



Design and Validation of AR- Based Learning Tool Integrated with Deep Learning Approach for Secondary EFL Learners

Wa Ode Sinta Kalsum^{1*}; Sariyatun²; Nur Arifah Drajati³

¹Department of Educational Technology, Universitas Sebelas Maret, Indonesia

²Department of History Education, Universitas Sebelas Maret, Indonesia

³Department of English Education, Universitas Sebelas Maret, Indonesia

^{1*}Corresponding Email: waode_sintak@student.uns.ac.id

Article History:

Received: Nov 30, 2025

Revised: Dec 27, 2025

Accepted: Dec 31, 2025

Online First: Jan 29, 2026

Keywords:

Augmented Reality,
Deep Learning,
Educational Media,
EFL,
Vocabulary Learning.

Kata Kunci:

Augmented Reality,
Deep Learning,
EFL,
Media Pembelajaran,
Pembelajaran Kosakata.

How to cite:

Kalsum, W. O. S., Sariyatun, S., & Drajati, N. A. (2026). Design and Validation of AR- Based Learning Tool Integrated with Deep Learning Approach for Secondary EFL Learners. *Edunesia : Jurnal Ilmiah Pendidikan*, 7(1), 655-672.

This is an open-access article under the CC-BY-NC-ND license



Abstract: This study designed and validated an Augmented Reality (AR)-based vocabulary learning tool integrating deep learning pedagogy for secondary EFL learners in under-resourced contexts. Using a Research and Development approach within the ADDIE model (Analyze, Design, Develop), the Research collected data from classroom observations, needs-analysis questionnaires, and expert validation by media and subject-matter specialists. An offline-capable mobile AR prototype was developed to address infrastructural constraints and to provide contextualized vocabulary presentation, guided attention, and reflection to support mindful learning, authentic AR visualization for meaningful learning, and interactive quizzes to foster joyful learning. Expert validation indicated high feasibility and validity: media expert mean = 86.67% (very feasible) and Material expert mean = 93.72% (very valid). Collectively, these findings provide robust empirical evidence that the media is pedagogically grounded, technically feasible, and aligned with curriculum objectives. The study contributes a validated instructional design framework that demonstrates how AR can be operationalized to embody mindful, meaningful, and joyful learning principles, offering practical guidance for educators and developers seeking accessible, context-responsive vocabulary-learning solutions in marginalized EFL settings.

Abstrak: Penelitian ini merancang dan memvalidasi media pembelajaran kosakata berbasis Augmented Reality (AR) yang mengintegrasikan prinsip deep learning untuk peserta didik EFL tingkat sekolah menengah. Penelitian memakai pendekatan Research and Development (R&D) dengan model ADDIE, dibatasi pada tahap Analyze, Design, dan Develop. Data dikumpulkan melalui observasi kelas, angket analisis kebutuhan, serta validasi ahli melibatkan ahli media dan ahli materi. Hasil analisis menjadi dasar pengembangan prototipe AR yang dapat diakses luring pada perangkat mobile, menampilkan penyajian kosakata kontekstual, pemusatan perhatian dan refleksi terarah (mindful learning), visualisasi AR autentik untuk pembelajaran bermakna, serta kuis interaktif untuk mendukung joyful learning. Validasi ahli menunjukkan media memenuhi kriteria kelayakan dengan skor validasi ahli media 86,67% (sangat layak) dan skor validasi ahli materi 93,72% (sangat valid). Temuan ini menunjukkan bahwa media layak secara pedagogis, feasible secara teknis, dan selaras dengan kurikulum. Secara praktis, penelitian menyediakan kerangka desain pembelajaran tervalidasi yang mengintegrasikan teknologi AR dan prinsip deep learning sebagai acuan pengembangan media kosakata yang aksesibel dan responsif pada konteks EFL yang kurang terlayani.

A. Introduction

English language acquisition continues to face persistent challenges in under-resourced secondary EFL contexts. Limited instructional resources, low parental educational support, and students' social responsibilities often disrupt the continuity of learning and hinder sustained development of English proficiency (Fathoniet al., 2024; Poedjiastutie, 2021). These conditions significantly reduce learners' exposure to English input and limit opportunities for meaningful practice, particularly in vocabulary learning, a foundational component of language competence. As emphasized by Nation (2013), effective vocabulary acquisition requires repeated exposure, contextual understanding, and active use. However, such learning conditions are difficult to achieve in environments characterized by inconsistent instructional time and limited learning support (Hartini & Ratminingsih, 2024).

Empirical evidence further confirms these challenges. Studies consistently report low levels of vocabulary mastery among secondary school students in under-resourced settings. Specifically in coastal school contexts, Kurniawan et al (2018) documented substantial vocabulary obstacles that hinder students' English speaking proficiency due to limited exposure and inadequate learning resources. For instance, Laoli & Purba (2025) found that a substantial proportion of eighth-grade students failed to meet basic vocabulary benchmarks, especially in contexts with limited continuity of learning and exposure. These findings indicate that conventional vocabulary instruction remains insufficient to support students' functional use of vocabulary in authentic communicative contexts (Hartini & Ratminingsih, 2024; Astriyani et al., 2022).

In response to these challenges, technology-enhanced learning has increasingly been explored as a strategy to improve vocabulary instruction. Digital learning media offer multimodal input, flexible access, and interactive learning experiences that support vocabulary comprehension and retention (Pahlevi et al., 2024; Radianti et al., 2020). Among these technologies, augmented reality (AR) has attracted growing attention for its ability to blend virtual content with real-world environments, thereby enabling contextualised, immersive learning experiences. Recent studies have demonstrated that AR-based vocabulary learning can enhance learner engagement, comprehension, and retention compared to traditional instructional approaches (Lai et al., 2021; Lin et al., 2021; Wahyuni & Widyaningrum, 2022).

