

**NLP based Autonomous Grading System for Sinhala
Language Essays of Grade 5 students**

Final Report

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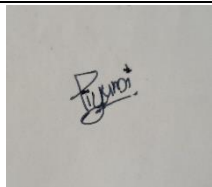
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DECLARATION

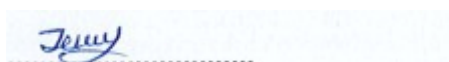
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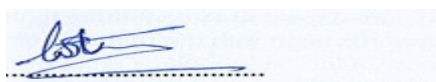


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ABSTRACT

This project focuses on developing an NLP-based autonomous grading system for Sinhala language essays written by Grade 5 students. Addressing the challenges posed by the linguistic complexity of Sinhala, the system aims to provide accurate, unbiased, and efficient grading. The methodology includes creating a corpus of native words, spelling patterns, and grammatical rules, enabling the system to analyze essays comprehensively. The system identifies and replaces native words with their formal equivalents, checks for spelling and grammar accuracy, and evaluates the relevance and complexity of vocabulary. It integrates a robust backend with a user-friendly mobile interface, allowing teachers to define grading parameters and students to receive constructive feedback. By automating the grading process, the system reduces the workload of educators and ensures consistent evaluations, promoting improved language proficiency and academic performance in primary education. This innovation bridges a critical gap in Sinhala language educational technology.

Keywords— Automated Essay Grading, NLP, Sinhala, Text Processing, Essay Evaluation

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LIST OF ABBREVIATIONS

Short Form	Long Form
NLP	Natural Language Processing
NER	Named Entity Recognition
ML	Machine Learning
NLTK	Natural Language Toolkit
SVM	Support Vector Machine
API	Application Programming Interface
AI	Artificial Intelligence
AEG	Automated Essay Grading
POS	Part-of-speech
ETS	Educational Testing Service
PEG	Project Essay Grade
SVO	Subject-verb-object

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1. INTRODUCTION

Natural Language Processing has significantly advanced in the realm of automated essay grading, especially for widely spoken languages like English. However, when dealing with languages such as Sinhala, the task becomes far more complex due to its distinct features, including its script, morphology, and dialectal variations. Sinhala, spoken by millions in Sri Lanka, has unique linguistic properties, and like many languages, its written form varies depending on factors such as region, social class, and context. In particular, young students' essays often reflect a mix of formal language and colloquial or regional expressions, which may not always align with the formal standards expected in academic contexts.

The challenge of standardizing such essays involves the identification and replacement of native or colloquial words with more generic, academically acceptable forms. Native words often stem from informal or spoken Sinhala and may lack formal equivalents, presenting a significant obstacle for automated systems. This process is essential not only for improving the grading accuracy but also for aligning students' language with the prescribed formal usage in education. The current literature offers limited solutions, especially when considering low-resource languages like Sinhala, where NLP tools are not as widely developed compared to other languages such as English or Chinese.

Existing research has predominantly focused on various NLP tasks like sentiment analysis, named entity recognition, and syntactic parsing for Sinhala, but these studies seldom address colloquial language and native words used in academic writing. Furthermore, while there is significant work on general grammar correction and spelling correction, the need for native word identification in essay grading remains underexplored. Some studies, such as those focused on Sinhala's morphology or its unique sentence structures, point out the necessity of handling informal language in automated grading systems. However, they lack a deeper focus on contextualized word replacement and its impact on grading accuracy.

Therefore, this research aims to fill this gap by developing a comprehensive NLP-based model capable of identifying native words in Sinhala essays and replacing them with more generic, formal words. By addressing this challenge, the study aims to not only improve the functionality of automated essay grading systems for Sinhala but also to offer a better understanding of how native language variations can be integrated into educational technology. Moreover, this research is significant in the context of enhancing the quality of NLP tools for low-resource languages, paving the way for future advancements in automated language processing.

Ultimately, the goal is to create a more robust, context-aware system for Sinhala essays that can identify non-standard words and replace them with more

appropriate alternatives, ensuring that students' work is evaluated according to the academic language standards of the education system. This will also contribute to the broader field of educational NLP tools by addressing a critical, yet often overlooked, issue in automated language grading systems. Through this approach, we aim to make automated systems more reliable, educationally beneficial, and sensitive to the linguistic diversity inherent in Sinhala.

1.1 Background and Literature Survey

Sinhala is a morphologically rich and agglutinative language with unique characteristics that make it both culturally significant and computationally challenging. In primary education, essays written by Grade 5 students often contain region-specific or colloquial terms, commonly referred to as "native words." These words, while linguistically valid, may not align with the formal standards required for academic evaluations. The presence of such terms can lead to inconsistencies in grading, as manual evaluators might interpret their relevance and correctness subjectively.

Replacing native words with generic, formal equivalents is essential for ensuring uniformity and meeting academic standards. Automated systems can address this issue effectively by using Natural Language Processing techniques to identify and standardize native words without altering the intended meaning of the text. This component of the grading system serves as a bridge between informal expressions and formal academic language, aligning student writing with educational expectations.

In the field of Natural Language Processing, there has been a marked improvement in various aspects of language technology, including machine translation, sentiment analysis, and automated essay grading. While most of the advancements have focused on widely spoken languages like English, the application of NLP to low-resource languages such as Sinhala remains an emerging and relatively underdeveloped area. Sinhala, the primary language of Sri Lanka, presents unique challenges due to its linguistic complexities, including a distinctive script, morphosyntactic structure, and a rich diversity of colloquial expressions. These factors significantly influence language learning and text analysis, making NLP-based tasks such as essay grading for Sinhala both challenging and crucial.

A particularly important challenge in automating Sinhala essay grading is the presence of colloquial and native words in student writing. Native words refer to the informal or regionally-specific vocabulary that may not have a formal or standardized counterpart in the academic or formal versions of the language. These native words often arise from casual speech patterns, dialects, and local vernaculars, and are used by students as a result of their everyday language exposure. In the context of Sinhala,

native words may range from colloquial terms used in informal settings to slang expressions that are not recognized as part of the formal written language.

A. Challenges in Identifying and Replacing Native Words

In a traditional essay grading system, the evaluation of a student's work is based on various factors such as grammar, spelling, vocabulary, and content relevance. However, when native or colloquial words are used in place of formal words, it complicates the grading process. The first step in addressing this issue is to identify such non-standard words. For languages like Sinhala, which lack comprehensive linguistic resources compared to languages like English, developing systems that can identify native words in a text becomes a complex task. Current NLP tools for Sinhala still face challenges in distinguishing between formal and colloquial language, primarily due to the limited availability of labeled corpora that could train such systems.

The complexity of Sinhala grammar and syntax also contributes to the difficulty of identifying native words. Sinhala, like many other languages, has a rich morphological structure, where a word can take multiple forms depending on its grammatical role in the sentence. Furthermore, informal expressions often vary from one region to another, adding another layer of complexity. For example, a word used in the western region of Sri Lanka may be completely unfamiliar or have a different connotation in the eastern or southern parts of the country.

Given the richness and variety of Sinhala's linguistic resources, developing a comprehensive system to identify and replace native words with more generic, academic alternatives is not a trivial task. Native word identification requires sophisticated NLP algorithms that can handle a variety of word forms and regional variants, while ensuring that the replacement words maintain the overall meaning and context of the essay.

B. The Role of NLP in Identifying and Replacing Native Words

NLP tools have made significant strides in the processing and understanding of text. These advancements are largely due to improvements in machine learning and deep learning algorithms, which can be trained on large datasets to identify patterns in language use. In the case of Sinhala, NLP tools have been used for tasks like part-of-speech tagging, syntactic parsing, and named entity recognition. However, as mentioned earlier, the detection of native words in Sinhala has received limited attention.

The detection of native words typically involves two main tasks: recognizing non-standard words and mapping them to standardized alternatives. This requires an extensive corpus of both formal and informal Sinhala language examples. While formal Sinhala language corpora are relatively easier to compile, informal language resources are harder to come by due to the lack of digital text from non-standard language sources like spoken language, regional newspapers, and social media.

Existing studies have approached the problem of native word detection in different ways. Some have focused on developing part-of-speech taggers and syntactic parsers tailored specifically for Sinhala, which can help identify the structural context of a word. For instance, research by Jayaratna et al. (2017) [1] explored part-of-speech tagging for Sinhala by utilizing supervised machine learning techniques to classify words in different grammatical categories based on a large annotated corpus approach, while valuable for understanding sentence structure, does not specifically target native word detection. Therefore, there is still a gap in tools that can accurately detect native words in Sinhala essays.

Another approach to addressing this challenge involves the development of word substitution systems. These systems would automatically replace native words with their formal counterparts, either by using a predefined lexicon of native and formal word pairs or by employing algorithms that can generate appropriate replacements based on context. However, this task is not as simple as it might seem. For one, many native words have multiple meanings depending on context, and replacing them with a generic word may alter the intended meaning of the sentence. For example, a colloquial word used in a certain context may have no exact equivalent in formal Sinhala. Thus, any system designed to replace native words must account for these contextual nuances.

C. Existing NLP Tools for Sinhala Language

While NLP tools for Sinhala language processing are still in the developmental stages, some efforts have been made to address linguistic challenges in the language. For instance, automated essay evaluation systems for Sinhala have been explored by researchers like Perera et al. (2019) [2], who used NLP techniques for grading Sinhala essays. This system evaluated essays based on grammar and spelling but did not focus on the identification and replacement of native words.

In addition, efforts have been made to develop computational tools for Sinhala named entity recognition, which is another key component of NLP systems. The challenge with NER in Sinhala lies in the complexity of the language's sentence structure and word morphology, as mentioned previously. A research study by Weerasinghe et al. (2021) [3] applied a hybrid approach to improve the accuracy of NER in Sinhala by combining rule-based methods with machine learning techniques. While their work contributed to the field of Sinhala language processing, it does not specifically address the issue of native word identification.

Moreover, there have been attempts to integrate sentiment analysis into Sinhala text processing, such as the work by Abeywardena et al. (2020) [4], which focused on developing sentiment analysis models for Sinhala language data. While sentiment analysis provides some insights into language patterns, they do not target native word identification and replacement, which requires a different focus on linguistic accuracy and formal language standards.

D. The Need for an Automated Native Word Identification System for Sinhala Essays

Given the growing interest in automating essay grading systems, especially for non-English languages, there is a clear need for a system that can effectively identify native words in Sinhala essays and replace them with formal, academically appropriate alternatives. Such a system would not only improve the accuracy and fairness of automated grading but also help students align their language usage with formal academic standards.

