# SPELLINGUAL: A GAMIFIED APPROACH TO ENHANCE MULTILINGUAL SPELLING SKILLS

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A Capstone Project Submitted to the
University of North Carolina Wilmington in Partial Fulfillment
of the Requirements for the Degree of
Master of Science

Department of Computer Science
Department of Information Systems and Operations Management

University of North Carolina Wilmington

2024

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

# ABSTRACT

Spellingual: A Gamified Approach To Enhance Spelling Skills. Parrott, Caitlin, 2024. Capstone Paper, University of North Carolina Wilmington.

This project introduces Spellingual, an educational application aimed at enhancing the spelling abilities of second-grade multilingual children who are verbally fluent in Farsi. This web-based application acts as a platform for fostering foreign language learning, focusing on spelling proficiency as a fundamental aspect of language acquisition. Spellingual seeks to encourage these skills through a gamified and multimedia-rich environment. With its highly adaptable nature, the application is designed to aid multilingual children of varying proficiency levels but allowing them to work at their own pace. Central to Spellingual is its emphasis on accessibility and visual appeal, improving motivation and fostering a desire to learn. By incorporating feedback mechanisms, level progression, point accumulation, and a hint system, the application ensures sustained engagement and helpful tools for learners through positive reinforcement. This approach is informed by comprehensive research demonstrating the effectiveness of game-based learning strategies in keeping children interested and motivated over time. Additional research supporting this project include the benefits of multilingualism in children and lack of accessible tools to assist with spelling proficiency in a non-native language. Future works include expansion to additional grade levels, additional user testing, and the integration of Spellingual into educational environments as a supplementary tool.

# CHAPTER 1: INTRODUCTION

Multilingualism is increasingly recognized for its cognitive and social advantages, especially when it is incorporated into early education. By providing a means to become proficient in a foreign language, children are presented with a strong foundation for success throughout their lives. In the age of digital education, applications focusing on foreign language acquisition are more prevalent than ever. However, the focus of these applications is predominantly on general language skills like pronunciation, sentence formation, and vocabulary - often overlooking foreign language spelling skills like forming words and letter recognition. Existing applications that do address spelling are either inaccessible or not specifically designed for elementary children, particularly those who are multilingual. This gap is pronounced for second-grade multilingual children who are verbally fluent in Farsi, where educational applications with a focus on foreign language spelling skills are scarce and opportunities for holistic language development are limited.

This project intends to address these issues with the introduction of a web-based educational application designed specifically for second-grade multilingual children who are verbally fluent in Farsi. Spellingual incorporates gamification elements and multimedia content to enhance Farsi spelling skills through an effective and engaging learning process. The application is designed to be inclusive, catering to varying levels of spelling proficiency and familiarization with the Farsi writing system. It aims to improve motivation and sustained engagement through interactive elements, feedback mechanisms, and a hint system tailored to early elementary needs. This approach is intended to provide a positive learning environment that continuously encourages interaction with the application, thus reinforcing spelling proficiency in Farsi.

## *Background*

The development of Spellingual is supported by an extensive review of recent research on multilingualism, foreign language education, vocabulary learning applications, mobile-assisted language learning (MALL), and gamification in education.

Focusing on studies published more recently to ensure the technology standards, this review ensures the relevance and efficacy in the current e-learning environment. These applications have surpassed traditional classroom instruction and conventional textbooks in recent years, using technology to engage learners in innovative ways. The progression of foreign language skill development applications has changed language education by providing dynamic and interactive learning opportunities. These technological advancements in foreign language acquisition have consistently proven their effectiveness in language education using attributes like widespread accessibility, multimedia technology, and contextualization, all of which contribute to improved comprehension and retention of knowledge. Recent research results demonstrate the influence of these applications, with mobile applications being acknowledged as effective mechanisms for enhancing spelling skills (Panfilova et al., 2022, p. 2).

Gamification, or the incorporation of game design elements into non-game contexts, has become a powerful factor in applications for the development of foreign language spelling skills. It does this by providing a sense of "achievement and progression" that fulfills the psychological needs of competence, autonomy, and relatedness (Bitrián et al., 2021, p. 181). Gamification elements like rewards, interactivity, feedback mechanisms, and progressive levels also play a pivotal role in sustaining learners' engagement and commitment to the learning process (Wang et al., 2021, p. 265). The potential of gamification in foreign language learning, particularly in the development of spelling skills among young multilingual children, holds great promise and has proven effective in application. Gamified education applications on mobile devices leverage the prevalence of technology to offer a flexible and accessible means of learning, free from constraints related to time and location (Mortazavi et al., 2021, p. 3).

*Objective*

The goal of this project is to develop Spellingual, an application specifically designed to address the needs of second-grade multilingual children fluent in Farsi,

aiming to improve their spelling skills in foreign language learning (FLL). It is designed to streamline the learning process while engaging the learner through the incorporation of various game elements, enhancing motivation and language proficiency. The elements used within the application encompass rewards, interactivity and feedback, progressive levels, points, and unlockable content through the inclusion of a support system. Through this approach, the result is intended to be an engaging and motivating education application for second-grade multilingual children verbally fluent in Farsi, contributing to the field of language education and technology-enhanced learning.

This introduction lays the foundation for the project, emphasizing the importance of vocabulary acquisition and the effective potential of gamification and multimedia integration in foreign language spelling skills development. Chapter 2 discusses the literature review and analysis of findings, focusing on vocabulary learning applications, gamification in education, and multimedia elements. Chapter 3 discusses the methodology for the application's implementation and design. Chapter 4 documents the functionality and testing of the vocabulary application. Chapter 5 discusses the recommendations for future work and the conclusion of the application's development.

# CHAPTER 2: LITERATURE REVIEW AND ANALYSIS

In contemporary education and training, educational applications have emerged as indispensable tools. They remove geographical limitations, rendering education accessible to a global audience, and promote inclusivity by accommodating diverse learning styles and the needs of individuals with disabilities. Their adaptability and convenience empower learners to engage with content at their own pace and on their schedules, catering to the varied demands of learners with diverse lifestyles. An intriguing aspect of educational applications is their capacity to incorporate gamification elements, which enhance engagement and aid in information retention, as corroborated by research in this field. This literature review discusses the key factors supporting the utilization of vocabulary learning applications enriched with gamification elements, specifically examining their impact on learner motivation, engagement, and the cultivation of a positive attitude towards vocabulary skills with consideration to cultural factors.

## *Multilingualism in Children*

Multilingualism or bilingualism in children has proven to provide significant improvements in cognitive and social-emotional skills as well as vocabulary and writing studies compared to monolinguisitic children. These children are better "at focusing on a task while tuning out disruption," and these benefits are compounded when the child learns a second language before the age of five (Pransiska, 2016, p. 391). The social-emotional benefits can lead to better global networking skills later in life as well as a a more tolerant frame of mind that implies multilingualism positive affects multiculturalism, benefiting academics and career paths. Additionally, bilingualism has been found in studies to provide "an advantage on children's conversational understanding," improving their communication when exposed to multiple languages early in life (Liberman et al., 2017; Siegal et al., 2010, pp. 6, 3).

Findings on the impact of multilingualism in child development have been found as far back as 1939, where language development skills were first observed to be boosted in

a bilingual child (Barac & Bialystok, 2011, p. 40). Though results vary since this point in time, no meaningful detriments to cognitive or social-emotional skills in bilingual children have been reported and those that report benefits indicate such skills as attentional control, working memory, and executive function. Even as far back as infancy, multilingual infants demonstrated greater working communication skills, and even those that were inconsistently exposed to more than one language were "better at taking a speaker's perspective than monolingual children without such exposure" (Liberman et al., 2017, p. 8). These conversational benefits are shown to not only improve a child's ability to engage in conversations but to also initiate conversations, further improving social-emotional skills (Anatoli & Cekaite, 2023, p. 46). In one study that assessed the performance of children that were monolingual, bilingual, and exposed to other languages, the bilingual group of children outperformed the monolingual and exposed groups on the Dimensional Change Card Sort task score used to measure executive function (Fan et al., 2015, p. 1095).

However, it is worth noting that these skills were found in some studies to translate best between languages that "used similar writing systems" (Barac & Bialystok, 2011, p. 52). This bring to question how to provide additional support to multilingual children that switch between different forms of writing to continually provide the same benefits. One such study on Hangul and English writing systems found that young children gradually improve their of writing system letters identification by "highlighting their knowledge of the similarities and differences between writing systems" (Nam, 2018, p. 513). This evidence further supports the case to expose children to foreign language writing systems in early elementary, providing additional opportunity to improve social and cognitive skills by taking advantage of their adaptability during this age.

*Foreign Language Learning*

In early education, foreign language learning (FLL) skills require a "clear, interesting, and well-placed learning environment" with personal investment and

engaging learning activities (Oga-Baldwin et al., 2017, p. 149). With previously revealed declines in motivation to learn a foreign language, digital learning models have evolved to focus on how best to improve the state of foreign language acquisition. Modern models may rely on applications to assist learners in "develop their reading, listening, writing, and speaking skills as well as providing them with new vocabulary and grammar structures" (Pitarch, 2018, p. 1155). This is possible due to the relationship between learner motivation and emotion which can determine the success of FLL and the interpersonal motivation factors that engage learners with a foreign language: cooperation, competence, and recognition (Pitarch, 2018, p. 1149). If these requirements are satisfied, then the success of FLL significantly improves.

