Amanu: Deep Learning-Based System for Kapampangan Language Learning Using CNN-RNN for Grade School Learners

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Keywords: Amanu, Kapampangan Language, Educational Technology, Pronunciation Checking, ISO 25010 Criteria

Abstract: This study examines the development and implementation of "Amanu", a deep learning-based computer system designed to enhance Kapampangan language acquisition among grade school learners. Utilizing a CNN-RNN architecture, the system addresses challenges in preserving and promoting the Kapampangan language. The research employed a quantitative descriptive approach, using ISO 25010-based surveys for data collection. Developed using Agile methodology, Amanu incorporates features such as a pronunciation checker, multimedia lessons, interactive games, and a comprehensive dictionary. Findings indicate that Amanu significantly aids both teachers and learners in Kapampangan language education, receiving high ratings across all ISO 25010 categories with an overall mean score of 3.80. The study concludes that integrating such systems into standard teaching methods can revolutionize language learning approaches, making Kapampangan acquisition more accessible and engaging. Recommendations include incorporating adaptive learning algorithms and expanding cultural content. This research contributes to educational technology and language preservation, demonstrating the potential of deep learning-based systems in supporting endangered language education.

1 INTRODUCTION

1.1 Background of the Study

With the upcoming curriculum "Matatag," the Department of Education (DepEd) removes mother tongue as a subject and instead continues to utilise it as a medium of instruction (mb.com.ph). However, this move has raised concerns from advocates of local language preservation, like the Kapampangan language. Due to the removal of the mother tongue as a subject, Kapampangan learning materials will likely decrease, limiting the opportunities for the next generation to learn and appreciate their local language.

As the mother tongue is only utilized as a medium of instruction for grades 1-3 under the new curriculum, learning materials for local languages will no longer be provided by the Department of Education. This means that Kapampangan learning materials will become scarce, and teachers will have to look for them themselves, which may not be possible for some given their other teaching responsibilities. With the absence of sufficient learning materials, it is highly likely that the effectiveness of learning Kapampangan and other local languages will decrease.

In light of this concern, it is imperative for teachers to adapt to the digital age, where technology can aid in the preservation and instruction of local languages, including Kapampangan. To solve the arising problem, various systems and applications can be used to provide a fun and easy way to teach Kapampangan. By incorporating these tools into their teaching methods, teachers could provide learners with a more interactive and engaging learning experience. Learners would benefit from a wider range of multimedia material and innovative resources that may improve their language acquisition and appreciation. In addition to making language instruction more engaging and accessible, incorporating Kapampangan learning systems could also help preserve and promote this important regional language. As digital tools increasingly shape our educational landscape, it is important that we take advantage of these opportunities to foster the continued use and appreciation of Kapampangan. By adopting new technologies and best practices, teachers can help ensure that this language remains a

vibrant and integral part of our cultural heritage. In turn, learners would have a greater appreciation for the unique beauty and value of Kapampangan.

1.2 Objective of the Study / Statement of the Problem

General Objective

The study aims to provide an engaging and effective tool for teachers to use in teaching and for young learners to acquire and reinforce Kapampangan vocabulary, pronunciation, and basic sentence structure.

Specific Objective

1. What are the appropriate algorithms in deep learning that can be applied to the development of the system that will help in aiding the grade school teachers in teaching Kapampangan?

2. What features and functionalities should the computer-based learning system provide to engage and motivate grade school learners in their Kapampangan language learning journey?

3. How can the system be an aid to the following:
a. Teachers
b. Learners

4. How might the use of the system impact the effectiveness of standard teaching methods and curriculum's?

5. How does the system satisfy the questions as defined in ISO 25010 in terms of:
a. Functional Suitability
b. Performance Efficiency
c. Usability
d. Reliability
e. Portability

1.3 Significance of the Study

The findings of this thesis will prove useful to the following:

To the learners. The Abe system will offer an engaging and effective approach to learning Kapampangan. Through the development of a computer-based learning system, learners can access a wide range of educational materials and activities that cater to their needs and preferences, ultimately enhancing their academic performance and personal development. Additionally, this study contributes to the preservation of the Kapampangan language and culture, which are integral to the country's cultural heritage. By promoting the use of Kapampangan in education and creating culturally appropriate materials, learners can develop a deeper appreciation for their language and heritage, fostering cultural pride and intercultural competence.

To the Teachers. The system will aid teachers by providing learning material that can significantly enhance their teaching strategies. With this system, teachers will have access to a wide range of instructional materials and tools that can promote effective and fun Kapampangan lessons for their learners. By improving their Kapampangan language skills, teachers can increase their confidence and competence in teaching the subject. This study can thus benefit teachers since it can aid in their professional development and improve their teaching effectiveness in the long run.

