

Design and Development of an Android-Based Digital Dictionary of the Naulu Language to Improve Language Literacy among Pre-Service Teachers in Maluku

Rigen Tawurutubun¹, Calvin Talakua², Ma'ruf Tehuayo³

^{1,2,3}STKIP Gotong Royong Masohi

Jalan Trans Seram, Behind Haruru Negeri, Masohi, Maluku, Indonesia

²calvin.talakua.2203419@students.um.ac.id

Abstract. The Naulu language, an indigenous language of Seram Island, Central Maluku, Indonesia, is endangered, with declining use among younger generations. This study aimed to develop an Android-based Naulu Language Digital Dictionary and examine its potential to improve the language literacy of pre-service teachers in Maluku. Using a Research and Development (R&D) approach based on the Lee and Owens model, the study employed needs analysis, design, development and implementation, and evaluation. The study collected data through interviews, observations, and pretest-posttest assessments involving students, educators, native speakers, and community members. The application features two-way translation (Naulu-Indonesian and Indonesian-Naulu), sentence translation, speech-to-text, and Optical Character Recognition (OCR). Findings showed that students' mean language literacy scores increased from 62.4 (fair) in the pretest to 84.7 (good) in the posttest. Vocabulary mastery rose from 58% to 87%, and reading comprehension of simple texts improved from 40% to 81%. Students also reported greater confidence and motivation to preserve the Naulu language. Overall, the Android-based dictionary shows potential as a digital learning medium for supporting vocabulary, reading skills, and regional language literacy while fostering cultural awareness and local identity.

Keywords: Naulu Language; Digital Dictionary; Language Literacy; Android Application; Pre-Service Teachers.

1. Introduction

Language literacy is an important component of learners' ability to understand, use, and communicate through language in academic and social contexts. For pre-service teachers, language literacy is particularly important because their future professional responsibilities require them not only to use language effectively but also to facilitate language learning among their students. Teacher education programs therefore need to provide prospective teachers with opportunities to develop strong language literacy competencies and to become familiar with learning resources that support language development.

This need is particularly relevant in Indonesia, a country characterized by substantial linguistic diversity. Indonesia has 718 regional languages, with a large proportion concentrated in eastern Indonesia. According to the latest language vitality data reported by Indonesia's Language Development and Cultivation Agency, 29 regional languages are classified as endangered, eight as critically endangered, and five as extinct. These conditions highlight the continuing need for language documentation, revitalization, and intergenerational transmission. The loss of a regional

language can also affect the transmission of cultural knowledge, traditions, and local identity because language functions not only as a means of communication but also as a medium through which cultural knowledge is transmitted across generations.

One of the indigenous communities in Maluku with its own language is the Naulu community of Seram Island, Central Maluku Regency. The Naulu, also referred to as Nuaulu or Noaulu, inhabit several settlements, including Nuanea and Sepa. The Naulu language forms an important component of the community's cultural identity and local knowledge. Given the broader vulnerability of regional languages in eastern Indonesia, efforts to document, teach, and maintain the Naulu language are important. Digital learning resources may provide one means of supporting these efforts, particularly by making language materials more accessible to younger learners and future educators.

Recent research has increasingly examined the use of digital technology for endangered and Indigenous language revitalization. Digital resources can support language documentation, vocabulary learning, independent practice, and broader access to language materials. In the context of Indigenous language revitalization, Richards et al. (2025), for example, reported the development of the *Warrma Mangarrayi* mobile application through an iterative community-based co-design process. The study emphasized the importance of incorporating community needs and aspirations into the development of digital language-learning resources. This work shows that mobile applications can serve not only as repositories of language information but also as learning resources designed around the communicative needs of language communities.

Research on mobile-assisted language learning (MALL) has also expanded considerably. A systematic review by Okumuş Dağdeler (2023), based on 687 publications identified through the Web of Science database, demonstrated the growing body of research on mobile-assisted vocabulary learning. The review found that vocabulary learning, learner achievement, and learner perceptions are among the major themes in empirical MALL research. Similarly, systematic evidence indicates that researchers have investigated mobile-assisted learning across different language-learning contexts. However, the available evidence largely focuses on major international languages rather than endangered regional or Indigenous languages.

The distinction between mainstream language learning and endangered-language revitalization is important. While mobile applications have been widely studied for vocabulary acquisition and language learning, far less empirical research has examined applications designed specifically to support literacy in endangered regional languages. Research on Indigenous language applications also indicates that successful digital resources need to consider community knowledge, cultural context, user needs, and the communicative functions of the target language. This suggests a research gap concerning the development and empirical evaluation of mobile-based resources that combine language documentation with practical literacy-learning functions for endangered regional languages.

