Artificial Intelligence support Scrabble Game for Sinhala Language

Y. S. Weerathunga

2024

Artificial Intelligence support Scrabble Game for Sinhala Language

A dissertation submitted for the Degree of Master of Computer Science

Y. S. Weerathunga
University of Colombo School of Computing
2024

Declaration

Name of the student: Y. S. Weerathunga
Registration number: 2019MCS098
Name of the Degree Programme: Individual Project (MCS)
Project/Thesis title: Artificial Intelligence support Scrabble Game for Sinhala Language

1. The project/thesis is my original work and has not been submitted previously for a degree at this or any other University/Institute. To the best of my knowledge, it does not contain any material published or written by another person, except as acknowledged in the text.

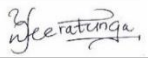
2. I understand what plagiarism is, the various types of plagiarism, how to avoid it, what my resources are, who can help me if I am unsure about a research or plagiarism issue, as well as what the consequences are at University of Colombo School of Computing (UCSC) for plagiarism.

3. I understand that ignorance is not an excuse for plagiarism and that I am responsible for clarifying, asking questions and utilizing all available resources in order to educate myself and prevent myself from plagiarizing.

4. I am also aware of the dangers of using online plagiarism checkers and sites that offer essays for sale. I understand that if I use these resources, I am solely responsible for the consequences of my actions.

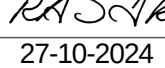
5. I assure that any work I submit with my name on it will reflect my own ideas and effort. I will properly cite all material that is not my own.

6. I understand that there is no acceptable excuse for committing plagiarism and that doing so is a violation of the Student Code of Conduct.

Signature of the Student	**Date (DD/MM/YYYY)**
	28/09/2024

Certified by Supervisor(s)

This is to certify that this project/thesis is based on the work of the above-mentioned student under my/our supervision. The thesis has been prepared according to the format stipulated and is of an acceptable standard.

	Supervisor 1	**Supervisor 2**	**Supervisor 3**
Name	Dr. M.D.R.N Dayaratna		
Signature			
Date	27-10-2024		

ACKNOWLEDGMENT

I would like to express my sincere gratitude to everyone who contributed to the success of this project. Special thanks to my academic supervisor for their invaluable guidance and support throughout this journey. I'm also grateful to my peers and colleagues for their insights and encouragement. My heartfelt appreciation goes to my family and friends for their unwavering support and motivation. Additionally, I acknowledge the contributions of the research community and any funding bodies that have supported this work. Their collective knowledge and resources were instrumental in the completion of this project.

ABSTRACT

The combination of technical and traditional word games in language learning tools creates a new approach to language learning and cognitive development. This study begins to develop a Scrabble game designed for Sinhalese, incorporating advanced artificial intelligence (AI) to enhance gameplay and educational value Recognizing the rarest of language games with unique orthographic and syntactic characteristics in non-English languages, especially Sinhala , This project aims in order to fill the gap necessary for By carefully analysing existing Scrabble games and adapting them to the Sinhalese language system, this research seeks the intricacies of the language, including its rich morphology and unique text, to create a complex and instructive AI-driven game.

The approach includes critical revision of linguistic standards of Sinhalese, development of complex Sinhalese vocabulary, and AI algorithms capable of simulating strategic games using and is to strengthen language skills instead It is also a model for the use of AI in educational language games.

Quantitative and qualitative impacts of the game were assessed in terms of improved language skills, player engagement and AI competitiveness. Preliminary findings indicate a positive relationship between routine use of games and improved language skills, emphasizing the potential of games as new language learning tools.

The research contributes to the development of computational linguistics, AI and language learning by showing how technology can bridge the language learning gap. It opens the way for future studies on the integration of AI into teaching tools for the development of new languages with unique linguistic features.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

1.1. Motivation

The integration of technology into language learning has revolutionized educational methodologies, offering diverse and flexible learning environments. Digital platforms, from mobile applications to online courses, have facilitated access to language learning resources beyond traditional classroom settings. These technologies not only provide interactive and personalized learning experiences but also enable learners to practice at their own pace, accommodating various learning styles and preferences.

Educational games, particularly, have emerged as powerful tools in language education, engaging learners through play and practical application. The gamification of learning tasks transforms them into enjoyable activities, significantly enhancing motivation and retention. Games in educational technology foster a hands-on learning environment, allowing for the contextual application of language skills in a simulated, risk-free setting. This approach not only improves vocabulary and grammar proficiency but also enhances cognitive skills such as problem-solving and critical thinking, essential for language acquisition. The importance of games in educational technology underscores the need for innovative approaches to language learning, combining the engaging nature of games with the educational value of technology-driven language instruction.

1.2. Statement of the Problem

Scrabble is one of the best educational games in the current society. In contrast to games such as Checkers, Go, and Chess, which are regarded as perfect information games, Scrabble is believed to be an imperfect information game. However, according to Sheppard, Scrabble transforms into a perfect information game during its end-game phase, when the tile bag is empty. The literature on artificial intelligence in games has a tendency to concentrate more on some games, such as chess and checkers, rather than other games, such as scrabble and poker. The implementation of an artificial intelligence that plays legal moves and is capable of defeating a human player with a

high degree of skill is a tough task. This is due to the fact that Scrabble is a game with a wide state space, even larger than that of Go or Chess. As this is a game with incomplete information, in which the current player is uninformed of the opponent's rack, making it extremely difficult to predict the opponent's future move till the game is over. So, it will help to improve the critical thinking of the personnel, decision making, evaluate the decisions taken, strategic thinking, etc. Also, scrabble is a source to improve a particular language as well. Due to those reasons, versions of scrabble games developed among the worlds. With the development of technology, almost all games computerized, and AI also came into the context. Most people like to play such games in their mother language. According to Voinov, scrabble has versions of 29 major languages that are commercially available. So, when it comes to the Sinhala language there are no successful implementations of scrabble games integrating with AI. Which has the capability of playing the game with the computer player. That will happen due to the complexity of the Sinhala language words like linguistic variations, letter distribution etc. Therefore, the usage of data structures and algorithms related to the AI module need to be identified correctly when using this kind of language. So the aim of this research is to implement a scrabble game in the Sinhala language that the human player can play with an AI player. This includes move algorithms and a scoring system which will be specific to the Sinhala language. By implementing this scrabble game, it will help to globalize the game as well as to promote the Sinhala language among the world.

1.3. Research Aim and Objectives

1.3.1. Aim

Implement a scrabble game in the Sinhala language that the human player can play with an AI player. This includes move algorithms and a scoring system which will be specific to the Sinhala language. By implementing this scrabble game, it will help to globalize the game as well as to promote the Sinhala language among the world.

1.3.2. Objectives

- Do the literature review and identify the approaches used to develop the existing scrabble games for different languages (ex: MAVEN and Quackle in English

Language).

- Identify limitations with the language by analysing the game rules, scoring system of the scrabble game and assign the points to each letter in the tile bag.
- Use good data structure to generate the best move that provide high score and challenging to the opponent.
- Design user interface that offers a superior user experience to encourage engagement with the Sinhala language Scrabble game.
- Performance evaluation stands on feedback from users under difficulty levels, winning criteria, the quality of moves and the attraction towards the game. Also, some game specific criteria are there to evaluate the performances.

1.4. Scope

- Scrabble game can be played in Sinhala language.
- Only 2 players are allowed to play. So human and AI player can play the game.
- There is a predefined dictionary to allow the Sinhala words.
- Scrabble board, letter tiles and scoring system is also predefined and specific to game and language.

1.5. Structure of the Thesis

This study is significant as it addresses the urgent need for innovative language learning tools for Sinhala speakers, integrating educational technology and artificial intelligence. By developing a Sinhala version of Scrabble that is both culturally relevant and educationally effective, this research contributes to the fields of computational linguistics, AI in education, and language preservation. It offers a model for leveraging technology to enhance language learning, providing insights into the effective integration of AI for educational game development. The project's outcomes are expected to benefit language learners, educators, and researchers, encouraging further advancements in language education technology. The thesis structure aims at leading the reader through the reason why the study was conducted, methodology with the research gap, design and implementation, evaluation with both frontend and backend functionalities and model accuracy levels. Also, it includes the evaluation of basic game overall behaviour as well, and conclusions in a consistent and logical way.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction to the Literature Review

The Literature Review chapter serves as the cornerstone of this thesis, establishing the theoretical and empirical foundation upon which the research is built. It aims to critically assess the existing body of knowledge on the intersection of language learning, game-based education, and artificial intelligence, specifically focusing on how these domains apply to the Sinhala language. This review is crucial for identifying the research gap that this thesis aims to address, namely, the development of an AI-integrated Sinhala language learning game.

To ensure a comprehensive and systematic analysis, a meticulous methodology was employed for selecting and reviewing the literature. This involved searching academic databases and journals for relevant studies, focusing on those published in the last decade to ensure the information's currency and relevance. Keywords such as "language learning games," "AI in education," "Sinhala language tools," and "language processing" were used. Each selected study was then critically analysed to evaluate its methodology, findings, and relevance to the research objectives. This process not only highlights the current state of research but also underscores the innovative nature of the proposed project by situating it within the broader context of educational technology and computational linguistics.

2.2 Benefits of Games in Language Learning

The intersection of gaming and education has unfolded new vistas for language learning, providing an engaging and effective medium for enhancing linguistic skills. Games, particularly word-based ones like Scrabble, have been acknowledged for their cognitive benefits, including enhanced vocabulary acquisition, spelling proficiency, and grammatical awareness. Scrabble, with its strategic demand for word formation and vocabulary usage, stands out as a potent educational tool. It necessitates players to delve into their mental lexicon, thereby reinforcing language structures and vocabulary in a context that is both competitive and cooperative.

Research underscores the significant impact of Scrabble and similar word games on language learning outcomes. For instance, studies have highlighted how these games not only improve a learner's vocabulary but also contribute to higher engagement levels, motivation, and retention of linguistic information. The gameplay encourages critical thinking, problem-solving, and the application of language rules in a dynamic setting, making learning an active and enjoyable process.

According to Hainey et al. (2016), this synthesis of gaming and learning exemplifies a shift towards more immersive and interactive educational experiences, leveraging the intrinsic motivation and engagement that games provide to facilitate language acquisition. The positive implications for language education are profound, offering learners a multifaceted approach to developing their linguistic competencies in a manner that is both effective and enjoyable.

2.3 Artificial Intelligence in Scrabble Game Design

Dulanga (2017) presents a significant advancement in the domain of educational games by designing a Scrabble game tailored for the Sinhalese language and augmented with artificial intelligence (AI). This innovation addresses the specific challenges posed by the Sinhalese language's complex script and phonetic system, which had previously been underrepresented in digital language learning resources. By integrating a new AI framework that combines a hybrid algorithm with backtracking and alpha-beta pruning techniques, the game achieves more efficient move generation and evaluation. This approach not only enhances the gameplay experience by providing support for the Sinhalese language but also sets a new benchmark in the use of AI within language learning tools.

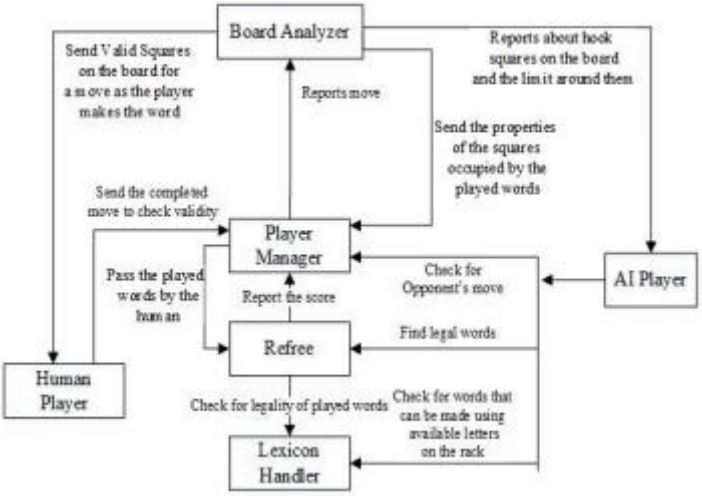


Figure 2-1 Move Generation Algorithm (Flowchart) Implemented for a Sinhala Scrabble Game (Dulanga, 2017)

The potential of AI to improve educational games is particularly notable in the context of language retention and the provision of engaging learning models. Dulanga's work exemplifies the integration of AI to address the intricate nature of language processing, offering a sophisticated model for future developments in AI-driven language learning applications. The legal move generation algorithm developed showcases the game's ability to challenge players with complex word formations, encouraging deeper engagement with the language and contributing to the broader aim of educational technology. This contribution is a testament to the transformative power of AI in enhancing the educational value of games, especially for languages that lack substantial digital resources.

