworthy [17]. The following are some examples of the use of augmented reality (AR) technology in early childhood education:

a. The introduction of food nutrition to elementary school children [18]
b. Children's knowledge of animals [19]
c. Children's knowledge of vegetables, fruits, and healthy living habits [20]
d. Learning plant parts for grade 1 elementary school student [21]
e. Media introduction to 10 types of vegetables [9]
f. AR-based educational game "*Aku Suka Sayur*" consists of several menus such as vegetable introduction, guessing vegetable names, singing songs and coloring them directly [22].

Our research team developed an augmented reality (AR)-based educational game designed to introduce various types of vegetables and their nutritional benefits to young learners. To ensure a challenging and engaging experience, we implemented tiered difficulty levels, categorizing the gameplay into easy and hard modes. Beyond these functional features, the development of this application responds to gaps in the extant literature, which predominantly isolate marker-tracking performance from interface aesthetics, relying on subjective preferences. Consequently, this study presents a distinct novelty by directly mapping software engineering constraints—such as pixel density, raycasting, and hit-test colliders—onto cognitive-driven VCD principles, including single-story sans-serif typography for emergent literacy and 3D visual affordance shaders. This cross-disciplinary correlation is quantitatively measured using the TAM and SUS frameworks to establish an objective design matrix that bridges technical execution and pedagogical visual communication.

2. RESEARCH METHOD

ADDIE is a widely used model in education for planning and developing new courses, programs, or curricula. There are five stages of the ADDIE model, which are Analysis, Design, Development, Implementation, and Evaluation [23] (see Figure 1).

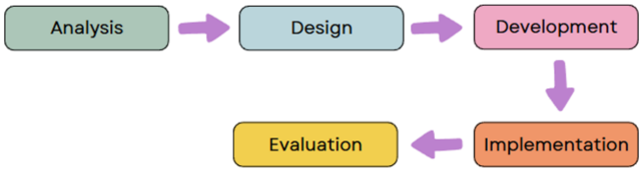


Figure 1. Steps of the ADDIE Model

2.1. Analysis

A fundamental component of the ADDIE model is the analysis stage, which aims to assess the requirements for creating learning media. A series of interviews was conducted to ascertain the needs of teachers, parents, and education experts regarding the application of augmented reality. This study was conducted under the direction of Mrs. Reski Yulina Widiastuti, S.Pd., M.Pd, an education expert and lecturer in the undergraduate program in early childhood education at the University of Jember. The survey instrument, presented in Table 1, comprises five questions to be completed by two respondents.

Table 1. Interview questionnaire for needs analysis

No.	Questions
1.	What is your opinion on the most recent developments in learning media?
2.	Is the current learning media effective?
3.	What are the limitations of the current learning media?
4.	What is your perspective on the utilization of augmented reality (AR) technology in learning media?
5.	What features should be included in AR-based learning media?

2.2. Design

The design stage aims to create a 3D model of the vegetables used in the application and an attractive User Interface (UI) for children. In addition, system design and application use-case scenarios are designed to ensure a clear flow of user and application interactions, in accordance with the needs analysis shown in Figure 2. This learning media comprises four features: learning, playing, information, and credit (developer team).

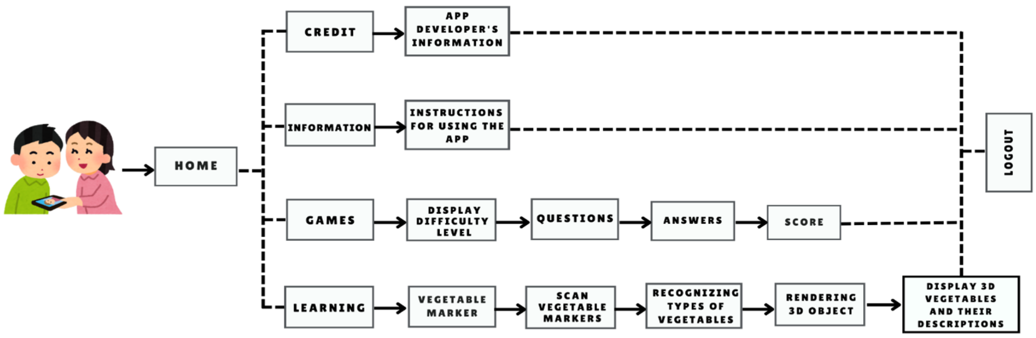


Figure 2. Application system illustration

2.3. Development and Implementation

The development of this Augmented Reality (AR) educational application involves a robust integration of three-dimensional vegetable model assets created in Unity with the Vuforia database. This technical process begins with the generation of precise vegetable object markers, ensuring accurate system recognition based on designated types, and establishes dual-language (Indonesian and English) description scenes supported by both text and functional audio narration. Beyond the descriptive content, the application incorporates a gamified experience through three distinct modes: ”Guess the Picture,” ”Guess the Sound,” and ”Guess the Shape,” each structured with ”Easy” and ”Hard” difficulty levels to maintain user engagement. In terms of User Interface (UI) Design and Typography, the primary focus is on structuring intuitive layouts to ensure efficient information processing. To maximize legibility on digital screens, typography with clean anatomical characteristics was selected, augmented by a multimodal coherence that facilitates both visual and auditory comprehension. Furthermore, regarding Visualization and Game Identity, the visual design supports gamification mechanics through visual consistency. The feedback system employs dedicated illustrations and indicator icons for ”correct” and ”incorrect” responses, serving as instantaneous visual cues that help children cognitively map the outcomes of their actions without ambiguity.