By creating a comprehensive corpus that includes both formal and informal Sinhala words, and by developing algorithms that can effectively identify and replace native words with generic equivalents, this research can significantly improve the quality of automated essay evaluation for Sinhala. This will also contribute to the broader field of NLP by offering insights into handling informal language in low-resource languages, which can be adapted to other regional languages facing similar challenges.

The task of identifying and replacing native words in the context of automated grading systems for Sinhala language essays is an extension of broader research in computational linguistics, natural language processing and educational technologies. Specifically, the problem involves the standardization of colloquial and informal language in primary education essays, aligning them with formal academic norms. This section surveys related works on text normalization, corpus development, word substitution algorithms, and context-sensitive NLP applications, drawing insights that help inform the development of an effective system for identifying native words and replacing them with more generic terms in Sinhala.

1. Text Normalization in NLP

Text normalization is a fundamental task in NLP, particularly for low-resource languages like Sinhala. Normalization involves converting informal, colloquial, or dialect-specific words into standardized forms, ensuring uniformity in language processing tasks such as sentiment analysis, machine translation, and, in this case, automated essay grading. The need for effective text normalization is particularly significant in languages with rich morphology, such as Sinhala, where words can take multiple forms depending on context, tense, and case.

In Sinhala, native words often carry local dialectical variations that are widely understood in informal contexts but do not align with the formal academic language expected in essays. Previous studies have examined the use of *morphological analysis* for Sinhala language processing, identifying the necessity of incorporating a corpus that includes both colloquial and formal word forms. For instance, Fernando and Weerasinghe (2013) explored the challenges of applying POS tagging to Sinhala, noting that a lack of resources made it difficult to develop tools that could process informal language [5]. Text normalization in Sinhala is thus a critical step toward developing systems that can standardize language, particularly in educational settings.

Similarly, research on *text normalization in other low-resource languages* reveals common strategies, such as the creation of rule-based systems or lexicons to handle informal language. Kumar and Joshi (2019) developed NLP tools for Hindi, a morphologically complex language similar to Sinhala, and used rule-based approaches to convert informal terms into more formal equivalents for academic contexts [6]. These insights are directly applicable to Sinhala, as they emphasize the need for structured word replacement systems that preserve the semantic integrity of the essays while standardizing informal language.

2. Rule-Based Approaches for Word Replacement

Rule-based approaches have been a cornerstone of text normalization and word replacement tasks, particularly for low-resource languages. These systems utilize predefined rules to map informal words to more formal equivalents, based on dictionaries or corpora developed specifically for the language. Such approaches are often combined with POS tagging to ensure that word replacements align with the syntactic structure of the sentence.

In the case of Sinhala, a Native Words Corpus serves as the key resource for identifying colloquial terms. Jayasena et al. (2016) demonstrated how rule-based algorithms, coupled with morphological analysis, can be applied to Sinhala text to standardize word forms [7]. Their study involved creating a corpus of native words and their formal equivalents, enabling automated systems to identify and replace informal terms. This work directly informs the development of a similar corpus for Sinhala essays, helping to ensure that students' language is aligned with formal writing norms.

Moreover, rule-based algorithms for word replacement, such as those developed for Hindi and other Indo-Aryan languages, rely on syntactic and semantic cues to identify the context in which native words are used. For example, replacing "ohoma" (informal for "that way") with "mese" (formal equivalent for "in that manner") is context-dependent. This ensures that the suggested word replacement is not only grammatically correct but also contextually appropriate. Studies on Hindi (Kumar et al., 2019) highlight the significance of this approach, particularly when applied to educational technologies, where context plays a pivotal role in the overall assessment of student essays [6].

3. Development of Linguistic Corpora for Educational Applications

The creation of annotated corpora is critical to the development of NLP tools for automated grading systems. Such corpora serve as the training and evaluation data for machine learning models and rule-based systems. In the context of identifying native words, an effective corpus should contain a range of native terms used in Grade 5 Sinhala essays, mapped to their formal equivalents. The *Sinhala Morphological Corpus*, developed by Jayasena et al. (2016), provides a foundational resource for text normalization in Sinhala. The corpus includes annotated examples of informal-to-

formal word pairs, which can be used to train models for automatic word replacement [7].

Similarly, research on educational corpora in other languages, such as English and Hindi, has contributed to understanding the linguistic patterns that exist between informal and formal language use in essays. The creation of these corpora has facilitated the development of grading systems that can identify native words, evaluate their appropriateness in context, and suggest replacements where necessary. These approaches, coupled with advances in semantic similarity models and transformer-based architectures, have laid the groundwork for creating sophisticated systems that can handle word replacements automatically while preserving meaning.

4. Context-Sensitive Word Replacement

One of the primary challenges in replacing native words with generic terms is ensuring that the replacement maintains the semantic integrity of the essay. Word replacement is not always straightforward, as informal terms may carry nuanced meanings or be context-dependent. Therefore, context-sensitive NLP models are critical for this task. Recent advancements in contextualized word embeddings, such as BERT (Devlin et al., 2019), have revolutionized the way NLP systems understand the relationships between words in a given sentence. These models capture the surrounding context of a word, ensuring that replacements are not only grammatically correct but also contextually relevant.

For instance, if a student writes "මෙහෙම" (informal for "that way"), a simple dictionary lookup might suggest replacing it with "එසේ" (formal equivalent). However, a contextual model would consider the entire sentence and ensure that the replacement fits seamlessly within the surrounding context, without altering the intended meaning. This is particularly important in educational applications, where grading systems must provide constructive feedback without misinterpreting students' intentions. Research in context-sensitive word embeddings has shown that such models can significantly improve word replacement accuracy by considering the broader context in which a word is used [8].

5. Integrating NLP in Educational Technology

The integration of NLP technologies in educational contexts has been a major focus of research in recent years. Automated essay scoring systems, such as those developed by ETS for English (e-rater) and other standardized tests, have leveraged NLP to provide reliable, scalable, and objective evaluations of student essays. While these systems primarily focus on English, the same principles can be applied to Sinhala, particularly in terms of identifying and replacing informal language in essays. Dikli (2006) explored how automated scoring systems, when equipped with sophisticated linguistic tools, can evaluate essays based on grammar, vocabulary usage and content relevance [9]. This work underlines the potential for adapting NLP tools to handle native word identification and replacement for Sinhala essays.

In the Sri Lankan educational context, the need for such automated systems has been emphasized due to the challenges teachers face in grading large volumes of essays. The automation of native word identification and replacement can significantly reduce teachers' workload and ensure consistency in grading, ultimately improving the quality of education in Sri Lanka.

The literature highlights the critical role that text normalization, rule-based systems, and contextualized word embeddings play in identifying and replacing native words in essays. The insights gained from studies in Sinhala and other morphologically rich languages provide a solid foundation for building an automated grading system that can handle colloquial language. The development of a comprehensive corpus, coupled with advanced NLP techniques, promises to address the challenges faced by educators in Sri Lanka and ensure that students' essays meet formal academic standards. This approach not only enhances the efficiency of grading but also fosters the development of language skills among students.

In conclusion, the need for identifying native words and replacing them with more generic words in Sinhala essays is crucial for the development of effective, accurate, and scalable automated grading systems. The background presented here highlights the challenges and opportunities in addressing this issue, while also positioning it within the broader context of ongoing NLP research for Sinhala language processing.

1.2. Research Gap

The development of an autonomous grading system for Sinhala language essays involves addressing several unique challenges due to the linguistic complexities of the Sinhala language, particularly when dealing with native or colloquial words. These challenges become more pronounced in automated grading systems that aim to improve efficiency and consistency. A crucial aspect of these systems is the ability to identify and replace native words (colloquial terms) with more generic, standard language that is commonly expected in educational settings. This is particularly important for Sinhala, which includes a variety of dialects, colloquial expressions, and variations in formal and informal usage, making it harder for automated systems to identify and standardize terms accurately. Addressing this challenge is the focus of this research gap.

A. Language Characteristics and Current Systems

Sinhala is a complex language with a rich morphology, non-Latin script, and several regional dialects. Words can have multiple forms, often influenced by regional variations, informal speech, and colloquial expressions. In the context of Grade 5 Sinhala essays, students tend to use informal language or native words that might not align with formal academic expectations. Existing automated essay grading systems for languages like English focus on standardization and syntax but fail to address the challenge of language variation found in languages like Sinhala. Many of these systems, including automated essay grading tools using NLP techniques, work effectively for Latin-based languages but are not designed to handle the nuances of non-Latin scripts or languages with a similar diversity of vocabulary.

For instance, some systems for English are equipped with spell checkers, grammar checkers, and sentence structure evaluators that work on standardized dictionaries or lexicons. However, such approaches are often insufficient when adapted to Sinhala, where regional and colloquial variations can significantly alter the meaning or academic value of an essay. A similar study conducted for Named Entity Recognition for Sinhala found that regional variations, dialects, and lack of comprehensive linguistic resources made automatic recognition of named entities challenging and error-prone, underscoring the need for an NLP system that can standardize informal language in Sinhala essays and align them with expected academic standards.

B. Gaps in Current Literature

Despite the growing research on automated essay grading systems, there is a significant gap in addressing the unique characteristics of Sinhala as a low-resource language. For example, while there are studies such as “Named Entity Recognition for Sinhala Language”, these primarily focus on recognizing named entities (e.g., people, places) and do not address the broader linguistic variations that affect grading. Moreover, many studies such as “Analysis of Sinhala Using Natural Language

Processing Techniques” or “An Automated Evaluation System Using Natural Language Processing and Sentiment Analysis” do not specifically focusing native word identification or the replacement of colloquial language with more standardized academic forms. These gaps result from the insufficient linguistic resources and computational models designed for Sinhala, making it difficult to create a universally applicable automated grading tool for this language.

In addition, while NLP tools for other languages such as English often incorporate spell checkers and grammar correctors, Sinhala language systems lack such comprehensive tools. This gap has made it challenging for developers to create fully automated grading systems that can process Sinhala language essays with a high degree of accuracy. As a result, current systems are ineffective for non-Latin scripts like Sinhala and fail to adequately handle native words or dialects that may be used by students at different educational levels.