From a pedagogical standpoint, however, effective vocabulary learning requires more than technological enhancement alone. It necessitates instructional designs that promote deep cognitive engagement, contextual meaning-making, and positive emotional involvement. Within this perspective, *deep learning* is conceptualized not as a computational or artificial intelligence construct, but as a pedagogical approach emphasizing mindful learning (focused attention and reflection), meaningful learning (contextualized and authentic knowledge construction), and joyful learning (emotional engagement and learner motivation). Integrating these principles into technology-enhanced learning environments positions digital tools as pedagogically driven learning systems rather than mere content

delivery platforms. Consequently, integrating AR technology with deep learning pedagogy requires systematic instructional design and validation to ensure that technological affordances effectively support vocabulary acquisition, particularly in under-resourced EFL contexts.

Despite the growing body of Research on AR-based vocabulary learning, existing studies predominantly emphasize learning outcomes such as engagement, motivation, and vocabulary gains. Relatively little attention has been given to the systematic design process and pedagogical validation of AR-based vocabulary learning media grounded in explicit instructional frameworks (Umar et al., 2025; Huang et al., 2022; Parmaxi & Demetriou, 2020). Moreover, although the concept of deep learning is increasingly referenced in educational technology Research, it is often employed implicitly, without clear operationalization of its pedagogical dimensions within AR-based language learning environments. As a result, the literature lacks empirically validated instructional models that demonstrate how AR technology can be deliberately designed to embody mindful, meaningful, and joyful learning principles, especially in under-resourced secondary EFL settings.

Addressing this gap, the novelty of the present study lies in its contribution to instructional design knowledge rather than technological experimentation alone. This study explicitly integrates augmented reality technology with deep learning pedagogy—operationalized through mindful, meaningful, and joyful learning principles—within a systematically designed, expert-validated vocabulary-learning media. By employing a Research and Development approach using the ADDIE instructional design model, this study contributes a validated pedagogical design framework that demonstrates how AR can function as a context-responsive, pedagogically grounded learning environment for vocabulary instruction in under-resourced secondary EFL contexts. This contribution extends prior AR Research by shifting the focus from technology effectiveness toward instructional design validity and pedagogical coherence.

Therefore, this study aims to design and validate an augmented reality-based vocabulary learning tool integrated with deep learning pedagogy for secondary EFL learners in under-resourced contexts. Specifically, this study addresses the following Research questions: (1) How can an AR-based vocabulary learning tool integrating mindful, meaningful, and joyful learning principles be systematically designed for secondary EFL learners? Moreover, (2) To what extent is the developed AR-based vocabulary learning tool valid and feasible based on expert evaluation?

In line with these Research questions, the objectives of this study are: (1) to design an AR-based vocabulary learning tool grounded in deep learning pedagogy using an instructional design framework, and (2) to validate the feasibility and instructional suitability of the developed AR-based vocabulary learning tool through expert judgment.

B. Method

This study employed a Research and Development (R&D) method using the ADDIE instructional design model proposed by Branch (2009), limited to the Analyze, Design, and

Develop stages. The primary objective of this Research was to develop a feasible, validated Augmented Reality (AR)-based vocabulary learning tool integrated with deep learning principles for secondary EFL learners. The study was conducted over two months in coastal secondary schools.

The participants in this study were 32 eighth-grade students and three English teachers who completed classroom observations and needs analysis surveys. In addition, four experts were involved in the validation process, including two media experts from different universities, one of whom had expertise in deep learning-based instructional design, and two English lecturers who served as subject matter experts for vocabulary learning. The following table presents the participants:

Table 1. Participants of the Study

| Participants | Number |
|--|--------|
| Eighth-grade students | 32 |
| English teachers | 3 |
| Media experts (Media and <i>Deep Learning</i> specialists) | 2 |
| Content experts (English lecturers) | 2 |

The Research procedure followed three stages of the ADDIE model. At the analysis stage, the researcher identified educational challenges and learning requirements related to English vocabulary instruction among coastal EFL learners. This stage involved: (1) validating performance gaps between expected curriculum outcomes and actual classroom conditions; (2) determining instructional goals aligned with the English Learning Outcomes (CP Phase D) of the Merdeka Curriculum; (3) confirming learner characteristics and needs; (4) identifying required resources; (5) determining potential delivery systems suitable for coastal school contexts; and (6) establishing a project management plan to guide the development process.

The design stage focused on translating the analysis results into a structured instructional plan. Following Branch (2009), this stage involved: (1) conducting a task inventory to define learning activities and instructional components; (2) writing performance objectives that specified the expected learner outcomes; and (3) generating testing strategies to support the evaluation of instructional feasibility and media validation.

During development, the AR-based vocabulary-learning media prototype was produced in accordance with the established design specifications. This stage involved: (1) developing instructional content and AR media components; (2) preparing a teacher guide to support classroom implementation; and (3) creating a student guide to assist learners in navigating the content and using the AR features effectively; (4) formative evaluations were conducted through expert validation to ensure the quality, usability, and instructional suitability of the developed media. The development process was intentionally concluded at this stage, as the study's focus was on producing a validated and feasible learning medium rather than measuring learning effectiveness.