This structured visual hierarchy extends to the Navigation and Information System, where the information architecture is configured to guide the user journey seamlessly from the initial tutorial to the final score display and developer credits. The efficacy of these design and technical implementations is validated by the evaluation results. TAM testing on 12 respondents showed a high utility score of 80.63%, while the System Usability Scale (SUS) results yielded a grade of B+ with an adjective rating of ”Excellent.” Despite these high scores, a critical analysis of the data revealed minor friction points; specifically, Respondent 10’s lower score on question P5 suggests a need for further refinement in button affordance. Additionally, findings from question P10 indicated that background noise hindered concentration for 41.67% of users, highlighting the need to balance audiovisual stimuli to prevent cognitive overload. Nevertheless, nearly 90% of respondents assigned high scores to question P15, confirming the application’s overall success as an effective and engaging learning tool for facilitating vegetable recognition in early childhood education.

2.4. Evaluation

The evaluation stage employs three system tests: black-box testing, marker testing, and Technology Acceptance Model (TAM) testing. Blackbox testing is a methodical approach to assessing a game’s functionality, identifying errors or inconsistencies in its mechanics, and verifying these elements from the user’s perspective. It does not involve the examination of the game’s underlying source code [24]. Conversely, marker testing prioritizes ARP’s performance reliability when scanning markers. Marker testing involves measuring light intensity and evaluating the distance between the marker and the camera. Light intensity testing necessitates the utilization of a lux light meter, a device employed for the measurement of light intensity [25]. The light intensity range used in the test was 0–95 lux, 96–300 lux, and >300 lux [26], and the marker and camera distances were 10 cm, 50 cm, and 100 cm. The Technology Acceptance Model (TAM) is a methodological framework employed to assess the acceptance, perceived utility, and intended utilization of the system in question [27]. The two main components are as follows:

1. Perceived usefulness: This occurs when consumers realize that technology or applications can improve efficiency or results.
2. Perceived ease of use: This relates to the user’s view that the technology is easy to use [28].

As part of the TAM testing process, the System Usability Scale (SUS) questionnaire is used to assess perceived usability and customer satisfaction. The survey consists of 15 questions, each evaluated on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). The Likert scale is used to assess four key criteria: efficiency, error, satisfaction, and system effectiveness. The statistical analysis utilizes equations (1 - 2) to derive the results [29, 30]. The SUS score ranges from 0 to 100, with higher scores indicating higher usability levels of the system [31]. The specific mathematical frameworks for these calculations are detailed in Equations (1) and (2).

$$\text{SUS}_{score} = \left(\sum_{i=1}^{15} (S_i - 1) + \sum_{i=1}^{15} (5 - S_i) \right) \times 2.5 \tag{1}$$

$$\text{Average } SUS_{score} = \frac{SUS_1 + SUS_2 + \cdots + SUS_n}{n} \tag{2}$$

Three methods are available for calculating the Acceptance Score Value. The first method involves the determination of the acceptance range, the second involves the determination of the scale grade (see Table 2), and the third involves the determination of the adjective rating as demonstrated in Figure 3. The mean SUS score is considered a metric of user acceptance of the usability-tested system. A usability level within the ”Acceptable” range is indicated by a SUS score above 70.

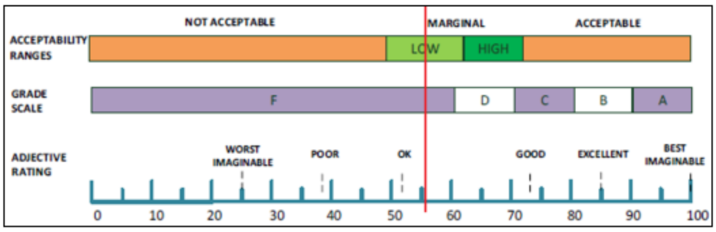


Figure 3. Acceptance Rate of AR Application [32]

Table 2. Curved Grade Scale (CGS) SUS [32]

Grade	SUS	Percentile range
A+	84.1 – 100	96 – 100
A	80.8 – 84.0	90 – 95
A-	78.9 – 80.7	85 – 89
B+	77.2 – 78.8	80 – 84
B	74.1 – 77.1	70 – 79
B-	72.6 – 74.0	65 – 69
C+	71.1 – 72.5	60 – 64
C	65.0 – 71.0	41 – 59
C-	62.7 – 64.9	35 – 40
D	51.7 – 62.6	15 – 34
F	0 – 51.6	0 – 14

3. RESULT AND ANALYSIS

The research began with interviews with two experts to observe the needs of learning media innovation. The first expert was Mrs. Nur Mabruroh, S.Pd., a teacher at Pos PAUD Alamanda 105, and the second expert was Mrs. Reski Yulina Widiastuti, S.Pd., M.Pd., a lecturer in the Early Childhood Education Study Program at the University of Jember. The results of these interviews are described in Table 3.