An important aspect of FLL is the development of interest. Regardless of the setting, offering foreign language courses in early elementary settings may help with foreign language fluency. While traditional learning environments do not guarantee fluency, foreign language learning applications provide "opportunities for more informal language development" that may improve the odds of success (Parkinson & Dinsmore, 2019, p. 8). Additionally, early-start language programs lay the foundation for FLL programs that span throughout elementary and secondary school systems, which is found necessary "to ensure cumulative language learning across educational levels" (Baumert et al., 2020, p. 1126). It is important to note that proficiency levels were found in early-start programs regardless of age, but have been cited to begin as early as age six, equating to the average age of a second-grade elementary student (Baumert et al., 2020, p. 1126). Finally, results of recent studies found that creative endeavors that introduced "interactive problem-based tasks" provided better success in soft skills development and "task and linguistic performance" during interaction with a FLL application (Medvedeva et al., 2022, p. 13).

*Vocabulary Learning Applications*

The integration of multimedia technology in vocabulary learning applications has consistently demonstrated its effectiveness, particularly among young learners. Research in this area consistently highlights the positive impact of these applications on reading and writing skill acquisition in foreign languages, achieved through interactive exercises and multimedia-rich content. Users benefit from their high accessibility, contextualization features, and the incorporation of multimedia elements such as visuals and interactive components (Wang et al., 2021). Vocabulary learning applications enriched with multimedia have shown promise in enhancing vocabulary comprehension and memorization (Mortazavi et al., 2021, pp. 8–9). The inclusion of visuals, audio pronunciations, and interactive exercises offers a multi-sensory learning experience that is particularly advantageous for young learners (Panfilova et al., 2022, p. 3). These applications facilitate improvement in reading and writing skills by providing an engaging and enjoyable learning process, especially for children (Elaish et al., 2019, p. 13327).

Research consistently shows the advantages of vocabulary learning applications in language education. They boost learner motivation, resulting in more positive attitudes towards learning (Elaish et al., 2019, p. 13327). Mobile language learning applications have proven effective by enhancing vocabulary knowledge, retention, and overall enjoyment of the learning process. They offer practicality, user-friendliness, convenience, and time-saving benefits compared to traditional learning environments, highlighting the efficacy of such applications as a tool for language acquisition (Polakova & Klimova, 2022, p. 8). Additionally, vocabulary is recognized as a vital component of language, influencing listening, speaking, reading, and writing skills (Sari et al., 2022, p. 3). Vocabulary learning applications improve learners' skills and allow them to choose their preferred learning settings, providing a flexible learning environment. Engaging learners in constructing meaning rather than rote memorization is a more effective approach to vocabulary acquisition, aligning with the concept of matching words to cultural

significance (Sari et al., 2022, p. 12).

Research has illustrated the significant cognitive gains that digital learning methods bring to foreign language education. These methods empower learners to take control of their learning pace, breaking free from the constraints of time and place (Klimova & Pikhart, 2023, p. 2). Such autonomy fosters personalized and self-directed learning, ultimately leading to more effective language acquisition. While the effectiveness of foreign language learning varies depending on individual needs, motivations, and the tools employed, digital methods in particular exhibit a positive impact on vocabulary acquisition. To maximize cognitive gains, learners should be exposed to a variety of engaging techniques that stimulate their senses, enhancing the overall learning experience. Providing timely and constructive feedback is paramount, as it not only maintains learners' motivation but also nurtures continuous progress in their foreign language studies (Klimova & Pikhart, 2023, p. 7). These insights emphasize the potential of digital language learning by enhancing cognitive growth and proficiency in foreign languages.

Additional research findings indicate that students hold a strong appreciation for vocabulary learning applications. In a study involving a substantial number of English as a foreign language (EFL) students, a notable 86% of participants recognized mobile applications as highly effective tools for vocabulary acquisition (Wang et al., 2021, p. 253). It is important to note that the standard assessment measure of success is academic achievement, but additional measures include behavioral and cognitive engagement. Based on the results of these measures were reliant on individual differences, meaningful gamification, and diversified element selection (Luo, 2023, p. 12). This widespread acceptance reinforces the potential of such applications in promoting language skills among young learners and suggests a shift towards more learner-centered and engaging language education. These findings collectively emphasize the pivotal role of vocabulary learning applications in motivating learners and fostering effective language acquisition, particularly when integrated with multimedia-rich content and

Mobile-Assisted Language Learning (MALL) methods.

*Gamification in Education*

Within the realm of gamification, several elements come into play to enrich the educational experience. One of these elements involves implementing a points system, whereby learners accumulate points as they advance through tasks or modules. These points often correlate with rewards like badges, certificates, or virtual items, capitalizing on individuals' innate desire for recognition and accomplishment (Sandberg et al., 2014, p. 120). Additionally, progress tracking elements, such as progress bars or indicators, visually represent learners' advancement, evoking a sense of achievement and motivating them to persevere during the educational process (Zeybek & Saygı, 2024, p. 250).

Dividing the learning material into challenges or levels offers a structured approach to the educational process. Each new challenge presents an opportunity to apply knowledge and attain mastery, further enhancing motivation. Lastly, interactivity and immediate feedback are indispensable gamification elements. Learners are prompted to actively engage with the content through puzzles, quizzes, or simulations and receive real-time feedback on their actions, promoting critical thinking and the adjustment of learning strategies (Zainuddin et al., 2020).

*Multimedia Elements*

Multimedia integration within vocabulary learning applications stands as a cornerstone in augmenting language acquisition. These applications ingeniously blend visual and interactive elements to create a comprehensive and engaging learning experience. Visual elements are instrumental in fortifying vocabulary acquisition. The inclusion of images within gamified vocabulary applications enables learners to associate words with visual representations. By intertwining language with tangible images, these applications facilitate not only heightened comprehension but also extended retention (Mortazavi et al., 2021, p. 8). Blending textual information with images that illustrate the meaning of words converts abstract vocabulary into tangible concepts, facilitating the

learners' understanding of the language.

Integrating gamification elements with multimedia enhances the educational experience, adding an extra layer of engagement and effectiveness, while also catering to diverse learning styles and preferences. This combination improves learner motivation and accommodates individual approaches to learning. Multimedia components, encompassing visuals like images and info-graphics, not only enhance comprehension but also render learning visually captivating. Interactive simulations create a risk-free environment for learners to experiment with complex concepts, thereby facilitating a deeper grasp of the subject matter. As seen in Figure 1, Game elements of applications, 15 existing applications that share a common emphasis on vocabulary learning were investigated. Among them, numerous gamified elements are currently incorporated and all of which have documented successful outcomes (Wang et al., 2021, p. 260).

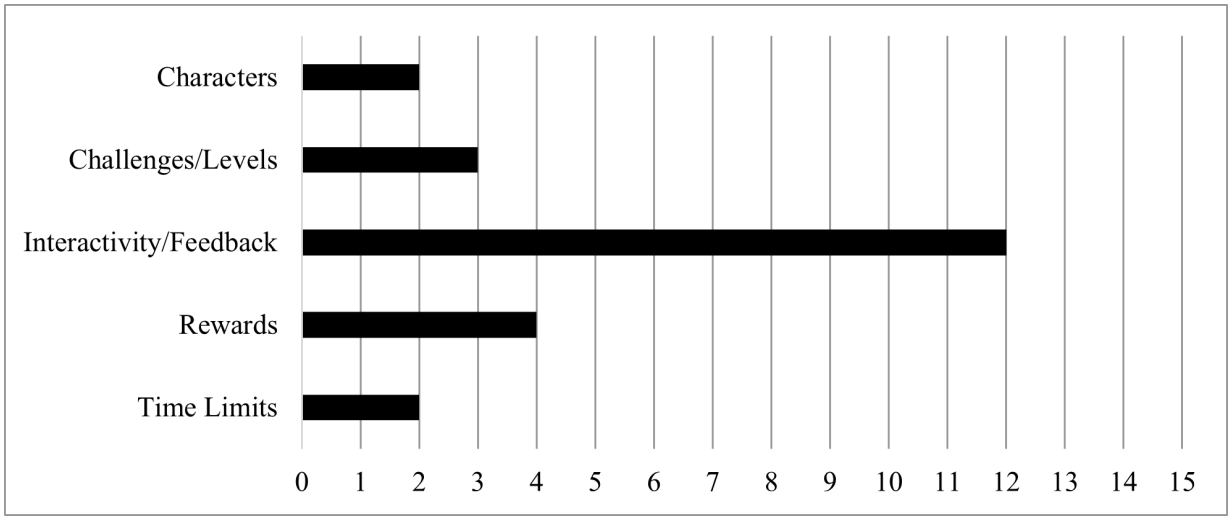


Figure 1. Game elements of applications

As seen in Figure 2, Multimedia input of applications, several forms of multimedia are used to enhance the learning process among the 15 existing applications investigated (Wang et al., 2021, p. 260). These applications facilitate improvement in challenges that not only encourage but require the practical application of freshly acquired vocabulary, providing learners with immediate feedback that reinforces their comprehension (Wang et al., 2021, p. 262). Consequently, what were once passive vocabulary acquisition

processes have became dynamic learning experiences. These gamification elements, such as rewards, points, and level progression, serve as motivators that drive learners to actively participate with the application (Chen et al., 2019, p. 172).