This gap is particularly relevant to the Naulu language in Maluku. Although digital technology has increasingly been used in language revitalization, accessible Android-based learning resources specifically designed for Naulu language literacy remain limited. A digital dictionary may address this need by providing learners with readily accessible vocabulary and language examples while supporting independent learning through mobile devices. The integration of functions such as bilingual translation, sentence-level translation, speech-to-text, and Optical Character Recognition (OCR) may further extend the role of a conventional dictionary from a reference resource to an interactive language-learning tool.

Therefore, this study aimed to develop an Android-based Naulu Language Digital Dictionary to support the language literacy of pre-service teachers in Maluku. The study focused on developing a digital resource that integrates Naulu–Indonesian and Indonesian–Naulu translation, sentence translation, speech-to-text, and Optical Character Recognition (OCR). The study also examined the usability and learning outcomes associated with the developed application in supporting Naulu vocabulary acquisition and reading literacy among pre-service teachers.

2. Method

Research Design

This study employed a Research and Development (R&D) design to develop an Android-based Naulu Language Digital Dictionary and examine its usability and potential contribution to Naulu language literacy among pre-service teachers. The development procedure adopted the Lee and Owens model, which consists of needs assessment, design, development, implementation, and evaluation stages. The R&D process involved multiple stakeholders to ensure that the linguistic content, instructional functions, and technical features of the application were appropriate for the target users and the Naulu language context.

Participants and Stakeholder Selection

The study involved several groups of participants and stakeholders at different stages of development. The main users were 30 pre-service teachers who participated in the implementation and evaluation of the developed application. They were selected using [purposive/convenience/other] sampling based on the following criteria: (1) they were enrolled as pre-service teachers at STKIP Gotong Royong Masohi, (2) they were willing to participate in the study, (3) they had access to an Android smartphone, and (4) they had [relevant prior experience/no prior formal experience] in learning or using the Naulu language.

In addition to the pre-service teachers, the study involved 3 lecturers, 5 Naulu native speakers, 5 community members, and 2 other relevant stakeholders during the needs analysis, content development, validation, and implementation stages. The researchers selected lecturers based on their involvement in language education and/or instructional technology. We selected Naulu native speakers based on their fluency in the Naulu language and their familiarity with Naulu vocabulary, expressions, and language use in the community. We selected community members based on their knowledge of the Naulu language and cultural practices. We selected other stakeholders based on their professional or community involvement relevant to Naulu language preservation and education.

The expert validation involved 4 experts, consisting of 2 language/content experts and 2 media/instructional technology experts. The experts were selected purposively based on their academic qualifications, professional experience, and expertise relevant to the aspects being evaluated. The language experts were selected based on their expertise in regional languages, linguistics, and/or the Naulu language, with particular attention to vocabulary accuracy, language use, spelling, meaning, and cultural appropriateness. The media/instructional technology experts were selected based on their expertise in educational media, mobile learning, software development, and/or instructional technology, particularly in evaluating the usability, functionality, interface design, navigation, accessibility, and technical quality of the Android-based digital dictionary.

Data Collection Instruments

Data were collected using needs-analysis interview protocols, observation sheets, expert-validation questionnaires, user-practicality questionnaires, confidence questionnaires, and a language-literacy test. The interview protocol identified the linguistic needs of prospective users

and gathered information on the availability, use, and preservation of the Naulu language. Interviews were conducted with lecturers, native speakers, community members, and other relevant stakeholders. Observations documented the existing conditions of Naulu language use and the learning context.

The expert-validation questionnaire assessed the quality of the developed application before the user trial. The content validation instrument consisted of indicators covering the accuracy of vocabulary, accuracy of translation, appropriateness of sentence examples, relevance of the content to learning objectives, clarity of language, and suitability of the materials for pre-service teachers. The media-validation instrument assessed interface design, navigation, readability, consistency, functionality, accessibility, and technical presentation.

The user-practicality questionnaire was administered to the 30 pre-service teachers after they had used the application. The questionnaire assessed ease of use, clarity of instructions, navigation, accessibility, readability, usefulness of the dictionary functions, and suitability of the application for independent learning. A separate confidence questionnaire assessed students' self-reported confidence in recognizing, understanding, translating, and using Naulu vocabulary and simple sentences.

Language-Literacy Test

The language-literacy test measured students' ability to understand and use the Naulu language after using the digital dictionary. The test consisted of indicators covering vocabulary knowledge and reading comprehension. The vocabulary component measured students' ability to recognize Naulu words, identify their Indonesian meanings, match Naulu vocabulary with corresponding meanings, and use selected vocabulary in simple contexts. The reading-comprehension component measured students' ability to identify explicit information, understand the meaning of simple Naulu sentences or texts, interpret vocabulary in context, and answer questions based on short Naulu texts.