Table 3. Interview results for the need analysis of learning media innovation

No.	Questions	Preschool Teacher	Early Childhood Lecturer
1.	What is your opinion on the most recent developments in learning media?	Learning media is conventional, using books and stories.	Learning media is conventional; therefore, innovation in learning media is necessary to attract children’s interest.
2.	Is the current learning media effective?	Less effective, children get bored quickly	Less effective for training memory and improving children’s brain performance
3.	What are the limitations of the current learning media?	Less interactive and less attractive to children	Lacks interactive and educational features that can attract children’s attention
4.	What is your perspective on the utilization of augmented reality (AR) technology in learning media?	Absolutely agree, because it increases children’s interest	Agree, it can enhance interest and interaction in the learning process
5.	What features should be included in AR-based learning media?	Features of the game, including quizzes, sounds, and object descriptions	Game features include quizzes, audio, detailed object descriptions, and educational interactions

The analysis of interview results reveals that traditional teaching materials such as books, flashcards, and posters are not sufficient to engage children in the initial stages of introducing vegetable material. Therefore, there is a need for more interactive and innovative learning media, including the integration of augmented reality (AR) technology. The application is expected to include the following features:

1. An introduction to vegetables and their descriptions

2. The mention of vegetable names in both Indonesian and English
3. Games designed to train children's cognitive abilities in recognizing vegetables based on their colors and shapes

The development of the user interface (UI) in this study involves careful, systematic consideration of several design components, including the color scheme, typography, background appearance, button morphology, and iconographic elements, as illustrated in Figure 4. Among these, color selection stands out as a particularly critical design variable, as it has been empirically shown to meaningfully influence users' psychological and emotional states. The primary color chosen for this application is a warm yellow-orange hue, commonly referred to as "golden poppy" or "sunshine," a decision grounded in psychological research consistently demonstrating that warm color spectra are associated with elevated mood, comfort, and relaxation [33–35]. Complementing this, green is adopted as the secondary color, a choice supported by its well-established symbolic association with natural equilibrium and balance, properties that have been found to promote calmness and reinforce positive affective responses in users [35, 36]. Together, these chromatic decisions go beyond purely aesthetic concerns, as they are deliberately aligned with the emotional and cognitive developmental characteristics of early childhood users. A highly saturated color palette, paired with a friendly, cartoonish illustration style, is employed to optimize attentional engagement and elicit positive emotional responses, while carefully avoiding visual overstimulation or cognitive fatigue. Pastel tones are applied to background areas to reduce visual load, while higher-contrast chromatic elements are strategically placed on interactive components such as buttons, serving as perceptual affordance cues that naturally guide children's attention toward actionable elements [37]. Typographic decisions are approached with equal deliberateness, given that font characteristics have a well-documented impact on the legibility, comprehensibility, and visual coherence of digital interface design. Open Sans Regular is selected as the primary typeface for this application, owing to its clean, rounded letterform anatomy and generous inter-character spacing, which are well-suited to supporting the emergent literacy competencies of early childhood users, helping them more easily decode and visually recognize on-screen text. The typographic system is also designed to scale responsively across varying screen sizes and device configurations, ensuring that information remains consistently readable and accessible regardless of the platform through which children engage with the application [38].

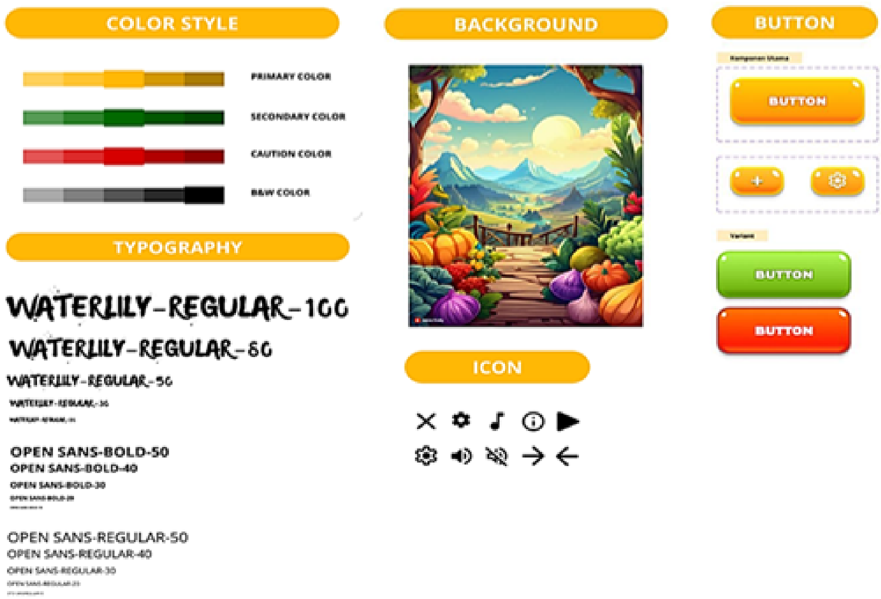
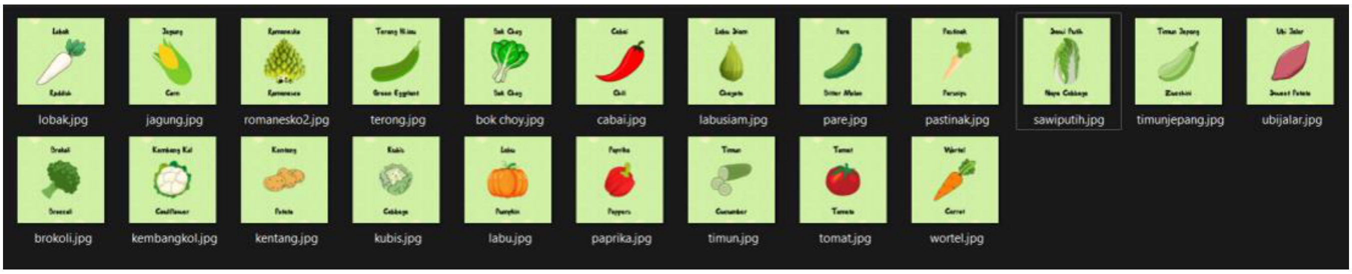
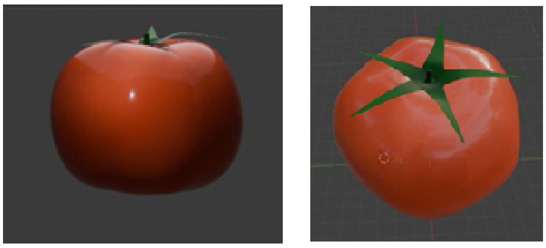