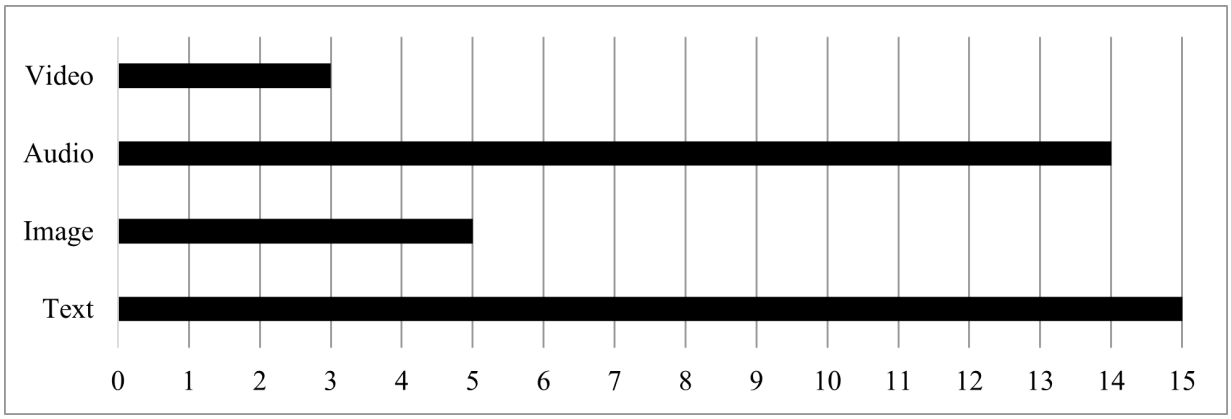


Figure 2. Multimedia input of applications

In conjunction with these interactive elements, the inclusion of visual and interactive components in gamified vocabulary applications directly impacted learner performance and outlook of learning vocabulary, leading to "improved learning outcomes" (Chen et al., 2019, p. 184). The benefits of this approach extend beyond the limitations of conventional teaching, amplifying not only vocabulary comprehension but also injecting an element of enjoyment into the educational process. As a result, multimedia elements are pivotal in enhancing the overall learning experience, making it both enjoyable and engaging for learners. This integration transforms the educational journey into an interactive and engaging adventure, fostering improved comprehension and knowledge retention. Ultimately, it stands as a compelling approach in modern education.

*Definition of Terms*

This section provides the terminology used in this paper that may not be common knowledge for an average reader. These terms are technical jargon commonly used in areas of software development and educational technology.

*Amazon Web Services (AWS).* A widely adopted cloud platform that provides a wide range of services including computing power, database storage, and content delivery.

In the context of educational applications, AWS offers scalable infrastructure solutions to host and manage web-based applications.

*Client-Server Model.* The client-server model is an architectural framework for web-based applications where the client (user interface) and server (application server) communicate over a network. This model is commonly used for centralized data management, scalability, and accessibility from any internet-connected device.

*Cross Browser Compatibility.* Cross-browser compatibility refers to the capacity for a web application to provide consistent functionality to improve the user experience across different web browsers and devices. Cross-browser compatibility is essential for educational tools to reach a wide audience regardless of the technology used to access the application.

*Educational Applications.* Educational Applications are digital tools used to facilitate learning and instruction using interactive technologies to deliver content, assess learner performance, and provide feedback. The nature of these tools supports various learning styles and accessibility needs.

*English as a Foreign Language (EFL).* EFL refers to the teaching of English to students whose native language is other than English.

*Foreign Language Learning (FLL).* FLL refers to the acquisition or sharing of nonnative language outside of its native context, where it is prevalent among speakers. It also refers to learning a foreign language where it is not the native language of the learner.

*Gamification.* The definition of gamification utilized in this paper is the integration of game design elements and principles in a non-game context to engage and motivate learners. This approach uses elements like rewards, challenges, and feedback mechanisms to increase engagement and promote learning outcomes.

*Interactive Exercises.* Activities within educational software that require active participation from learners to complete the tasks or solve the problems are considered interactive exercises. Their design is intended to engage learners directly, offer immediate

feedback, and reinforce learning by adjusting difficulty based on performance.

*Mobile-Assisted Language Learning (MALL).* MALL is a form of language education that utilizes mobile devices to facilitate learning and teaching. It supports learning beyond the constraints of location and time and offers accessibility, personalization, and multimedia integration.

*Multimedia Technology.* Multimedia Technology is the use of combined forms of media like text, audio, images, and video in educational software to improve the learning experience. It supports diverse learning preferences by providing information in diverse formats to aid in comprehension and retention.

*Vue Framework.* Vue is a progressive framework for JavaScript used to build user interfaces and is favored for its simplicity, flexibility, and performance. This makes it suitable for developing interactive and dynamic educational platforms.

# CHAPTER 3: METHODOLOGY

The methodology section of this project outlines the framework for the development of Spellingual, an educational vocabulary learning application aimed at second-grade multilingual children verbally fluent in Farsi. It summarizes the strategic approach by describing the architectural and design blueprint, requirements and limitations identification, iterative prototype, planned timeline, and risk mitigation strategies. It also includes the data collection methods and analytical technique for evaluating the application's impact on spelling skills. This methodology provides a structured and effective development process aimed at delivering an educational tool tailored at the specific learning needs of its target audience.

## *Architecture and Design*

*Architecture.* The architecture of Spellingual utilizes a client-server model, with the client operating through the user's web browser and the server component hosted on Amazon Web Services (AWS). This design is ideal for web-based applications as it provides essential scalability and accessibility, crucial for the success of the project. AWS plays a critical role in deploying and maintaining key technologies like the Vue.js framework, HTML5, and CSS3, which form the backbone of the application.

As seen in the System State Diagram in Figure 3, the components included in this application demonstrate the methods used for gathering and storing data, interaction with the player, and navigation between elements. The interaction begins when the player visits the application's web page, where the initialization begins. During initialization, the application gathers the Farsi alphabet and dictionary of words from file to store in Local Storage. Local Storage holds the player's current state within the application, while the application's state management system acts as a driver to dynamically update data while the player interacts with the application.

Once the data is loaded and the user provides their chosen username on the Landing, they are taken to the Level Select where a list of available dictionary entries is

transformed into Levels. The player's progress is linear but they may revisit previous Levels at any time. Once they select a Level, it will gather the information from the Store and display the information required to play the game. At any point while playing a Level, the player may access the Hint Modal that will allow them to purchase Hints using their accumulated points as currency. After the user completes a Level, they are returned to the Level Select screen or to the next Level depending on their choice. Additionally, at any point, the player may access the Menu, which displays their information and allows them to reset their progress. Upon progress reset, the player loses all stored data and returns to the Landing to provide a new username and start the game over.

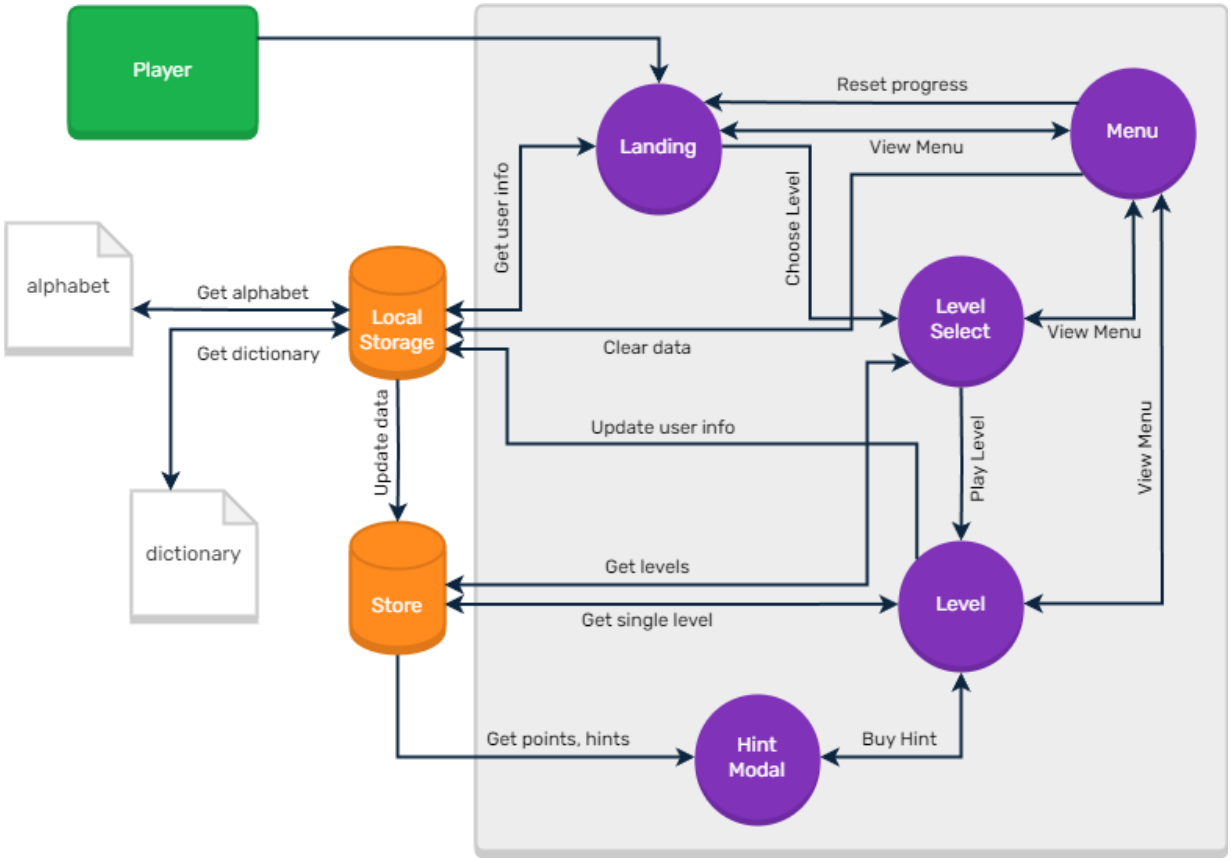


Figure 3. System State Diagram

*Design.* JavaScript and Vue.js were chosen for their strong support of web-based interactivity, crucial for this educational application. JavaScript facilitates real-time interactivity through its Virtual DOM, enabling immediate feedback and a responsive

user interface that can dynamically adjust to user interactions. Vue.js, known for its progressive features, streamlines user interface development by employing reusable components and an efficient state management system. These technologies not only ensure scalability and future expandability but also guarantee cross-browser compatibility, essential for reaching a diverse user base. Additionally, Vue.js is supported by a robust developer community, offering extensive resources and cost-effective solutions, making it an ideal choice for developing Spellingual.