Data were collected using multiple instruments, including classroom observation sheets, needs analysis questionnaires addressing learners' and teachers' needs, available resources, and initial learning conditions, as well as expert validation sheets for evaluating media and content quality. The collected data were analyzed using descriptive quantitative techniques, following [Creswell & Creswell \(2018\)](#), focusing on percentage distribution and feasibility category interpretation. The Research procedure of this study is summarized in the Research flow presented in Figure 1 as follows:

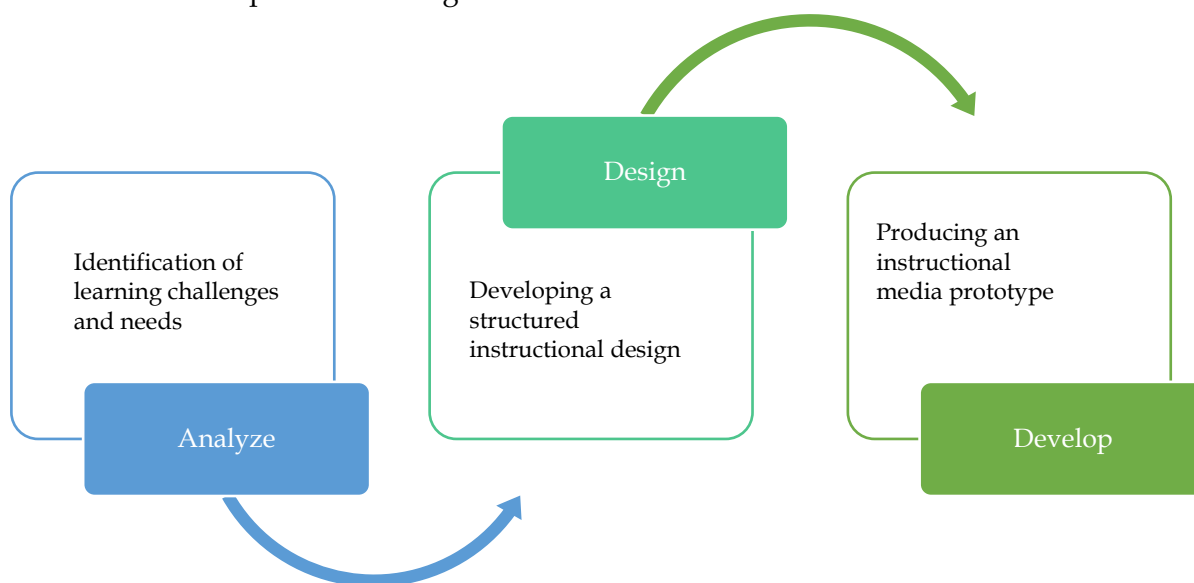


Figure 1. Research Flow

C. Result

This section presents the results of the Analyze, Design, and Develop stages of the ADDIE model. The findings are organised to demonstrate how each stage contributed to achieving the Research objective: producing a feasible, validated Augmented Reality (AR)-based vocabulary-learning media for coastal EFL learners. The results are supported by summarized tables presented in the main text, while detailed data are provided in the Appendix to enhance clarity and readability.

1. Analyze

The analysis phase aimed to identify instructional problems, learner needs, and contextual constraints that underpinned the development of an Augmented Reality (AR)-based vocabulary learning media for coastal EFL learners. This phase followed six analytical steps as proposed by [Branch \(2009\)](#).

a) Validate the Performance Gap

Validation of the performance gap began with classroom observations aimed at identifying teachers' actual instructional practices and students' learning performance during vocabulary lessons. The observation results revealed a clear discrepancy between

the expected curriculum outcomes and classroom implementation, particularly in media use, student engagement, and vocabulary application. The summary of the observation findings is presented in Table 2:

Table 2. Classroom Observation Results

| Observed Aspect | Average Percentage | Category |
|---|--------------------|----------|
| Instructional orientation and content mastery | 79.2% | Good |
| Use of Instructional Media | 50.0% | Low |
| Vocabulary Contextualization | 66.7% | Moderate |
| Teacher Interaction and Support | 62.5% | Moderate |
| Accommodation of Learner Diversity | 50.0% | Low |
| Students Engagement | 41.7% | Low |
| Students' Vocabulary Mastery | 37.5% | Very Low |

The performance gap analysis, as summarized in Table 2, reveals a significant discrepancy between current instructional practices and the desired learning outcomes. The results indicate that while teachers generally demonstrated strong instructional orientation and content mastery (79.2%), the integration of instructional media and the accommodation of diverse learner characteristics were limited (50.0%). Consequently, student engagement remained low at 41.7%, and most critically, students' functional vocabulary mastery was categorized as 'Very Low' at only 37.5%.

These findings confirm that traditional instructional methods are insufficient to meet the needs of coastal EFL learners. The clear gap between the teacher's delivery and the students' ability to apply vocabulary meaningfully provides a strong empirical basis for this Research. This underscores the urgent need to develop an AR-based learning media that is more contextually grounded, interactive, and multimodal to bridge the identified performance gap.

b) Determine Instructional Goals

Based on the identified performance gap, instructional goals were formulated to improve students' mastery of English vocabulary, particularly their ability to identify word meanings and apply vocabulary functionally in sentence contexts. These goals were aligned with the English Learning Outcomes (CP Phase D) of the Merdeka Curriculum.

c) Confirming the Learners' Characteristics and Needs

Surveys of students' characteristics and needs indicate that students have diverse learning styles, with a strong tendency toward visual learning. Although students demonstrated a moderately positive attitude toward learning English, their learning experience outside school and vocabulary mastery were limited.

Table 3. Results of Learners' Characteristics and Needs Analysis (N = 32)

| Indicator | Percentage |
|---|------------|
| Visual learning preference | 64.06% |
| Auditory learning preference | 40.63% |
| Kinesthetic learning preference | 39.06% |
| English learning experience outside school | 15.63% |
| Positive attitude toward English learning | 47.66% |
| Need for vocabulary relevance to students' coastal life context | 92.5% |
| Need for interactive and easy-to-use technology/media | 88.5% |
| Need for a simple and practical interface design | 86.5% |
| Need for step-by-step learning guidance and self-check features | 90.0% |
| Need for multimodal vocabulary presentation (visual and audio) | 89.0% |
| Need for reflective, meaningful, and enjoyable learning (deep learning) | 90.3% |
| Difficulty in understanding vocabulary and long sentences | 95.5% |
| Ownership and ability to operate smartphones | 98.0% |
| Availability of stable internet access | 15.0% |