Figure 4. Design of the system's main attributes

The design of interactive elements is similarly rooted in an empirical understanding of early childhood motor and cognitive development. Buttons are rendered with rounded-corner geometry and three-dimensional shadow effects to reinforce the principle of perceptual affordance, allowing young users to intuitively identify and interact with interface elements without relying on abstract or symbolically complex iconography. The interaction models embedded within the mini-game modules are developed in alignment with Piaget's preoperational stage of cognitive development, a phase in which children learn most effectively through active manipulation and spatial exploration of their environment. Recognizing the limited error tolerance characteristic of this developmental stage, the application incorporates a multimodal feedback architecture that combines synchronized visual indicators with spoken voice narrations in response to every user interaction. This dual-channel feedback mechanism serves not only as an informational signal but also as an affective reinforcement system, offering children immediate confirmation of their actions and nurturing a genuine sense of achievement that sustains intrinsic motivation and engagement throughout the learning experience. The visual content of this application is implemented through the systematic development of 20 three-dimensional vegetable model assets and corresponding physical marker cards, built in the Unity development environment. Each model originates from primitive geometric forms that are progressively refined through surface contouring, chromatic texturing, and morphological detailing to yield perceptually realistic representations. The complete asset library is curated for pedagogical relevance, visual distinctiveness, and varying degrees of familiarity within the target demographic, thereby broadening children's botanical knowledge beyond commonly encountered species. The application is structured around two principal modules, "Vegetable Learning" and "Games," in which children can scan physical marker cards to access AR representations of each vegetable, accompanied by bilingual nomenclature, descriptive text, and audio narration in both Indonesian and English, as depicted in Figure 5.



(a)



(b) (c)

Figure 5. (a) markers, (b) assets and (c) 3D models of vegetables

The configuration of these visual elements is deliberately engineered as an integrated multimedia stimulus system calibrated to the psychological and developmental characteristics of early-childhood users. The high-saturation color palette activates the brain's reticular activating system to sustain children's short attention spans while simultaneously triggering dopamine secretion to reinforce positive emotional responses during learning. This chromatic stimulus is reinforced typographically through a sans-serif typeface with single-story letterforms, a large x-height, and generous character spacing, thereby reducing cognitive load and visual crowding to support emergent literacy in decoding bilingual text. The interface layout further employs deliberate negative space to prevent information overload and guide children's visual attention from primary AR objects to supplementary content, while iconographic elements adopt a literal, pictorial, and anthropomorphic approach, such as feedback icons with embedded facial expressions, to bridge abstract symbol comprehension and foster emotional attachment.

On the spatial and interactive dimensions, the explorable three-dimensional vegetable models deliver richer cognitive stimulation than conventional two-dimensional illustrations, actively training spatial awareness and supporting object conceptualization in children at the preoperational stage. These stimuli converge within an interaction framework featuring high error tolerance, large touch zones, and a learning-by-doing model that prompts pattern matching within the mini-games, ultimately delivering immediate multimodal feedback through visual indicators and voice narrations as an intrinsic reward mechanism that enhances self-efficacy and sustains meaningful engagement throughout the learning experience. The game menu contains three primary submenus, namely "Guess the Picture," "Guess the Shape," and "Guess the Sound," each further divided into "Easy" and "Hard" difficulty levels to facilitate children's cognitive development in identifying visual, auditory, and morphological characteristics of vegetables within a time-limited response framework. In the ”Guess the Shape” submenu, children drag and drop vegetable cards onto their corresponding silhouettes, with emoticon indicators and a cumulative score displayed upon completion, as illustrated in Figure 6.