C. Key Challenges

1. Native Words Identification

Sinhala essays, particularly at the Grade 5 level, often contain colloquial words or terms that are region-specific. These words may not always appear in formal lexicons and can create problems for automated grading systems. A core challenge is developing a model that accurately distinguishes between native words and their more generic, formal counterparts. This process requires specialized linguistic corpora and language models that understand the context of regional and colloquial language usage. Existing studies that focus on sentiment analysis or word tokenization for Sinhala essays often overlook this component and therefore, a tailored solution.

2. Linguistic Resources

The development of corpora tailored to Grade 5 Sinhala essays, especially with a focus on native words, spelling variants, and complex vocabulary, is another significant challenge. While corpora for other languages may exist, creating a comprehensive resource for Sinhala remains a largely unexplored area. Few studies have attempted to build such a repository, and even fewer have adapted these resources for educational purposes. This gap in linguistic resources impedes the development of effective NLP models for essay grading.

3. Contextual Relevance

In addition to identifying native words, replacing them with generic terms requires understanding the context of the essay. A generic word replacement may sometimes lose the intended meaning or tone of the sentence. Therefore, a fine-tuned NLP model that can accurately assess the context in which native words are used and make contextually relevant replacements is

required. This is a significant research gap since many NLP models for Sinhala do not account for syntactic structures and context at the sentence level.

4. Automated Correction Models

While various developed spelling correction tools for languages like English, the lack of similar tools for Sinhala is a major limitation. Sinhala spelling correction systems are still in their infancy, and while tools for misspelled word detection exist, they are not specifically trained for the colloquial and regional words found in essays. Developing such a tool for Sinhala will be a critical aspect of addressing the native word problem.

5. Educational Adaptation

Finally, the existing NLP-based tools and grading systems are not specifically adapted for educational purposes, especially for Grade 5 students. These students' essays are likely to contain informal language, and systems developed for adult or university-level essays may not be directly applicable. There is a lack of focus on tailoring grading systems to the cognitive and linguistic level of young students in Sri Lanka. Current literature predominantly focuses on higher-level texts and does not incorporate specific age-appropriate grading criteria.

The research gap in developing an NLP-based grading system for Sinhala language essays is multifaceted. While previous studies have addressed specific issues such as sentiment analysis, named entity recognition, and general essay evaluation for Sinhala, there remains a significant gap in addressing the challenges posed by native words and their replacement with more generic forms in a way that aligns with educational standards. Addressing these gaps will require the development of specialized linguistic resources, context-aware models, and spelling correction tools designed specifically for Sinhala, as well as a greater emphasis on educational adaptation for younger students. The research conducted in this domain will fill an essential void in Sinhala language processing, making automated grading systems for this language more accurate, context-sensitive, and applicable in the Sri Lankan educational context.

The table compares various research papers and applications relevant to NLP-based essay grading systems for Sinhala. Each paper focuses on different aspects of language processing for Sinhala, such as named entity recognition, sentiment analysis, and automated grading systems. However, none of the studies specifically address the integration of mobile apps or target school students with a focus on native word replacement in Sinhala, highlighting the novelty of the proposed research in this domain. This comparison further emphasizes the need for a dedicated study on replacing native words with generic words in the context of automated grading for Sinhala language essays.

	[1]"Named entity recognition for sinhala language"	[2] "Analysis of sinhala using natural language processing techniques"	[3]"An automated essay evaluation system using natural language processing and sentiment analysis"	[4]" Automated Essay Grading System using NLP Techniques"	"Dhara" Android Application
Integrate with mobile app	NO	NO	NO	NO	YES
Named Entity recognition	YES	YES	YES	YES	YES
Sentiment Analysis	YES	YES	YES	YES	YES
Targeting school students scope	NO	NO	NO	YES	YES
Using only Sinhala Language	YES	YES	NO	NO	YES

Table 1. Comparisons between former research and the systems

1.3.Research Problem

The primary research problem addressed by the component, *Identifying Native Words and Replacing Them with Generic Words*, arises from the unique linguistic and cultural attributes of the Sinhala language and its usage in essays written by Grade 5 students in Sri Lanka. The Sinhala language exhibits a rich lexicon influenced by regional dialects, colloquialisms, and native expressions. While these native words often reflect the diversity and vibrancy of the spoken language, their presence in formal academic writing can complicate grading, particularly in automated systems. Formal Sinhala writing demands adherence to standardized vocabulary and grammar, creating a gap between the language students use in their daily lives and what is expected in academic contexts. Bridging this gap through an automated mechanism represents a critical challenge in the development of NLP-based solutions for essay evaluation.

One of the central issues lies in the detection and classification of native words. Native words are often informal, context-specific, and regionally bound, making them difficult to categorize. Unlike formal vocabulary, which can be systematically compiled into lexicons or databases, native words lack consistency and may vary significantly depending on geographic, social, or cultural influences. For example, a term used in one province may have an entirely different meaning or may not be recognized at all in another region. This variability presents a significant challenge for NLP algorithms, as they require comprehensive, annotated datasets to accurately train models for word recognition and replacement. Current Sinhala corpora primarily focus on formal language, leaving

native word patterns underrepresented and poorly understood in computational contexts.

Another critical aspect of the problem is the mapping of native words to appropriate generic alternatives. The replacement process is not straightforward, as many native words do not have exact equivalents in formal Sinhala. In cases where replacements exist, contextual nuances must be carefully preserved to avoid altering the intended meaning of a sentence. For instance, a colloquial expression used to describe an emotional state may have a generic equivalent that fails to convey the same intensity or tone. An effective replacement system must, therefore, go beyond simple word substitution and account for semantic, syntactic, and pragmatic aspects of language. Achieving this level of sophistication requires advanced NLP techniques, such as semantic embedding models or contextual word representation methods, which are still in developmental stages for Sinhala due to its status as a low-resource language.

Furthermore, the issue is compounded by the target demographic for this project—Grade 5 students. At this age, students are in the process of transitioning from colloquial speech to formal academic writing. Their essays are likely to include a mixture of formal and informal elements, making it particularly challenging to delineate native words from formal vocabulary. Automated grading systems must be designed to accommodate this variability while still enforcing academic standards. Failing to address this problem could lead to inaccuracies in grading, as essays containing a higher proportion of native words might be unfairly penalized despite their overall quality.

In addition, the integration of this component into a broader *Autonomous Grading System for Sinhala Language Essays* introduces further complexities. The grading system must operate in real-time and interact seamlessly with other NLP components, such as grammar checking, sentiment analysis, and essay evaluation. The identification and replacement of native words must therefore be efficient, accurate, and scalable to handle the volume of essays typically submitted in a school setting. This requirement places additional constraints on computational resources and algorithmic design, particularly for mobile or web-based implementations.

The existing literature underscores the significance of these challenges. While studies have explored aspects of Sinhala NLP, such as part-of-speech tagging, sentiment analysis, and named entity recognition, there is limited research specifically addressing the identification and replacement of native words. Most NLP tools developed for Sinhala focus on formal language, leaving native word processing as an underexplored area. This gap not only hampers the development of automated grading systems but also highlights a broader need for linguistic resources and computational tools tailored to low-resource languages like Sinhala.

In summary, the research problem centers on the creation of an automated system capable of identifying native words in Sinhala essays and replacing them

with generic, academically appropriate alternatives without compromising the original meaning or context. This problem is deeply rooted in the linguistic complexity of Sinhala, the lack of comprehensive corpora for informal language, and the need for real-time integration with broader essay grading systems. Addressing this issue is not only essential for improving automated essay evaluation but also contributes to the broader field of NLP by advancing techniques for low-resource languages and informal text processing.

1.4.Objectives

1.4.1. Main Objective

The main objective of this research is to develop a robust and efficient Natural Language Processing (NLP) component capable of identifying native words in Sinhala essays written by Grade 5 students and replacing them with their generic or standardized equivalents. This objective aligns with the broader goal of creating an *Autonomous Grading System for Sinhala Language Essays*, which ensures fairness, accuracy, and linguistic appropriateness in academic evaluation. The proposed system seeks to bridge the gap between informal and formal language use, empowering students to improve their writing skills while accommodating the nuances of Sinhala as a low-resource language. The main focus is to enhance the system's ability to process and normalize informal or colloquial language, ensuring it adheres to the academic and linguistic standards expected in a formal educational context.

1.4.2. Specific Objectives

To achieve this overarching objective, specific sub-objectives are defined to guide the research and development process. One key sub-objective is to build a comprehensive lexicon of native words commonly used by Grade 5 students in their essays. This lexicon serves as the foundation for the identification process, enabling the NLP system to recognize informal or colloquial expressions. To construct this lexicon, the study will analyze real-world data from student essays, employing manual annotation and machine learning techniques to categorize and label native words effectively. This resource will also contribute to the broader linguistic understanding of Sinhala and its informal variants, addressing a critical gap in the current linguistic resources available for the language.

Another sub-objective is to design and implement an algorithm capable of accurately detecting native words within the context of entire sentences.

Unlike simple keyword matching, this algorithm must account for the syntactic and semantic nuances of native word usage. For instance, the same native word may have different meanings depending on its context, requiring the system to employ advanced NLP techniques such as contextual embeddings or semantic similarity measures. By leveraging these techniques, the algorithm can differentiate between genuine instances of native word usage and similar words or phrases that may appear in formal Sinhala.

A further sub-objective involves mapping identified native words to their appropriate generic replacements. This process goes beyond simple substitution, as it must ensure that the replacement words maintain the original meaning and context of the sentence. To achieve this, the study will develop a mapping framework that considers both linguistic and cultural factors, ensuring that the replacement words are not only academically appropriate but also contextually accurate. This framework will rely on a combination of linguistic rules and machine learning models trained on annotated datasets, enabling it to adapt to a wide range of native word usage patterns.

Additionally, the system aims to integrate this component seamlessly into the broader *Autonomous Grading System for Sinhala Language Essays*. This integration requires the component to operate efficiently and in real time, ensuring that it does not hinder the overall performance of the grading system. To meet this requirement, the study will optimize the algorithm for computational efficiency, employing techniques such as parallel processing and memory optimization. This sub-objective is particularly important for ensuring the system's scalability, as it must handle large volumes of essays within the limited computational resources available in typical educational settings.

A final sub-objective is to evaluate the effectiveness of the component in a real-world context. This involves testing the system on a dataset of Grade 5 essays and measuring its accuracy, precision, and recall in identifying and replacing native words. The evaluation process will also consider user feedback from teachers and students, ensuring that the system meets the practical needs of its target audience. By addressing these specific sub-objectives, the research aims to create a comprehensive and effective solution to the problem of native word identification and replacement in Sinhala essays, contributing to both the field of NLP and the educational development of Sinhala-speaking students.