The test was administered as a pretest before implementation and as a posttest after the learning activities. Each correct answer received a score of 1, whereas each incorrect answer received a score of 0. The total score was converted into a percentage using the following formula:

$$\text{Score} = (\text{number of correct answers} / \text{total number of test items}) \times 100$$

The resulting scores were interpreted according to the predetermined achievement categories used in the study, as follows:

Table 1. Achievement Category Criteria Based on Percentage Score

<u>Percentage Score</u>	<u>Achievement Category</u>
81-100	Very Good
61-80	Good
41-60	Fair
21-40	Poor
0-20	Very Poor

The same scoring procedure was applied to both the pretest and posttest to facilitate comparison of students' language literacy performance before and after the implementation of the Android-based Naulu digital dictionary. The comparison was used to identify changes in students' performance following the use of the developed digital dictionary.

Instrument Validity

Content validity was assessed through expert judgment involving four experts. The experts reviewed each instrument item in terms of relevance, clarity, appropriateness, and alignment with

the intended construct. The validity analysis was conducted using Aiken's V coefficient. Experts calculated the validity coefficient based on their ratings on a five-point scale.

The results showed that the content-validity coefficient of the language literacy test was 0.92, while the coefficients for the individual indicators ranged from 0.88 to 0.96. The practicality questionnaire obtained an Aiken's V coefficient of 0.94, with item coefficients ranging from 0.90 to 0.98. In contrast, the confidence questionnaire obtained an Aiken's V coefficient of 0.91, with item coefficients ranging from 0.87 to 0.95. Based on the predetermined criteria, all three instruments were categorized as very valid and considered appropriate for use in the study. Items that received suggestions from the experts were revised in terms of wording, clarity, and suitability to the Naulu language-learning context before the instruments were administered to the participants.

Instrument Reliability

The internal consistency of the instruments was examined using Cronbach's Alpha. The reliability analysis was conducted after the validity assessment and revision of the instruments. The results indicated that the practicality questionnaire obtained a Cronbach's Alpha coefficient of $\alpha = 0.921$, while the confidence questionnaire obtained a coefficient of $\alpha = 0.908$. The language literacy test obtained a reliability coefficient of $\alpha = 0.887$. Based on the predetermined criterion of $\alpha \geq 0.70$, all instruments demonstrated a good level of internal consistency.

These findings indicate that the items within each instrument were sufficiently consistent in measuring the intended constructs and were therefore considered reliable for use in the study. The reliability coefficients were reported separately for each instrument because the instruments measured different aspects of the research, including students' language literacy, perceptions of the practicality of the Android-based digital dictionary, and students' confidence in learning and using the Naulu language.

Expert-Validation Criteria

The resulting percentages were interpreted using the following criteria:

Table 2. Expert Validation Criteria Based on Percentage Score

Percentage	Category	Interpretation
81–100%	Very valid	Suitable for use without major revision
61–80%	Valid	Suitable with minor revision
41–60%	Moderately valid	Requires revision
21–40%	Less valid	Requires substantial revision
0–20%	Invalid	Not suitable for use

The same general percentage approach was used to summarize the expert assessments of the application. Qualitative comments from the experts were also considered in revising the application before implementation.

Data Analysis

The quantitative data were analyzed descriptively to determine the validity, practicality, user confidence, and language-literacy outcomes. Expert-validation, practicality, and confidence responses were converted into percentages. Pretest and posttest scores were summarized using mean scores and percentage changes. Vocabulary mastery and reading-comprehension performance were also compared between the pretest and posttest.

Because the implementation involved a single group of 30 pre-service teachers without a comparison group, changes in pretest and posttest scores were interpreted as observed improvements following implementation rather than as definitive evidence of a causal effect of the application.

3. Result

The research results align with the objectives and problems studied and the procedures described in the methods section. The results of the data analysis presented are in the form of patterns, characteristics, statistical analysis, hypothesis testing, and others according to research characteristics. Include tables, diagrams, images, or citations needed so that the visualization of research results is easy for readers to understand. Write the method in Book Antiqua 11, with 1-line spacing.

Create the table with only three full horizontal lines. Avoid using "table above," "table below," and "table below," and instead refer directly to the table number (Table 1).

In this study, the author used qualitative data collection and analysis methods, along with the Lee & Owens development model. The author chose this model because it is fast and well-suited to application development. The method consists of four main stages: (1) Needs Analysis, (2) Design, (3) Development and Implementation, and (4) Evaluation. The following is a discussion of each stage.

Needs Analysis

The needs analysis identified several requirements for the development of the Naulu Language Digital Dictionary. Interviews with lecturers and pre-service teachers indicated that access to practical Naulu-language learning resources was limited and that existing materials were mostly available in print. Participants expressed a need for a digital resource that provides rapid access to vocabulary and translations.