Overall, the findings reveal a strong alignment between learners' characteristics and the need for an instructional medium that is visually rich, interactive, and contextually grounded in students' coastal lives. Despite high smartphone ownership, limited internet access, and substantial difficulties with vocabulary comprehension, conventional digital learning approaches are insufficient in this context. These results support the development of an offline-capable, mobile-based AR vocabulary learning media that integrates multimodal input, guided learning support, and deep learning principles to address both pedagogical and contextual challenges faced by coastal EFL learners.

d) Identification of Required Resources

The identification of required resources encompassed four main components. Instructional content resources were derived from the English textbooks used at the junior secondary level (SMP) and other relevant supporting materials. Technological resources: software Unity integrated with an AR framework, Vuforia, and supporting multimedia tools for developing 3D objects, images, and audio pronunciation files, with offline functionality enabled through local data storage. Learning facilities relied on students' personal devices and existing classroom settings, allowing implementation without additional infrastructure or stable internet access. Human resources involved the researcher as the media developer, English teachers as instructional facilitators, media experts for technical validation, and subject matter experts for content validation.

e) Determination of Potential Delivery Systems

Based on the identified resources and contextual constraints of coastal schools identified in the need analysis, the potential delivery system for the AR-based vocabulary learning media was determined to be a mobile, offline-accessible application installed on students' Android smartphones. This delivery system was selected to ensure high

accessibility, as almost all students owned and could operate smartphones, while stable internet access remained limited. The mobile offline system also allowed learning activities to take place both inside and outside the classroom, accommodating students' irregular attendance patterns influenced by socio-economic and environmental factors. Furthermore, the mobile AR platform enabled the integration of multimodal content, including 3D visuals, text, and audio pronunciation, supporting contextual and engaging vocabulary learning aligned with the characteristics and needs of coastal EFL learners. The integration of visual, textual, and audio elements in the developed AR media aligns with multimedia learning principles (Mayer, 2021), which emphasize that learners process information more effectively when content is presented through multiple sensory channels.

Overall, the analysis stage confirmed a substantial gap between expected vocabulary-learning outcomes and actual classroom practices in coastal EFL contexts. Students demonstrated limited mastery of functional vocabulary and low engagement, while the existing instructional media were insufficiently contextualised and interactive. The analysis of learner characteristics, learning needs, available resources, and feasible delivery systems collectively indicated the need to develop a contextual, multimodal, and offline-accessible AR-based vocabulary learning medium. These findings provided a strong empirical foundation for proceeding to the design stage, where instructional objectives, learning tasks, and assessment strategies were systematically formulated to address the identified challenges.

2. Design

The purpose of the design phase is to verify the desired instructional program and determine appropriate testing methods before development begins. In this study, the design phase focused on translating the analysis stage's results into a structured instructional plan for an Augmented Reality (AR)-based vocabulary learning media integrated with deep learning principles. The main procedures conducted at this stage included task inventory, formulation of performance objectives, and development of testing strategies.

a) Task Inventory

The task inventory was conducted to structure both the instructional and media design to be implemented in the target learning media, aligning with deep learning principles, including mindful, meaningful, and joyful learning. The instructional components included learning objectives, required competencies, learning activities, and learner tasks necessary to achieve the intended learning outcomes. Meanwhile, the media components comprised the design of the AR learning flow, features, and navigation functions. The output of this process was a storyboard design, as presented in the following section:

Table 4. Storyboard Design

| Component | Description |
|------------------------|--|
| Starting | <ul style="list-style-type: none"> Splash screen featuring the application logo and a coastal-themed graphic. Welcoming note |
| Home | Main menu: <i>Lesson, LeARn, Quiz, Information</i> |
| Lesson | Topic: Chapter 3, Unit 1, <i>Look Around You</i> ; Element Goals, Instructional Goals (CP), and Learning Objectives. |
| LeARn | <p>Things Around Us: focused on objects surrounding the coastal environment Lesson flow: Instruction; 3D character "Nilla" with a short narrative to capture students' attention and focus; Vocabulary discovery through augmented reality, contextualized within students' authentic environment; engaging vocabulary exercise in pairs.</p> <p>Asking and Giving Opinions: Lesson flow: Warm up question; instruction; guided expressions related to topic; example of using the expression in AR dialogue; reflective prompts; vocabulary supplements and sample sentences for asking and giving opinion; exercise on asking and giving opinion; reflective video project "Day One vs One Day" (write a statement with illustration/ picture about negative experience related to the environment vs one about opinion for better action)</p> |
| Quizzes 1 and 2 | Self-check on vocabulary proficiency: multiple choice and matching (drag & drop) with real-time scores and engaging emoticons. |
| Information | Details about AR media, a developer profile, and a user manual. |
| Exit page | Motivational statement |

b) Generate a Strategy for Testing

To assess the feasibility and instructional suitability of the AR-based vocabulary learning tool, a structured testing plan was established, including: 1) internal testing by the researcher to ensure the functionality, accuracy, and consistency of the developed media; 2) expert review conducted to evaluate the feasibility of the media and instructional content involving media experts and subject matter experts.

The results of expert validation were interpreted using predefined validity and feasibility criteria as presented in Table 5:

Table 5. Criteria for Media Validity and Feasibility Levels

| Percentage Category | Qualification | Feasibility Level |
|---------------------|--------------------|-------------------|
| A (81% - 100%) | Valid | Usable |
| B (61% - 80%) | Sufficiently Valid | Usable |
| C (41% - 60%) | Less Valid | Not Usable |
| D (<40%) | Not Valid | Not Usable |

Source: Şimşek et al (2009)

3. Develop

a) Content Development

Content development focused on preparing English vocabulary materials and corresponding worksheets. The learning materials were structured around the topic Look

Around You. Each topic included explanations, vocabulary items contextualised within the coastal environment, example sentences, and short dialogues. Worksheets reinforced learning and assessed comprehension through exercises such as matching words with definitions or images, fill-in-the-blank tasks, multiple-choice quizzes, and reflective activities. In addition, multimedia assets were prepared, including images, 3D objects, graphics, pronunciation audio, and animations for integration in the media.