2.4 Scrabble as a Tool for Vocabulary Acquisition

The efficacy of Scrabble as a pedagogical tool for vocabulary enhancement is underscored by the quasi-experimental study conducted by Khaira, Mahyudin Ritonga, and Halim (2021). Focusing on Arabic vocabulary learning, the research implemented a controlled pre-test and post-test design to gauge the impact of Scrabble on language acquisition. The findings indicated a significant improvement in students' vocabulary skills, attributable to the interactive and engaging nature of the game. This underlines Scrabble's potential as an effective educational medium, which not only aids in the retention of vocabulary but also in making the learning process enjoyable.

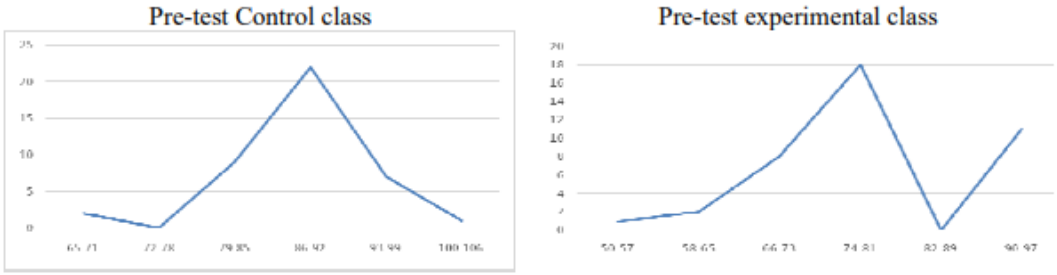


Figure 2-2 The frequency distribution curve of the post-test score for the vocabulary ability of the control and the experimental class

Tests of Normality

	Class Group	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	Df	Sig.
The score of vocabulary skills	Experiment Class	,253	40	,000	,860	40	,000
	Control Class	,195	41	,000	,889	41	,001

a. Lilliefors Significance Correction

Figure 2-3 Kolmogorov-Smirnov Normality Test

The study is instrumental in expanding the discourse on game-based learning, reinforcing the notion that games can serve as powerful educational aids. By transforming a traditional game into an academic tool, Scrabble has demonstrated its capacity to motivate and engage learners, thereby enhancing the educational process. The study's contribution is twofold; it provides empirical evidence supporting the use of games in education and offers a framework for incorporating such game-based strategies into language learning curricula. This establishes a precedent for further exploration into the use of traditional games enhanced with educational objectives, potentially reshaping language learning methodologies.

2.5 Algorithmic Innovations in Game AI

The study by Appel and Jacobson (1988) presents a landmark advancement in the field of game-playing AI, particularly within the Scrabble game framework. Their research yielded the development of an optimized Scrabble program, utilizing a GADDAG data structure to accelerate the move generation process. This algorithmic innovation significantly reduces the search space and speeds up the decision-making steps, enabling the AI to play at near-human or even superhuman levels of word knowledge and strategy.

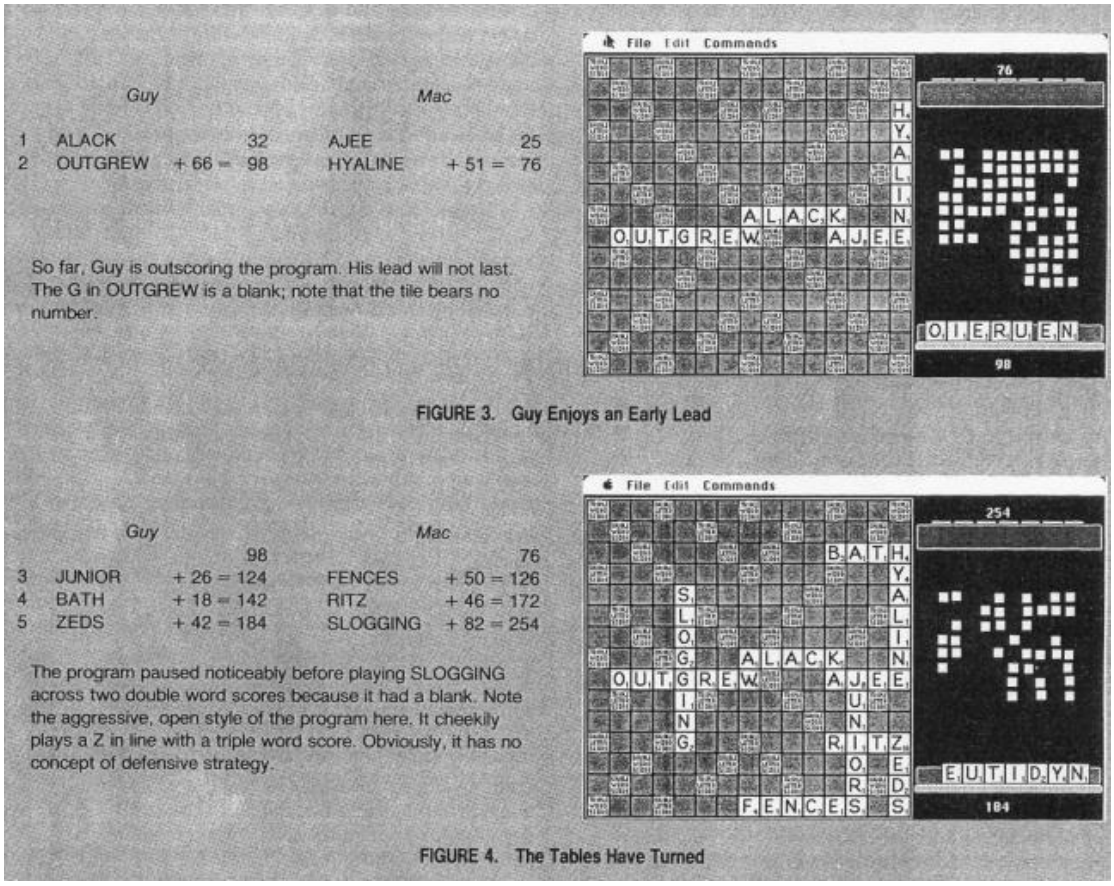


Figure 2-4 Move Generation Process Implementation according to GADDAG Algorithm (Appel and Jacobson, 1988)

The implications of such advances extend beyond Scrabble. They demonstrate the potential of algorithmic efficiency in enhancing the cognitive capabilities of AI within educational settings. By enabling AI to handle complex word formations and strategic gameplay, these algorithmic improvements lay the groundwork for more sophisticated educational tools that can adapt to the user's skill level and learning pace.

The GADDAG algorithm, with its emphasis on speed and memory efficiency, serves as a prime example of how computational techniques can be adapted to improve both game design and educational software. This alignment of AI with user engagement and educational outcomes suggests a promising direction for future research and development in AI-driven language learning applications.

2.6 Recurrent Neural Networks in Language Processing

The transformative potential of Recurrent Neural Networks (RNNs) in language processing is brought into focus by advances that address their traditionally challenging

training process. The groundbreaking work cited in this paper demonstrates how recent developments in Hessian-free optimization have enabled the effective training of RNNs, allowing them to excel in character-level language modeling tasks. This is a leap forward, considering the historical difficulty posed by the unstable dynamics of RNNs, often described as the vanishing or exploding gradients problem.

The paper (Ilya Sutskever, Martens and Hinton, 2011), introduces a novel RNN architecture that incorporates multiplicative connections, enabling a dynamic and context-sensitive transition matrix between hidden states. This variant, trained with the Hessian-Free optimizer, has shown to outperform other models, marking a significant achievement in RNN applications. The study not only showcases the capacity of RNNs to handle complex sequence modeling but also highlights the architecture's ability to generate text with nuanced understanding, opening new avenues for in-depth language comprehension.

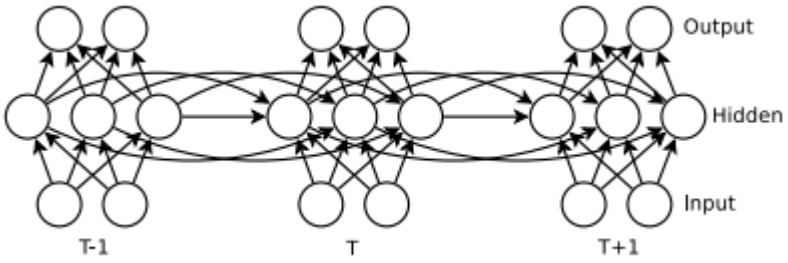


Figure 2-5 Graphical Preview of Recurrent Neural Network (Ilya Sutskever, Martens and Hinton, 2011)

Such advancements underscore the promise of RNNs in educational tools, particularly in the realm of language learning. The ability of these networks to process and predict sequences can be leveraged to create more interactive and intelligent language learning applications, capable of adapting to the user's proficiency and learning style. The implications for AI-integrated language learning platforms are profound, suggesting a future where language acquisition is deeply personalized and contextually rich, empowered by the advanced capabilities of RNNs.

2.7 Challenges in Developing Language Learning Games

The venture into creating language learning games, such as a Sinhala version of Scrabble, is fraught with both technical and linguistic challenges (Kam et al., 2008). The primary obstacle is designing a user interface that not only supports the Sinhala script but also provides a seamless, culturally resonant gaming experience. This involves extensive linguistic analysis to ensure the game's vocabulary database is comprehensive and contextually appropriate, reflecting the nuances of Sinhala syntax and morphology.

Figure 2-6 Indian Mobile Game developed to work even in feature phones to easily bypass the technical challenges (Kam et al., 2008)

Technologically, developing an AI that can process the intricacies of Sinhala and simulate a human-like opponent presents significant hurdles. The AI must be able to generate valid words, strategize based on the state of the game, and adapt to the player's skill level. To accomplish this, algorithms capable of handling the unique characteristics of the Sinhala language are required, along with machine learning models trained on large datasets of Sinhala words. These models must be robust enough to support natural language processing techniques that can accurately analyze word validity and language rules, ensuring the AI can engage players in a linguistically rich and competitive manner.

Furthermore, the scoring system and game mechanics must be adapted to reflect the cognitive effort involved in forming words in Sinhala, which may have more letters or

complex syllable structures than those in English. This includes not only technical implementation but also the preservation of educational value, ensuring that the game remains a tool for language learning as much as it is a source of entertainment. Balancing these elements is essential to create a game that is both enjoyable and beneficial to language learners.

2.8 Gaps in the Literature Review

The literature review has unveiled specific gaps in the research concerning language learning games for Sinhala speakers and the application of AI in this context. Firstly, there is a scarcity of digital educational tools and resources tailored to the unique orthographic and syntactic characteristics of the Sinhala language. This lack of support hampers the ability of Sinhala speakers to utilize technology for language acquisition effectively. Secondly, while AI has shown promise in language learning applications, its integration into games designed for Sinhala speakers remains unexplored, leaving a significant area of potential development untouched.

Furthermore, there is limited research on the effectiveness of language learning games in improving the comprehensive language skills of Sinhala speakers, including vocabulary, grammar, and pronunciation. Studies have not adequately addressed the cultural aspects of game design, which are crucial for engaging Sinhala speakers and promoting language retention. Additionally, the literature reveals a gap in the development of AI algorithms that are capable of understanding and processing the Sinhala language, a necessity for creating an interactive and adaptive learning environment.