To the Researchers. The thesis project can significantly benefit the researchers who created it. This system provides an opportunity for the researchers to develop and apply advanced deep learning techniques in a real-world environment. Developing this system requires extensive research and analysis, which can result in the creation of innovative and groundbreaking algorithms. Through trial and error, researchers can improve their deep learning models and gain valuable insights on their strengths and limitations.

To Future Researchers. The thesis project can highly benefit future researchers. It can provide an opportunity for new researchers to build on the existing knowledge base and advance research in the field of deep learning in education. The project can also serve as a valuable resource for future learners and researchers who are interested in and working towards developing advanced systems.

2 METHODOLOGY

2.1 Research Design

The thesis project used a quantitative descriptive research design to gather and analyse numerical data via surveys, questionnaires, and measurement equipment. The acquired statistics include information about learners' competency, satisfaction, and overall learning experience, as well as the system's correctness, efficiency, and usability. This technique allowed for a more in-depth understanding of learners' motivations, obstacles, and nuances, which influenced future improvements to the computer-based learning system. According to USC Libraries (2022), quantitative research focusses on the objective study of numerical data obtained via surveys and other similar instruments in order to draw significant insights about a particular community.

2.2 Technical Background

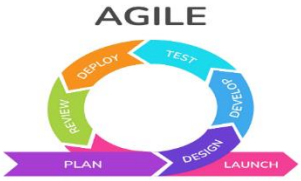

Figure 1. Phases of Agile SDLC

The researchers employed the Agile methodology, specifically Scrum Methodology, for the efficient and effective development of the system. Scrum agile methodology is a flexible and iterative project development approach for small teams that encourages adaptive planning, ongoing collaboration, and step-by-step delivery of software. It prioritizes customer satisfaction, teamwork, and the capability to adapt to changes during the development phase. This approach empowers businesses to deliver top-notch software solutions promptly while also accommodating evolving needs and preferences.

2.3 Respondents

The researchers chose teachers and IT professionals, as their respondents, each bringing unique insights to the project. Teachers offer valuable perspectives on the educational aspects, while IT professionals contribute their expertise in information technology. Computer experts bring a deep understanding of technical aspects. Together, their diverse backgrounds enriched the project, ensuring a comprehensive examination of the topic at hand.

2.4 Participants

Respondents	Number of Respondents
Teachers	10
Learners	10
Total	20

Table 1. Participants

For this study, the researchers carefully selected a group of participants to provide comprehensive feedback on the Abe system. The participant pool consisted of 20 individuals: 10 teachers and 10 learners from Sta. Ana Elementary School.

The teachers were chosen based on their experience in teaching Kapampangan language or their involvement in mother tongue-based multilingual education. These educators brought valuable insights into the system's potential integration into existing curricula and its effectiveness as a teaching aid.

The learners were selected from grades 1-3, representing the target user group for the Abe system. Care was taken to include a diverse range of learners, including those with varying levels of prior Kapampangan language knowledge. This selection ensured that the system's effectiveness could be evaluated across different learning needs and abilities.

This balanced group of participants allowed for a holistic evaluation of the Abe system, combining the pedagogical perspectives of experienced educators with the direct user experiences of young learners. Their collective feedback provided crucial insights into the system's usability, effectiveness, and potential impact on Kapampangan language acquisition in elementary education.

2.5 Instrument

Figure 2. ISO 25010

To ensure reliable and valid research outcomes, the researchers adopted a standardized research instrument based on ISO 25010. The questionnaire was composed of validated items related to software quality attributes such as functionality, usability, reliability, performance, and portability. The standardized approach of using ISO 25010 allowed for objectivity and comparability, enabling the researchers to gather valuable feedback from respondents and identify the system's strengths and areas for improvement. With strict confidentiality and anonymization of data, the research instrument's administration and analysis ensured the research findings' reliability and validity.

To validate the ISO 25010 process, the researchers employed a rigorous approach. Firstly, an expert

review was conducted, seeking insights from individuals knowledgeable about ISO 25010. Following this, a pilot test was performed with a subset of respondents to identify and address any issues in the questionnaire. Content validity was ensured by confirming comprehensive coverage of software quality aspects outlined in ISO 25010. Reliability was tested through consistent responses over time, and peer feedback was sought for additional perspectives. The questionnaire was cross-referenced with ISO 25010 documentation, and an iterative refinement process based on feedback enhanced the overall validity and reliability of the research outcomes.

2.6 Statistical Treatment

The researchers have selected a questionnaire based on the ISO 25010 standard, utilizing a four-point Likert scale as the statistical treatment for the study. This type of Likert scale is a valid and widely used measure in research, which allows for more detailed responses than a yes/no or agree/disagree scale, and can be effectively used when questions are carefully designed, respondents remain anonymous, and the goal is to obtain honest and accurate responses.