b) Media Development and Integration

The AR-based learning tool was developed using Unity 3D and Vuforia SDK, including programming the application to enable interactive features. The structure enabled smooth navigation between features, integrating the prepared learning materials and quizzes. Features such as 3D character interactions and guided vocabulary discovery were programmed to provide interactive, engaging learning experiences that effectively connect content and worksheets. This section presents a preview of the developed AR learning media, illustrating some of its features and interface:



Figure 2. Developed Media

c) Create the Instructor and Learner's Guide

To support the implementation of AR-based vocabulary-learning media, instructor and student guides were developed. The instructor's guide provided an overview of the AR media, detailed instructional guidance, and practical recommendations for classroom implementation. It included sections on preparation (required devices and installation procedures), menu overview (Lesson, LeARn, Quiz, and Information), navigation (Back, Next, Home, Volume, Exit, and Camera Activation), and working with AR (scanning markers and interacting with 3D objects). It suggested lesson flows to promote student engagement.

Similarly, the student guide was designed to help learners navigate and use the AR media independently. It included sections on preparation, menu overview, navigation,

working with AR, and lesson flow, along with suggestions to help students remain focused, reflective, and motivated during learning activities.

d) Feasibility Testing

Formative testing was conducted to evaluate the feasibility and validity of the AR-based learning media. Expert validation involved media and subject-matter specialists who assessed the media using structured validation instruments focused on content relevance, instructional design, usability, and curriculum alignment. The following are the results of expert validation:

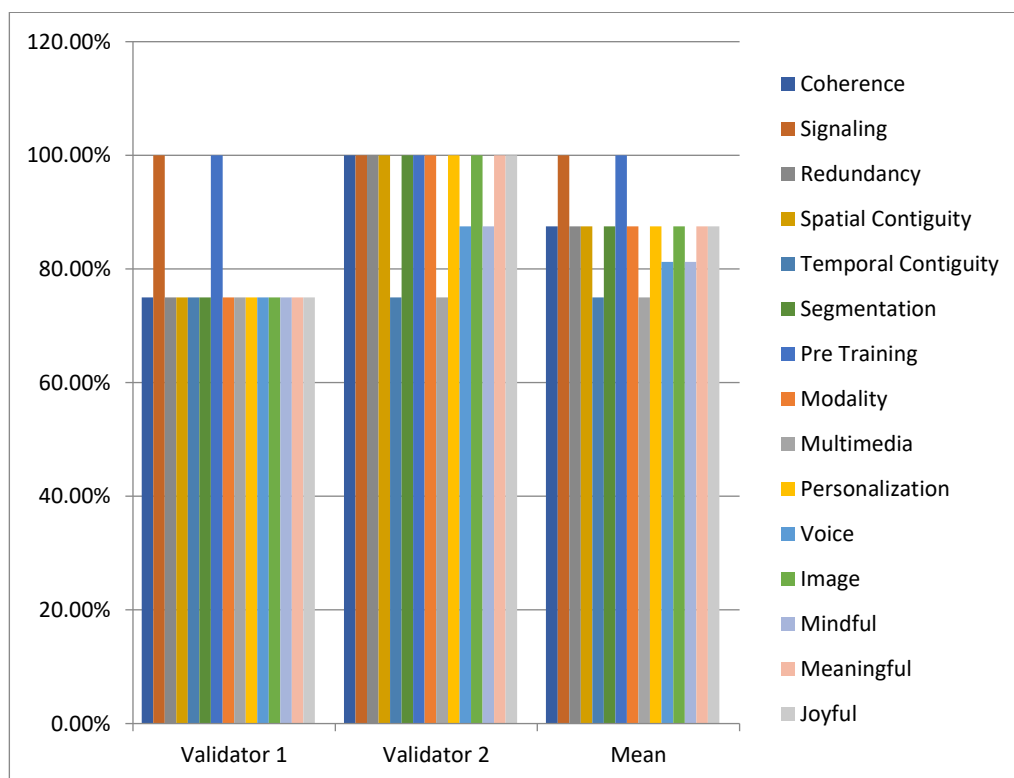


Figure 3. Media Validation

Based on the media expert validation results, analyzed using the mean (average) scores of two validators, as presented in Table X, the mean values for all evaluated aspects ranged from 75.00% to 100.00%. The Signalling and Pre-Training principles achieved the highest mean scores (100.00%), indicating that the developed media effectively highlight key information and provide an optimal introduction to the learning Material. In addition, most other aspects, namely Coherence, Redundancy, Spatial Contiguity, Segmentation, Modality, Personalisation, Image, Meaningful, and Joyful Learning, obtained mean scores of 87.50%, demonstrating that the media is systematically designed and aligned with established multimedia learning principles.

Overall, the validation results show that the media expert evaluation mean score is 86.67%, which falls into the very feasible category. Although the Voice and Mindful aspects

achieved slightly lower mean scores (81.25%), and the Temporal Contiguity and Multimedia aspects obtained the lowest mean scores (75.00%), all aspects still met the feasibility criteria for instructional media. Therefore, based on an overall mean score of 86.67%, it can be concluded that the developed learning media is valid, highly feasible, and successfully meets the Research objective of producing effective, well-structured, and meaningful instructional media.