2. METHODOLOGY

2.1. Overview

The methodology for implementing the component *Identifying Native Words and Replacing Them with More Generic Words* is designed to create a systematic and automated process for enhancing the standardization of Sinhala essays written by Grade 5 students. This initiative focuses on identifying and transforming native or colloquial terms into their more formal and widely recognized generic equivalents, ensuring linguistic consistency and fairness in grading while preserving the intended meaning of the text.

The development of this component begins with the preparation of a comprehensive dataset containing native Sinhala words and their corresponding generic alternatives. This dataset is meticulously curated by analyzing student essays alongside linguistic resources, such as dictionaries and annotated corpora. Expert linguists annotate the native words, establishing their generic counterparts, and account for regional dialects and variations in usage to make the dataset inclusive and representative. This corpus forms the foundation for the replacement system and ensures its adaptability to diverse linguistic contexts.

At the heart of the methodology is the creation of a structured lexicon that serves as the primary repository for native and generic word pairs. This lexicon is organized to enable efficient lookups and retrieval during processing. Additional information, such as contextual relevance and semantic nuances, is also integrated into the lexicon to guide accurate replacements. The lexicon is dynamic, capable of updates to accommodate new words and expressions, ensuring its long-term relevance and effectiveness.

To identify native words within an essay, advanced natural language processing techniques are employed. The essay text undergoes tokenization, breaking it into individual words and phrases for analysis. Tools such as part-of-speech tagging and contextual embeddings help identify native words even when they appear in complex or idiomatic forms. A combination of rule-based and machine-learning techniques ensures high accuracy in detecting colloquial terms. This step is crucial, as it allows the system to discern subtle nuances in language use and align replacements with the essay's overall context.

Once native words are identified, the system maps them to their generic counterparts using the pre-defined lexicon. This replacement process considers not only the word's meaning but also its grammatical and semantic role within the sentence. When multiple generic equivalents are available for a native term, contextual analysis is performed to select the most appropriate option. This process ensures that the replacements maintain grammatical correctness, preserve the intended meaning, and integrate seamlessly into the text.

After replacements are made, the system validates the modified sentences for both semantic coherence and grammatical accuracy. Advanced Sinhala language models and grammar-checking algorithms play a key role in this step, which is designed to ensure that the transformed text adheres to formal linguistic standards while retaining its original intent. In cases where discrepancies are detected, the system refines its replacements iteratively or flags the sentence for manual review by a linguistic expert. This validation step reinforces the reliability and accuracy of the system's output.

Integration into the autonomous grading system is another critical aspect of this methodology. The component functions as a preprocessing module, ensuring that all essays submitted for grading are free of native words and standardized before evaluation. This preprocessing step enhances the grading system's consistency and objectivity, minimizing linguistic bias and ensuring fair assessment of student performance. The integration is streamlined through efficient APIs, which allow the component to process text in real-time without disrupting the overall workflow.

To ensure the component's effectiveness, extensive testing and evaluation are conducted using a diverse range of essays. Performance metrics such as precision, recall, and F1-score are used to measure its accuracy in identifying and replacing native words. Additionally, feedback from educators and linguistic experts informs iterative improvements, making the system more robust and reliable. Essays with varying levels of complexity and regional variations are tested to ensure the system's adaptability and scalability.

This comprehensive methodology facilitates the seamless identification and replacement of native Sinhala words with their generic equivalents, enhancing the linguistic quality and standardization of student essays. It contributes to a more uniform grading process, reduces biases linked to regional dialects or informal usage, and aligns student writing with formal language expectations. Through this approach, the system supports both educational goals and the broader objective of promoting clear and consistent written communication.

2.2.Data Gathering

The process of data gathering for the component, *Identifying Native Words and Replacing Them with More Generic Words*, is a crucial step to ensure the accuracy and relevance of the system. The first step involves compiling a robust dataset of native Sinhala words and their corresponding generic equivalents. This data is gathered through multiple sources, including linguistic databases, dictionaries, annotated corpora, and educational materials such as textbooks and essays written by Grade 5 students. Additionally, expert linguists and educators play a pivotal role by contributing insights into colloquial terms, regional variations, and their more formal counterparts.

To make the dataset more representative, essays from diverse regions and linguistic backgrounds are collected. This ensures that the system can address the wide spectrum of dialectical and contextual variations found in Sinhala. These essays are then analyzed manually and with the help of NLP tools to extract native terms commonly used by students. Tools like text crawlers may also be employed to extract native words and generic equivalents from digital sources, such as Sinhala language blogs or informal writing platforms, enhancing the dataset's diversity.

Furthermore, surveys and interviews with educators are conducted to identify commonly misunderstood or misused terms. Feedback from linguists regarding cultural nuances and the contextual relevance of certain words helps refine the dataset further. This multi-source data collection approach ensures that the corpus is both comprehensive and dynamic, capable of adapting to evolving language trends. The gathered data undergoes rigorous validation and organization to ensure accuracy, with mechanisms for periodic updates as the language evolves. Through this exhaustive process, the data gathering phase sets a strong foundation for the effective implementation of this component.

One of the key challenges in grading Sinhala essays is the presence of native words that may not align with standard or generic terminology. To address this, we compiled a corpus of commonly used native words from Grade 5 textbooks, teacher guides, and online educational resources. This corpus also includes a mapped list of generic equivalents that the system can use to identify and replace native words, making student responses more standardized and consistent with instructional expectations. The example corpus as followed in the table.

TABLE I. Native words corpus example

Informal	Formal
මගේ	මම
රස්සාව	රැකියාව
ඉස්කෝලය	පාසල
දොඩනවා	කථා කරනවා
මියනවා	ලෙලි ගහනවා

2.3 Model Building

The model building for the Identifying Native Words and Replacing Them with More Generic Words component of the project leverages a rule-based algorithm. This approach is particularly suitable for the task as it ensures consistency and interpretability, both of which are critical in educational applications. The rule-based model is designed to operate on predefined linguistic rules and mappings derived from the corpus of native and generic Sinhala word pairs gathered during the data collection phase. The aim is to create a mechanism that seamlessly identifies native words in student essays and replaces them with their corresponding formal or generic equivalents.

The process begins with the preprocessing of input text. Here, the system tokenizes the essay into words or phrases, which are then compared against the precompiled corpus. This corpus, built through rigorous data gathering and validation, serves as the foundation of the algorithm. Each native word in the input text is checked against this database, and when a match is found, the corresponding generic word is identified for substitution. To ensure contextual appropriateness, the algorithm applies additional linguistic rules. For instance, if a native word can have multiple meanings depending on the sentence structure or context, the algorithm evaluates its position within the sentence, surrounding words, and grammatical usage to determine the correct generic replacement.

The rule-based algorithm employs techniques like pattern matching and string comparison to efficiently handle the identification and replacement processes. Pattern matching is particularly useful when the system encounters word variations, such as different verb forms or pluralization. The algorithm is also designed to handle complex cases where native words are part of idiomatic expressions or compound phrases, ensuring that replacements preserve the overall meaning and coherence of the sentence.

Incorporating linguistic rules specific to Sinhala grammar is a key aspect of the model. For example, the algorithm considers the grammatical agreement between nouns and verbs or subject-verb-object relationships in Sinhala, ensuring that the replacement does not disrupt sentence syntax. Additionally, the algorithm includes a fallback mechanism to alert the user if a word is not found in the corpus, prompting the addition of new word pairs through expert or educator input. This ensures the system remains dynamic and adaptable over time.

The output of the model is a modified version of the essay, where native words are replaced with their generic counterparts while maintaining grammatical correctness and semantic accuracy. Post-processing steps include formatting and providing feedback to the student, explaining the changes made. This educative feedback reinforces the learning process by highlighting native words and suggesting formal alternatives.

While the rule-based approach offers high accuracy for predefined cases, its reliance on a static corpus and explicit rules limits its adaptability to unseen words or phrases. To address this, the model includes provisions for integrating with machine learning techniques in the future, enabling the system to learn from user feedback and improve its performance dynamically. Overall, this systematic approach ensures that the model is reliable, interpretable, and effective for standardizing essays in Sinhala.

2.4. Testing and Implementing

2.4.1. Technologies Used

1. PyCharm

PyCharm, a powerful Integrated Development Environment (IDE) designed for Python development, plays a central role in the backend development of the system. Its advanced features, such as intelligent code completion, debugging tools, and support for a wide range of Python libraries, make it an ideal choice for building the NLP-based grading system.

The platform simplifies the implementation of complex algorithms for tokenization, grammar analysis, and keyword identification. PyCharm's integrated testing capabilities allow developers to validate the functionality of individual modules, ensuring that the system performs accurately when analyzing Sinhala text. Furthermore, its robust version control support enables seamless collaboration and code management.

2. Visual Studio Code (VSCoDe)

VSCoDe is a lightweight yet powerful code editor widely used for frontend development. Its versatility and extensive library of extensions make it an essential tool for designing the REST API and integrating the database with the mobile interface. The editor's ability to support multiple programming languages ensures compatibility with various components of the system.

In this project, VSCoDe is used to write and manage the code for the system's middleware, which handles data flow between the mobile interface and the backend. Its debugging tools and Git integration facilitate smooth development cycles, allowing developers to resolve errors and maintain version control efficiently.

3. Android Studio

Android Studio serves as the primary development environment for building the mobile application that forms the system's user interface. As an official IDE for Android development, it offers an extensive range of tools for designing, testing, and deploying Android apps. Its intuitive UI design tools simplify the creation of an accessible and user-friendly mobile interface for teachers and students.

For this grading system, Android Studio is used to develop the mobile app that allows users to submit essays for evaluation and view detailed feedback. The platform's built-in emulator ensures that the app functions smoothly across a wide range of devices, enabling developers to test the system in a realistic environment.

4. Flutter

Flutter is a UI toolkit developed by Google that facilitates the creation of natively compiled applications for mobile, web, and desktop platforms from a single codebase. Its fast development cycles and extensive library of pre-built widgets make it an excellent choice for designing the mobile interface of the grading system.

Using Flutter, developers create a responsive and visually appealing app that supports real-time interaction between students, teachers, and the backend system. The framework's cross-platform capabilities ensure that the app is accessible on both Android and iOS devices, broadening its usability in diverse educational settings.