Point	Scale Range	Explanation
4	3.26 – 4.00	Strongly Agree
3	2.51 – 3.25	Agree
2	1.76 – 2.50	Disagree
1	1.0 – 1.75	Strongly Disagree

Table 2. Four-point Likert Scale

3 RESULTS AND DISCUSSION

3.1 Algorithms Used on Amanu

The project adopted a hybrid Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN) approach, focusing on the generation of spectrograms and the utilization of Mel Frequency Cepstral Coefficients (MFCC) to enhance pronunciation accuracy checks.

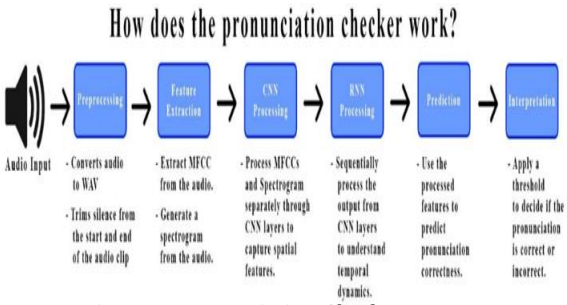

Figure 3. Pronunciation Checker Process

In the initial phase of developing "Abe," the focus was on employing a single algorithm to address the statement of the problem: "What are the appropriate algorithms in deep learning that can be applied to the development of the system to aid teachers in teaching Kapampangan?" Initially, the Recurrent Neural Networks (RNN) algorithm was chosen for its proficiency in handling sequential data, making it a seemingly ideal choice for language learning applications, particularly in understanding and generating linguistic patterns over time.

However, while RNNs provided a solid foundation for processing the temporal dynamics of language, it became evident that incorporating another dimension of analysis could significantly enhance the system's capabilities. This led to the integration of Convolutional Neural Networks (CNN) alongside RNNs, creating a hybrid model that leverages the strengths of both algorithms. The addition of CNNs, known for their exceptional ability to analyze visual imagery, allowed for the incorporation of spectrogram analysis into the system. Spectrograms offer a visual representation of the spectrum of frequencies of a sound signal as they vary with time, which, when combined with the Mel Frequency Cepstral Coefficients (MFCC), provides a rich dataset for accurately assessing and improving pronunciation.

This hybrid approach proved to be more successful than the initial implementation using only RNNs. The combination of CNN for extracting detailed features from spectrograms and RNN for analyzing the temporal sequence of speech patterns resulted in a more robust system capable of offering nuanced feedback on pronunciation, thereby enhancing the Kapampangan language learning experience for grade school learners.

3.2 Features and Functions of Amanu

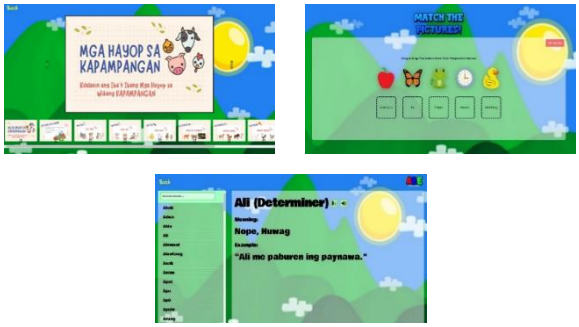

Figure 3. Features of Abe

To create an engaging and motivating environment for elementary learners of Kapampangan, a computer-based learning system should include features tailored to young learners' needs. A key component is the pronunciation checker, which helps learners master correct pronunciation with immediate feedback, allowing for continuous improvement and building confidence.

The system should also provide a library of visual images and videos for each lesson and grade level. This multimedia content makes language concepts more concrete, aiding understanding and retention. Additionally, engaging games designed for each lesson introduce fun, reinforce language concepts, and sustain interest through interactive competition.

A comprehensive dictionary with over 100 Kapampangan words and audio previews of pronunciations is essential. This feature supports vocabulary expansion and pronunciation accuracy, especially for auditory learners. These combined features create a holistic and interactive learning environment, fostering fluency in Kapampangan and catering to diverse learning styles, ensuring a balanced and inclusive approach to language education.

3.3 How Can the System be an Aid in the Teaching and Learning Kapampangan?

To Teachers: The computer-based learning system for Kapampangan aids teachers with innovative features like the pronunciation checker, ensuring students learn accurate pronunciation. This tool integrates into daily lessons, allowing teachers to demonstrate correct pronunciation effectively. The system's extensive library of visual images and videos for each lesson and grade level enriches teaching materials, making lessons more engaging and interactive. Interactive games designed to reinforce language concepts offer a fun and educational tool for classroom activities or homework, promoting learning beyond traditional methods.