Interviews with Naulu native speakers and community members indicated that the use of Naulu among younger generations were using Naulu less in everyday communication. This finding reinforced the need for accessible learning resources that could support language learning and encourage continued engagement with the language.

Based on the needs analysis, the main functional requirements were a two-way Naulu-Indonesian and Indonesian-Naulu translation system, a simple interface, accessible language content, cultural information, and interactive functions. These requirements subsequently guided the design and development of the application.

Design

Existing dictionary applications include word search and suggestion features but only provide translations of single words and do not allow translation of full sentences or word equivalents simultaneously. Based on observations, the development of the dictionary application requires additional features such as a sentence translator, speech-to-text functionality for direct spoken sentence translation, and Optical Character Recognition (OCR). OCR is a technology that recognizes text in images and converts various document types, such as turning letters in images into ASCII characters that computers can recognize. This feature helps users translate Naulu texts using only their device camera.

The dictionary application will translate both Naulu and Indonesian, thus addressing communication challenges for both local and international users. Hardware, software, and cloud server requirements include:

- a) Hardware: laptops for application development, smartphones for testing, flash drives for data transfer, and internet access.
- b) Software: Ubuntu Linux for server management, Windows OS for application design, Android OS for testing.
- c) Server: Virtual Private Server (VPS) for flexible configuration.

Development and Implementation

Existing dictionary applications generally feature word search and suggestions but are limited to single-word translations and cannot translate full sentences. Observations and stakeholder interviews concluded that the Naulu Dictionary application should include:

- Sentence Translator:** Allows translation of phrases or simple sentences, helping users understand the Naulu language structure more fully.
- Speech-to-Text:** Users can speak directly to the app, and the system automatically translates into the target language. Useful for students, prospective teachers, and tourists.
- Optical Character Recognition (OCR):** Recognizes text in images and converts it into digital characters that a computer can process. Useful for tourists or researchers translating Naulu texts using their phone camera.

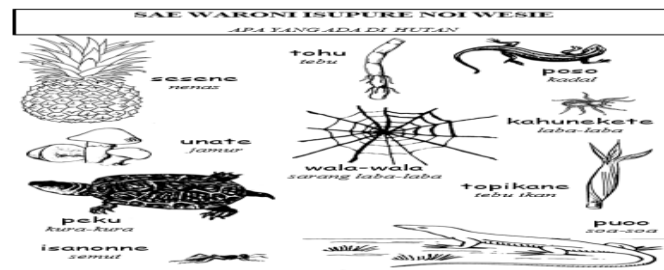


Figure 1. Optical Character Recognition (OCR) Design

Other main pages include:

- SplashScreen Page:** Displays a welcome message and a “Start” button. Pressing the button navigates to the main widget screens.

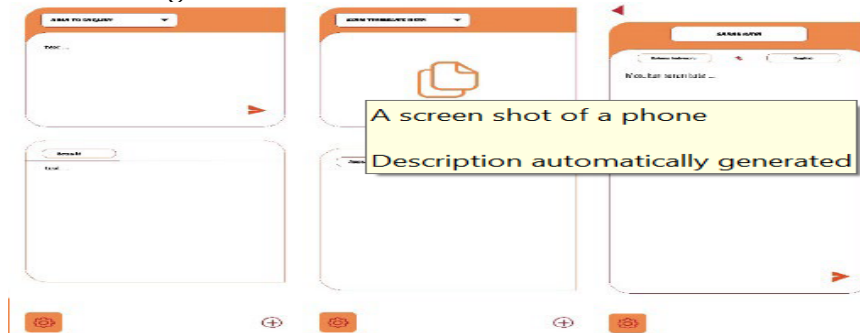


Figure 2. SplashScreen Design

- Indonesian-Naulu Page:** Users can input words or sentences in Indonesian, and the system translates them into Naulu.

Bahasa Naulu	Bahasa Indonesia	Bahasa Naulu	Bahasa Indonesia
aha	got sagu	buka	buku
aheni	menjual	enu	penyu
ai	makan	eti	menokok sagu
ai	pohon	etine	ular
aini atue	kaki	habu	babi
ainata	mengatapi	haka	perahu
ainati	awai	hanai atue	tangan
akasupa	membakar	hanai nalcate	jari
akachu	berturu	hatane	pohon sagu
ana	memamah	heue	busar
ause	anak	heune	dedeso
apalam	manga	hohai	mulut
apapari	memancing	hohu	mencabut
apia	pakaian	hona	senapan angin
apuoo	membangun	honi	menjahit
asara	menjemur	hofune	stap tungku api
asu	anjing	huse	buah
atane	gata-gata	ikae	ikan
atananae	jepitan bambu	imananne	lalut
atanana	memasak	imasasae	imasasae
atiene	tombak	inae	induk, betina
atuhete	mengajar	isanonne	semut
asahu	memakai	isikola	sekolah
avane	belut	isikotol	mangkok
avari	kurwal	kahunekete	laba-laba
baca	membaca	kawasi	gelas
belajar	belajar	kalefi	baju langsung

Figure 3. Indonesian Naulu Page Design

- c) Word Suggestion Page: If a word is not found in the database, the system provides the closest suggestions.