The review also indicates a lack of evaluation frameworks specific to the Sinhala language that can assess the educational impact of language learning games. Such frameworks are essential for continuous improvement and ensuring that the games serve both as effective teaching tools and as means of preserving the linguistic heritage of Sinhala. The gaps identified through this literature review set the stage for the current research to contribute significantly to the fields of computational linguistics, AI in education, and language preservation.

2.9 Summary of the Literature Review

The literature review culminates in the recognition of the integral role games, particularly Scrabble, can play in language learning. Studies have consistently shown that the incorporation of AI in game design significantly enhances the learning experience by providing tailored educational content and interactive experiences. In the context of the Sinhala language, the review reveals a distinct gap in resources that cater to its linguistic intricacies.

The main findings from the literature underscore the effectiveness of language learning through games, the potential of AI to revolutionize educational tools, and the necessity for culturally and linguistically appropriate resources. These insights support the research objectives by highlighting the need for a Sinhala version of Scrabble that is augmented with AI, addressing the current scarcity of digital educational tools for Sinhala speakers.

Moreover, the literature points to the need for AI systems that can handle complex language patterns, suggesting that the development of such technologies could significantly contribute to the field of computational linguistics. By addressing these gaps, the research aims to provide an innovative solution that not only enhances the language learning experience for Sinhala speakers but also contributes to the preservation and appreciation of their language in the digital age. This aligns with the broader research goals of fostering inclusive educational technologies that can adapt to various linguistic contexts.

CHAPTER 3: METHODOLOGY

3.1 Introduction

The methodology employed in this research is inherently multidisciplinary, drawing upon principles from computational linguistics, game development, and machine learning to create a novel educational tool: the Sinhala Scrabble game integrated with AI capabilities. This subsection serves as an introduction to the research approach, elucidating the rationale behind the integration of these diverse disciplines and outlining the overarching goals of the methodology.

Computational linguistics forms the foundation of the methodology, providing insights into the structure, rules, and nuances of the Sinhala language. By leveraging computational linguistics principles, we aim to develop a game that not only respects the linguistic intricacies of Sinhala but also enhances language learning outcomes for its users.

Game development principles are essential for crafting an engaging and immersive user experience. Through meticulous design, prototyping, and iteration, we seek to create a Sinhala Scrabble game that captivates players while facilitating language acquisition and retention. Moreover, game development methodologies enable us to tailor the game mechanics to suit the unique characteristics of the Sinhala language, ensuring cultural relevance and authenticity.

In summary, the methodology employed in this research represents a synergistic fusion of computational linguistics, game development, and machine learning. Through this interdisciplinary approach, we endeavor to create a groundbreaking educational tool that revolutionizes language learning for Sinhala speakers.

3.2 Designing the Game (Scrabble Mechanism)

Designing the Sinhala Scrabble game with AI capabilities involves a detailed process that starts with conceptualization, where the game's core idea and goals are defined. The planning phase involves outlining the game's rules, mechanics, and how it will adapt to the Sinhala language and culture. Prototyping allows for the creation and testing of a basic version of the game to refine these ideas.

The adaptation of Scrabble mechanics to Sinhala requires a careful consideration of the language's unique characteristics, including its script and syntax. The game logic particularly focuses on handling Sinhala letters and words, utilizing Unicode values for each character to facilitate word formation and scoring.

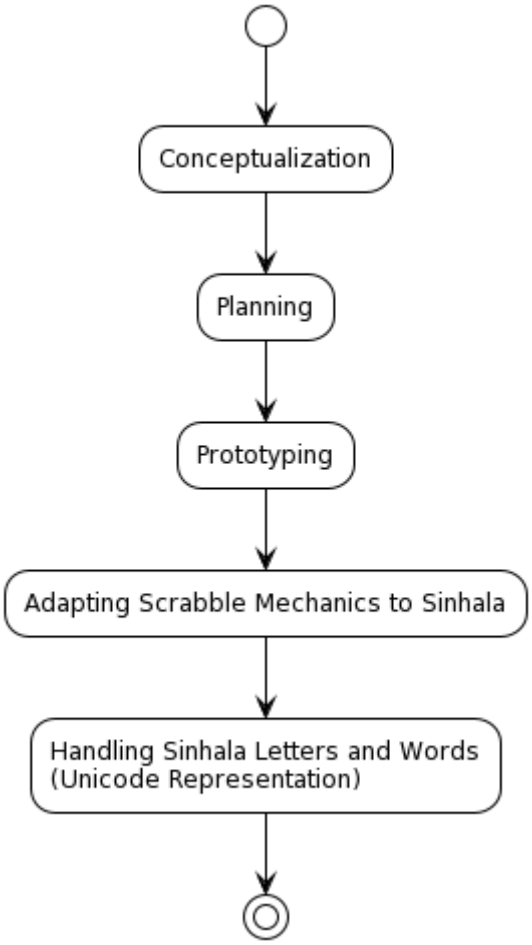


Figure 3-1 Process of Game Building

3.3 Solution and Algorithms

The literature review conducted as a part of this thesis has illuminated the intersection of language learning, game-based education, and artificial intelligence, with a special focus on the Sinhala language. This exploration was aimed at identifying the current state of research and development in these areas, highlighting successful applications, and recognizing potential opportunities for innovation. Through this comprehensive analysis, several significant gaps were identified, particularly concerning the scarcity

of language learning tools for Sinhala speakers, the unexplored potential of AI in educational games tailored to Sinhala, and the challenges inherent in adapting a globally recognized game like Scrabble to fit the linguistic nuances of the Sinhala language.

3.3.1 Board Representation

For the purpose of digitally representing the Scrabble board, a grid measuring 15 by 15 squares is utilised. Each square on the grid can either retain a letter or suggest a specific scoring position. This grid has special scores that are coded, which enables the artificial intelligence to recognise and plan for the use of these scores in order to maximise points.

3.3.2 Rack Representation

A straightforward list is used to represent the letters that are available to the player. The artificial intelligence then draws new elements from this list in order to imitate the random nature of tile selection in the game.

3.3.3 State Transitions

Changes in the grid (with new letters), updates to the player's score, and the reorganisation of the player's letter list are the elements that determine the course of the game after each move. Either the placement of letters, the passing of tiles, or the exchange of tiles from the list are the three markers that indicate the completion of a turn.

3.3.4 Letter Distribution

The distribution of letter tiles is crucial when translating the game to a new language. Factors such as the quantity of tiles in the bag, the allocation of tiles for each letter, and the allotted point values for each letter all have an impact on the game. Hence, it is necessary to calculate the frequencies of characters in the Sinhala alphabet. The frequencies of the 18 vowels and 42 consonants in the Sinhala script were determined by analysing a wordlist containing unique words. In earlier development basic letters were used as the tiles an there were option to select a compound consonant when they had a specific consonant in their hand while playing the game. This would allow them to use the tile with the compound consonant to form words that include the compound version of that consonant. This system is distinct from the older systems that were stated

earlier since it offers a collection of compound letters rather than merely supplying basic letters and allowing users to select complex letters. By implementing this process, the primary objective is to raise the level of difficulty that the players are experiencing. Consequently, just the frequencies of vowels and consonants were computed, excluding compound consonant frequencies.

3.3.5 Agent Design

3.3.5.1 Move Generation

Given that the move generation should be extremely efficient, it is obvious that using Steven's GADDAG structure with contemporary machines will be preferable. Furthermore, given that the Sinhala alphabet, as previously mentioned, is complex (having 12 vowels, 39 consonants that are suitable for a game of Sinhala scrabble, and 22 additional variations for each consonant to form compound consonants), using a data structure and searching through it with a pool of letters to find word permutations to form words will result in a very large branching factor. This means that choosing a data structure should speed up the generation of moves.

Steven Gordon proposed the GADDAG data format, which is designed specifically for word searches in word games like Words With Friends and Scrabble. Though it is arranged so that all "hooks," or letter sequences on the board, are accessible from the root node, it resembles a Trie prefix tree. To do this, each prefix and suffix that can occur in a word is stored. The prefix is then reversed off of the root node, and a node that is commonly represented by the character ">" separates the two pieces.

In implementing the Scrabble game for Sinhala language also used the improved version of universal GADDAG data structure for possible move calculation. GADDAG was improved to satisfy any language by providing 2 input functions.

- split_word function -> split a word into letters.
- get_base_letter -> get the base letter from a compound letter

Above mentioned functions are using as the improved inputs to the particular GADDAG data structure in order to accomplished the move generation with valid Sinhala words as it is supported by any language. Here in the current system it is supported by a compound letters to create a correct word matching with the current board state. So, the current system is using two improved functions as below:

i. search_words: This tool is utilised to locate words that correspond to the present hooks on the board. In order to achieve this, it necessitates the use of the substrings that reflect the existing state of the board and the collection of tiles held by the robotic user.
ii. add_words: Adding new words to the dictionary in order to moderate and improve the possible word list.

With the above described GADDAG structure and improved functionalities game play implemented from below steps.

1) **Generate Playable Space:** This step involves generating the possibilities based on the challenge the particular game exists currently. In this process evaluates the options that can be used in the current turn considering user rack and board status.
2) **Generate Playable Options to Get Rows:** In this step, identify which rows within the playable space are available for making a move. This typically involves scanning the grid to determine which rows are not fully occupied or otherwise unavailable.
3) **Generate Playable Options to Get Columns**: Similar to the previous step, but for columns. This identify which columns within the playable space are available for making a move.
4) **Identify Valid Move**: Based on the identified rows and columns, this step involves checking each potential move to determine if it is valid according to the rules of the game.
5) **Valid Move Exists:** Here, evaluates if there are any valid moves. If there are valid moves, proceed to return the valid move. If there are no valid moves, the turn is passed to the next player.

By following this flow, systematically generate playable options and identify valid moves in a structured and logical manner.

3.3.5.1 Move Evaluation

Sheppard suggests that a successful approach to evaluating moves in Scrabble should take into account the three variables that alter after each move: the score, the rack, and the board. In order to get a practical and effective assessment of moves, it is crucial to possess a resilient assessment of the player's rack, employ tailored search algorithms for each stage of the game, and conduct a comprehensive evaluation of the game board. Scoring heuristic is a technique employed to assess possible actions or solutions by considering their anticipated performance, particularly in relation to the immediate

benefit or score. Within the framework of a Scrabble artificial intelligence, a scoring heuristic evaluates the possible movements by computing the points they would accumulate if executed on the game board. This methodology enables the AI to prioritise actions that optimise immediate benefits, establishing a basis for making strategic choices during games.

A scoring heuristic is a method created to streamline the decision-making process by prioritising a primary goal: maximising the score. It is a pragmatic approximation technique that assesses every potential word placement on the board to ascertain the move that would produce the most score. This heuristic provides guidance to the AI in choosing movements that have a high probability of enhancing its competitive standing in the game.

Elements of Scoring Heuristic

Calculation of Word Value: The main element of the scoring algorithm is the computation of the word's worth. This entails calculating the total value of each letter in the word, taking into account any additional points gained from special squares such as double letter scores or triple word scores.

Board Configuration: The heuristic should consider the present condition of the board, which includes the locations of the existing tiles and the premium squares that are accessible. The positioning of the word can have a substantial impact on its score, taking into account these factors.

Tile Multipliers: Premium squares on the Scrabble board, such as double letter score and triple word score, play a crucial role in determining the score. The heuristic assesses the impact of inserting a word on these squares on the overall score.

Word Multipliers: This heuristic evaluates if the position of a word overlaps with any existing words, resulting in the formation of more legitimate words and the accumulation of their scores.

Approach

Generate a comprehensive list of all valid words that can be created by combining the

current tiles in the player's rack with the tiles already on the board.

Analyse every move:

Word Score: Determine the fundamental score of each word by adding together the point values assigned to its individual letters.

Apply Multipliers: Modify the score by taking into account the premium squares that the word covers. For instance, when a letter is placed on a square that doubles the value of letters, its score is multiplied by two.

Take into account supplementary vocabulary. Include in the score computation any new valid words that are created by placing the word and intersecting with existing words.