A distinct aspect of the system is its back-end technology, operating in a manner that avoids the use of a separate database to house data. Instead, JSON files were adopted to store static information, taking advantage of the application's storage capacity on the server to manage vocabulary dictionaries used for language integration into the system. The design optimized data handling, provided an efficient retrieval and management system for resources, simplified data processing. Additionally, this removes a level of data insecurity by reducing the external dependencies for the application.

*Requirements and Limitations*

*Requirements.* The following list outlines the key system requirements for the development of Spellingual. These requirements encompass various aspects, ranging from usability and security to scalability and multimedia integration. By adhering to these requirements, the application delivered a seamless and engaging learning experience to its target audience, aiming to foster effective language acquisition while ensuring its quality and security.

- *Cross browser compatibility.* The application functions seamlessly across major web browsers like Chrome, Firefox, Safari, and Edge, accommodating a diverse user base and enhancing accessibility.
- *Responsive design.* A responsive user interface adapts to different screen sizes and orientations including desktops, tablets, and mobile devices for an optimized user experience.

- *Fast Loading Times.* Fast loading times were prioritized to promote user engagement crucial for young users by reducing loading times and waiting periods.
- *Intuitive User Interface.* A child-friendly interface was developed to reduce user frustration, improve navigation abilities, and promote an effortless learning experience.
- *Multimedia Integration.* Multimedia elements were effectively incorporated through the use of visual styles, audio, and interactive components to enhance comprehension and engagement.
- *Scalability.* The system was designed with scalability in mind, allowing for future expansion to accommodate new languages, vocabulary words, and features to meet evolving educational needs.
- *Gamification Elements.* Gamification components were integrated to motivate and engage the target audience through the use of a level progression system, points, streak bonuses, and feedback mechanisms.

Amidst the numerous gamification elements made available to incorporate into educational applications, Spellingual leverages a select few based on their previous success. Table 1 displays the gamification elements incorporated into the application. These elements were determined based on the literature review and their success.

Interactivity and feedback encompasses the vast majority of Spellingual as a means to guide how they interact with the application. This involves sounds to signify confirmation of interaction, outcome of a result, or confirmation of a task. For example, when a user clicks the button to 'guess' their attempt to complete a level (1) they hear a click sound to confirm they clicked the button; (2) a celebratory sound or warning sound signifies the result of their guess; (3) they are asked what task they would like to do next depending on the result.

Additional elements like Levels, Points, Progression View, and Unlockable Content are combined to create a player pace and to prevent overwhelming the player. The player

will see their Points before and during their attempts to complete Levels, and earn Points by completing Levels. The Points can be used to purchase Hints as Unlockable Content to provide additional material to progress. The Progression View is made available in the form of Level Select, allowing the player to see how many levels they have completed, where they are now, and how many levels remain ahead.

| Element | Implementation |
|---|---|
| Interactivity/Feedback | Visual and audible validation of an action to guide interaction. |
| Levels | An individual piece of interactive content used to guide progress. |
| Points | Accumulated numerical value based on progress and performance. |
| Progression View | Visual element depicting and encouraging progress. |
| Rewards/Streaks | Incentive based on level accuracy to encourage improvement. |
| Unlockable Content | Incentive to gain points to unlock support systems. |

Table 1. Gamification Elements Incorporated into Application

*Limitations.* Spellingual is designed with a specific audience and purpose in mind, which introduced certain limitations. These were directly affected by the project's scope, time frame, and objectives. These limitations allowed for informed decision-making with a priority focused on the application's key aspects in functionality and user experience.

- *Scope.* Resource constraints, particularly in terms of time and project scale, imposed restrictions on the application's scope, resulting in a reduced capacity to cater to advanced language learning requirements.
- *Time Constraints.* The project was required to be completed in time for testing and feedback. This limited time frame restricted the depth of features and content that was incorporated.
- *Multimedia Inclusion.* Due to scope limitations and time constraints, the application has limited multimedia features. User interface sounds as feedback mechanisms, and audible pronunciation of words were incorporated, but additional audio elements were not included.
- *Age Range.* The application is designed exclusively for children in kindergarten and

early elementary school. It does not cater to the more advanced needs of an older audience.

- *Proof of Concept.* This project is a proof of concept for an educational application. It provides an effective learning tool but does not contain a full range of features found in mature education platforms.
- *Content Depth.* Spellingual is intended to provide a basic vocabulary learning platform focusing on a specified target audience with the intention of improving spelling skills. It is intended as a supplementary resources for a more complex language learning environment.

*Prototyping*

The prototype for Spellingual served as the initial version of the application with a focus on core functionalities and the user experience. It provided a clear representation of the application's intended usage and user engagement. The functionalities are centered around spelling challenges introduced as levels. These levels provide a word in English and the letters to spell the word in Farsi. To complete the challenge, the user spells the word by tapping or clicking each letter to place it, or remove it, from the spaces representing the completed Farsi spelling of the word. The user is tasked to spell the word correctly using the tools provided within the interface.

The prototype incorporates multiple categories of words. Initially, difficulties for levels were considered, but later retracted in favor of categorization to continuously serve education over challenge. To enhance the learning experience, the prototype includes a feedback system. Users will audibly hear their interactions with the interface, and upon checking their guess for each level, immediate feedback mechanisms take place. The user receives a celebratory sound on a correct guess and a visual display applauding their efforts. On an incorrect guess, the audible sound is non-aggressive to discourage attempts to try again to promote a supportive and encouraging learning environment.

"Spellingual" integrates a touch-based interaction mechanism, allowing users to

intuitively spell words by tapping or clicking on letters. This method, which enables the addition and removal of letters seamlessly, significantly reduces cognitive and physical effort, thereby minimizing frustration and enhancing the learning experience. This approach is particularly beneficial for the application's target demographic, offering an engaging, efficient, and user-friendly interface (Holz & Meurers, 2021, p. 844).

*Timeline and Risks*

*Timeline.* The timeline provided in Table 2 describes the series of steps and key achievements in the development of Spellingual. Spanning from April 2023 to May 2024, the schedule includes a range of stages, beginning with project initiation and concluding with the defense presentation. This timeline follows a customized System Development Life Cycle (SDLC) approach.

| Phase | Task | Date |
|---|---|---|
| Initiation | Define objectives, scope, and requirements | 04/27 - 05/09 |
| Planning | Develop project plan and schedule | 05/10 - 07/20 |
| | Identify project resources, risks, and limitations | 07/21 - 08/22 |
| Analysis | Conduct research on relevant subjects | 08/23 - 09/23 |
| | Analyze similar systems | 08/23 - 09/28 |
| | Gather detailed requirements | 08/23 - 09/28 |
| Design | Define system architecture | 09/19 - 10/05 |
| | Develop system UI/UX design | 10/06 - 11/05 |
| Development | Code and implement system functionalities | 11/06 - 01/29 |
| | Conduct unit testing | 01/30 - 02/29 |
| Testing | Develop and execute test plans | 03/01 - 03/17 |
| | Conduct integration, system, and user acceptance testing | 03/18 - 04/12 |
| | Project refinement based on feedback | 04/13 - 04/19 |
| Defense | Draft final report | 04/20 - 04/26 |
| | Conduct research defense | 04/26 - 04/27 |

Table 2. Project Timeline

*Risks.* The project's success relied on the ability to identify, assess, and mitigate

potential risks. In the context of Spellingual, a comprehensive risk assessment was undertaken to proactively address challenges that may arise during development. The risk table found in Table 3 outlines various scenarios that could impact the project's progress by providing an overview of the likelihood, potential impact, and strategies in place for mitigation. By acknowledging and preparing for these risks, preparations were in place when developmental delays were encountered, reducing their impact. Proper planning ultimately ensured the delivery of a valuable and user-centric application.

| Risk Description | Likelihood | Impact | Mitigation Strategy |
|---|---|---|---|
| Technology Limitations | Moderate | High | Conduct tech feasibility studies, allocate extra time/resources, collaborate with experts. |
| Feedback Misalignment | Low | Moderate | Regularly engage with users, use Agile for feedback integration. |
| Scope Creep | Moderate | Moderate | Define clear scope, establish change request process. |
| Development Delays | High | High | Use Agile, monitor progress closely, adjust timelines/resources. |
| Compatibility Issues | Moderate | Low | Test on various platforms, prioritize fixes. |
| Limited Language Data | Low | Moderate | Collaborate with experts, use available resources, adjust timelines. |
| Technical Dependencies | Low | High | Identify alternatives, maintain communication, develop in-house expertise. |
| Personal Limitations | Low | High | Prepare for contingencies, backup plans, data backups. |

Table 3. Risk Assessment Table

*Data Collection*

Gathering comprehensive feedback from users was accomplished through observed user testing as the primary data collection method. Observations centered around hands-on interaction with Spellingual were conducted with consenting participants. Consenting participants initially included adults who were native Farsi speakers,

proceeded by children aged five to seven years old who were verbally fluent in Farsi. Initial user testing was performed through adult participants who participanted feedback and reported any issues encountered. Throughout early testing, changes were made based on this feedback to improve the application before testing with the target demographic. The intention of formal testing was to determine if the gamification elements included in the application improved acquisition of spelling skills through observed interaction.