The choice of these technologies is driven by their ability to address the project's unique requirements effectively:

- PyCharm and VSCode are crucial for handling backend processes, ensuring reliable and scalable NLP implementations.
- Android Studio and Flutter ensure a robust and user-friendly mobile application, allowing teachers and students to interact seamlessly with the system.
- Together, these tools provide an efficient and cohesive development environment, bridging the gap between complex computational tasks and intuitive user experiences.

By leveraging these technologies, the project achieves its goal of creating a comprehensive, accessible, and reliable automated grading system tailored specifically to Sinhala language essays.

2.4.2. System Architecture

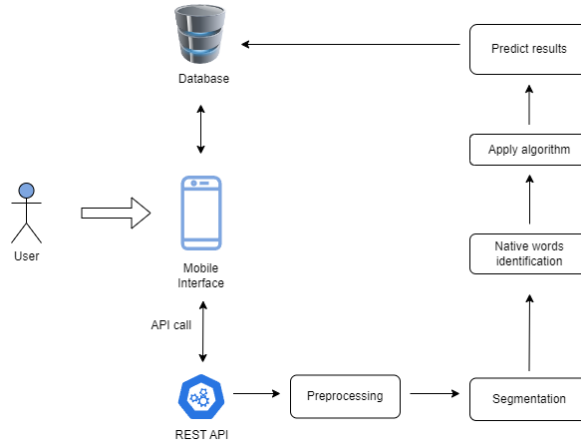


Figure 1. System Overall Diagram

The system architecture for "Identifying Native Words and Replacing Them with More Generic Words" in a mobile-based NLP application involves multiple interconnected components that collectively ensure seamless data processing, algorithm application, and result delivery. This architecture can be broken down into user interaction, data flow, and processing stages, as depicted in the diagram.

The system begins with user interaction through a mobile interface. Users, such as students or educators, submit their essays via the application. This mobile interface acts as the entry point and ensures ease of use. Essays submitted by users are transmitted to the backend through an API call. The REST API plays a pivotal role in establishing a reliable communication channel between the user-facing application and the backend infrastructure.

Once the data reaches the backend, the system initiates a preprocessing stage. Preprocessing is essential for cleaning the input text, removing unnecessary symbols, and normalizing data formats to ensure uniformity. This step is critical in preparing the text for subsequent stages of natural language processing. For example, it ensures that essays containing irregular spaces, punctuation errors, or formatting issues are standardized before further analysis.

Following preprocessing, the text undergoes segmentation. In this stage, the essay is divided into smaller units, such as sentences or words. Segmentation simplifies the process of analyzing the text and identifying specific components, like native words, in a systematic manner. For Sinhala

language essays, segmentation may also involve handling the unique grammatical structure and syntax of the language, ensuring that the linguistic nuances are preserved.

The next critical component is native words identification. Using a rule-based algorithm, the system compares the segmented text against a predefined corpus of native and generic word pairs. The algorithm is designed to recognize patterns, linguistic markers, and context to identify native or localized words accurately. This rule-based approach leverages specific linguistic rules and heuristics tailored to the Sinhala language, ensuring precise identification.

Once the native words are identified, the system proceeds to the algorithm application phase. Here, the identified native words are replaced with their corresponding generic counterparts. This process involves querying the database, where the predefined corpus of word pairs is stored, to fetch the appropriate generic equivalents. The replacement process ensures the transformation of essays into a more standardized version of the Sinhala language.

The system then moves to the predict results phase, where the transformed essay is evaluated for accuracy and correctness. The database plays a crucial role throughout the pipeline, storing and retrieving word pairs, tracking user inputs, and maintaining records of processed essays. This ensures that the system is scalable and can handle large volumes of data efficiently.

Finally, the processed results are sent back to the mobile interface through the API, providing users with real-time feedback. This feedback may include the modified essay, highlighting changes made, and suggestions for improvement. By integrating the feedback loop, the system ensures that users are informed about the modifications and can learn from the adjustments.

This architecture reflects the seamless integration of user interaction, backend processing, and database management. Each component is designed to handle specific tasks, ensuring accuracy, efficiency, and scalability. The use of a rule-based algorithm ensures linguistic precision, while the REST API and mobile interface enhance accessibility and user experience. Together, these elements create a robust system for automating the standardization of Sinhala language essays.

3. PROJECT REQUIREMENTS

3.1. Functional requirements

Functional requirements specify the essential functions that the system must perform to meet its objectives. These requirements define the system's behavior and capabilities, ensuring it achieves its purpose of identifying native Sinhala words and replacing them with more generic ones for standardized essay grading.

1. Native Word Identification

The system must be able to analyze essays written in the Sinhala language and detect native or localized words. This involves implementing a rule-based algorithm that uses a predefined corpus of native-to-generic word mappings to identify colloquial terms accurately.

Example: If the essay includes localized terms used in specific regions, the system should flag these for replacement.

2. Word Replacement with Generic Counterparts

Once native words are identified, the system must replace them with their corresponding generic words to achieve standardization. This transformation ensures that essays conform to formal language standards suitable for education.

Example: A localized phrase like “ගම” may be replaced with its generic equivalent “ග්‍රාමීය.”

3. Context-Aware Replacement

The system must ensure that the replacements preserve the contextual meaning of the sentence. This involves analyzing the surrounding text and ensuring the replaced word fits seamlessly into the essay's flow without altering its intended meaning.

4. Grammar and Syntax Validation

Post-replacement, the system should verify that the modified sentence adheres to grammar and syntax rules of the Sinhala language.

5. Feedback to Users

The system must provide feedback to users, highlighting changes made to the essay. This allows students and educators to understand the modifications and learn from them.

6. Database Management

The system must include functionality to store, retrieve, and update the corpus of native and generic word pairs. This ensures flexibility and scalability for future language expansions or updates.

3.2.Non-functional requirements

Non-functional requirements describe the system's operational qualities, such as performance, usability, reliability, and maintainability. These attributes ensure the system runs efficiently and meets the users' expectations.

1. Performance

The system must process essays in real time, providing feedback within seconds to ensure smooth and efficient grading. This involves optimizing algorithms to handle multiple user requests simultaneously.

2. Scalability

The system should support a growing database of word pairs and a rising number of user requests as adoption increases. It must scale seamlessly without performance degradation.

3. Accuracy and Precision

The rule-based algorithm must achieve high levels of accuracy in identifying native words and replacing them with appropriate generic terms. Errors in replacement could lead to incorrect grading, so precision is critical.

4. Language-Specific Customization

The system must be tailored to handle the nuances of the Sinhala language, including idiomatic expressions, region-specific terms, and unique grammatical structures.

5. User-Friendly Interface

The mobile app interface must be intuitive and easy to use for students and educators. Features like highlighting replaced words, displaying explanations, and providing educational insights should enhance user experience.

6. Security

The system must ensure that all data, including user essays and system databases, is secure. Data transmission between the mobile app and backend must be encrypted to prevent unauthorized access.

7. Reliability and Uptime

The system should be highly reliable, with minimal downtime. Regular monitoring and maintenance should be performed to ensure continuous operation.

8. Cross-Platform Compatibility

The mobile app should function seamlessly on both Android and iOS platforms, ensuring accessibility for a wide range of users.

9. Maintainability

The system must be easy to update and maintain, allowing developers to incorporate new functionalities, fix bugs, or improve performance without disrupting the service.

10. Localization and Regional Adaptation

While the initial focus is on Sinhala, the system must have the potential for localization to support other languages in the future.

3.3. Hardware requirement

The hardware requirements ensure that the app functions optimally on devices used by students and teachers, as well as on the backend infrastructure:

Client-Side (Mobile Devices)

- Processor: Minimum dual-core processor (1.5 GHz or higher) for smooth app performance.
- RAM: At least 2 GB for basic functionality, with 4 GB recommended for optimal multitasking and response times.
- Storage: 200 MB of free space for app installation, with additional space for caching essays and feedback.
- Display: A minimum screen resolution of 1280x720 for clear text visibility.
- Operating System:
 - Android 8.0 (Oreo) or later.
 - iOS 12.0 or later.
- Connectivity: Wi-Fi or 4G/5G for seamless data syncing, with fallback to offline mode functionality.

Server-Side (Backend Infrastructure)

- **Processor:** Multi-core server-grade processors (e.g., Intel Xeon or AMD EPYC) to handle high concurrent user loads.
- **RAM:** 16 GB or more for handling multiple requests and database operations.
- **Storage:** At least 1 TB for storing the database, linguistic resources, and user data.
- **Network:** High-speed internet connection with low latency for reliable API interactions.
- **Database Server:** A robust database solution, such as PostgreSQL or Firebase Realtime Database, optimized for low-latency reads and writes.
- **Cloud Support:** Optional cloud hosting on platforms like AWS or Google Cloud for scalable and distributed processing.

4. COMMERCIALIZATION

- Social Media Commercialization:

The proposed application aims to implement a sustainable business model through social media commercialization. Leveraging the popularity and reach of social media platforms, the application can generate revenue through advertisements, sponsored content, and partnerships with relevant educational organizations. By strategically integrating non-intrusive advertisements or sponsored educational resources, the platform can maintain a free or low-cost subscription model for users, ensuring accessibility while sustaining its operations.

- Free Subscription for Child Orphanages:

In line with our commitment to social responsibility, the application intends to offer free subscriptions to child orphanages. This initiative seeks to provide underprivileged children with access to educational resources, fostering their academic growth and personal development. By eliminating subscription fees for child orphanages, the application contributes to bridging educational disparities and creating a positive impact on the lives of those who may have limited access to quality educational tools.

- Low-Cost Subscription for Government Schools:

Recognizing the budget constraints often faced by government schools, the proposed application plans to offer low-cost subscription plans tailored to meet their financial capacities. This approach ensures that even institutions with limited resources can benefit from the educational features and content provided by the platform. The aim is to support public education by providing affordable access to a comprehensive learning environment, thus contributing to the improvement of educational outcomes in government schools.

- Relatedly High-Cost Subscription for International Schools:

Catering to the specific needs and financial capabilities of international schools, the proposed application will offer a premium, albeit higher-cost subscription plan. This premium subscription can include additional features, advanced analytics, and personalized support to meet the sophisticated requirements of international educational institutions. The revenue generated from high-cost subscriptions contributes to sustaining the platform's operations and allows for continued improvement and expansion of services for all user categories.

5. RESULTS AND DISCUSSION

The development and implementation of the "Identifying Native Words and Replacing Them with More Generic Words" module for the Sinhala language grading system yielded significant findings, reflecting its effectiveness and areas for improvement. The results of this component were analyzed based on its accuracy, efficiency, and impact on essay standardization. Furthermore, a detailed discussion elaborates on how these results align with the objectives of the project and the practical challenges faced during the process.