Sort the moves according on their score: After evaluating all feasible options, prioritise them according to their computed scores. The move with the greatest score is usually chosen as the most optimum move for that particular turn.

3.4 Frontend Development

The Sinhala Scrabble game is a modified version of the traditional Scrabble game specifically designed for the Sinhala language, which is the predominant language used in Sri Lanka. This version has distinct characteristics and alterations to accommodate the distinctive components of the Sinhala script and language framework.

The configuration of the tile bag is tailored according to the frequency of Sinhala letters. By utilising a linguistic corpus, the characters that are most commonly used in language are given greater representation in the tile bag, thereby ensuring that the game accurately mimics real-life language usage. This customisation enhances players' ability to interact with the game, hence facilitating more effective language acquisition and retention.

The scoring system is derived from the conventional Scrabble rules but has been adjusted to accommodate the Sinhala language. ones that appear frequently are given lower point values, and ones that appear less often are allocated higher point values. This scoring tactic promotes the utilisation of a diverse array of characters and the creation of clever word structures.

Academic Significance: The game functions as a means for acquiring knowledge and honing skills in Sinhala. It facilitates the expansion of players' vocabulary, comprehension of character frequencies, and enhancement of their overall language proficiency in an enjoyable and interactive way.

Globalisation: In order to increase its educational worth and expand its audience, the game could have a word translator function. By enabling players to acquire the definitions of Sinhala terms in different languages, this feature would additionally facilitate the process of language acquisition.

The frontend development of the Sinhala Scrabble game is meticulously engineered using a combination of HTML, CSS, JavaScript, and React.js. HTML provides the foundational structure of the game interface, CSS is employed to style elements ensuring visual appeal, while JavaScript and React.js facilitate dynamic interactivity and state management, enhancing the overall user experience (UX).

UI/UX design considerations are paramount in creating an engaging and intuitive experience. The game's interface is designed with a clear, user-friendly layout, incorporating responsive design principles to accommodate various devices. Accessibility features, such as keyboard navigation and screen reader support, ensure inclusivity. Attention to cultural elements relevant to the Sinhala-speaking community adds a layer of authenticity and connection for the user.

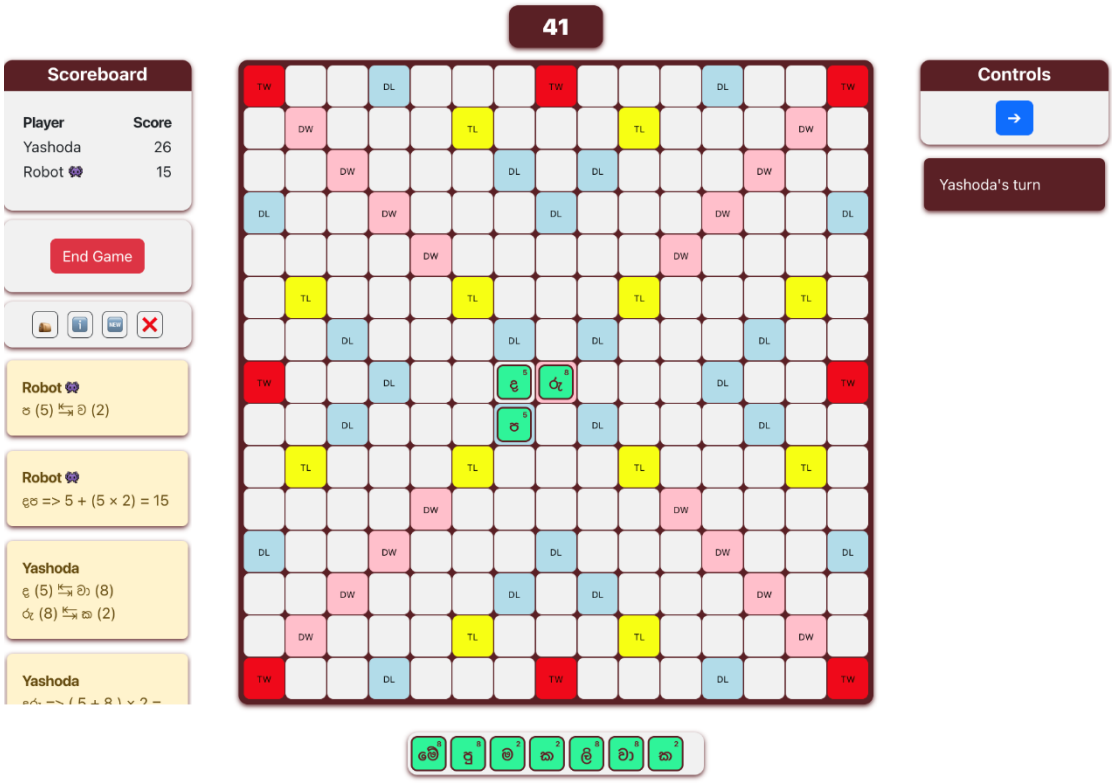


Figure 3-2 Designing the Scrabble Board

Each user is allotted 60 seconds to perform a legitimate manoeuvre. Once the user has added a legitimate motion, they can order the programme to advance to the next step. The user's movement data, including the specific score for that valid movement, will be displayed as in the image on the left side of the user interface (UI).

The development process is iterative, emphasizing rapid prototyping and frequent user testing. This approach allows for continuous feedback integration, ensuring the game not only meets but exceeds user expectations. User testing sessions are conducted at various development stages to assess usability, engagement, and learning outcomes. Feedback from these sessions informs adjustments and refinements, driving improvements in UI design and interaction flows.

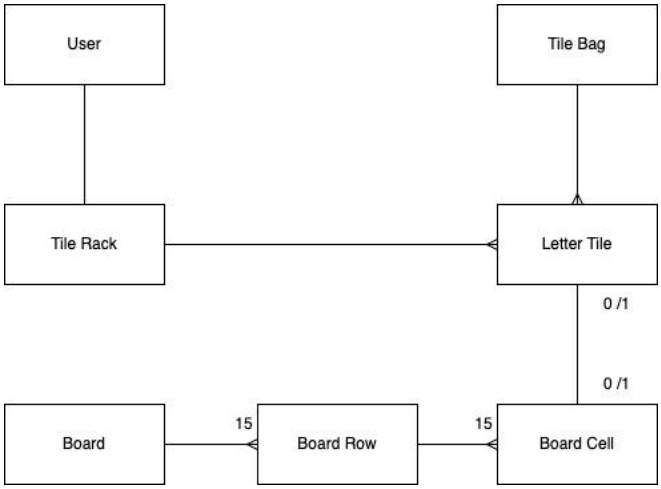


Figure 3-3 Frontend model

This careful blend of modern web technologies and user-centric design principles, underpinned by an iterative development methodology, ensures the Sinhala Scrabble game is both technologically robust and deeply engaging, offering a meaningful and enjoyable language learning experience.

Implementation challenges included optimizing performance for real-time gameplay and integrating complex game mechanics while maintaining a user-friendly interface. Through iterative development and user testing, challenges were addressed, resulting in a polished front-end experience that balances functionality with aesthetics.

Table 1: Challenges and solutions during frontend development

Challenge	**Solution**
Performance Optimization	Implemented lazy loading and code splitting techniques to improve initial load times.
Integration of Complex Game Mechanics	Broke down functionality into smaller components and utilized React.js state management.
Responsive Design	Utilized CSS media queries and responsive design principles to ensure compatibility.

3.5 Backend Development

The backend development of the Sinhala Scrabble game is built on a robust stack comprising python for the server framework and MongoDB for database management.

Python is selected for its simplicity and clarity, rendering it well-suited for both novices and seasoned programmers. The huge standard library and vast array of third-party packages make development fast and integration with other technologies easy. Moreover, Python's adaptability enables it to be employed in other domains, including web development, data analysis, and machine learning. Python's enduring relevance and potency as a programming language are guaranteed by its robust community support and ongoing advancements. Basic data structure used is GADDAG

The GADDAG algorithm is a highly advanced computational method employed in word games such as Scrabble to effectively identify potential word positions on the game board. It is especially beneficial for games that have intricate scripts, such as Sinhala.

The GADDAG data structure employs a graph-based format for the purpose of storing and retrieving words. GADDAG, unlike conventional Trie structures, is specifically designed to efficiently identify words that can be constructed by appending letters to already existing words on the board, a frequent occurrence in Scrabble gameplay.

The GADDAG method improves move generation efficiency by substantially reducing the search space. This is accomplished by dividing words at every conceivable point and organising them in a manner that enables rapid retrieval of legitimate word combinations and positions. The implementation of GADDAG for Sinhala Scrabble entails constructing a graph structure capable of accommodating the complexities of the Sinhala alphabet. This involves overseeing intricate combinations of characters and ensuring that the algorithm can effectively handle the distinctive features of the screenplay. The GADDAG system enhances move evaluation by allowing the AI to rapidly discover all potential word positions. Developing a competent AI opponent that can challenge players and enhance its methods over time is of utmost importance.

By incorporating GADDAG into the Sinhala Scrabble game, the AI may execute more advanced searches and assessments, enhancing the game's level of difficulty and player engagement. This integration facilitates a more profound comprehension of the language's framework and utilisation, hence improving both the gameplay experience and its educational advantages.

MongoDB is chosen for its adaptability and capacity to handle substantial amounts of unorganised or partially organised data, making it ideal for managing massive data sets. The schema-less nature of the system enables seamless modification of the data model without the need for any downtime. The query language and indexing features of MongoDB facilitate efficient data retrieval. Furthermore, its ability to horizontally scale by using sharding guarantees excellent performance and availability, making it a strong option for contemporary applications that demand flexible and scalable database solutions.

The server-side logic encompasses handling user requests, managing game sessions, and integrating with data structure for word verification and generation. API development is centered around RESTful principles, ensuring scalability and ease of integration with the frontend. Key endpoints include game play, game state management, and word submission and validation.

Throughout the development process, continuous integration and testing ensure the backends' reliability and performance, with user feedback driving iterative improvements to the system. This approach ensures that the backend infrastructure robustly supports the game's needs, offering a seamless experience for players.