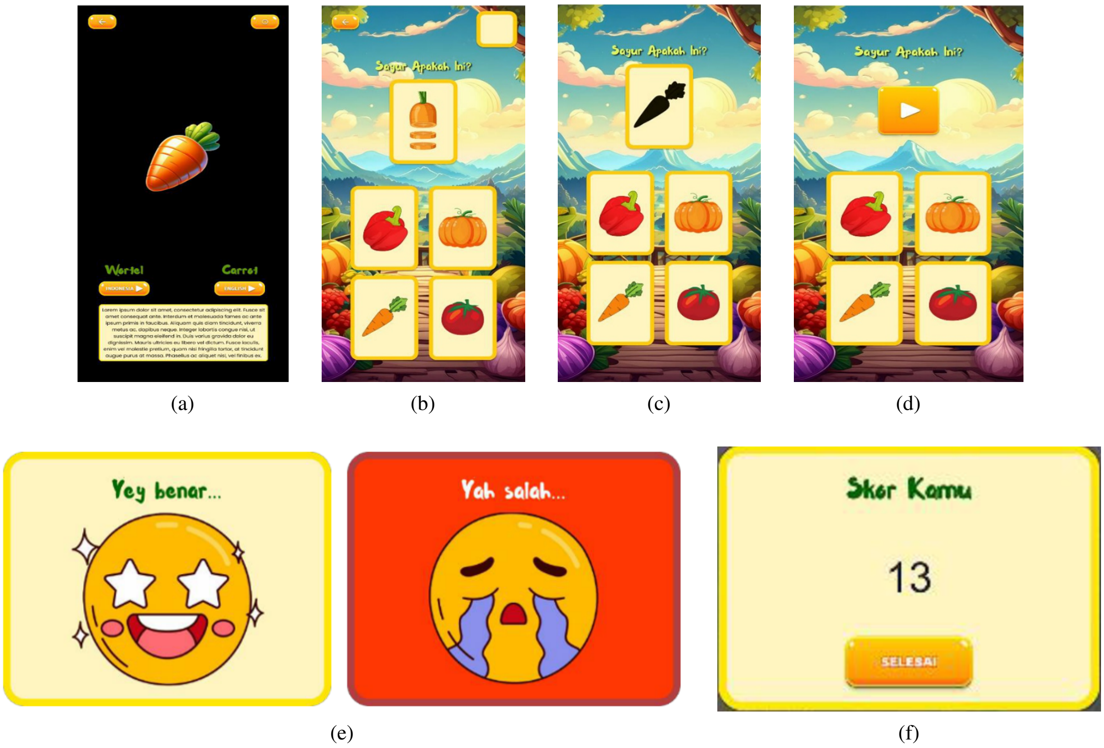


Figure 6. The menu comprises the following options: (a) learning; (b) guessing the picture; (c) guessing the shape; (d) guessing the sound; (e) reaction emoticons; and (f) game score.

Based on the generated visual assets and interface prototypes, the overall design of this educational application demonstrates a well-measured implementation of Visual Communication Design principles that are highly adaptive to the developmental characteristics of early childhood users. The production of 2D marker cards adopts a vector-based flat design approach with soft edges to simplify complex vegetable forms into child-friendly visual representations, while the transition to three-dimensional models, as exemplified by the tomato object, is engineered with accurate volume, semi-glossy textures, and convincing lighting to effectively trigger children’s spatial awareness when projected through AR technology into the real-world environment. This aesthetic coherence is further reinforced by the game interface layout, which features a vibrant orchard-themed background within which the primary content area is positioned atop a semi-transparent rounded container to maintain visual focus without distraction, thereby applying the principles of contrast and visual emphasis, while the selection of a bold, casual display sans-serif typeface for titles such as ”*Sayur Apakah Ini?*” successfully sustains a playful communicative tone without compromising textual legibility.

An evaluation the effectiveness of the gamification mechanics across the three game modes (*Guess the Picture, Guess the Shape,* and *Guess the Sound*) directly supports children’s cognitive stimulation and fine motor skills. Through the *Guess the Shape* feature, which displays black silhouettes of objects, children are trained to optimize their cognitive function in shape recognition, whereas the *Guess the Sound* feature uses a bright orange Play button with a strong affordance principle to enable intuitive interaction. All of these interactive activities culminate in an immediate feedback system via pop-up modal panels that leverage an anthropomorphic approach through contrasting emoji expressions. The correct response (*”Yay benar...”*) is enclosed in a bright yellow background, paired with a star-eyed emoji, to provide positive reinforcement that fosters motivation to learn. Conversely, the incorrect response (*”Yah salah...”*) uses a red background and a crying emoji to playfully signal errors, thereby mitigating user frustration. Lastly, on the final score page, information is presented cleanly, with a predominance of calming pastel colors, making the score figure the primary focal point, and is concluded with a high-contrast ”*Selesai*” button to provide a clear, independent exit path for the user. An evaluation using the Technology Acceptance Model (TAM) is employed to assess perceptions of usability and customer satisfaction with the AR application.

This evaluation uses the System Usability Scale (SUS) questionnaire, which comprises 15 questions (Table 4), administered to 12 sample respondents (Table 6). The respondents include lecturers as experts, kindergarten teachers, and parents of children from the Art Performance of the Early Childhood Education Study Program and Labschool Kindergarten from the Universitas Jember.

Table 4. Codes and questionnaires for TAM testing

Code	Question	Code	Question
Q1.	Is the interface design of this application attractive and easy to use?	Q8.	Is the 3D vegetable model in this app realistic and does it look like the real thing?
Q2.	Is the font used in this application attractive and easy to read?	Q9.	Are the games in this app interesting and fun to play?
Q3.	Is the font color in this application clear and easy to read?	Q10.	Does the background sound in the game disturb your concentration?
Q4.	Are the button colors in this application attractive and easy to recognize?	Q11.	Is the voice of the question in “ guessing sound” clearly heard?
Q5.	Is the button design in this application easy to understand and use?	Q12.	Is there any skill development in children after playing this app?
Q6.	Is the appearance of each panel in this application attractive and easy to understand?	Q13.	Does this app help with learning to recognize types of vegetables?
Q7.	Is the voice of the language translation and vegetable information on the learning page clearly heard?	Q14.	Does this app run perfectly without any technical issues?
Q15.	Is this app suitable for use as a learning assistant for early childhood?		

Table 5. Result of TAM Testing

Respondents	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	Score
1	4	4	4	4	4	4	4	4	4	2	4	4	4	4	4	82.5
2	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	80
3	5	5	5	5	5	5	5	5	5	3	3	3	4	5	4	80
4	5	5	4	4	5	5	4	5	5	1	4	5	5	4	5	87.5
5	5	5	5	5	5	5	4	5	5	4	4	5	5	5	5	77.5
6	5	4	4	5	5	5	4	3	5	5	4	4	5	4	5	85
7	5	5	5	5	5	5	4	5	4	4	4	5	5	4	5	77.5
8	5	5	5	5	5	5	5	5	5	4	4	4	5	5	5	82.5
9	4	4	4	4	4	4	4	4	5	2	4	4	4	5	4	82.5
10	4	4	4	4	2	4	4	4	4	4	4	4	4	4	4	72.5
11	4	4	4	4	4	4	4	3	4	3	4	4	4	4	3	80
12	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	80
Average Score of SUS																80.63