Figure 4. Suggestion Page

- d) OCR Page: Uses OCR technology to capture Naulu text via the camera and automatically translate it into Indonesian or English.

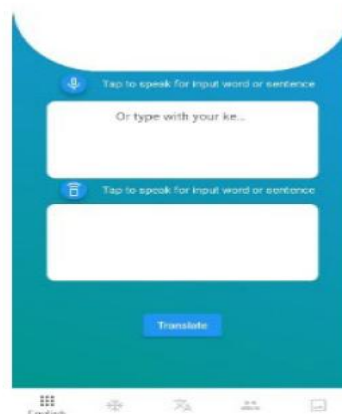


Figure 5. OCR Page

In the translation page, a microphone button and speaker button enhance interactivity:

- Mic Widget: Uses the `speech_to_text: ^6.3.0` package to convert voice input to text. Requires internet.
- Textfield Input Widget: Captures user input from text or converted speech, processed by the translation API.
- Speaker Widget: Uses `flutter_tts: ^3.7.0` to convert translated text to speech. Requires internet.
- Textfield Output Widget: Displays translated results and is integrated with the speaker button for audio playback.

The developed Android-based Naulu digital dictionary was evaluated through expert validation and user evaluation. Expert validation involved four experts, consisting of two language/content experts and two media/instructional technology experts. The experts assessed the product in terms of content accuracy, language appropriateness, vocabulary representation, interface design, navigation, functionality, usability, and suitability for language learning. The

content validity of the assessment instruments was examined using Aiken's V, with coefficients indicating a very high level of content validity.

Following expert validation and revision, the digital dictionary was implemented with the target users. User evaluation focused on two main aspects: practicality and learning confidence. Practicality was measured using a structured questionnaire consisting of items addressing ease of use, clarity of information, navigation, accessibility of vocabulary, interface design, and usefulness of the application for learning the Naulu language. Each item was rated using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The practicality score was calculated by comparing the total obtained score with the maximum possible score and converting the result into a percentage. The resulting practicality score was 92%, indicating that users perceived the application as highly practical.

Learning confidence was measured using a structured questionnaire designed to assess students' confidence in recognizing, understanding, reading, and using Naulu vocabulary after interacting with the digital dictionary. The questionnaire employed the same five-point Likert scale. We calculated the confidence score as the percentage of the obtained score relative to the maximum possible score. The resulting confidence score was 88%, indicating a high level of learner confidence following the implementation.

Experts reviewed the questionnaires before administration. We examined internal consistency using Cronbach's Alpha after the validity assessment and revision process. The practicality questionnaire produced a reliability coefficient of $\alpha = 0.921$, while the confidence questionnaire produced $\alpha = 0.908$, both exceeding the predetermined criterion of $\alpha \geq 0.70$. These results indicate that the questionnaire items demonstrated good internal consistency and were suitable for the user evaluation stage.

Evaluation

The expert validation results indicated that the Android-based Naulu digital dictionary met the expected criteria for content and technical quality. The language/content experts confirmed the appropriateness of the vocabulary, meanings, expressions, and language representations included in the dictionary. In contrast, the media/instructional technology experts evaluated the application in terms of interface, navigation, functionality, accessibility, and usability. The experts' recommendations were incorporated into the final version of the application before implementation.

The user evaluation further demonstrated positive perceptions of the developed product. The practicality questionnaire produced an overall score of 92%, indicating that the application was highly practical for learning and accessing Naulu vocabulary. The high practicality score reflected users' perceptions that the application was easy to operate, provided accessible vocabulary information, offered clear navigation, and supported independent learning.

The confidence questionnaire produced an overall score of 88%, indicating a high level of confidence among users after using the digital dictionary. The result suggests that the application supported students' confidence in recognizing, understanding, reading, and using Naulu vocabulary. In addition to these user-evaluation results, the pretest and posttest findings showed improvement in students' vocabulary and reading-comprehension performance after the implementation of the digital dictionary. Taken together, the findings provide evidence not only of the technical feasibility of the product but also of its perceived practicality and potential contribution to Naulu language literacy.