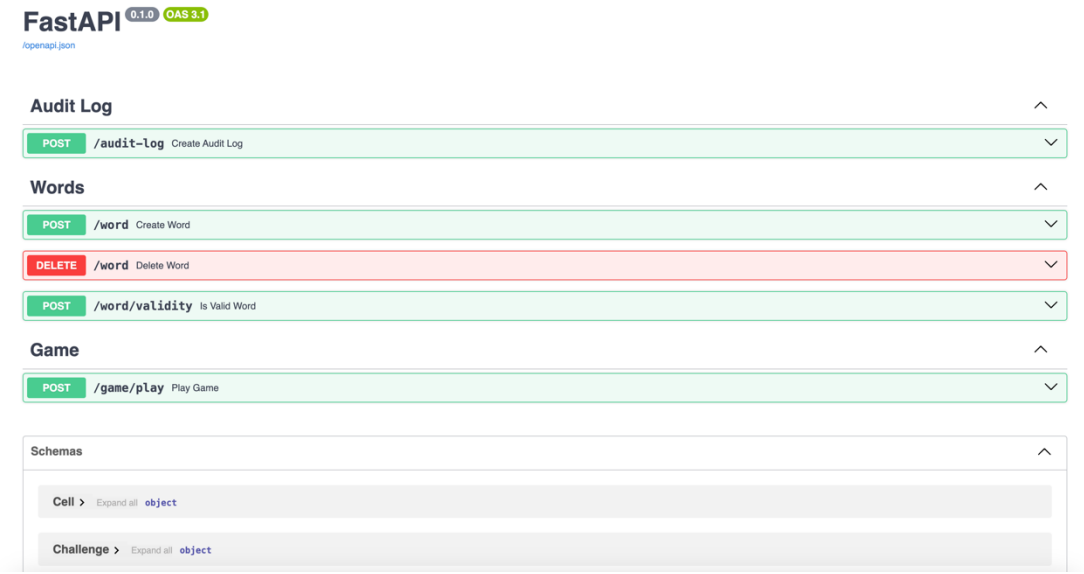


Figure 3-4: Backend API document

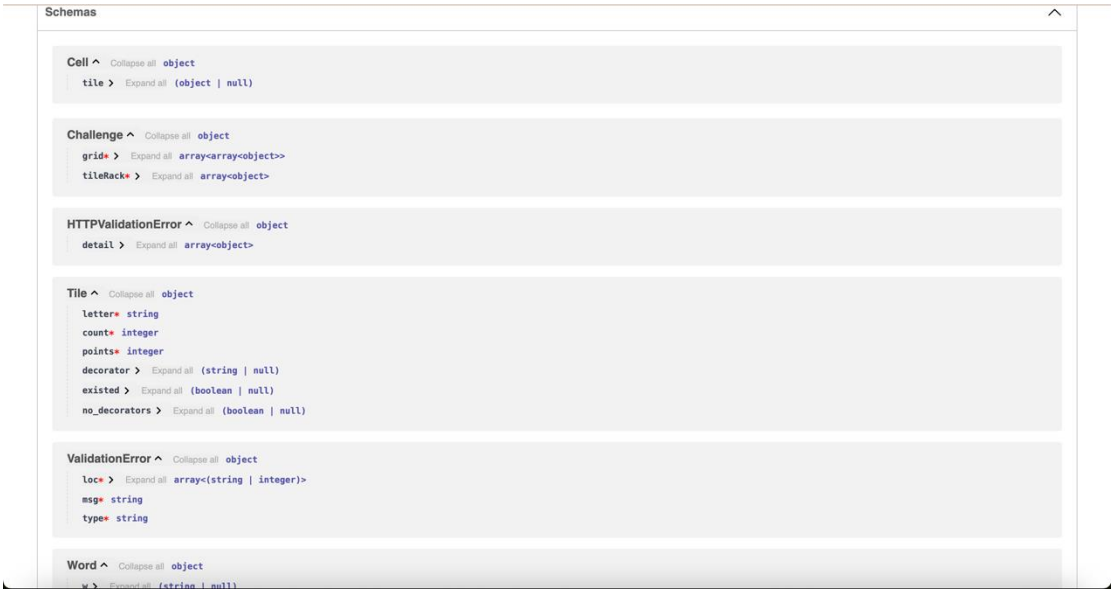


Figure 3-5: Backend request requirement

Configuration and Scoring System of the Tile Bag:

The score system strictly follows the official Scrabble rules and is automatically calculated by the algorithm. This scoring mechanism not only monitors the AI's performance during the game but also generates crucial data for the purpose of learning and enhancement.

- **Tile Count:** The game contains a total of 100 tiles, with 50 distinct letters.
- **Letter Frequency Analysis:** Instead of depending on a lexicon for determining letter frequencies and points, a corpus was utilised. This approach prioritises the specific frequency of letter usage in the language rather than the frequency of entire phrases, guaranteeing a more precise depiction of letter distribution as employed by individuals.
- **Frequency of Letters in the Tile Bag:** The arrangement of letters in the tile bag is determined by their frequency in the corpus data. The frequency of letters in the language directly influences their occurrence in the tile bag. For example, if a letter is often used, there will be more tiles of that letter available in the game.
- **Computation of Letter Points:** The points assigned to each letter are based on their frequency of occurrence. Commonly used letters are allotted lower point values, and less commonly used letters are given higher points. This guarantees a well-balanced gameplay in which uncommon letters hold greater value and common letters offer consistent scoring opportunities.

This setup amplifies the authenticity and complexity of the game, rendering it more captivating and instructive for players.

CHAPTER 4: EVALUATION AND RESULTS

4.1 Overview of Evaluation

In this evaluation, we delve into rigorous testing of the Sinhala Scrabble game's frontend and backend to ensure a seamless, efficient, and engaging user experience. Comprehensive testing is crucial to identify and resolve potential issues in user interface design, system performance, and AI-driven functionalities. By systematically evaluating each component, we aim to enhance the application's reliability, user satisfaction, and educational impact, ensuring that the game not only entertains but also effectively contributes to language learning advancements.

4.2 Performance Evaluation

The GADDAG structure underwent testing using the previously mentioned constructed wordlist, which consisted of 67259 words.

By utilizing the GADDAG, the programme may promptly propose valid words and word fragments by considering a specified rack and the hook letters, with an average response time of less than 0.5 second.

After conducting 10 games, the average duration for generating an AI move was determined to be 0.275 seconds, with an average of 20 valid movements generated every AI turn. On average, the AI achieved a score of 18 points per move, resulting in an average total score of 220 points. Game achieved an AI winning rate more than 90% with Human.

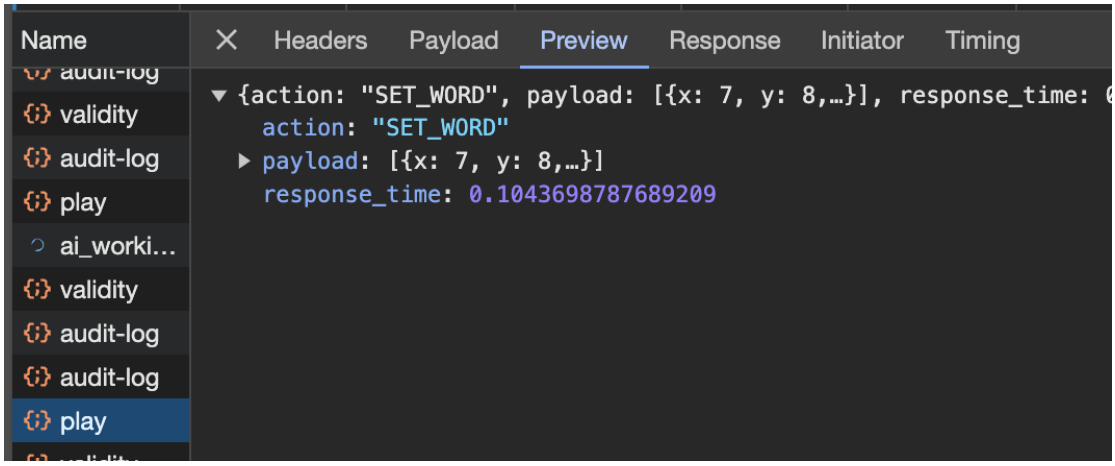


Figure 4-1: Response time for single agent move

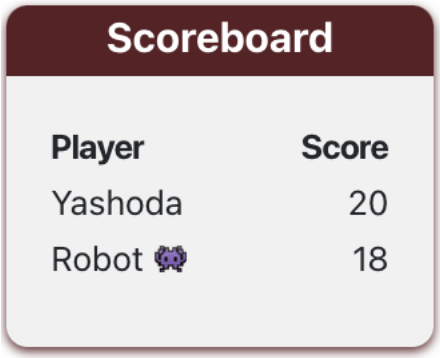


Figure 4-2: Score calculation for first words

4.3 Testing frameworks and Tools

Table 2: Testing Frameworks

component	Testing Framework/Tool	Purpose
Frontend	Jest, Cypress	Jest for unit tests to validate individual components. Cypress for end-to-end tests of user flows.
Backend	Postman, JUnit	Postman for API testing (response correctness and time). JUnit for server-side logic unit testing.

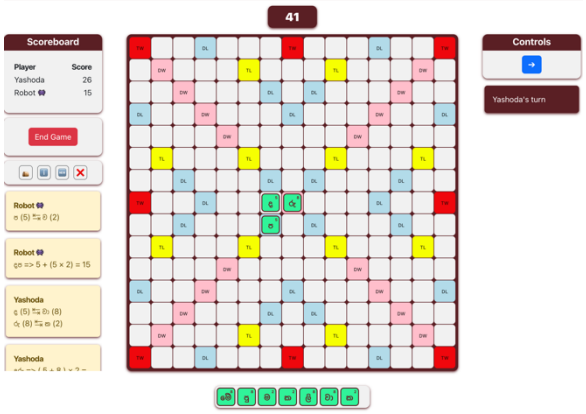
4.4 Front-End Testing

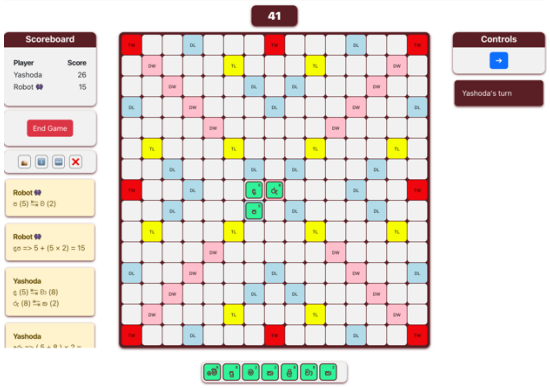
Table 3: Testing Frameworks

Test Category	Methodology	Key Test Cases	Results and Improvements
UI/UX Tests	Unit and Integration Tests	Alignment, color schemes, button sizes, and navigation flows.	Identified and corrected several misalignments; improved navigation clarity.
Responsiveness	End-to-End Tests	Screen size adaptation, touch interactions, and scrolling.	Enhanced responsiveness for various devices; optimized touch controls.
Functionality Tests	Unit, Integration, and End-to-End Tests	Game mechanics, score calculations, and AI interactions.	Fixed bugs in score calculation; refined AI response times for better gameplay.

4.5 Functionality Tests

Table 4: Functionality Test Cases

Test Case	Scenario	Expected Result	Actual Result	Status
TC01	Interface Loaded correctly with all elements	Display all buttons, letterboard, scrabble board , notation grid and timer.		Passed

TC02	Game start from user's turn and timer started successfully.	Game starts within user's first play and timer starts to countdown.		Passed
TC03	When user build a word turn the play side to the AI.	Turn the Play Side and build a word from the AI Opponent.		Passed
TC04	When user or AI Build a correct word score get updated.	Update the Scoreboard Simultaneously		Passed
TC07	Display the Winner	When the time is up show the winner depend on the highest score		Passed

4.6 Backend Testing

Table 5: Backend Testing

Testing Area	Methodology	Key Test Cases	Results and Improvements
API Functionality	Postman	Endpoint availability, response validation, error handling	Enhanced API reliability and improved error reporting
Database Integration	JUnit	Data consistency, read/write operations, concurrency control	Optimized database operations and enhanced data integrity checks
Performance	Custom Scripts	Load handling, response times under stress, memory leaks	Mitigated performance bottlenecks and improved scalability

4.7 Integration Testing

Table 6: Integration Testing

Testing Phase	Description	Challenges Faced	Solutions Implemented
Integration Testing	Ensured cohesive operation of frontend, backend	Syncing real-time data updates.	Optimized API calls; implemented websocket for live updates.

4.8 Game Evaluation – User perspective

Enlist a heterogeneous group of participants to participate in the game, assuring a wide range of proficiency levels and backgrounds to obtain thorough feedback. Following the playtime, gather comprehensive feedback from the players, focusing on specific criteria such as user engagement, interface usability, game mechanics, difficulty balance, and overall enjoyment. Examine this feedback to assess the effectiveness of the created game, pinpointing its strengths and areas that need development. Utilise the acquired knowledge to implement specific improvements, guaranteeing that the game fulfils user expectations and delivers an optimal gaming experience.