Following the media expert validation results, the next stage of this study focuses on the Material expert validation further to evaluate the quality and accuracy of the instructional content. The Results of validation are presented in the following charts:

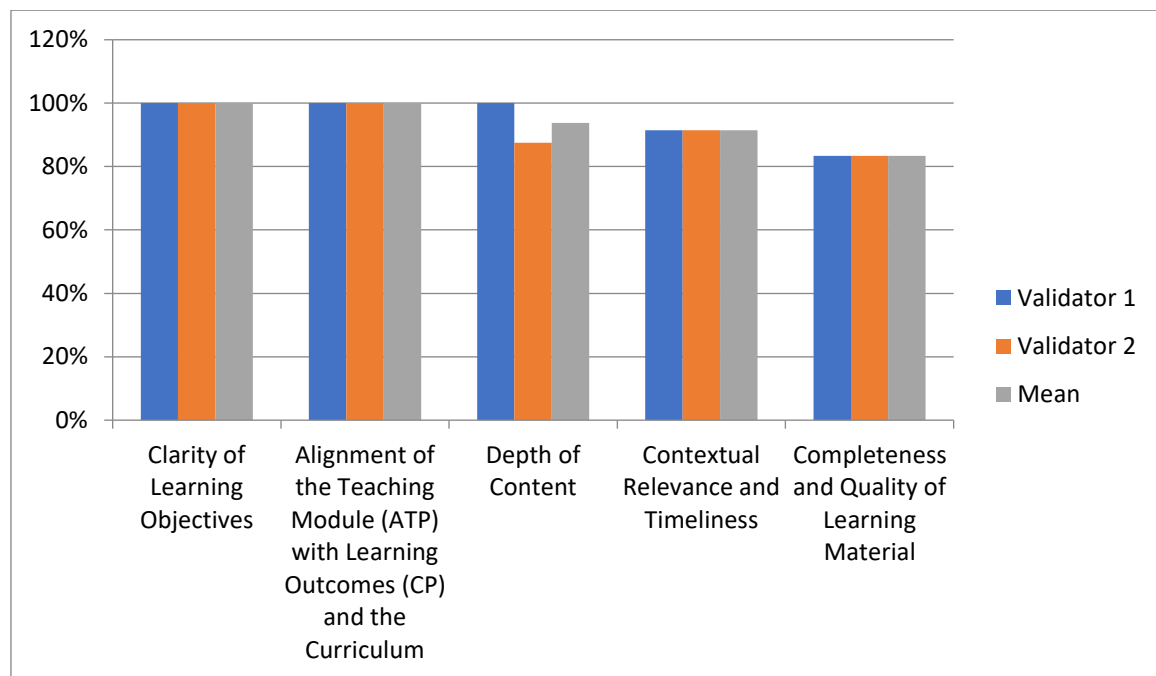


Figure 4. Subject Matter Validation

Based on the results of the Material expert validation, as presented in Figure 4, the mean scores for all evaluated aspects ranged from 83.33% to 100.00%, indicating a high level of content validity. The aspects of Clarity of Learning Objectives and Relevance of the Learning Objective Flow (ATP) to Learning Outcomes and the Curriculum achieved perfect mean scores of 100.00%, demonstrating that the instructional content is clearly structured and fully aligned with the curriculum requirements and intended learning outcomes.

Furthermore, the Depth of Material obtained a mean score of 93.75%. In comparison, Contextuality and Currency achieved a mean score of 91.50%, indicating that the learning materials are sufficiently comprehensive, conceptually sound, and relevant to current contexts. The aspect of Completeness and Quality of Learning Materials received a mean score of 83.33%, which, although comparatively lower than other aspects, still falls within the feasible to very feasible category. Overall, these results confirm that the developed learning materials are valid, curriculum-aligned, and appropriate for instructional use,

thereby supporting the Research objective of producing high-quality and relevant learning content.

D. Discussion

The results of this study indicate that the developed AR-based vocabulary learning tool integrated with deep learning principles meets the feasibility and validity criteria for instructional use in secondary EFL contexts. Based on media expert evaluation, the AR-based vocabulary learning tool achieved an overall mean score of 86.67%, placing it in the very feasible category. This result indicates that the media design, interactivity, and integration of multimedia elements are appropriate to support vocabulary learning. The high feasibility score suggests that the AR features were designed to facilitate learner engagement while maintaining instructional clarity. This finding is consistent with [Huang et al \(2022\)](#) and [Ibáñez & Delgado-Kloos \(2018\)](#), who reported that AR learning media integrating clear instructional structure and interaction principles tend to demonstrate high feasibility and usability.

Meanwhile, the Material expert validation yielded an overall mean score of 93.72%, indicating very high validity. This indicates that the vocabulary content is accurate, relevant, and aligned with curriculum objectives, and therefore suitable for use in secondary EFL learning contexts. This result supports the findings of [Lin et al \(2021\)](#) and [Pahlevi et al \(2024\)](#), who emphasized that contextual relevance and curriculum alignment are critical determinants of the feasibility of AR-based vocabulary learning.

The positive validation outcomes can be attributed to the integration of deep learning principles – mindful, meaningful, and joyful learning – into the AR instructional design. By presenting vocabulary through contextualized AR experiences, guided reflection, and emotionally engaging tasks, the learning media addresses both cognitive and affective dimensions of vocabulary acquisition. This explanation aligns with [Fullan et al \(2018\)](#) and is further supported by [Danaei et al \(2020\)](#), who found that pedagogically grounded AR environments enhance learner engagement and comprehension.

The findings of this study support and strengthen previous Research on AR-based language learning. Studies by [Wahyuni & Widyaningrum \(2022\)](#) and [Danaei et al \(2020\)](#) reported that AR-supported learning environments enhance learner engagement and comprehension through multimodal interaction. Furthermore, [Radianti et al \(2020\)](#) highlighted that accessibility and contextual feasibility are key determinants of AR effectiveness in educational settings, a conclusion reinforced by the present study, which developed an offline-capable AR application for coastal schools.

While previous studies have reported challenges related to technical complexity and potential cognitive overload in AR-based learning environments ([Cheng & Tsai, 2019](#)), the present study demonstrates that careful alignment with multimedia learning principles and deep learning pedagogy can mitigate these challenges. This finding extends earlier Research by showing that AR feasibility is not solely determined by technology, but by the quality of instructional design and contextual adaptation.