Table 3. Expert Validation Results

Aspect Evaluated	Number of Experts	Aiken's V	Category
Language and Content	2	0.92	Very Valid
Media and Instructional Technology	2	0.94	Very Valid
Overall	4	0.93	Very Valid

Table 4. Research Instruments

Instrument	Construct Measured	No. of Items	Scale	Reliability	Interpretation
Language Literacy Test	Naulu vocabulary and reading comprehension	20	Correct = 1; Incorrect = 0	KR-20 = 0.887	Reliable
Practicality Questionnaire	Ease of use, navigation, accessibility, clarity, and usefulness	15	1-5 Likert	$\alpha = 0.921$	Good
Confidence Questionnaire	Confidence in recognizing, reading, understanding, and using Naulu vocabulary	15	1-5 Likert	$\alpha = 0.90$	

**Figure 6.** Implementation Process of the Naulu Digital Dictionary

Implementation took place at STKIP Gotong Royong Masohi in the Indonesian Language and Literature Education program. Research on the use of the Naulu Digital Dictionary showed a significant increase in local language literacy among prospective teacher students. Pre-test average literacy scores were 62.4 (moderate), which increased to 84.7 (good) in the post-test. The paired-samples t-test showed a significance value of $0.000 < 0.05$, indicating a significant effect of the Naulu Digital Dictionary on literacy improvement. Vocabulary mastery increased most significantly, from 58% pre-intervention to 87% post-intervention, facilitated by quick search and contextual explanations. Reading comprehension in Naulu also improved from 40% to 81%, showing that the digital dictionary supports better reading skills. Student attitudes toward the local language became more positive: 92% found the dictionary practical, and 88% felt more confident using Naulu in simple conversations. The digital medium also encouraged pride and interest in preserving the Naulu language. Overall, the findings suggest the Naulu Digital Dictionary effectively improves vocabulary and reading skills while fostering positive attitudes toward local language preservation.

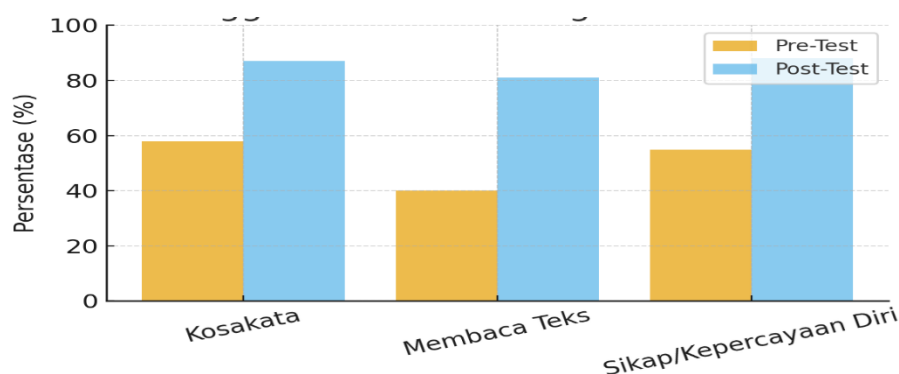


Figure 7. Profile of Local Language Literacy Improvement among Prospective Teachers Using the Naulu Digital Dictionary

This study used the Lee & Owens development model, consisting of four main stages: needs analysis, design, development and implementation, and evaluation. This model is systematic and flexible, suitable for developing technology-based learning products. Needs analysis identified a broad user base, from prospective teachers and students to native speakers and tourists, aligning with Branch's view that media development should start with audience and context analysis. Interviews showed the need of digital media because printed resources are limited. Naulu community data revealed decreasing language use among youth, highlighting the need for innovation to preserve the language.

The prioritized needs, including two-way translation, a simple interface, offline access, and cultural information, align with user-centered design principles. The design focused on additional features like sentence translation, speech-to-text, and OCR. OCR is particularly relevant because it lets users translate text from images, proving effective in digital language learning. Strategic selection of hardware, software, and servers supports application sustainability. Using a VPS enables flexible, long-term development, consistent with Rosenberg's view that proper technology infrastructure determines the success of e-learning and digital learning applications.

Application development added important new features, such as sentence translation and speech-to-text, creating a more natural learning experience. The splash screen, word suggestions, and OCR pages also enhanced the application's appeal. Implementation at STKIP Gotong Royong Masohi showed an increase in average student literacy scores from 62.4 (moderate) to 84.7 (good). t-test results ($0.000 < 0.05$) confirmed a significant effect of the application. Vocabulary mastery rose from 58% to 87%, and reading skills improved from 40% to 81%. Student attitudes toward the local language became more positive, with 92% finding the application practical and 88% more confident using Naulu. This aligns with linguistic identity theory, which states that digital media can strengthen pride in the local language and culture.

4. Discussion

The findings of this study indicate that the Android-based Naulu digital dictionary demonstrated positive evidence in terms of product validity, practicality, learner confidence, and language-learning outcomes. Importantly, these findings should be interpreted in relation to previous empirical studies on mobile-assisted language learning and digital resources for minority and Indigenous languages.