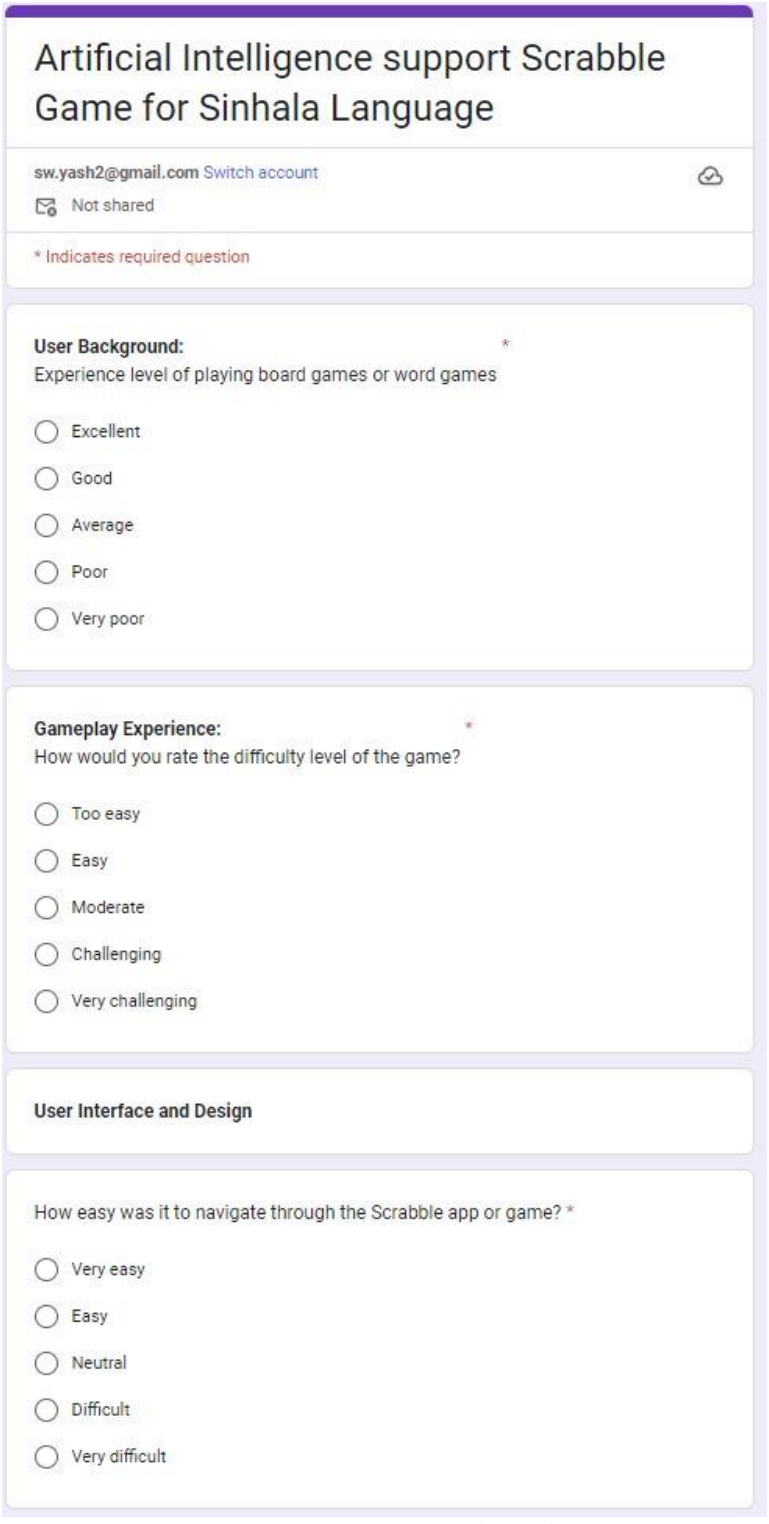


Figure 4-3 User Survey (Part 1)

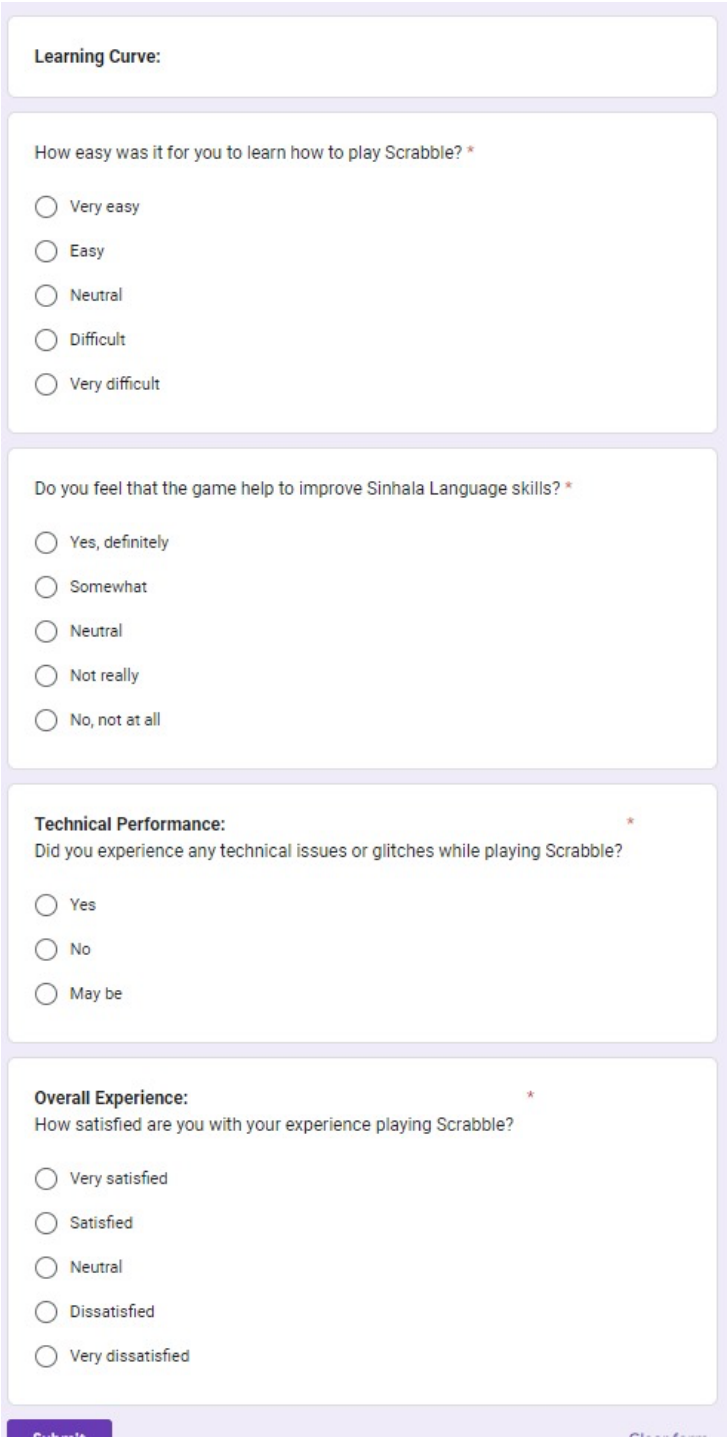


Figure 4-4: User Survey (Part 2)

The survey responses were subjected to a thorough examination, which revealed the following significant findings:

User Engagement: Participants expressed a significant degree of involvement, highlighting that the game successfully caught and sustained their attention during the play sessions.

Interface Usability: Feedback revealed that the game's interface was perceived as

intuitive and user-friendly, enabling players to effortlessly explore and comprehend the game concepts.

Game Mechanics: The fundamental mechanics of the game were positively welcomed, as players valued the equilibrium between difficulty and user-friendliness. Several recommendations were made to improve the gaming experience by making modest tweaks.

Difficulty Balance: The majority of players found that the game achieved a suitable equilibrium in terms of difficulty, offering a gratifying level of challenge without becoming excessively vexing. Several participants proposed adjusting specific levels to optimise the difficulty progression.

Overall pleasure: The game received a high overall pleasure rating, with numerous players expressing enthusiasm for both the game's premise and its implementation. There was also a significant amount of positive feedback on the graphics, sound design, and storyline.

The results emphasise the game's strong points and offer clear direction on areas that may be improved to enhance the user experience.

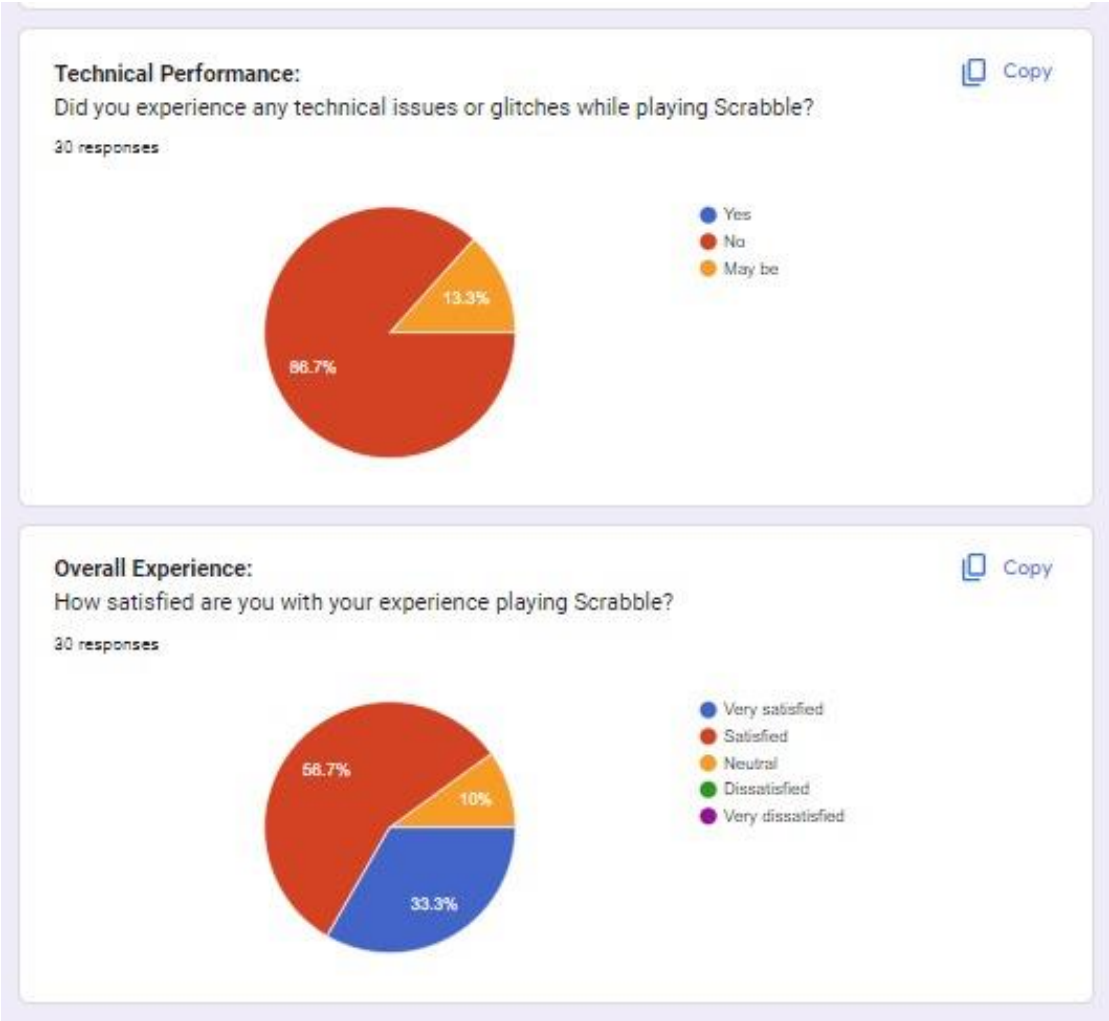


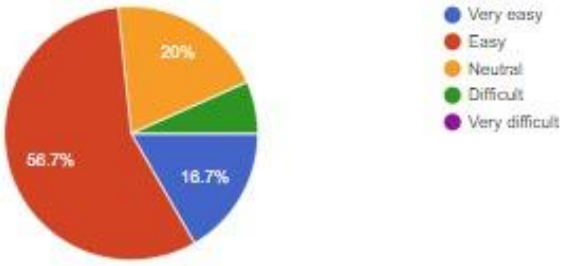
Figure 4-5: Survey results (Part 1)

Learning Curve:

How easy was it for you to learn how to play Scrabble?