Overall, the findings indicate that the developed AR-based vocabulary learning tool is pedagogically sound, technically feasible, and contextually appropriate for under-resourced EFL learning environments. Pedagogically, the learning media is grounded in a clear instructional design framework and explicitly integrates deep learning pedagogy through mindful, meaningful, and joyful learning principles, ensuring that vocabulary instruction supports focused attention, contextual understanding, and positive learner engagement. The expert validation results further confirm that the instructional content, learning flow, and multimedia integration align with curriculum demands and established principles of effective learning design. Technically, the AR-based application demonstrates high feasibility, as reflected in the media validation outcomes, with stable functionality, intuitive navigation, and coherent integration of visual, audio, and interactive elements. Its mobile-based and offline-accessible design addresses common infrastructural constraints in under-resourced contexts, enabling flexible use both inside and outside the classroom without reliance on continuous internet access. Contextually, the learning tool is designed to resonate with learners' real-life environments and experiences, thereby enhancing relevance and meaningful learning in EFL settings characterized by limited resources and learning continuity. Taken together, these findings suggest that the developed AR-based vocabulary learning tool not only meets technical and pedagogical standards but also provides a context-responsive instructional solution that supports equitable and sustainable vocabulary learning in marginalised EFL environments.

E. Implication

This study contributes to advancing deep learning theory in technology-enhanced language learning by demonstrating how mindful, meaningful, and joyful learning principles can be systematically embedded in an augmented reality-based vocabulary learning medium. Rather than positioning deep learning as an abstract pedagogical ideal, the findings show that these principles can be operationalized through structured instructional design, contextualized vocabulary presentation, and reflective learning tasks. In contrast to prior AR studies that predominantly emphasize cognitive outcomes such as engagement and retention, this study extends the deep learning framework by foregrounding the interaction between cognition, contextual relevance, and emotional engagement, particularly within under-resourced EFL settings. The high expert validation results further reinforce the view that deep learning emerges not solely from technological affordances but from pedagogically intentional design that integrates learners' experiences, environments, and affective dimensions of learning.

From a practical perspective, the validated AR-based vocabulary-learning media offer a pedagogically grounded, replicable instructional model for teachers and instructional designers. The study illustrates how augmented reality can function as a curriculum-aligned instructional tool rather than a technological novelty, emphasizing its role in supporting learning objectives and instructional coherence. The mobile-based and offline-accessible design directly addresses infrastructural constraints commonly faced by marginalized

schools, enabling both flexible classroom implementation and independent learning beyond formal instructional settings. Moreover, the instructional features—such as guided vocabulary exploration, multimodal input, and formative self-assessment—provide concrete design references for developing effective, context-responsive, and learner-centered vocabulary instruction in similar educational contexts.

Beyond pedagogical and practical contributions, this Research highlights the social significance of context-responsive educational technology in addressing digital inequity in marginalized coastal areas. By accommodating limited internet access and integrating learners' local environments into vocabulary learning activities, the developed media promotes cultural relevance, inclusivity, and learner agency. The findings suggest that technology-enhanced learning can contribute meaningfully to educational equity when it is designed with sensitivity to learners' social, cultural, and infrastructural realities. In this sense, the study offers empirical support for educators, policymakers, and educational stakeholders to consider adaptable, low-infrastructure digital learning models as viable strategies for expanding access to quality English language education in underserved regions.

F. Limitation and Suggestion for Further Research

This study has several limitations that should be considered when interpreting the findings. First, in terms of Research design, the development process was completed only to the ADDIE model's development stage, meaning that the learning media were not implemented or evaluated in real classroom settings; consequently, their effectiveness on students' vocabulary acquisition and retention could not be empirically measured. Second, the validation instruments relied on expert judgment using structured checklists, which, although appropriate for development studies, may not fully capture learners' cognitive engagement, affective responses, or learning difficulties during actual use. Third, the sample was limited to a small number of expert validators, restricting the generalizability of the validation results across broader educational contexts and stakeholder perspectives, such as teachers and students. Finally, technological limitations—including variations in mobile device specifications and potential constraints in AR tracking accuracy—may affect the consistency of user experience across different learning environments.

Given these limitations, future Research is recommended to proceed to the Implementation and Evaluation stages to examine the instructional effectiveness of the media using experimental or quasi-experimental designs with larger, more diverse student populations. Further studies may also refine the validation instruments by incorporating learner-based usability testing and learning analytics to provide a more comprehensive evaluation. Additionally, future Research could explore collaborative AR features and adaptive content design to enhance scalability and learning sustainability in coastal and other under-resourced educational settings.

G. Conclusion

This study aimed to design and validate an Augmented Reality-based vocabulary learning media integrated with deep learning principles for secondary EFL learners in coastal areas. The findings indicate that the developed media meet pedagogical and multimedia design standards and are considered feasible for instructional use, as validated by experts. By integrating mindful, meaningful, and joyful learning principles into an AR-based instructional framework, this study contributes a validated design model for context-responsive vocabulary learning. The Research demonstrates the potential of AR to support vocabulary instruction in under-resourced environments when grounded in sound pedagogical principles. Overall, this study achieves its Research objective by providing a theoretically informed and practically adaptable AR-based learning media tailored to marginalized educational contexts.

Acknowledgment

The authors would like to express sincere gratitude to the BPI (Indonesian Education Scholarship), PPAPT (Center for Higher Education Funding and Assessment), and LPDP (Indonesian Endowment Fund for Education) for the financial support provided for this Research. Special thanks are also extended to the expert validators for their invaluable feedback and professional insights during the media validation process. Furthermore, the authors appreciate the school community in the coastal area for their cooperation and for inspiring the contextual design of this study.