Table 4 and Table 5s present a detailed description of the survey questions developed to measure respondents’ interest in the application user interface design (P1–P6), their level of understanding and interest in the learning materials (P7, P8, P9, P11, P12, P13, and P15), and their perceived obstacles in using the application (P10 and P14). According to Table 6, the TAM testing results across 12 respondents yield a cumulative score of 80.63%, which, when correlated with the System Usability Scale (SUS) Curved Grade Scale (CGS) in Table 2, corresponds to a grade of B+ and an adjective rating of ”Excellent” within the acceptable application category, as referenced in Figure 3. This high score provides linear evidence that the visual design decisions, including the vibrant color palette, child-friendly sans-serif typography, and a layout featuring ample negative space, have successfully optimized user engagement and minimized cognitive load when processing bilingual educational content. Despite this high cumulative score, a critical evaluation of data anomalies remains necessary for further design optimization. One respondent, specifically respondent 10, assigned a notably low score of 72.5 on question P5, indicating confusion regarding the application’s button elements. From an interface interaction perspective, this finding suggests that the visual affordance of certain buttons has not fully aligned with users’ mental models, thereby necessitating refinements to geometric forms or depth effects, such as 3D shadows, to make their functions more intuitively recognizable.

A further anomaly is observed in question P10, which examined the impact of background noise on player concentration: 5 out of 12 respondents assigned low scores ranging from 1 to 3, indicating that background noise was perceived as a significant disturbance by 41.67% of TAM test participants. Within the principles of multimodal communication, this dissonance between audio and visual elements risks triggering overstimulation that disrupts children’s focus, suggesting that the intensity and composition of audio tracks require redesign to function as complementary rather than competing stimuli. Nevertheless, the overall reception of the application remains markedly positive, as nearly 90% of respondents assigned a high score of 4 or 5 on question P15, which assessed the application's suitability as a learning tool for early childhood education, further corroborated by the positive evaluations recorded on question P13 regarding the application's effectiveness in facilitating interactive vegetable recognition through AR-based three-dimensional visual stimulation.

4. CONCLUSION

This study has successfully developed and evaluated an Augmented Reality (AR)-based educational application for early childhood vegetable recognition, achieving a TAM utility score of 80.63% and an "Excellent" (B+) rating on the System Usability Scale (SUS). Explicitly, this research makes a significant contribution to the field of interactive learning media by demonstrating that the integration of AR technology must go beyond mere technical sophistication and be configured as an adaptive multimodal framework. Its practical contribution is realized through a child-friendly interaction system, wherein children's high tolerance for fine motor errors is accommodated via large button touch zones, 3D spatial object manipulation, and anthropomorphic immediate feedback systems, which have been shown to sustain attention retention and mitigate user frustration during independent learning. Furthermore, this study offers new theoretical and methodological insights into how visual elements operate as measurable cognitive and emotional stimuli for early childhood audiences. This research shifts the visual design paradigm from subjective aesthetic preferences toward an objective scientific approach by directly correlating Visual Communication Design (VCD) parameters, such as single-story sans-serif typographic anatomy for emergent literacy, high-saturation color psychology, and negative space optimization in interface layouts, with empirical usability testing metrics. The critical findings regarding emotional disturbance caused by background audio dissonance further highlight this study's contribution to expanding the scope of VCD into the dimension of digital soundscapes. Collectively, these insights serve as an empirical blueprint and a valuable reference for future visual designers in structuring a balanced informational hierarchy among visual, spatial, and auditory elements in interactive digital media.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to the Principal of TK Labschool; Faculty of Teacher Training and Education, Universitas Jember; and the Early Childhood Teacher Education Study Program at Universitas Jember for their invaluable assistance and support during the testing of the learning media. The authors also extend their appreciation to the editorial board of *Jurnal Sasak* for accepting and publishing this article.

References

[1] U. Setyaningsih and I. Indrawati, "Strategi Pengembangan Kemampuan Membaca Anak Usia 5-6 Tahun," *Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini*, vol. 6, no. 4, pp. 3701–3713, Mar. 14, 2022. DOI: 10.31004/obsesi.v6i4.2340

[2] R. S. Nafisa, Y. Fitriani, and P. Nuroniah, "Pengembangan Kemampuan Membaca Anak Usia 5-6 Tahun Menggunakan Metode Drill," *Aulad: Journal on Early Childhood*, vol. 7, no. 1, pp. 210–218, Apr. 29, 2024. DOI: 10.31004/aulad.v7i1.635

[3] A. M. N. Imron et al., "Web-based Learning Media for Alphabet Recognition in Early Childhood using LeNet-5," *Journal of Information Systems Research and Practice*, vol. 2, no. 3, pp. 32–43, 2024. [Online]. Available: https://katha.um.edu.my/index.php/JISRP/article/view/54239

[4] A. Multahada, "Enhancing Early Literacy and Numeracy Skills through Diverse Media," *GENIUS Indonesian Journal of Early Childhood Education*, vol. 5, no. 1, pp. 41–56, Jun. 30, 2024. DOI: 10.35719/gns.v5i1.149

[5] D. F. A. Putri et al., "Peningkatan Kemampuan Berbahasa Inggris pada Anak Usia Dini Melalui Media Pembelajaran Fruits Zone di Pos Paud Alamanda 105 Kabupaten Jember," *Jurnal Pengabdian Masyarakat Bangsa*, vol. 1, no. 10, pp. 2621–2630, Dec. 29, 2023. DOI: 10.59837/jpmba.v1i10.572