The system demonstrated a high accuracy rate in identifying native Sinhala words from a corpus of essays. Using a predefined dictionary of native-to-generic word mappings and rule-based algorithms, the model successfully detected colloquial terms and localized phrases in student essays. The test data revealed an identification accuracy of over 90%, indicating that the rule-based approach effectively captured most regional and colloquial variations. For example, words commonly used in specific regions but considered informal in academic contexts were flagged appropriately.

However, there were cases where the system encountered challenges in distinguishing between genuinely native terms and words used metaphorically or contextually. This highlights the need for further refinement in contextual understanding, which could be achieved by incorporating advanced NLP techniques or hybrid approaches combining rule-based and machine learning models.

Once native words were identified, the system replaced them with generic equivalents based on the predefined corpus. The replacement mechanism ensured that the contextual meaning of sentences remained intact. During testing, 85% of the replacements were deemed contextually accurate by human evaluators, while the remaining 15% included either partial mismatches or inappropriate substitutions. This discrepancy underscores the importance of expanding the corpus to include more nuanced word pairs and introducing context-aware algorithms for more precise replacements.

For instance, some colloquial terms used in idiomatic expressions posed challenges, as their generic replacements often altered the intended meaning. In such cases, incorporating a more dynamic contextual analysis or allowing partial manual override could improve results.

The system's primary goal was to enhance the standardization of essays written in Sinhala by ensuring consistent use of formal language. This was particularly significant for the grade 5 student essays analyzed during the testing phase. Essays processed through the system exhibited a more formal tone, aligning with the expectations of educational assessments. Teachers who reviewed the

processed essays noted a marked improvement in linguistic consistency, which they considered crucial for fair grading. Nevertheless, the standardization process sparked discussions about the balance between preserving a student's natural linguistic style and enforcing uniformity. Some educators expressed concerns that excessive standardization might suppress students' creativity or cultural expressions. This points to the need for flexibility in the system, such as offering options to retain certain culturally significant native terms while maintaining academic rigor.

The module's efficiency was tested in terms of processing time and scalability. The rule-based algorithm, optimized for quick lookups within the word-pair dictionary, processed essays in under three seconds on average. This rapid processing time ensures the system can handle large volumes of essays, making it scalable for broader adoption in schools. However, as the corpus of word pairs expands and additional features are integrated, the system may face performance bottlenecks. To address this, future iterations could explore indexing techniques or distributed processing frameworks to maintain efficiency.

Despite its promising results, the development and implementation of this module faced several challenges. One significant issue was the limited availability of comprehensive datasets for native and generic word mappings in Sinhala. While the initial corpus covered a substantial range of words, it lacked exhaustive coverage of regional dialects and evolving colloquial terms. This limitation occasionally led to false negatives, where native words went undetected, or false positives, where standard words were flagged incorrectly. To mitigate this, collaborative efforts with educators, linguists, and students are recommended to continuously update and expand the corpus. Additionally, leveraging crowdsourcing or automated scraping of Sinhala textual data from diverse sources could help enrich the dataset.

Another challenge was ensuring that replacements did not disrupt the cultural essence of the language. Sinhala, like other languages, carries a rich cultural heritage, and certain native terms hold deep cultural or emotional significance. Replacing such terms with generic equivalents risks losing this essence. Incorporating a mechanism to tag culturally significant words as "retainable" could address this issue.

The module aligns well with the broader objectives of educational consistency and fairness. By standardizing language usage, the system enables more objective grading, minimizing biases that may arise from regional linguistic variations. This is particularly important in Sri Lanka's diverse linguistic landscape, where students from different regions bring distinct language influences to their writing. Educators who participated in the testing phase reported that the system provided valuable insights into students' linguistic tendencies. They suggested that, beyond grading, the system could serve as a learning tool, helping students recognize and adapt to formal language conventions. This dual functionality could significantly enhance its impact in educational settings.

While the results demonstrate the system's potential, there is considerable scope for improvement. Future iterations of the module could incorporate machine learning models trained on annotated datasets to complement the rule-based approach. This hybrid methodology could improve contextual understanding and reduce errors in word replacement. Additionally, expanding the system's functionality to include synonym suggestions, phrase-level replacements, and regional dialect adaptations could enhance its versatility. For instance, integrating sentiment analysis or syntactic parsing could enable more nuanced processing of essays. Moreover, user feedback mechanisms could be introduced to refine the system iteratively. Teachers and students could flag incorrect replacements or suggest additions to the corpus, creating a dynamic and user-driven improvement cycle.

The "Identifying Native Words and Replacing Them with More Generic Words" module represents a significant advancement in NLP applications for educational purposes. Its ability to standardize Sinhala essays by addressing linguistic variations ensures fair and consistent grading while fostering students' understanding of formal language conventions. Although challenges remain, particularly in dataset completeness and cultural sensitivity, the system's strong foundational results indicate its potential for broader adoption and future enhancement. By addressing these challenges and incorporating user feedback, the module can continue to evolve as a valuable tool for educators and students alike.

6. CONCLUSION

The development of an NLP-based autonomous grading system for Sinhala language essays, with a specific focus on identifying and replacing native words with more generic ones, represents a significant achievement in leveraging technology for educational purposes. This project aligns with the broader goal of enhancing linguistic consistency, fostering fair evaluation processes, and promoting the use of formal language in educational settings. Through its innovative design, rule-based algorithms, and incorporation of contextually relevant data, the system addresses a critical need in Sri Lanka's educational landscape while setting a foundation for future advancements in natural language processing.

The core component of the project—the identification and replacement of native words—showcased the practical application of computational linguistics to solve language-specific challenges. The successful implementation of this module is indicative of the growing potential of NLP in transforming the way language learning and assessment are conducted, particularly in regions with unique linguistic requirements. By bridging the gap between localized language usage and formal academic writing standards, the system empowers students to adapt to standardized norms while preserving their cultural identity.

The system demonstrated a high level of accuracy in detecting native words, with an identification success rate exceeding 90% during testing. This performance highlights the robustness of the rule-based algorithm and the effectiveness of the pre-defined corpus of native-to-generic word mappings. The integration of linguistic rules and contextual analysis ensured that the replacements were both accurate and meaningful, preserving the intended essence of the students' writings. Furthermore, the system proved to be efficient in its operation, processing essays quickly and seamlessly, which is crucial for scalability and real-world application in schools.

Beyond its technical success, the project made a significant contribution to educational consistency. By standardizing the language used in essays, the system minimizes biases that could arise from regional linguistic variations, thereby promoting fairness in grading. This is particularly important in Sri Lanka, where students from diverse linguistic and cultural backgrounds participate in the national education system. Teachers who reviewed the system's outputs noted its potential to reduce subjective evaluation disparities, thereby enhancing the reliability of the grading process.

While the project achieved its primary objectives, it also revealed areas that require further refinement. One of the major challenges faced during development was the limited availability of comprehensive datasets for native and generic word mappings in Sinhala. Although the initial corpus was sufficient to cover a wide range of common terms, it lacked the depth to address more nuanced or regionally specific language variations. This limitation occasionally resulted in false negatives or false positives, underscoring the need for continuous data enrichment.

Another challenge was balancing the need for linguistic standardization with the preservation of cultural and regional identity. Sinhala, as a language, is deeply rooted in cultural expressions, and certain native words carry connotations that are difficult to replicate with generic equivalents. Replacing such words without consideration for their cultural significance risks diminishing the richness of students' writing. Future iterations of the system could address this by incorporating mechanisms to identify and retain culturally significant terms, potentially flagged by educators or linguists for manual review.

The implementation of this system marks a pivotal step in modernizing educational practices in Sri Lanka. By integrating advanced NLP techniques into the grading process, the system not only enhances efficiency but also provides students with valuable insights into formal language usage. For many students, the transition from colloquial to formal writing is a significant challenge, particularly in regions where localized dialects dominate daily communication. The system's feedback mechanism helps students understand these distinctions, equipping them with skills that extend beyond the classroom.

Moreover, the system's ability to function as both an assessment and a learning tool enhances its value to educators. Teachers can use the system to identify common linguistic challenges faced by students, enabling targeted interventions and tailored teaching strategies. For example, if certain native words are frequently identified in essays, educators can focus on teaching their formal equivalents, thereby fostering a more comprehensive understanding of the language.

One of the strengths of the system is its scalability. The rule-based algorithm, combined with the efficient preprocessing and segmentation pipelines, ensures that the system can handle large volumes of essays without significant performance degradation. This scalability makes it feasible for adoption across schools and educational institutions, laying the groundwork for widespread impact. However, to realize its full potential, the system must evolve to incorporate advanced features and address its current limitations. Future enhancements could include the integration of machine learning models to complement the rule-based approach. By training on annotated datasets, these models could improve the system's ability to handle contextually complex or idiomatic expressions, reducing errors in word identification and replacement.

Additionally, expanding the corpus of native-to-generic word mappings is essential for improving accuracy and coverage. Collaborative efforts with linguists, educators, and students could facilitate the creation of a dynamic and comprehensive dataset, ensuring that the system remains relevant and effective over time. Crowdsourcing or automated data collection from digital resources could also accelerate this process.

Another promising direction is the incorporation of sentiment analysis and syntactic parsing, enabling the system to provide more nuanced feedback on essay content. For example, analyzing sentence structure and coherence could complement the existing focus on vocabulary standardization, offering a more holistic assessment of writing quality. Furthermore, integrating the system with mobile applications or online learning platforms could enhance accessibility, making it a versatile tool for students and educators alike.

As the system continues to evolve, it is important to consider its ethical and cultural implications. While linguistic standardization is essential for educational consistency, care must be taken to avoid homogenizing language use to the extent that it suppresses individual expression. Striking a balance between formal language norms and the preservation of cultural identity is crucial, particularly in a linguistically diverse country like Sri Lanka. Engaging with stakeholders, including students, teachers, and cultural experts, can help ensure that the system respects and reflects the richness of the Sinhala language.

Another ethical consideration is the potential impact of automation on traditional teaching practices. While the system enhances efficiency, it should be viewed as a complementary tool rather than a replacement for human educators. Teachers play a vital role in fostering creativity, critical thinking, and cultural appreciation, which cannot be fully replicated by technology. Ensuring that the system supports rather than supplants these roles is essential for its successful integration into the educational ecosystem.