Additionally, the hands-on interaction during formal testing was observed to determine improved performance and motivation through progression in the application. These sessions allowed for the monitoring of user behavior, engagement levels, and determine challenges encountered during use. Real-time feedback was also encouraged during interactive simulations within Spellingual along with directed tasks where necessary. Participants were given the opportunity to provide immediate impressions and suggestions, helping to capture thoughts and insights as they engaged with the content. Since the participants were minors, some feedback was reported by the guardian or parent accompanying the minor who provided additional insight based on prolonged observations in a natural environment.

*Research Expectations*

The following outlines the research expectations of the project, including both the hypotheses and projected outcomes. These aspects combined shaped the project's overall framework, guiding the development and evaluation of an education vocabulary application specifically designed for second-grade multilingual children verbally fluent in Farsi. The hypotheses serve as the foundation for this research by posing key questions about the expected impact of project elements, including gamification and multimedia integration. The expected outcomes provide a glimpse into the results and benefits that the application delivers to its target audience.

*Hypotheses.* These hypotheses form the basis for evaluating the project's success and its impact on the intended audience.

- Implementation of gamification and multimedia elements in the educational vocabulary learning application will enhance user engagement and effectiveness in language acquisition.
- Regular user feedback sessions, along with iterative development, will lead to continuous improvements in the application's usability and effectiveness.
- The modular design of the application will allow for the seamless addition of new languages and content, ensuring scalability and adaptability.
- The application will demonstrate its effectiveness in improving foreign language spelling skills among second-grade multilingual children verbally fluent in Farsi during testing and feedback phases.

*Expected Outcomes.* The expected outcomes of this project include the development of a foreign language educational application tailored to the needs of second-grade multilingual children verbally fluent in Farsi. The application is intended to improve foreign language spelling skills as indicated through enhanced spelling accuracy and vocabulary retention. The incorporation of gamification and multimedia elements fosters higher levels of engagement and enjoyment in the learning process. The touch-based interaction method reduces cognitive and physical demands on the target audience, providing a positive user experience. The project gathers valuable user feedback for refining the application iteratively, resulting in an effective and user-centric application.

# CHAPTER 4: OUTLINE OF COMPLETED PROJECT

This section presents a detailed overview of Spellingual, a web-based educational tool designed to enhance foreign language spelling skills among second-grade multilingual children verbally fluent in Farsi. It describes the project phases from inception to its completion while highlighting key development milestones, iterative improvements, and significant adjustments required due to an evolving scope. This section also covers the testing methodologies employed, the analysis of results, and a reflective summary of the entire experience. Aimed at providing a comprehensive understanding of the project's progression, this section outlines the developmental achievements, challenges encountered, and the evolutionary process of Spellingual throughout its development, implementation, and testing phases.

## *Iterative Development Phases*

*Initial Concept and Planning.* The inception of Spellingual was formed from the idea of creating an educational tool catering to second-grade multilingual children fluent in both Farsi and English. This initial phase involved an analysis of existing educational software, focusing on a distinct gap: the absence of applications specifically designed to improve spelling proficiency in Farsi among bilingual learners. The research extended beyond direct counterparts, examining a range of applications dedicated to broader foreign language learning and English spelling skills. This preliminary research identified potential functionalities and design elements that could be adapted and refined to meet the unique requirements of Spellingual.

An important aspect of the planning was the emphasis on creating a user-friendly and visually engaging interface. Recognizing that motivation and sustained engagement are critical for a young audience, the conceptualization phase prioritized an immersive user experience. This strategic approach is designed to make learning both enjoyable and seamless, integrating educational content within a playful context. By incorporating gamification elements such as point systems and interactive feedback, alongside

multimedia enhancements, the application aims to create an immersive and engaging experience that effectively improves foreign language spelling skills.

In the early stages of developing Spellingual, the focus shifted to creating the initial user interface prototype and identifying effective gamification elements for engaging young users. This process was informed by successful applications highlighted in previous studies discussed in the literature review. Key gamification elements were selected for incorporation into Spellingual including a point system, levels, and feedback/interactivity. Additional research, though minor, was performed to ensure that all UX heuristics, shown in Table 5 of the Appendix, were closely examined and adhered to (Schön et al., 2017). Once these elements were determined and the proposal was accepted, prototyping began.

*Prototype Development.* The initial development of the prototype was performed using Adobe XD to visualize mobile use, as it is assumed to be the primary means of interaction with the application. This is due to the nature of the application in its ability to remove time and place constraints. Once the prototype met all requirements, development began using Vue.js framework for JavaScript in the Visual Studio Code editor. The application was linked to a private GitHub repository and hosted through Amazon Web Services (AWS) Amplify for server-side testing. This was continually used throughout unit integration and testing to determine the steps for each iteration and scope evaluation.

Early design decisions included a user-friendly design with multimedia elements for engagement with a focus on early childhood development. Colors suitable for grabbing and keeping the attention of a young audience were used, along with easy-to-read text. No icons were used in place of text for any user-interface elements to promote clarity for young users, and contrast was considered in all aspects of the application. Additionally, audio was identified as a requirement to provide helpful feedback and alert users of interactions and results.

The initial version of the prototype design, as development commenced, is depicted

in the figures below. Figure 4 displays the early design of the Level Select screen, where levels are distinguished by color according to the word category, with the number of levels varying by availability, complexity, and term. In this stage of development, the word category is determined by its level of difficulty based on the commonality of Farsi letters used to spell the word and the length of the word. Figure 5 presents the preliminary design for the Level screen itself, highlighting the word in English, the letters for spelling the word in Farsi, and the player's input. These elements are interactive and change in response to the player's actions. Figure 6 illustrates the original feedback modal, designed to inform the player about the outcome of the Level.

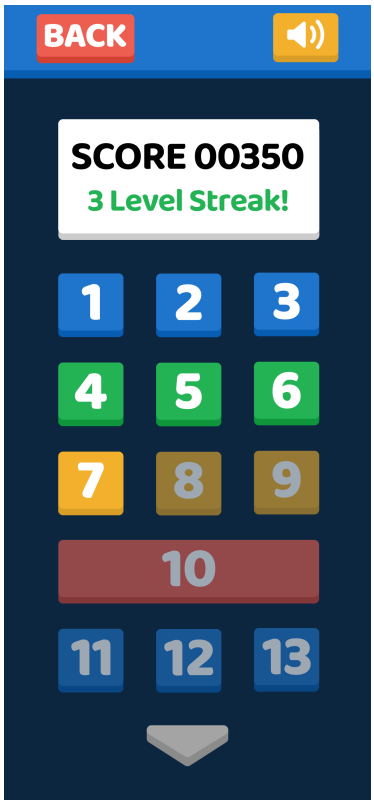


Figure 4. Level Select


Figure 5. Level

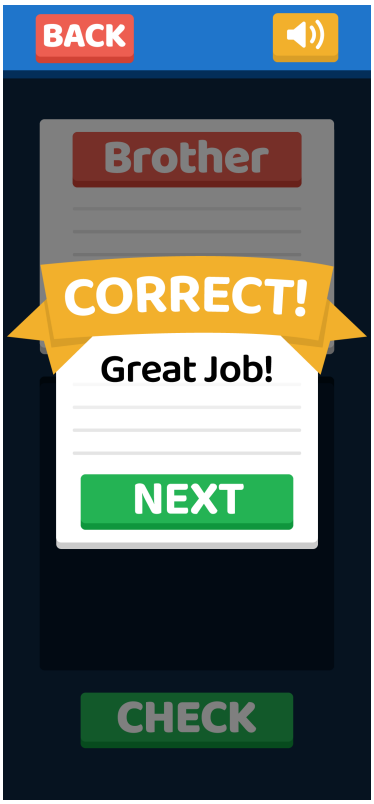


Figure 6. Level Modal

*First Iterations.* The first iterations, referred to as Version 1 of the application, involved necessary adjustments to the initial prototype, including dictionary component enhancements and level progression logic. Core features of this version were the levels, level select, landing screen, and level modal. This level modal was designed to provide feedback to the user when they check their attempt to complete the level. No aggravated

or jarring audio was used to promote a positive atmosphere, and distinct audio was included to differentiate a correct and incorrect guess. This modal also provided a means to return to the level or go back to the level select screen to review previous levels or the Farsi alphabet. User engagement features designed to boost user engagement, such as points and streaks, were also incorporated. The initial focus was on foundational functionality with finer details defined in subsequent versions. The figures below illustrate the applications development during the first iterations.