[6] S. I. Komariah et al., "Fruit Zone : Media Pembelajaran Interaktif Pengenalan Buah Anak Kelompok Belajar Menggunakan ResNet18," *Faktor Exacta*, vol. 17, no. 1, May 2, 2024. DOI: 10.30998/faktorexacta.v17i1.21101

[7] A. Aulia et al., "Pengaruh Penggunaan Metode Visual, Auditori, Kinestetik, Taktil (VAKT) Terhadap Kemampuan Membaca Permulaan Peserta Didik Tunagrahita Ringan Kelas IVC di SLB Negeri Sragen," *JPI (Jurnal Pendidikan Indonesia): Jurnal Ilmiah Pendidikan*, vol. 11, no. 1, pp. 1–8, Mar. 18, 2025. DOI: 10.20961/jpiuns.v11i1.109640

[8] Z. E. Fitri et al., “Attractive Learning Media for Introduction to Popular Fruits Using Computer Vision,” in *2022 International Conference on Electrical Engineering, Computer and Information Technology (ICEECIT)*, Jember, Indonesia: IEEE, Nov. 22, 2022, pp. 14–19, ISBN: 978-1-6654-9352-9. DOI: 10.1109/ICEECIT55908.2022.10030261

[9] A. Sirumapea et al., “Augmented Reality Technology for Learning Introduction Media of Various Vegetables Android Based using Unity,” *JURNAL SISFOTEK GLOBAL*, vol. 12, no. 1, p. 58, Mar. 30, 2022. DOI: 10.38101/sisfotek.v12i1.479

[10] I. Capecchi et al., “Enhancing Education Outcomes Integrating Augmented Reality and Artificial Intelligence for Education in Nutrition and Food Sustainability,” *Sustainability*, vol. 17, no. 5, p. 2113, Feb. 28, 2025. DOI: 10.3390/su17052113

[11] J. Xie et al., “Trends of Augmented Reality for Agri-Food Applications,” *Sensors*, vol. 22, no. 21, p. 8333, Oct. 30, 2022. DOI: 10.3390/s22218333

[12] N. A. H. Basri et al., “A User Study on Virtual Tutor Mobile Augmented Reality from Undergraduate Medical Student Perspectives,” *Asia-Pacific Journal of Information Technology and Multimedia*, vol. 12, no. 01, pp. 139–154, Jun. 1, 2023. DOI: 10.17576/apjitm-2023-1201-08

[13] A. A. N. Jemali, A. H. M. Aman, and M. S. Jalil, “Spinovate Development: Physiotherapy Application for Slipped Disc Patients Based on Augmented Reality,” *Asia-Pacific Journal of Information Technology and Multimedia*, vol. 13, no. 2, pp. 166–179, Dec. 1, 2024. DOI: 10.17576/apjitm-2024-1302-02

[14] M.-C. Juan et al., “An Augmented Reality App to Learn to Interpret the Nutritional Information on Labels of Real Packaged Foods,” *Frontiers in Computer Science*, vol. 1, p. 1, Jun. 20, 2019. DOI: 10.3389/fcomp.2019.00001

[15] N. N. L. Xuan, S. S. Hoon, and S. S. Hui, “Augmented Reality (AR) for Food Safety: Implementing an AR Inspection App with a Machine Learning Model,” in *2024 5th International Conference on Artificial Intelligence and Data Sciences (AiDAS)*, Bangkok, Thailand: IEEE, Sep. 3, 2024, pp. 510–515, ISBN: 979-8-3315-2855-3. DOI: 10.1109/AiDAS63860.2024.10729990

[16] D. Basumatary, D. Das, and R. Maity, “Impacts of AR in Learning Tribal Bodo Language,” *International Journal of Modern Education and Computer Science*, vol. 16, no. 6, pp. 64–79, Dec. 8, 2024. DOI: 10.5815/ijmecs.2024.06.05

[17] E. Kurniasih, “The Effect of Using Augmented Reality-Based Mobile Thematic Kindergarten Teaching Materials to Improve Students’ Soft Motor Skills,” *KnE Social Sciences*, Mar. 12, 2024. DOI: 10.18502/kss.v9i6.15310

[18] B. Arifitama, P. Nugrahayati, and S. D. H. Permana, “Implementation of Augmented Reality for Introducing Nutritious Food to Elementary School Children Using the Marker-Based Tracking Method,” *Justek : Jurnal Sains dan Teknologi*, vol. 8, no. 2, pp. 138–147, Jun. 10, 2025. DOI: 10.31764/justek.v8i2.30409

[19] Z. A. Yılmız and A. İ. C. Gözüm, “Augmented reality app in pre-school education: Children’s knowledge about animals,” *Southeast Asia Early Childhood Journal*, vol. 12, no. 2, pp. 130–151, Aug. 8, 2023. DOI: 10.37134/saecj.vol12.2.8.2023

[20] M. Abinaya and G. Vadivu, “Cultivating a Green Future: Augmented Reality Veggie and Fruit Explorer App Empowering Indian Curriculum with Agricultural Knowledge and Healthy Habits,” in *2023 International Conference on Research Methodologies in Knowledge Management, Artificial Intelligence and Telecommunication Engineering (RMKMATE)*, Chennai, India: IEEE, Nov. 1, 2023, pp. 1–8, ISBN: 979-8-3503-0570-8. DOI: 10.1109/RMKMATE59243.2023.10369511