First, the expert validation result of 0.93 indicates a very high level of agreement regarding the appropriateness of the developed product. This finding is comparable to previous research on Android-based regional-language dictionaries in Indonesia. For example, a study developing an

Android-based bilingual dictionary for the Lampung language used expert judgment, interviews, questionnaires, and product try-outs and reported that the application was positively perceived as a tool for language maintenance and preservation. However, the Lampung study focused mainly on product development and user perception, whereas the present study combines expert validation with user evaluation and learning-performance measures. Thus, the present study provides a broader evaluation framework by examining not only whether the dictionary is appropriate as a digital resource but also how users perceive and use it for learning.

A similar comparison can be made with the development of an Android-based Muyu-Indonesian-English dictionary in Papua. That study involved 40 university students and found that the application could perform its intended vocabulary-search functions and could serve as a resource for learning and preserving the Muyu language. However, students reported attitudes toward the usefulness of the application in the medium category. In contrast, the present Naulu digital dictionary obtained a 92% practicality score, categorized as very practical. This difference should not be interpreted as evidence that one application is inherently superior because the studies used different participants, instruments, contexts, and evaluation procedures. Nevertheless, the comparison suggests that the present application received particularly positive user responses regarding usability and practical application in learning.

The findings are also closely related to the recent development of a Higaonon mobile dictionary in the Philippines. That study developed a culturally responsive mobile dictionary through collaboration with Indigenous elders, educators, and young people and used participatory lexicography to document vocabulary across culturally significant domains. The Higaonon study therefore emphasizes the importance of community participation and cultural responsiveness in digital Indigenous-language resources. The present study similarly incorporates community and native-speaker knowledge into the development and validation of the Naulu dictionary. However, this research goes further by evaluating the application through learning-related measures, including vocabulary and reading comprehension, as well as practicality and learner confidence.

The 92% practicality result also aligns with the broader empirical literature on mobile-assisted language learning. Lin and Lin's meta-analysis of 33 experimental and quasi-experimental studies found a positive and large overall effect of mobile-assisted L2 vocabulary-learning interventions on word retention. They also found that treatment duration, learning setting, and the degree of learner autonomy could moderate the observed effects. The present study similarly provides evidence that a mobile platform can serve as an accessible vocabulary-learning resource. However, it focuses on an Indigenous/local language rather than English as an L2. This distinction matters because the Naulu application supports not only language learning but also the documentation and educational use of a local language.

Okumuş Dağdeler's systematic review of mobile-assisted vocabulary-learning research further supports this. The review mapped a substantial body of research on mobile vocabulary learning and showed that mobile technologies have become an established area of language-learning research. However, much of this literature has focused on conventional second- or foreign-language learning rather than endangered, minority, or Indigenous languages. Consequently, the present study extends the application of mobile-assisted vocabulary learning into the context of Naulu language education, thereby addressing a context that is less represented in the mainstream mobile vocabulary-learning literature.

A particularly relevant empirical comparison comes from a study of a theory-based mobile application among 108 Chinese university EFL learners. That quasi-experimental study reported

greater vocabulary-learning gains for the experimental group than the control group and also found better vocabulary retention among students using the mobile application. Participants additionally reported positive perceptions of the application. The present study shows a similar pattern in which positive user perceptions and improvement in vocabulary-related learning outcomes accompany digital mobile support. However, the present study differs in both target population and language context: rather than learning English vocabulary, participants used the application to learn and engage with Naulu vocabulary.

Another relevant comparison is the longitudinal study of 139 EFL learners that examined the effect of mobile-assisted language learning on vocabulary-learning attitudes and self-regulatory capacity. Over one year, mobile applications were integrated into regular instruction, and the study examined changes in learners' attitudes and self-regulation. The study demonstrates that the value of mobile-assisted learning extends beyond immediate vocabulary scores to learner-related variables. The present study similarly includes a confidence measure, which produced an 88% score, thereby providing evidence about learners' perceptions in addition to achievement outcomes. Nevertheless, the present study measures confidence after a more focused implementation period and therefore should not be interpreted as evidence of long-term change in self-regulatory capacity.

Research on mobile vocabulary applications has also examined longer-term retention. A quasi-experimental study involving 82 Chinese university students compared a mobile vocabulary application with a paper-based word list and specifically investigated vocabulary memory retention. This research matters because vocabulary learning should ideally lead not only in immediate recognition but also in sustained retention. The present study demonstrates improvement in vocabulary and reading comprehension following implementation, but it does not yet establish long-term retention. Therefore, compared with studies explicitly measuring delayed retention, the present study provides evidence of immediate learning outcomes while leaving sustained Naulu vocabulary retention for future investigation.