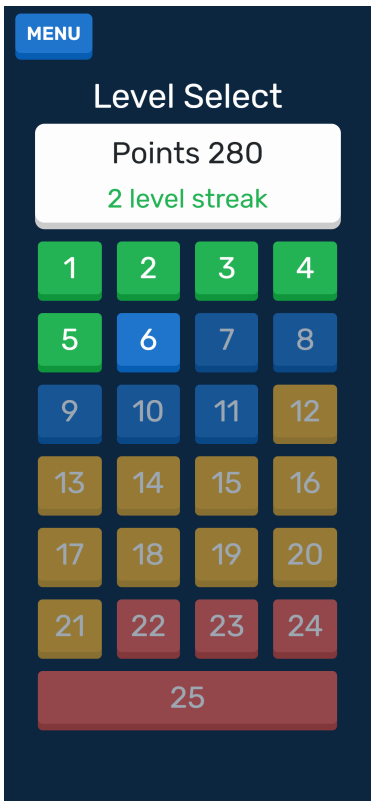


Figure 7. Level Select v1

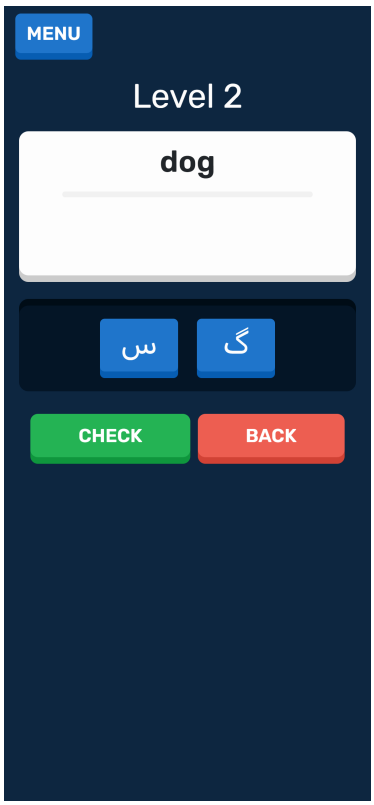


Figure 8. Level v1

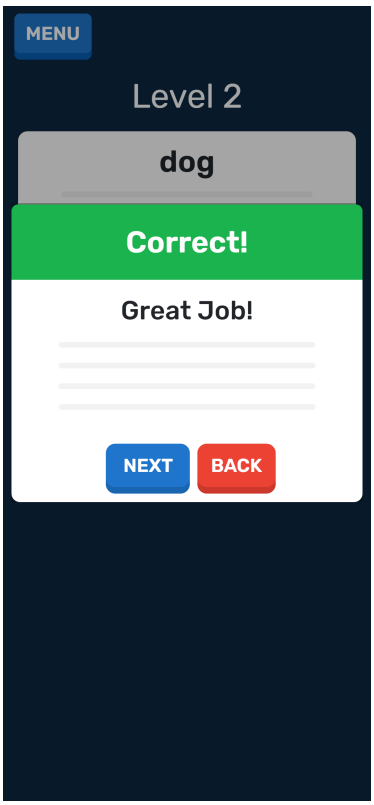


Figure 9. Level Modal v1

Figure 7 displays the Level Select screen as of Version 1 after applying simple styling using Bootstrap Version 5 and custom styling. On this screen, the user can view their accumulated points and ongoing streaks, with streaks awarded for consecutive levels completed correctly on the first try. Figure 8 displays the Level screen as of Version 1, where selecting a letter populates a blank space below the word in English to spell the word in Farsi. Letters are populated into the spaces from right to left as they are spelled in Farsi.

Figure 9 displays the Level Modal screen for Version 1, detailing user performance on level attempts. At this development phase, audio for clicks were included while correct and incorrect guesses were not due to challenges in selecting suitable sounds and integrating them effectively. Importantly, this version omitted background music, a decision driven by the complexity of integrating non-intrusive yet helpful audio feedback and hints, avoiding any potential conflict or distraction from essential audio cues. Below is a list of design changes form the prototype to Version 1 of the application:

- Background music is omitted to prioritize audio elements for feedback.
- Letter block sizes are increased for ease-of-use.
- Font sizes were adjusted to accommodate varying heights for Persian letters.
- A back button is conveniently placed next to the check button for easy access.
- Level Modal screens were adjusted for better accessibility, focusing on function first.
- Levels are organized by difficulty, from easy to very hard.

*Mid-project Iterations.* The mid-project iterations, referred to as Version 2 of the project, introduced substantial enhancements both to the application's core architecture and its user interface. Through regular feedback sessions on usability and desired features, significant modifications were integrated. These included a hint system to assist players, a reset feature for erasing current inputs, and a point display on the Level screen to visualize user progress. Additionally, the internal adoption of Vuex for state management and optimizations in application methods were implemented to improve both performance and data handling. Through the use of Vuex state management, a Reset Progress button was included in the Menu along with the user information, to allow resetting of the entire game's state. This feature enables the complete reset of the game's state, wiping clean all user progress such as points, unlocked levels, and username, for those wishing to begin anew. The figures below illustrate the applications development during the mid-project iterations.

Figure 12 displays the redesigned Landing screen for Version 2, designed to capture

usernames for a tailored user experience and track individual progress. This screen also serves as an introduction to the game, emphasizing engagement over promotion. A newly created logo, present across all screens, offers a consistent visual identity and a direct link back to the Landing page. Figure 11 displays the Level Select screen for Version 2, where levels are organized by difficulty and complemented by a "View Alphabet" feature. This feature reveals the entire Farsi alphabet, along with English pronunciations, supporting educational engagement.

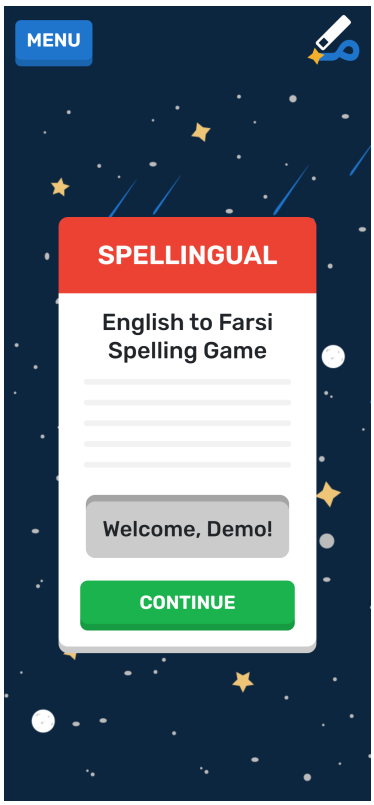


Figure 10. Landing v2

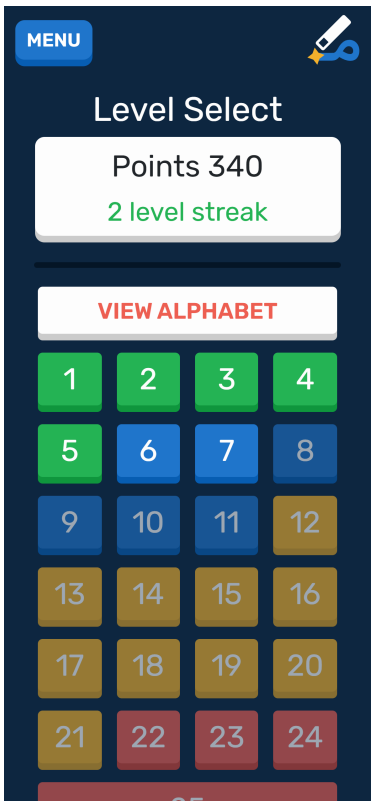


Figure 11. Level Select v2

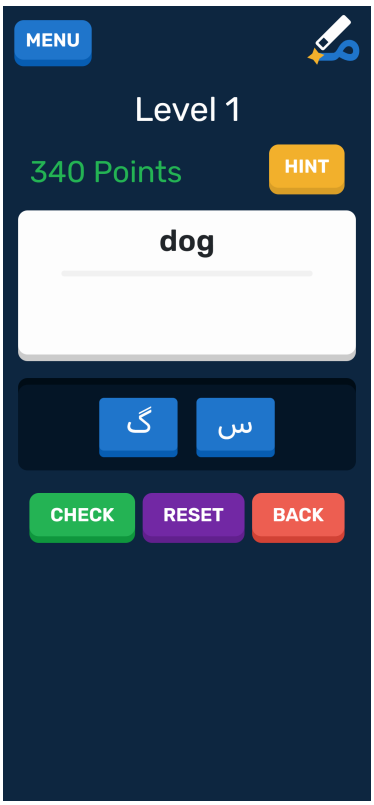


Figure 12. Level v2

Figure 12 displays the enhanced Level screen for Version 2, including a Reset button, a Points display, and a Hint button. These elements are designed to improve the gameplay experience and engage the user with the application. The Reset button simplifies guess corrections by clearing the input area, while the Hint button, intended for future implementation, allows an exchange of points for assistance with word guesses. These mid-project iterations not only refined the application's functionality and user interaction but also set a foundation for continuous improvement and feature expansion.

Below is a list of design changes from Version 1 to Version 2 of the application:

- The Landing screen was incorporated to gain username.
- The Level screen now displays points and a Hint button for point-based hint purchases to be included at a later date.
- Reset buttons are now available in each level for improved accessibility.
- Progress Reset allows the user to erase all progress and start from the beginning.
- A "View Alphabet" button was introduced to the Level Select screen for reviewing Persian letters and their English pronunciations.
- A logo in the Menu now redirects the user to the Landing screen.

*Final Iterations and Refinement.* In the final iterations of development, the app was open for live testing, which led to several modifications. This phase was particularly time-consuming, spanning over a month and a half, during which major functions and continuous minor adjustments were made to enhance the application's user experience. Many minor changes were informed through early user testing, improving the functionality of the Version 3 live prototype of Spellingual. The enhancements introduced during this period included the implementation of three distinct types of hints, the reorganization of how levels were categorized, and significant upgrades to the word dictionary. Following the integration of all essential functionalities, Spellingual underwent further refinement. This refinement process included the improvement of on-screen text clarity, the provision of complimentary hints for the initial levels to assist young learners, and the offering of additional points for the completion of levels already cleared by users.