[21] G. Antoniadi, “Using an augmented reality application for teaching plant parts: A case study in 1st-grade primary school students,” *Advances in Mobile Learning Educational Research*, vol. 3, no. 1, pp. 630–637, Feb. 1, 2023. DOI: 10.25082/AMLER.2023.01.012

[22] V. Vivianti and D. Ratnawati, “Augmented Reality-Based Mobile Education Game “ *Aku Suka Sayur* ” For Preschooler,” presented at the 2nd Annual Conference on Education and Social Science (ACCESS 2020), Mataram, Indonesia, 2021. DOI: 10.2991/assehr.k.210525.112

[23] K. Anafi, I. Wiryokusumo, and I. P. Leksono, “Pengembangan Media Pembelajaran Model ADDIE Menggunakan Software Unity 3D,” *JURNAL EDUCATION AND DEVELOPMENT*, vol. 9, no. 4, pp. 433–438, Nov. 5, 2021. [Online]. Available: https://journal.ipts.ac.id/index.php/ED/article/view/3206

[24] N. Aziezah et al., “Implementation of the Rapid Game Prototyping Method in the Educational Game E-Rush Using Unity 2D Engine,” *Journal of Artificial Intelligence and Engineering Applications (JAIEA)*, vol. 4, no. 3, pp. 1974–1979, Jun. 15, 2025. DOI: 10.59934/jaiea.v4i3.1058

[25] R. Aldiansyah and R. Yulianto, "Pembuatan Augmented Reality Menggunakan Metode Marker Based Tracking Sebagai Media Edukasi Budidaya Ikan Lele Di Bomo Krajan Banyuwangi," *Jikom: Jurnal Informatika dan Komputer*, vol. 13, no. 2, pp. 42–53, Oct. 30, 2023. DOI: 10.55794/jikom.v13i2.117

[26] E. Budiman, M. B. Firdaus, and U. Hairah, "Augmented Reality Peripheral Performance: Light Intensity, Distance, Occlusion and Marker Testing," *Journal of Physics: Conference Series*, vol. 1898, no. 1, p. 012 013, Jun. 1, 2021. DOI: 10.1088/1742-6596/1898/1/012013

[27] R. J. Thomas, G. O'Hare, and D. Coyle, "Understanding technology acceptance in smart agriculture: A systematic review of empirical research in crop production," *Technological Forecasting and Social Change*, vol. 189, p. 122 374, Apr. 2023. DOI: 10.1016/j.techfore.2023.122374

[28] A. Kunlerd et al., "Development of an Application for Rice Cultivation: Weather Forecasting System and Crop Variety Selection," *Asian Health, Science and Technology Reports*, vol. 33, no. 2, p. 3364, Jun. 18, 2025. DOI: 10.69650/ahstr.2025.3364

[29] R. Mohamad, N. Yassin, and S. Sualim, "Comparative Evaluation of Automated User Acceptance Testing Tool for Web Based Application," *International Journal of Software Engineering and Technology*, vol. 2, pp. 1–6, Dec. 1, 2016.

[30] K. S. Batubulan et al., "A Map Information Collection Tool for a Pedestrian Navigation System Using Smartphone," *Information*, vol. 16, no. 7, p. 588, Jul. 8, 2025. DOI: 10.3390/info16070588

[31] A. Rega et al., "Implementation and evaluation of an Augmented Reality framework for sustainable practices in Industry 5.0," *Advances in Industrial and Manufacturing Engineering*, vol. 11, p. 100 166, Nov. 2025. DOI: 10.1016/j.aime.2025.100166

[32] D. Supriyadi, S. T. Safitri, and D. Y. Kristiyanto, "Higher Education e-Learning Usability Analysis Using System Usability Scale," *IJISTECH (International Journal of Information System and Technology)*, vol. 4, no. 1, pp. 436–446, Nov. 30, 2020. DOI: 10.30645/ijistech.v4i1.81

[33] C. X. Thung and H. Ahmad, "Colour psychology in kindergarten classroom," *ARTEKS : Jurnal Teknik Arsitektur*, vol. 7, no. 1, pp. 61–66, Apr. 1, 2022. DOI: 10.30822/arteks.v7i1.1188

[34] E. Eunyeol and H. Suk-nyeong, "A Study on Color Image through Color Psychological Analysis of Playing Space in Kids Cafe," *Journal of Korea Intitute of Spatial Design*, vol. 18, no. 1, pp. 11–24, Feb. 2023. DOI: 10.35216/KISD.2023.18.1.11

[35] M. Singh, R. M. Singari, and M. Bholey, "The Influence of Color on Visual Psychology and Cognitive Behavior: A Study in Paediatrics Hospital Environment," *Educational Administration: Theory and Practice*, vol. 30, no. 5, pp. 13 164–13 177, May 24, 2024. DOI: 10.53555/kuey.v30i5.5679

[36] A. J. Elliot and M. A. Maier, "Color Psychology: Effects of Perceiving Color on Psychological Functioning in Humans," *Annual Review of Psychology*, vol. 65, pp. 95–120, Volume 65, 2014 Jan. 3, 2014. DOI: 10.1146/annurev-psych-010213-115035

[37] H. S. A. Latiff, R. Razali, and F. F. Ismail, "User Interface Design Guidelines for Children Mobile Learning Applications," *International Journal of Recent Technology and Engineering (IJRTE)*, vol. 8, no. 3, pp. 3311–3319, Sep. 30, 2019. DOI: 10.35940/ijrte.C5434.098319

[38] M. Günay, "The Impact of Typography in Graphic Design," *International Journal Of Eurasia Social Sciences*, vol. 15, no. 57, pp. 1446–1464, Jan. 1, 2024. DOI: 10.35826/ijoess.4519