The strongest comparison with the present research comes from the 2026 randomized controlled trial of the Quechua Collao mobile application in Peru. This study involved 4,464 students across 200 schools and evaluated a mobile intervention designed to strengthen an Indigenous language. The intervention improved reading, listening, and speaking, with an overall effect of 0.137 standard deviations and a larger effect of 0.330 standard deviations on an assessment aligned with the application content. It also increased reported use of Quechua in public and non-family settings.

The Quechua study and the present Naulu study share an important characteristic: both apply mobile technology to an Indigenous language rather than a globally dominant foreign language. However, their research designs differ substantially. The Quechua study used a large randomized controlled design with treatment and control groups, whereas the present study focuses on the development and initial evaluation of a Naulu digital dictionary. Therefore, the present finding of improved vocabulary and reading comprehension should be interpreted as evidence of promising learning outcomes associated with the implementation, rather than as causal evidence equivalent to an RCT. This distinction is important to avoid overstating the effectiveness of the Naulu application.

Nevertheless, the Quechua findings provide an important empirical basis for interpreting the present results. The Quechua intervention combined a culturally relevant mobile application with pedagogical guidance and teacher support. Its authors emphasized that technology alone is insufficient and that sustainable Indigenous-language learning requires integration among technology, curriculum, and teacher support. The present study similarly suggests that the Naulu dictionary should be regarded as a supporting learning resource, rather than a replacement for teachers, community language practices, or direct interaction with native speakers.

Recent meta-analytic evidence further strengthens the interpretation of the vocabulary findings. A synthesis of 65 quasi-experimental and experimental studies published between 2010 and 2024 found a large overall effect of mobile applications on vocabulary learning when interventions lasted at least 10 weeks, although effect sizes varied by learning and application characteristics. This evidence suggests that duration and implementation conditions are important when interpreting mobile-learning outcomes. Since the present Naulu study evaluates an initial implementation rather than a long-term intervention, future research should examine whether the observed vocabulary gains remain after a delayed posttest and whether extended use produces stronger retention.

Taken together, the comparison with previous research reveals both similarities and differences. Like the Lampung, Muyu, Higaonon, and Baduy-related digital-language initiatives, the present study demonstrates the feasibility of using mobile technology to document, access, and support learning of a local or Indigenous language. Like the broader mobile vocabulary-learning literature, the present study reports positive evidence on vocabulary learning and user responses. However, unlike much of the existing literature, this study combines language documentation, Android-based dictionary development, expert validation, practicality evaluation, learner confidence, and learning-performance assessment in the specific context of the Naulu language.

The 88% confidence score should also be interpreted carefully. It indicates a high level of self-reported confidence but does not directly demonstrate increased language proficiency. The distinction between perceived confidence and actual achievement is important because self-reported measures and performance measures assess different constructs. In the present study, the confidence finding is therefore best understood as complementary evidence: students reported positive perceptions of their ability to engage with Naulu vocabulary. At the same time, the pretest-posttest results provide evidence concerning changes in observed learning performance.

Overall, the findings contribute to the literature in two related ways. First, they provide empirical evidence that an Android-based dictionary can be developed and evaluated as a learning resource for Naulu. Second, they extend mobile-assisted language-learning research beyond the dominant EFL/ESL context toward an Indigenous/local-language setting. The combination of very high expert validation (Aiken's $V = 0.93$), high practicality (92%), high learner confidence (88%), and improvement in vocabulary and reading comprehension provides a multidimensional basis for evaluating the product. Nevertheless, the results should be regarded as evidence of feasibility and promising educational value rather than definitive causal evidence. Larger samples, control or comparison groups, longer intervention periods, and delayed retention tests are needed to establish the sustained educational effects of the Naulu digital dictionary.

5. Conclusion

This study developed and evaluated an Android-based digital dictionary to support Naulu language literacy among pre-service teachers in Maluku. The expert validation and user evaluation indicated that the developed application was considered appropriate and practical for use as a supporting resource in Naulu language learning. Following implementation, students' vocabulary and reading-comprehension scores improved from the pretest to the posttest. At the same time, users also reported positive perceptions of the application's practicality and their confidence in engaging with Naulu language materials.

These findings suggest that the Android-based digital dictionary has potential as a supplementary resource for supporting Naulu language learning and preservation. However, the improvement in literacy scores should not be interpreted as definitive evidence of a causal effect of

the application or of the development model itself. Further research using controlled or comparative designs, larger samples, longer implementation periods, and delayed posttests is needed to examine the sustained effects of the application on Naulu language literacy and vocabulary retention.

AI Usage Statement

The authors used ChatGPT (OpenAI) for language editing, grammar checking, and improving the clarity and readability of the manuscript. AI was not used to generate or modify research data, perform statistical analyses, or make scientific decisions. The authors remain fully responsible for the content, accuracy, interpretation, and conclusions of the manuscript.

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