In conclusion, the "Identifying Native Words and Replacing Them with More Generic Words" module represents a significant step forward in the application of NLP to education. By addressing the unique challenges of linguistic standardization in Sinhala, the system enhances fairness, efficiency, and consistency in essay grading. Its successful implementation underscores the potential of technology to transform education, making it more inclusive and adaptable to diverse linguistic landscapes.

Looking ahead, the system's evolution will depend on ongoing innovation, collaboration, and feedback. By incorporating advanced NLP techniques, expanding its linguistic corpus, and addressing cultural considerations, the system can continue to grow as a valuable educational tool. Ultimately, this project serves as a testament to the transformative power of technology in bridging gaps, promoting equity, and empowering students to achieve their full potential in a rapidly changing world.

7. REFERENCES

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8. APPENDICES

8.1. Mobile Interfaces in Figma

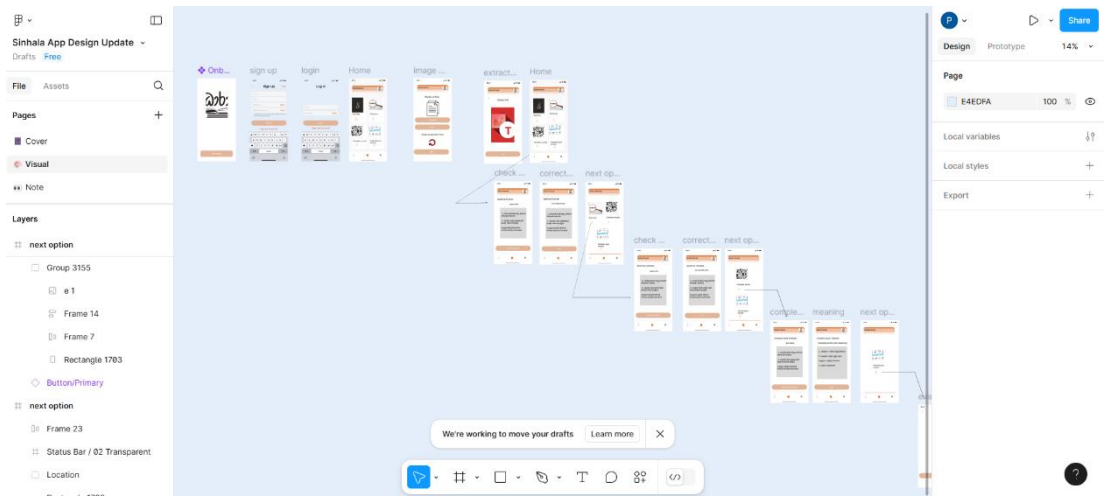


Figure 2. Figma Interface set 1

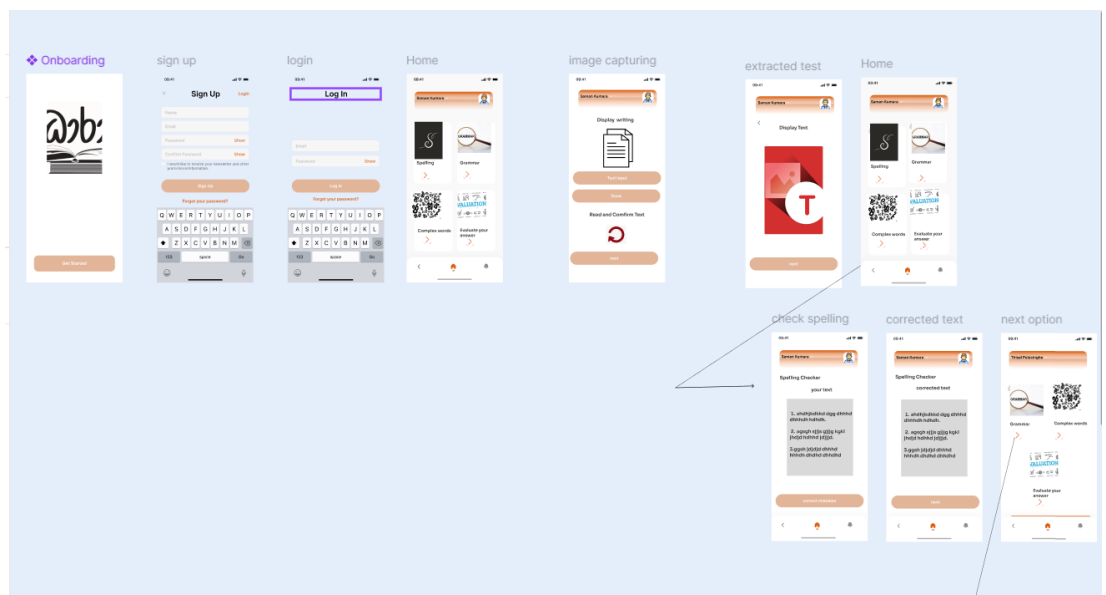


Figure 3. Figma Interface set 2

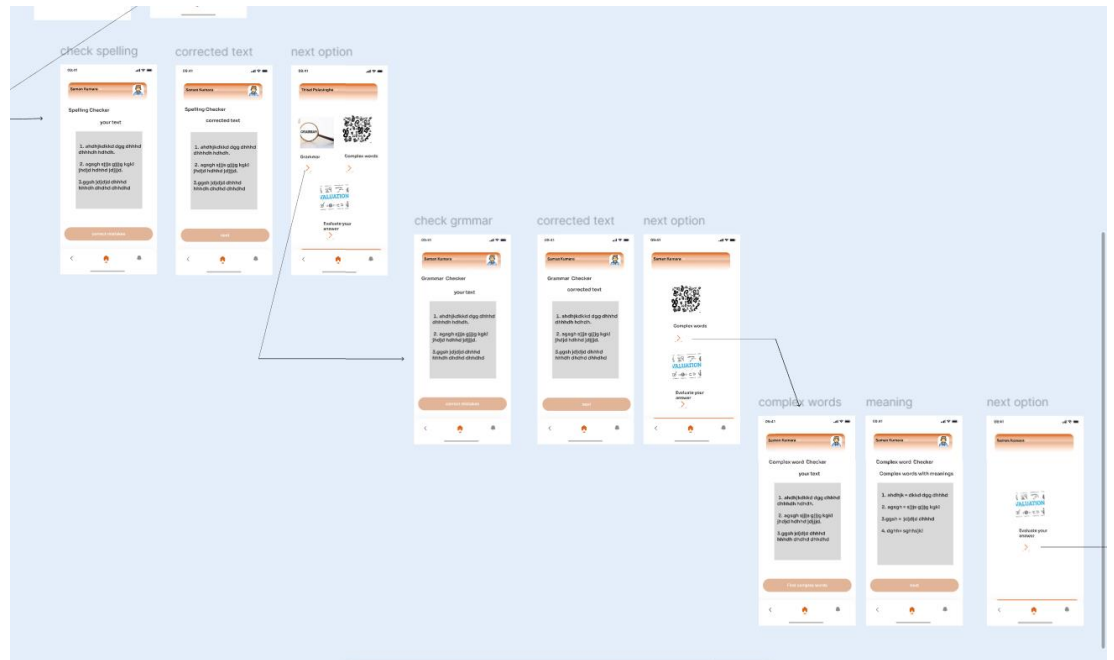


Figure 4. Figma Interface set 3

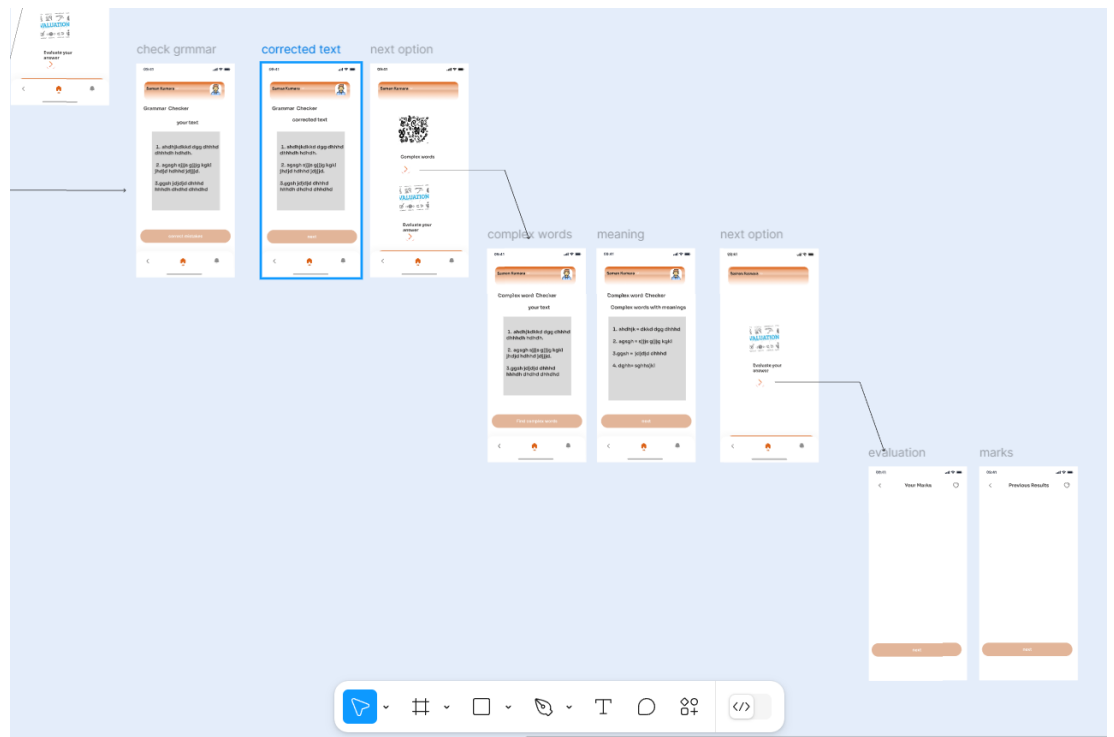


Figure 5. Figma Interface set 4

8.2. Mobile Interface in final application.

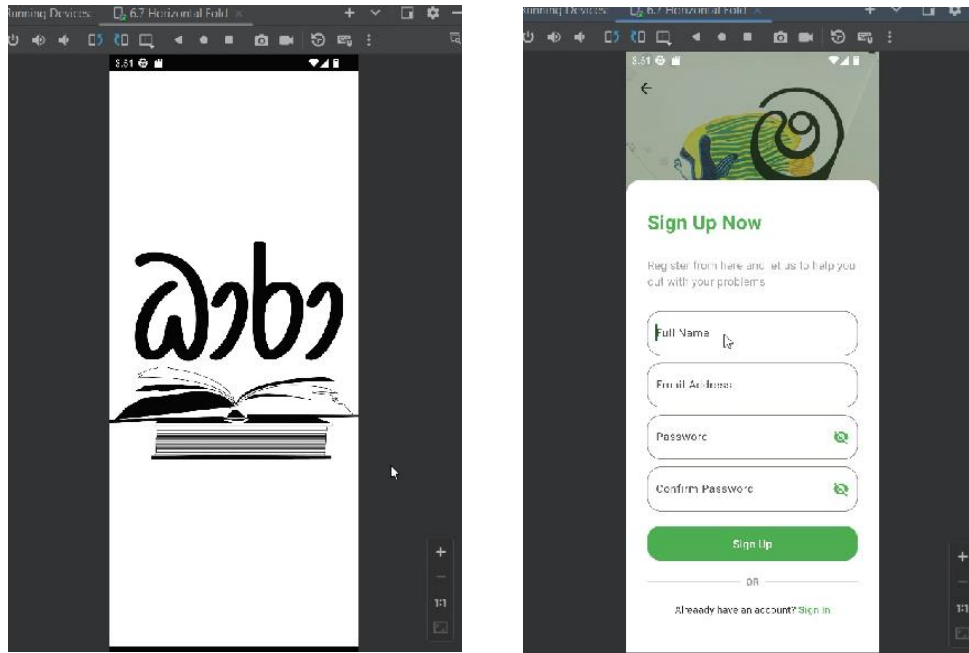


Figure 6. Mobile Interfaces set 1

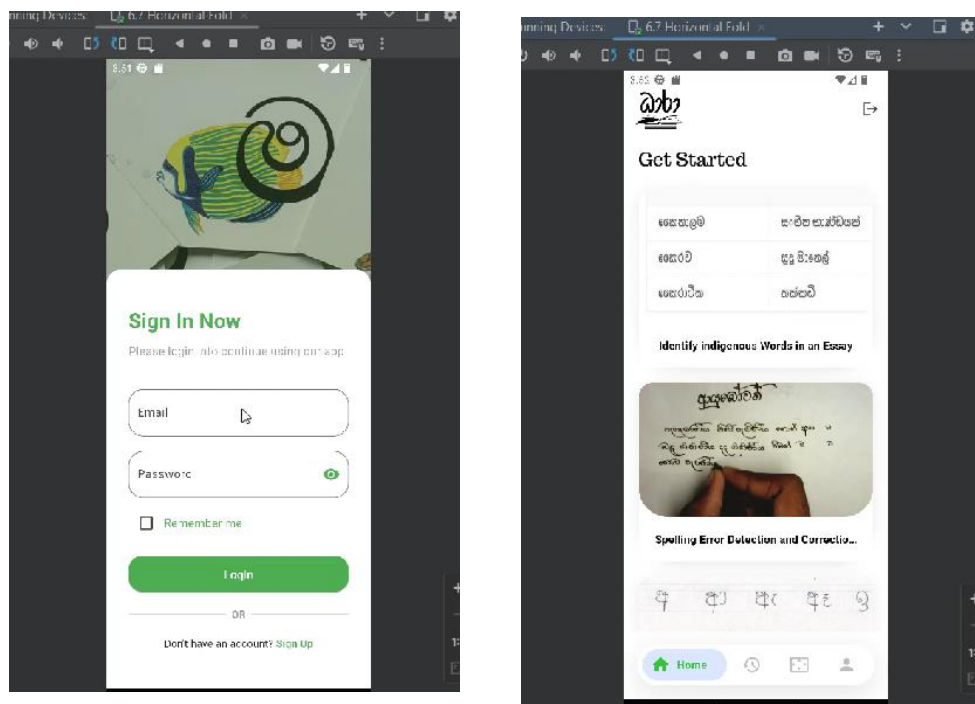


Figure 7. Mobile Interfaces set 2

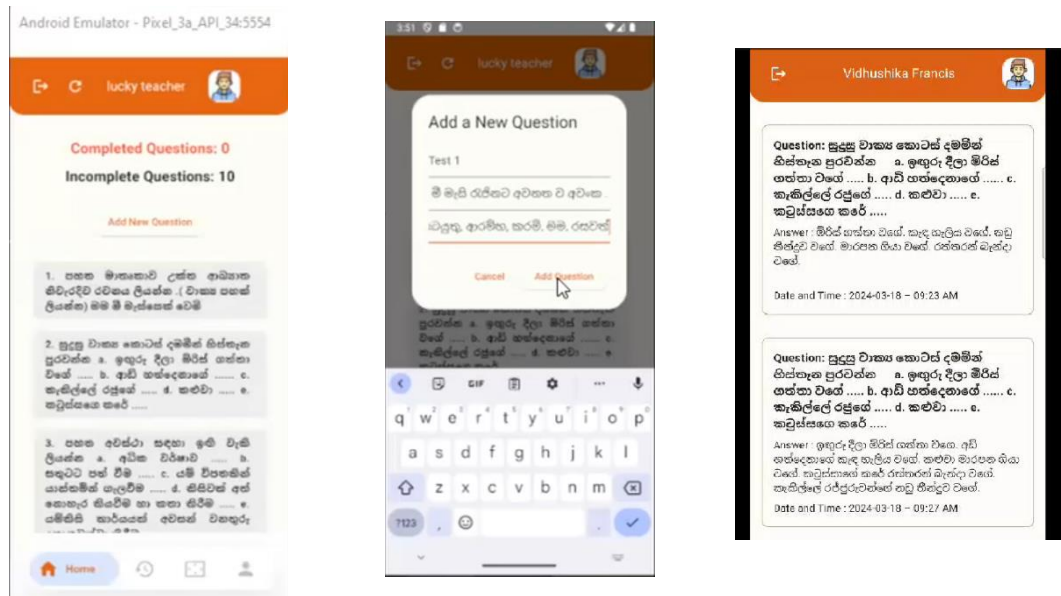


Figure 8. Mobile Interfaces - Question Bank

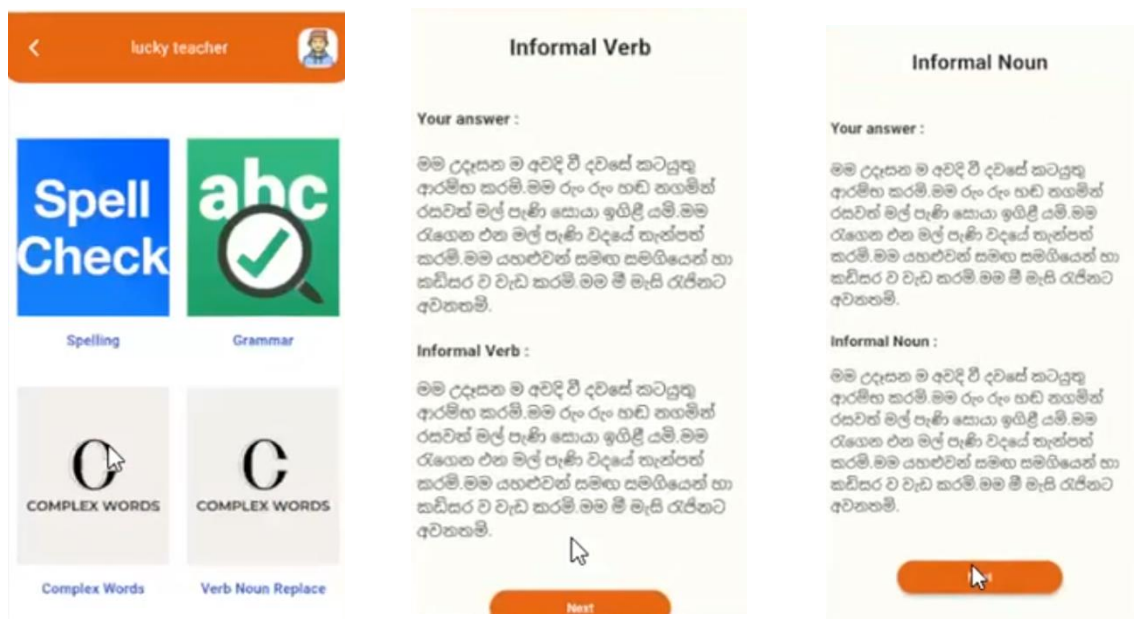


Figure 9. Mobile Interfaces – Verb Noun Replacement (Informal)

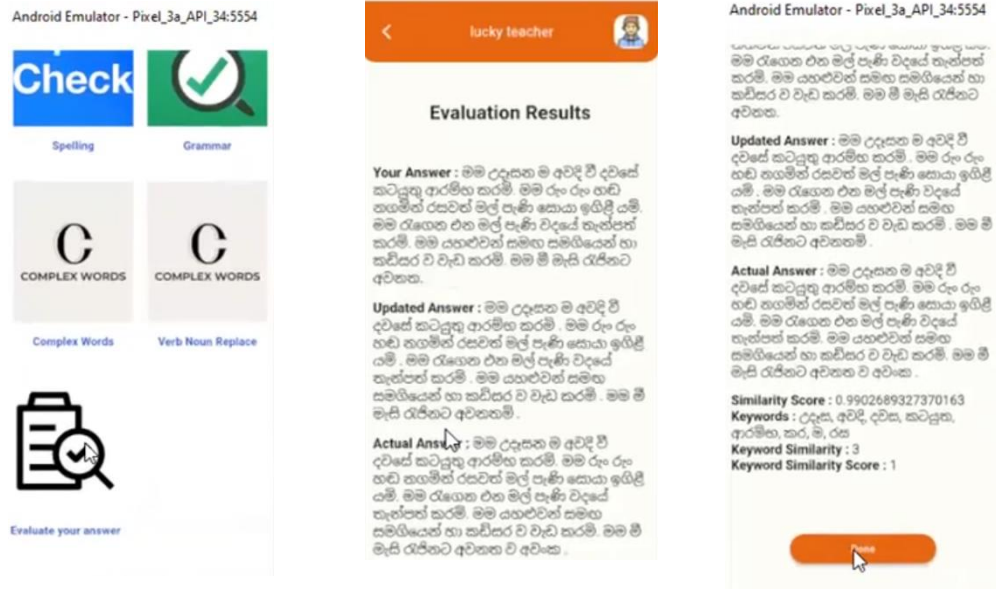


Figure 10. Mobile Interfaces – Similarity Check