One of the standout achievements of this development phase was the introduction of the Hint system, which has proven to be a major support mechanism, making Spellingual more suitable for its intended demographic. The provided hints comprise word definitions, which address the potential for words to have multiple meanings in English but specific ones in Farsi; audio pronunciations to assist users in confirming the Farsi word; and letter sounds, designed to aid in phonetic spelling by demonstrating the

English pronunciation of each Farsi letter. Collectively, these hints offer substantial benefits to the user, working in tandem to ensure that players are well-equipped to progress through each level given sufficient time. The figures below illustrate the applications development during the final iterations and refinement.

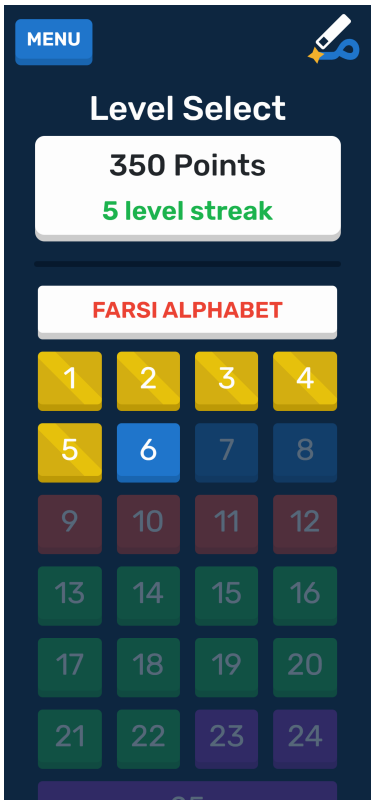


Figure 13. Level Select v3

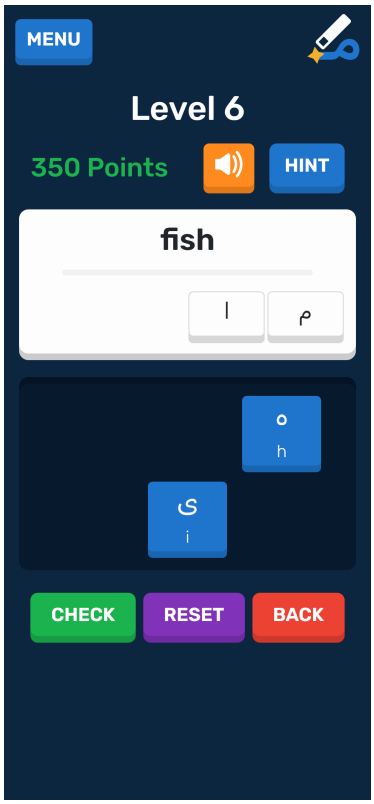


Figure 14. Level v3

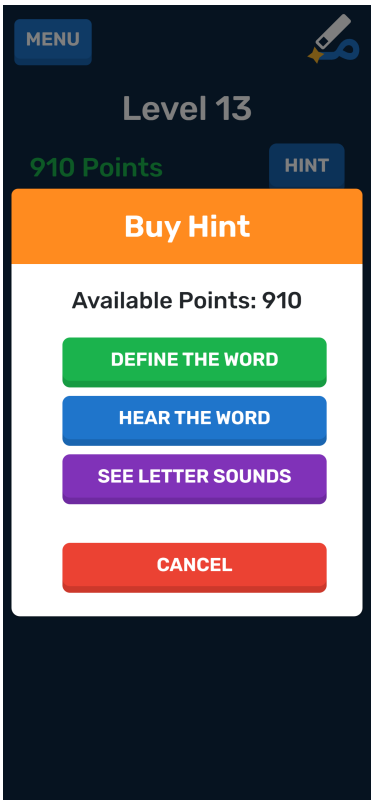


Figure 15. Hint Modal v3

Figure 13 displays the Level Select screen for Version 3, highlighting updated levels, the modified 'View Alphabet' button, levels' new arrangement, and the visual update for completed levels, which now feature a gold color to signal progress and indicate where users left off. Levels are organized to introduce users to smaller word sets with initially free hints. As progress is made, hints gradually become purchasable with points, encouraging strategic use and learning. Figure 14 displays the Level screen for Version 3, demonstrating the use of all three hints. The word's definition appears below the English spelling for clear viewing, while the pronunciation of each letter is shown under the corresponding Farsi character in the blocks provided. Additionally, a clickable audio icon next to the hint button enables users to listen to the word's pronunciation as often as

necessary, facilitating understanding of the word's meaning and its phonetic breakdown.

Figure 15 displays the Hint Modal screen for Version 3, accessible via each level during gameplay. This screen allows users to buy one of three hints, each priced differently. After selecting and confirming their purchase, users are taken back to the level screen where the newly acquired hint is ready for use. Purchased hints stay accessible for the corresponding level without expiration, unless the user opts to reset their progress via the Menu. Users have the option to cancel the purchase and go back to the level by clicking the Cancel button. Notably, players may obtain a portion of points by replaying previous levels as incentive to continue to practice spelling skills. If a hint is unavailable, the button is no longer accessible to prevent user confusion. Below is a list of design changes from Version 2 to Version 3 of the application:

- Enhanced audio feedback for click actions, including distinct sounds for correct and incorrect responses.
- Replaced difficulty levels with word categories for improved progression.
- Fully integrated hint system offering three types of support: word definitions, audio pronunciations, and phonetic letter sounds from Farsi to English.
- Refined interface language to improve user comprehension.
- Improved visibility of locked levels and unavailable hints.
- Initial levels include free hints, which gradually decrease as progress is made.

*User Testing*

*Professional Involvement.* The development of Spellingual benefited significantly from the informal contributions of computer science professionals. These individuals participated on a volunteer basis throughout the iterative development process, offering their expertise without the formality of signing permission forms or undergoing a structured user testing protocol. To ensure privacy and encourage open, honest feedback, the identities of these volunteers were kept anonymous throughout the process. This pool of volunteers included native Farsi speakers and non-Farsi speakers within the computer

science profession, serving as academic advisors and peers. Their insights were often shared during unit integration and testing, then implemented for evaluation through formal meetings with the capstone committee chair, as well as through less structured interactions.

Guidance from the capstone committee chair was vital, guiding the direction of the application's development. Regular meetings provided an outlet for discussing feedback and integrating it into a comprehensive series of revisions and improvements. This feedback was critical in shaping the initial versions of the application, preparing it for more formal user testing with the intended demographic of second-grade multilingual children fluent in Farsi. The informal yet substantial role played by these volunteers, guided by the structured oversight of the capstone committee, was crucial, allowing for a flexible, iterative enhancement of the application's usability and educational effectiveness. This approach ensured that the subsequent formal user testing could proceed with a refined and more effective version of the application.

*Participant Recruitment.* Formal user testing of the Spellingual application was meticulously planned, beginning with securing an approved UNCW IRB policy to ensure the protection of human subjects. The testing involved direct user interaction with the application and included collecting behavioral observations and participant feedback. Preparatory steps included assessing participants' current proficiency in English and Farsi spelling, accompanied by an introductory session on the Farsi alphabet. The testing sessions were designed to simulate a natural usage environment: children, guided by a native Farsi-speaking parent, interacted freely with the application. Each participant was allocated approximately one hour to explore the application, with no restrictions on how they navigated through its levels.

Participants were recruited via a series of IRB-approved social media campaigns and through personal networks of the committee members. The testing sessions consisted of children residing within the United States who will be observed and provide feedback

in-person at the University of North Carolina Wilmington or remotely via online video sharing platforms. Due to the specificity of the target demographic of second-grade children verbally fluent in Farsi with basic English spelling skills, the age range for participants expanded beyond the typical second-grade age range to include children aged from five to ten years of age. However, since there is no restriction to the application, this variation was considered acceptable for testing. Parental involvement, or guardian presence, is required to ensure that the child participant had an advocate present and manipulation of results did not lie on the observer of the testing session.

*Testing Strategies.* The application incorporates feedback mechanisms to facilitate user interaction, either independently or with parental guidance. Key features include visual and auditory cues designed to enhance usability: numbered levels guide progress, distinct confirmation sounds acknowledge user actions, and action buttons are clearly labeled on every screen, streamlining the learning process. These cues aimed to ensure that the target demographic could navigate across Spellingual with minimal assistance. To accurately assess the effectiveness of these design elements, the observer's involvement during testing was deliberately reduced, allowing the application's built-in guidance systems to operate in conditions that closely mimic real-world environments. This approach tested the intuitiveness of the application and helped refine these features based on natural user interactions.

Observational strategies focused on utilizing these features within Spellingual to monitor improvements and behaviors, assessing engagement, motivation, and comfort levels of the participants. Behavior was observed closely and verbal feedback from the parent. This behavior demonstrated how the participant moved through the application, initial assumptions of interface controls, and reaction to textual and audible feedback. Engagement was observed directly and was correlated to the pace of continuation through the available levels as well as the return to previous levels by either revisiting them directly or resetting player progress entirely. Motivation and comfort levels were

based on body language observed during observation and through direct verbal feedback from the participant or their parent.

*Parental Involvement.* Parental involvement, or guardian presence, is crucial to help the child participant understand and comfortably use the application, mimicking the typical interactions with technology at home. Parents were encouraged to assist in ways that would naturally occur within their household, providing a realistic simulation of the application's intended use environment. Additionally, insights from parents and guardians on their child's spelling abilities before and after using the application were invaluable, helping gauge the application's effectiveness in engaging and motivating young learners.

Parental involvement was highly valued and provided as much feedback as direct observation of the participant. The role of the parent was to guide the participant in a manner that the child would positively respond to during engagement with the application where applicable. This provided additional insight into the level of use context made available naturally through the application as well as the understanding of the application's intended use from the perspective of the parent. With the ultimate goal of making a child-friendly user experience, it was vital to gauge the intuitive nature of the interface to ensure that context was properly provided and the gamification aspects were clearly denoted without immediate and explicit direction.