References

- Astriyani, A., Afandi, D. S., Aji, M., Lianasondari, T., & Octaviarani, W. A. (2022). Challenges of Teaching and Learning Speaking in EFL Context. *Prosiding Seminar Nasional Pendidikan*, 4, 84-90.
- Branch, R. M. (2009). *Instructional Design: The ADDIE Approach*. Springer.
- Cheng, G., & Tsai, C. L. (2019). Challenges of Using Augmented Reality in Education: A Review of Recent Studies. *Journal of Educational Computing Research*, 57(5), 1227-1253. <https://doi.org/10.1177/0735633119836799>
- Creswell, J. W., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th ed.). SAGE Publications.
- Danaei, D., Salehi, H., & Yunus, M. M. (2020). Augmented Reality in Language Learning: A Systematic Review. *Journal of Education and e-Learning Research*, 7(2), 131-141. <https://doi.org/10.20448/journal.509.2020.72.131.141>
- Fathoni, A., Setiawan, S., & Mukminatien, N. (2024). Strategies for Teaching English Vocabulary in Indonesian Secondary Schools. *TEFLIN Journal*, 35(1), 1-18.












- Fullan, M., Quinn, J., & McEachen, J. (2018). *Deep Learning: Engage the World Change the World*. Corwin Press.
- Hartini, L. W., & Ratminingsih, N. M. (2024). The Relationship Between Indonesian EFL Learners' Vocabulary Size and Their Reading Comprehension. *Journal of English Education*, 6(1), 1-12.
- Huang, X., Zou, D., Cheng, G., & Xie, H. (2021). A Systematic Review of AR and VR Enhanced Language Learning. *Sustainability*, 13(9), 4639. <https://doi.org/10.3390/su13094639>
- Ibáñez, M. B., & Delgado-Kloos, C. (2018). Augmented Reality for STEM Learning: A Systematic Review. *Computers & Education*, 123, 109-123. <https://doi.org/10.1016/j.compedu.2018.05.002>
- Kurniawan, R., Setiawan, A., & Hasan, F. (2018). English Speaking Proficiency and Vocabulary Obstacles in Coastal Schools of Bengkulu. *Jurnal Pendidikan Bahasa Inggris*, 9(1), 22-35.
- Lai, J. Y., Cheong, K. H., & Zhang, Y. (2021). Impacts of Augmented Reality Apps on First Graders' Motivation and Performance in English Vocabulary Learning. *SAGE Open*, 11(4), 1-17. <https://doi.org/10.1177/21582440211047549>
- Laoli, A., & Purba, N. (2025). Strategies and Challenges of English Vocabulary Mastery: University Students' Perception and Experience. *ELT in Focus*, 8(1), 1-14.
- Lin, C. J., Chang, C. Y., & Wu, C. H. (2021). Effects of Augmented Reality and Multimedia Presentation on Elementary Students' Vocabulary Learning. *Journal of Educational Technology & Society*, 24(2), 45-58.
- Mayer, R. E. (2021). *Multimedia Learning* (3rd ed.). Cambridge University Press.
- Nation, I. S. P. (2013). *Learning Vocabulary in Another Language* (2nd ed.). Cambridge University Press.
- Pahlevi, H., Nur, R., & Wijayanti, S. (2024). AR-Based English Learning Media for Secondary School Students. *Jurnal Teknologi Pembelajaran*, 12(1), 66-78.
- Parmaxi, A., & Demetriou, A. (2020). Augmented Reality in Language Learning: A Meta-Analysis. *Educational Media International*, 57(2), 97-115. <https://doi.org/10.1080/09523987.2020.1743669>
- Poedjiastutie, D., Mayaputri, V., & Arifani, Y. (2021). Socio-Cultural Challenges of English Teaching in Remote Areas of Indonesia. *TEFLIN Journal*, 32(1), 97-116. <https://doi.org/10.15639/teflinjournal.v32i1/97-116>
- Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A Systematic Review of Immersive Virtual Reality Applications for Higher Education. *Computers & Education*, 147, 103778. <https://doi.org/10.1016/j.compedu.2019.103778>

Şimşek, A., Özdamar, N., Uysal, Ö., Kobak, K., Berk, C., Kılıçer, T., & Çiğdem, H. (2009). Current Trends in Educational Technology Research in Turkey in the New Millennium. *Educational Sciences: Theory & Practice*, 9(2), 941–966.

Umar, U., Yuliadi, Y., Hidayatullah, M., Rahman, A., & Hassan, Z. (2025). Augmented Reality for Vocabulary Learning and Speaking Skills of Tourism Employees. *JOLLT Journal of Languages and Language Teaching*, 13(2), 661–677. <https://doi.org/10.33394/jollt.v13i2.13860>

Wahyuni, S., & Widyaningrum, R. (2022). Augmented Reality in Indonesian Junior High Schools: Impact on Vocabulary Retention. *Sembilan Pemuda e-Journal*, 6(2), 88–100.

Author's Biography

| | |
|---|---|
|  | <p>Wa Ode Sinta Kalsum, S.Pd.    Earned a Bachelor's degree in English Education from Halu Oleo University (UHO) Kendari in 2012. Currently a Master's student in Educational Technology at the Faculty of Teacher Training and Education, Universitas Sebelas Maret (UNS), Surakarta. Email: waode_sintak@student.uns.ac.id</p> |
|  | <p>Prof. Dr. Sariyatun, M.Pd., M.Hum.    Earned a Bachelor's degree in History Education from Universitas Sebelas Maret (UNS). Completed Master's degree in History Education from IKIP Jakarta, Master's degree in History Literature from Universitas Gadjah Mada (UGM), and Doctoral degree in Social Studies Education from Universitas Pendidikan Indonesia (UPI) Bandung. Professor at the Faculty of Teacher Training and Education, Universitas Sebelas Maret (UNS). Email: sariyatun@staff.uns.ac.id</p> |
|  | <p>Dr. Nur Arifah Drajadi, M.Pd.    Earned a Bachelor's degree in English Education from Universitas Sebelas Maret (UNS). Completed a Master's and a Doctoral degree in English Education from Universitas Negeri Jakarta (UNJ). Lecturer at the Undergraduate Program of English Education and the Master's Program of Educational Technology, Faculty of Teacher Training and Education, Universitas Sebelas Maret (UNS). Email: nurarifah_drajati@staff.uns.ac.id</p> |