To Learners: Learners benefit from the pronunciation checker, which allows them to practice and refine their pronunciation independently with instant feedback. This fosters autonomy and motivation. The system's visual and video content caters to diverse learning styles, enhancing memory retention and making learning more engaging. Interactive games transform language learning into a fun and competitive activity, encouraging practical application of knowledge. The comprehensive dictionary, with audio previews, supports vocabulary expansion and pronunciation practice, offering a reliable learning resource at any time.

3.4 Impact and Effectiveness of Amanu to Standard Teaching Methods and Curriculum

Integrating the computer-based learning system into standard teaching methods for Kapampangan can greatly enhance traditional approaches. Features like the pronunciation checker, multimedia content, interactive games, and a comprehensive dictionary add a dynamic and interactive element to language learning.

The pronunciation checker provides individualized feedback, helping learners practice and improve their pronunciation independently. A study by Dillon and Wells (2023) on Korean English learners found that using automatic speech recognition technology for pronunciation training significantly improved pronunciation accuracy. This highlights the potential of such technology in enhancing language learning platforms for Kapampangan.

Multimedia content and interactive games boost learner engagement and motivation by catering to diverse learning styles. Berdiyeva (2023) in her study, "Unlocking Language Learning Potential: The Impact of Multimedia in Language Education," found that multimedia learning accommodates various sensory modalities, making learning more inclusive and effective. "Abe" uses visual aids and educational videos to break down complex language concepts into engaging formats, complementing the interactive elements and offering a flexible approach to language learning.

The dictionary feature with audio previews supports vocabulary expansion and pronunciation practice, providing an accessible resource for both teachers and learners. This tool can supplement lesson plans and offer additional support outside the classroom, extending learning opportunities beyond traditional teaching hours.

3.5 Implementation of Amanu Using ISO 25010

The Abe system demonstrated robust performance across all evaluated categories based on the ISO 25010 standard. Table 3 summarizes the mean scores for each category:

Category	Mean	Descriptive Interpretation
Functional Suitability	3.70	Strongly Agree
Usability	3.87	Strongly Agree
Reliability	3.72	Strongly Agree
Performance	3.87	Strongly Agree
Portability	3.82	Strongly Agree
Overall Satisfaction	3.82	Strongly Agree
Overall mean for category	3.80	Strongly Agree

Table 3. ISO 25010 Categories with Corresponding Marks

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The tests conducted on the "Abe" system for Kapampangan language learning received positive feedback, with scores reflecting its strong performance. Users rated the system highly, with a mean score of 3.70 for functional suitability, 3.87 for both performance efficiency and usability, 3.72 for reliability, and 3.82 for portability. These ratings highlight the system’s ability to meet user needs, respond promptly, and operate reliably across different devices, while maintaining ease of use.

In conclusion, the "Abe" system provides an innovative and efficient solution for Kapampangan language learning. Its high scores in functionality, performance, and usability make it an effective tool for engaging young learners, supporting both teachers and students. The system’s design enhances language education, promoting the preservation of the Kapampangan language while demonstrating the potential of educational technology in improving the learning process.

4.2 Recommendations

To enhance the effectiveness and engagement of the language learning experience, several key features could be incorporated into the system. First, an adaptive learning algorithm might be used to personalise the curriculum depending on each learner's success, strengths, and areas for growth, resulting in a more individualised approach to Kapampangan language learning. Expanding the dictionary tool to incorporate more words, phrases, and sample sentences would provide greater contextual learning, allowing students to acquire terminology within a larger linguistic and cultural framework. Furthermore, a community element that allows learners to connect, share suggestions, and practise together would promote social learning and create a supportive atmosphere for language mastery.

To further enrich the learning experience, cultural teachings on the history, traditions, and customs of Kapampangan-speaking regions should be included to enhance the learning experience. These classes would provide learners with a more in-depth understanding of the language's cultural context, hence increasing interest and retention. A more advanced pronunciation checker powered by machine learning might potentially provide subtle feedback, allowing students to fine-tune their accent and intonation with more accuracy. Furthermore, obtaining feedback from educators to ensure the system satisfies varied educational needs will improve the tool's robustness and suitability for classroom use, making it a more valuable resource for both instructors and students.

ACKNOWLEDGEMENT

First and foremost, the researchers would like to express their profound gratitude to Almighty God, the source of wisdom and strength, for His constant guidance and countless blessings throughout the journey of this research project. Without His divine grace, this accomplishment would not have been realized.

The researchers would also like to extend their sincere appreciation to the School of Engineering, Computer, and Library Studies for providing the resources, guidance, and continuous support necessary to complete this research. Their encouragement and dedication to fostering academic

excellence have been vital to the success of this project.
Lastly, the researchers express their heartfelt gratitude to Holy Cross College of Pampanga for offering a nurturing academic environment that promotes learning and growth. The institution's unwavering commitment to quality education has inspired the researchers to strive for excellence throughout their study.

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