Copy

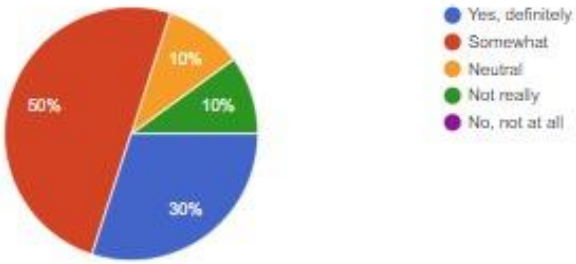
30 responses



Do you feel that the game help to improve Sinhala Language skills?

Copy

30 responses



Technical Performance:

Did you experience any technical issues or glitches while playing Scrabble?

Copy

30 responses

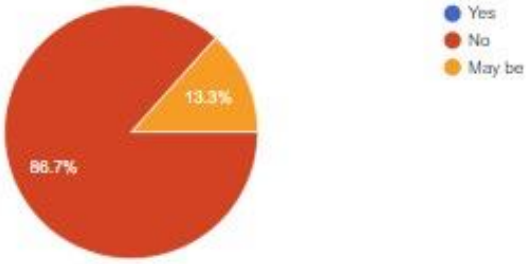


Figure 4-6:Survey results (Part 2)

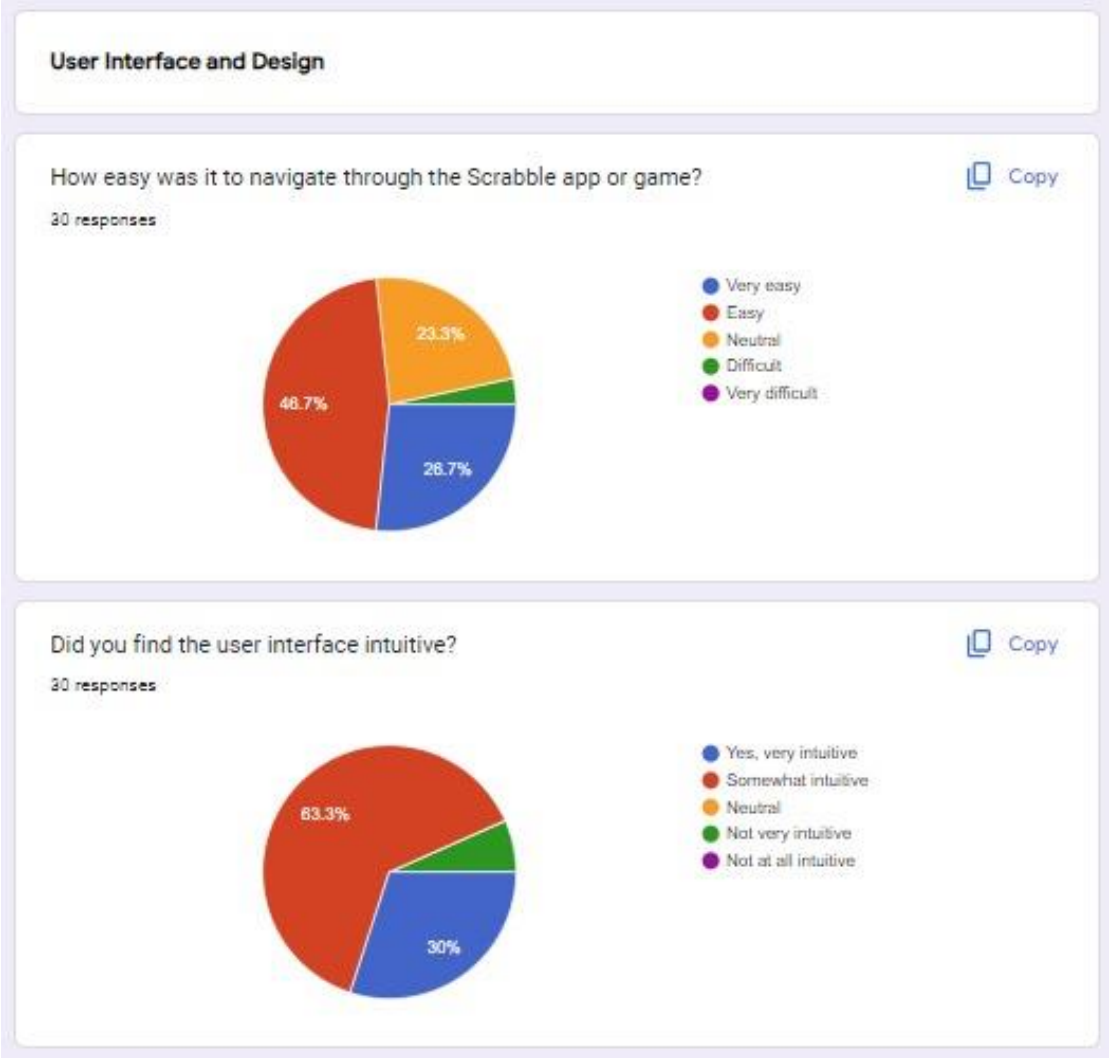


Figure 4-7:Survey results (Part 3)

CHAPTER 5: CONCLUSION AND FUTURE WORK

5.1 Conclusion

In conclusion, the development of the Sinhala Scrabble game integrated with AI capabilities represents a significant achievement in the realm of educational technology. This project aimed to create an engaging and culturally relevant platform that not only entertains but also facilitates language learning and cultural preservation for Sinhala speakers.

Through meticulous design, development, and testing, we successfully created a dynamic and immersive game experience. The integration of Scrabble mechanics with the complexities of the Sinhala language posed several challenges, but our multidisciplinary approach, combining computational linguistics, game development, and machine learning, enabled us to overcome these hurdles effectively.

The Sinhala Scrabble game serves as a valuable tool for language learners, offering an interactive and entertaining way to practice vocabulary, spelling, and language comprehension skills. By incorporating culturally relevant content and gameplay elements, we aim to foster a deeper connection to the Sinhala language and its rich linguistic heritage.

The user interface (UI) and user experience (UX) design principles were carefully considered to ensure accessibility, engagement, and ease of use. Features such as drag-and-drop functionality, visual cues for valid moves, and responsive design contribute to a seamless and enjoyable gameplay experience.

Moreover, the Sinhala Scrabble game represents a pioneering effort in leveraging technology to support language learning and cultural preservation. By providing a digital platform that combines entertainment with education, we aim to address the scarcity of educational resources for Sinhala speakers and promote the continued vitality of the language in the digital age.

In summary, the Sinhala Scrabble game is not just a game but a testament to the power of innovation in advancing education and preserving cultural heritage. As technology

continues to evolve, we remain committed to further enhancing the game's functionality, expanding its reach, and fostering a thriving community of language learners and enthusiasts.

This project has been a journey of exploration, creativity, and collaboration, and we are excited to see how it will continue to make a positive impact on language learning and cultural awareness in the years to come.

5.2 Future Works

1. Enhancements to AI Model

Future iterations of the game could explore enhancements to the AI model to further improve its word generation and validation capabilities. This could involve refining the algorithms used for word prediction, expanding the vocabulary database, and implementing more sophisticated scoring mechanisms. Additionally, exploring machine learning techniques such as reinforcement learning could enable the AI to adapt and improve its gameplay over time, providing players with a more challenging and rewarding experience. Also can use heuristic approaches to provide more advance system with high challenging level. Below are some of them to improve the scrabble game with more AI capabilities.

Positional Heuristic: Assessing the value of words by considering their specific location on the game board, such as occupying advantageous squares or hindering the opponent's chances.

Future Potential: A heuristic could take into account the possibility of future moves, such as strategically keeping high-value tiles like 'ඣ' or blank tiles for future turns.

2. Challenging Levels

Furthermore, the program's AI assessment functions could be improved by incorporating a rack evaluator, in addition to the existing Scrabble and user features. This approach takes into account the possibilities of letter tile usage and the frequency of Sinhala characters, hence enhancing strategic gameplay. Integrating a word translator into the game might be a potential way to enhance its instructional value and expand its worldwide reach. Improving game usability may entail incorporating various difficulty levels to more accurately evaluate the abilities of the player. Moreover,

creating web and mobile iterations of the game would serve as a potent means of promoting the Sinhala language via a Scrabble game.

3. Language Expansion

Expanding the game to support additional languages would broaden its appeal and accessibility to a more diverse audience. This could involve translating the game's interface, instructions, and content into other languages and adapting the gameplay mechanics to accommodate the linguistic characteristics of different languages. By supporting multiple languages, the game could cater to a global audience of language learners and enthusiasts, promoting cross-cultural understanding and appreciation.

4. Educational Features

Integrating additional educational features would further enhance the game's value as a learning tool. This could include interactive tutorials on language fundamentals, grammar lessons, vocabulary quizzes, and cultural insights related to the Sinhala language and Sri Lankan culture. Incorporating adaptive learning algorithms could personalize the learning experience for each player, identifying areas for improvement and providing targeted feedback and resources to support language acquisition and skill development.

5. Community Engagement

Building a vibrant community around the game would be essential for its long-term success and sustainability. This could involve creating online forums, social media groups, and community-driven content platforms where players can share their experiences, exchange tips and strategies, and collaborate on language-related projects. Organizing events such as language meetups, tournaments, and collaborative challenges could further foster community engagement and camaraderie among players, strengthening their connection to the game and its broader language learning community.

In conclusion, the future of the Sinhala Scrabble game holds exciting possibilities for further innovation, expansion, and community building. By continuously refining the AI model, introducing multiplayer functionality, expanding language support, integrating educational features, and fostering community engagement, we can

continue to enhance the game's value as a learning tool and cultural resource for Sinhala speakers and language enthusiasts worldwide.

CHAPTER 6: APPENDICES

Novelty of Research Approach

Our research approach is characterized by its innovative and multidisciplinary nature, bringing together principles from computational linguistics, game development, and machine learning to create a ground-breaking educational tool: the Sinhala Scrabble game with AI integration.

- Computational Linguistics: This project stands out for its deep integration of computational linguistics principles into the game design and development process. By leveraging computational linguistics insights, we ensured that the game respects the linguistic intricacies of the Sinhala language. This includes considerations such as phonetic structure, morphological analysis, and semantic nuances, which are crucial for creating a linguistically accurate and culturally authentic gameplay experience.

- Game Development: Another novel aspect of our research approach is the application of game development principles to create an engaging and immersive user experience. We meticulously designed the game mechanics, prototyped various gameplay elements, and iteratively refined the user interface to ensure that players are captivated while simultaneously enhancing language acquisition and retention. By tailoring game mechanics to suit the unique characteristics of the Sinhala language and culture, we ensure cultural relevance and authenticity, further enriching the player experience.

Advancements in Educational Technology

Our project represents a significant advancement in the field of educational technology, particularly in the context of language learning and cultural preservation. By creating the Sinhala Scrabble game integrated with AI capabilities, we have introduced several innovations that contribute to the advancement of educational technology.

- Enhanced Learning Experience: The Sinhala Scrabble game provides users with a dynamic and interactive platform for language learning. Through gameplay, players are able to practice vocabulary, spelling, and language comprehension skills in a fun and engaging way. The integration of AI enhances the learning experience by providing personalized feedback and adaptive gameplay, catering to individual learning styles and preferences.

- Personalized Learning: One of the key advancements in educational technology introduced by our project is the use of AI to provide personalized learning experiences. The AI component of the game analyzes player interactions and adapts gameplay accordingly, providing targeted feedback and suggestions for improvement. This personalized approach to learning enhances engagement and motivation, leading to more effective language acquisition and retention.

- Cultural Relevance: Another significant contribution of our project is the emphasis on cultural relevance in educational technology. The Sinhala Scrabble game not only teaches language skills but also promotes cultural awareness and appreciation. By incorporating culturally relevant content and gameplay elements, we aim to foster a deeper connection to the Sinhala language and its rich linguistic heritage. This cultural authenticity enhances the overall learning experience and promotes cross-cultural understanding.

Impact on Language Learning

The Sinhala Scrabble game has a profound impact on language learning outcomes for Sinhala speakers and language learners alike. Through its immersive and interactive gameplay, the game facilitates language acquisition, cognitive development, and long-term language retention.

- Language Acquisition: The game provides a practical and engaging platform for players to practice vocabulary, spelling, and language comprehension skills in the context of real-world scenarios. By actively participating in gameplay, players reinforce their understanding of Sinhala language rules and structures, leading to improved language proficiency over time. Additionally, the game's adaptive nature

allows players to progress at their own pace, ensuring a tailored learning experience that meets individual needs and preferences.

- Cognitive Development: In addition to language skills, gameplay also enhances cognitive abilities such as memory, attention, and problem-solving. Players must strategize and plan their moves carefully, considering factors such as word placement, tile values, and potential scoring opportunities. This cognitive engagement stimulates mental agility and critical thinking skills, contributing to overall cognitive development and academic success.

- Long-Term Language Retention: One of the key benefits of the Sinhala Scrabble game is its potential for long-term language retention. By providing repeated exposure to Sinhala vocabulary and language patterns in a fun and engaging context, the game reinforces learning and helps solidify language skills over time. Moreover, the game's adaptive AI component ensures that players continue to be challenged as they progress, maintaining interest and motivation in the learning process.

Overall, the Sinhala Scrabble game has a positive impact on language learning outcomes by providing an effective and enjoyable way to practice language skills, enhance cognitive abilities, and promote long-term language retention. As technology continues to evolve, educational games like Sinhala Scrabble have the potential to play a significant role in language education and cultural preservation efforts, empowering learners to achieve fluency and proficiency in the Sinhala language.

Contribution to Cultural Preservation

The Sinhala Scrabble game makes a significant contribution to the preservation and promotion of Sinhala language and culture. Through its immersive gameplay and culturally authentic content, the game serves as a digital repository of Sinhala language and cultural heritage, ensuring that linguistic nuances, idioms, and expressions are preserved for future generations.

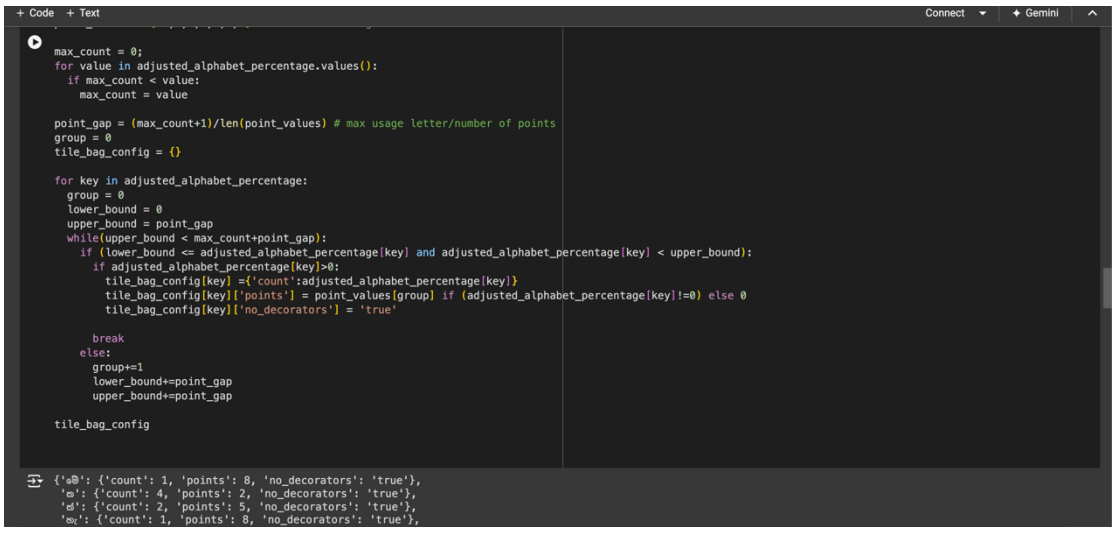
- Digital Heritage: The game encapsulates the essence of Sinhala language and culture, featuring vocabulary, phrases, and cultural references that reflect the

richness and diversity of Sri Lankan society. By showcasing these elements in a digital format, the game preserves linguistic and cultural traditions that might otherwise be lost or forgotten over time. This digital heritage serves as a valuable resource for language learners, educators, and researchers interested in exploring and studying the intricacies of the Sinhala language and culture.

- Community Engagement: The Sinhala Scrabble game fosters community engagement and pride in Sinhala language and culture. Through gameplay, players connect with each other, share experiences, and celebrate their shared cultural identity. By providing a platform for cultural exchange and collaboration, the game strengthens community ties and fosters a sense of belonging among Sinhala speakers and enthusiasts worldwide.

- Broader Implications: The project's contribution to cultural preservation extends beyond the game itself, influencing broader discussions on language revitalization, multicultural education, and digital humanities research. By showcasing the vibrancy and resilience of the Sinhala language and culture in a digital context, the game challenges stereotypes and misconceptions and promotes cross-cultural understanding and appreciation. This broader impact underscores the importance of incorporating cultural relevance and authenticity into educational technology initiatives, ensuring that diverse linguistic and cultural heritage are celebrated and preserved for future generations.

Letter Distribution and Scoring

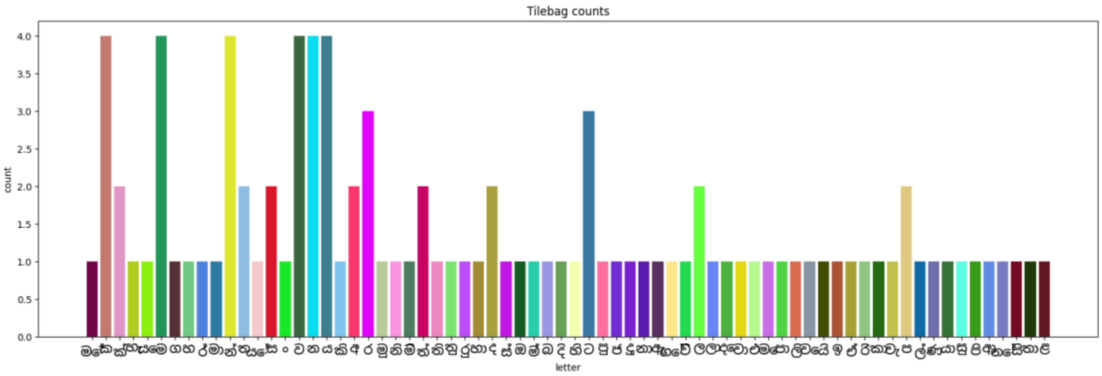


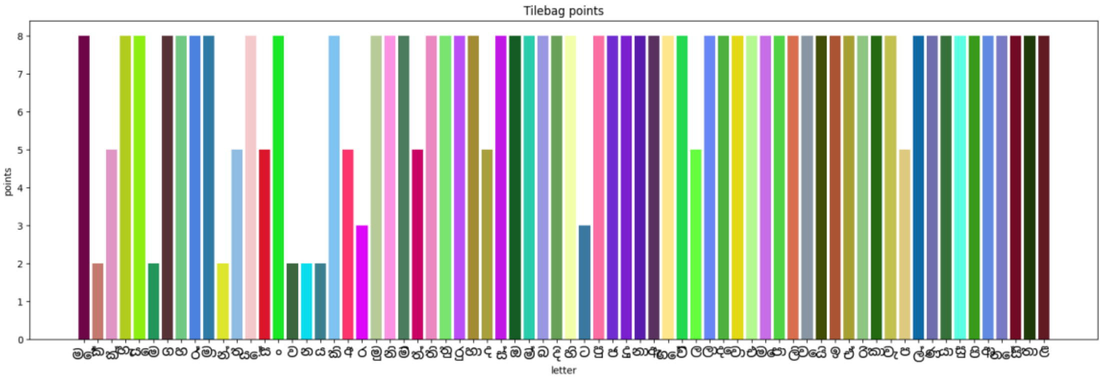
Visualization

```
value_letters = {}
for key in tile_bag_config:
  if tile_bag_config[key]['count'] in value_letters:
    value_letters[tile_bag_config[key]['count']]['letters'].append(key)
  else:
    value_letters[tile_bag_config[key]['count']] = {'letters': [key], 'points':tile_bag_config[key]['points']}

for i in range(1,max_count+1):
  if i in value_letters:
    print(i, ' : points = ', value_letters[i]['points']  ,'=>',value_letters[i]['letters'])
```

```
1  : points =  8 => ['මේ', 'හැ', 'යෙ', 'ග', 'හ', 'ඊ', 'මා', 'යේ', 'ං', 'කි', 'මු', 'නි', 'මී', 'ති', 'තු', 'රු', 'හා', 'ස්', 'ඔ', 'ඕ', 'ඛ', 'දී', 'හි', 'පු', 'ඊ', 'දු', 'නා', 'ඇ
2  : points =  5 => ['ක්', 'ත', 'ස', 'අ', 'ත්', 'ද', 'ල', 'ර']
3  : points =  3 => ['ර', 'ව']
4  : points =  2 => ['ක', 'ම', 'න්', 'ච', 'න', 'ය']
```





REFERENCES

Appel, A.W. and Jacobson, G.J. (1988). The world's Fastest Scrabble Program. *Communications of the ACM*, 31(5), pp.572–578. doi:https://doi.org/10.1145/42411.42420.

Dulanga, D. (2017). An Artificial Intelligence Based Scrabble Game for Sinhala Language. *Proceedings of APIIT Business, Law & Technology Conference*.

Gordon, S.A. (1994). A Faster Scrabble Move Generation Algorithm. *Software: Practice and Experience*, 24(2), pp.219–232. doi:https://doi.org/10.1002/spe.4380240205.

Khaira, M., Mahyudin Ritonga and Halim, S. (2021). The Effectiveness of Scrabble Game Media in Improving Learning Outcomes. *Journal of Physics: Conference Series*, 1933(1), pp.012128–012128. doi:https://doi.org/10.1088/1742-6596/1933/1/012128.

Supriadi, S. and Jalaluddin, J. (2023). The Use of Scrabble Game as a Teaching Medium to Improve Students' Vocabulary Mastery. *JUPEIS : Jurnal Pendidikan dan Ilmu Sosial*, 2(1), pp.62–67. doi:https://doi.org/10.57218/jupeis.vol2.iss1.510.

Hainey, T., Connolly, T.M., Boyle, E.A., Wilson, A. and Razak, A. (2016). A Systematic Literature Review of games-based Learning Empirical Evidence in Primary Education. *Computers & Education*, 102, pp.202–223. doi:https://doi.org/10.1016/j.compedu.2016.09.001.

Ilya Sutskever, Martens, J. and Hinton, G.E. (2011). Generating Text with Recurrent Neural Networks. pp.1017–1024.

Kam, M., Agarwal, A., Kumar, A., Lal, S., Mathur, A., Tewari, A. and Canny, J. (2008). Designing e-learning Games for Rural Children in India. *Designing Interactive Systems*. doi:https://doi.org/10.1145/1394445.1394452.

Aris Maulana Hakim (2014). Reinforcing Students' Vocabulary Through Scrabble Game.

Arratia, R., Morris, P. and Waterman, M.S. (1988). Stochastic scrabble: large deviations for sequences with scores. *Journal of Applied Probability*, 25(1), pp.106–119. doi:https://doi.org/10.2307/3214238.

Lin, C.-P., Shelley Shwu-Ching Young, Hung, H.-C. and Lin, Y. (2007). Implementation of the scrabble game on the mobile devices to increase english vocabulary acquisition. doi:https://doi.org/10.3115/1599600.1599681.

Michael, D.C. and Chen, S. (2005). *Serious Games: Games That Educate, Train, and Inform*.

Robinove, C.J. (2002). Letter-Frequency Bias in an Electronic Scrabble Game. *CHANCE*, 15(1), pp.30–31. doi:https://doi.org/10.1080/09332480.2002.10542311.

Schaeffer, J. (2000). The games computers (and people) play. *Advances in Computers*, pp.189–266. doi:https://doi.org/10.1016/s0065-2458(00)80019-4.

Werbach, K. and Hunter, D. (2012). *For the Win: How Game Thinking Can Revolutionize Your Business*.