*Direct Metrics.* Metrics such as in-game scores in the case of one participant provided quantitative data on the application's impact. However, due to time constraints could not be utilized for all participants as the length of each testing session accommodated only the initial playthrough. Future testing should involve resetting progress and progressing through the game a second time to determine the immediate recognition of letters and words based on the first playthrough. However, quantitative data was gathered through the direct observation and parental insights based on known behavior of the participant.

Quantitative metrics included the frequency and helpfulness of hints, parental

reporting of the participant's familiarity with the Farsi alphabet pre- and post-playthrough, and the speed at which the participant recognized Farsi letters or words. Additionally, memory recall of letters were determined based on observation, determining how frequently the participant would exhibit concentration, hesitation, or confidence levels through body language for each level. Though direct values for hint utilization were not gathered, immediate recognition of frequency was seen through the incentive provided by the point system and the participant's reluctance to utilize them to buy hints over time. This is due to the participant's preference to collect points to gain a higher score over using them to obtain hints.

*Participant Observations*

*Participant One.* This initial participant, a child from our intended audience, age five, who speaks Farsi fluently but had only basic knowledge of the Farsi alphabet, showed great enthusiasm for the game. This testing session was conducted in person at the University of North Carolina Wilmington campus with the parent present. The child engaged with the game twice, once completing it and then resetting to start over. In the first session, the participant scored 1160 points, utilizing hints —which deducted 10, 30, and 50 points each—to aid in word spelling. In the subsequent session, the score improved significantly to 2600 points, with the participant recognizing letters more readily and reducing the reliance on hints.

Feedback from the participant's parent highlighted that although the child initially knew only a few Farsi letters, they now show increased interest in learning more. This newfound curiosity has been encouraged by the game's design to amass more points by minimizing hint usage, which also boosted the child's focus on the letters used in the game. It was observed that by level 15 out of 31, there was a significant improvement in letter association. Parental guidance in context of use proved vital during the observation, highlighting the need to improve intuitive controls.

It was noted that although the participant began with some hesitation, they gained

confidence as they progressed, eventually preferring to attempt spelling words independently without help from their parents. The child's eagerness to continue playing even after the formal testing phase was a positive sign of engagement. The hints most commonly utilized by the participant were those displaying letter sounds, which presented the pronunciation in English below the Farsi character.

These observations have been instrumental in refining the game. Version 3 of the application incorporates significant improvements in clarity and usability based on these initial user testing insights, enhancing both the experience for users and the functionality of the app, readying it for further evaluations.

- Unavailable hints were hidden to simplify the user interface and reduce confusion.
- Players can return to previous levels to earn more points, thereby increasing the game's replayability.
- Early levels offer free hints, decreasing progressively to foster skill development.
- Challenging words were eliminated from the game's dictionary to concentrate on learning basic Farsi vocabulary and letter recognition.
- Interface language was refined for clarity and more intuitive interactions.
- The cost of hints was reduced to a fairer rate for young players.

*Participant Two.* This participant, a ten year old child fluent in Farsi and learning the Farsi alphabet, fit well within most parameters of our target demographic, aside from being slightly older. This testing session was conducted virtually via Zoom, with the participant resiging in the state of California. Attending a Persian school in the U.S., the participant provided valuable, detailed feedback. They found the game more enjoyable than traditional methods of learning Farsi, such as repetitive writing, and expressed a desire to incorporate it into their school curriculum.

The participant suggested several enhancements:

- Verbal pronunciation for Farsi letters to assist in distinguishing similar sounds.
- A hint that places a letter correctly within a word.

- A pre-test to tailor the game's vocabulary to the user's reading level.

The game's escalating difficulty was appreciated, as it mirrored the challenge levels of commercial mobile games, enhancing engagement. The participant noted improvements in their spelling speed and pronunciation of Farsi letters as they advanced through the game, completing all levels with minimal use of hints. The letter sounds hint was the most frequently used, while audio pronunciations were seldom used and definitions were not used at all. The feedback highlighted the utility of hints, although their accessibility could be improved for better user experience.

Additionally, the participant's parent recommended collaborating with the school system to gather feedback from English and foreign language teachers, believing their insights could significantly improve "Spellingual" as a supplementary educational tool. This enthusiasm promotes the application's success, highlighting its motivational and enjoyable aspects appreciated by both the target demographic and their supporters.

*Participant Three.* This participant, squarely within the target age range at age six and fluent in verbal Farsi with full English understanding, had only limited knowledge of the Farsi alphabet, relying heavily on pronunciation to spell words. This testing session was conducted virtually via Zoom with the participant residing in an undisclosed location within the United States. While initially not personally motivated to continue learning Farsi, the participant's experience offered valuable insights into how the application appeals to different attitudes toward language learning. Initially, the participant needed parental guidance to grasp the game's mechanics due to their unfamiliarity with typical gaming applications.

The game's mechanics influenced the participant's engagement. Initially motivated to correctly spell the words, their enthusiasm waned as they faced increasing difficulty and reduced hints, leading to frustration and random guessing to progress through the levels. However, when hints were used, there was a noticeable improvement in both their success rate and enjoyment. The participant showed a preference for audio hints,

although they effectively used both audio and letter sounds together to advance through several levels. Additionally, observations revealed that the participant was least familiar with vowel sounds; however, their proficiency with these improved as they interacted more with the application.

The participant's parent, a professional in linguistics and English, was impressed with the game's concept. They provided extensive feedback, offering to help enhance the Farsi alphabet learning component. They emphasized starting with vowels and shared insights into the evolving nature of Farsi language education, which could be leveraged to improve the application's effectiveness for learning Farsi as a foreign language. This feedback underscores the importance of adapting educational tools to accommodate both language evolution and user preferences in language instruction.

*Testing Results*

Throughout the user testing phase of the Spellingual capstone project, feedback from three participants highlighted the application's success in engaging children while facilitating their language learning. Participant one, squarely within the intended age range, demonstrated high enthusiasm and notable improvements in letter recognition, suggesting that the game's design effectively captures and maintains the interest of young learners. This participant's increased interest in learning more Farsi letters, as noted by their parent, and their eagerness to continue playing beyond the testing sessions, illustrate the game's strong engagement and educational potential. Notably, the point system provided a strong incentive to improve Farsi letter recognition and spelling skills by motivating participants to forego hints to gain a higher score, proving the effectiveness of this gamification element. The level system also caused a progressively increasing difficulty level that kept the attention of the paricipants, particularly with paricipants one and two.

However, the feedback also brought to light several areas for improvement. Participant two, who was slightly older, provided more nuanced feedback that led to

actionable suggestions such as introducing verbal pronunciation aids and a pre-test to customize the learning experience based on the user's reading level. These suggestions point to the need for adaptive features that can cater to diverse learning paces and styles. Participant three's initial lack of motivation and unfamiliarity with gaming conventions highlighted the importance of making the game more accessible and intuitive for all users. This participant's eventual improvement and engagement demonstrated how adaptive gameplay mechanics can help overcome initial disinterest and learning hurdles. The feedback from all participants collectively suggested enhancements that could make the game not only more engaging but also more educationally effective by addressing specific learning challenges.

Parental feedback was particularly insightful, with suggestions emphasizing the game's educational alignment and potential integration into formal learning settings. One parent, a professional in linguistics, suggested prioritizing vowel sounds, a strategy that could enhance the foundational language skills essential for Farsi learners. This type of feedback suggests that educational tools like Spellingual are not only beneficial for individual learning but could also serve as valuable supplements in broader educational contexts.

In conclusion, the testing phase confirmed that Spellingual effectively meets its educational aims by teaching the Farsi alphabet and improving spelling skills while maintaining high levels of learner engagement. The detailed feedback provided has led to targeted improvements in the game's design and functionality, making it more user-friendly and educationally relevant. These enhancements, informed by direct user and expert insights, position the game well for future integration into educational curriculum and highlight its adaptability to evolving educational methodologies.

# CHAPTER 5: CONCLUSIONS AND FUTURE WORK

## *Summary of Key Findings*

The development of Spellingual, a web-based application tailored to enhance the spelling abilities of second-grade multilingual children, is considered successful. Specifically targeting those proficient in English and beginning to learn Farsi, the application includes gamification and multimedia elements to create a dynamic and interactive learning environment through the use of points, hints, interactivity and feedback, and more. The design incorporates these elements to attract and retain the attention of second-grade children verbally fluent in Farsi, utilizing game mechanics and visual stimuli to foster an engaging learning atmosphere. The focus on this demographic is crucial, as early educational interventions can positively impact language acquisition and cognitive development when thoughtfully developed.

The primary goal of Spellingual was to provide a platform that was motivating, user-friendly, and engaging for the target demographic. By integrating interactive elements and feedback mechanisms, the application encourages continual improvement in spelling skills. This interactive approach caters to the needs of second-grade learners, making the learning process both fun and effective. The application was designed to keep users engaged through a system of rewards and achievements, enhancing their motivation and encouraging a deeper engagement with the content, which is essential for language learning.

Spellingual effectively utilizes a point system and other gamification techniques to motivate users to engage with the application. These elements are designed to challenge participants, urging them to concentrate on accurately spelling words to earn points. This gamification approach is particularly effective in educational settings as it mirrors the reward systems that children encounter in games, making the learning process enjoyable and rewarding. The feedback and rewards for correct answers build confidence and a sense of accomplishment among users, which are key drivers in educational

persistence and success.

Throughout the development and initial testing phases, the application was refined based on feedback from users and educational experts. This feedback highlighted areas for interface improvement and enhanced user experience, such as the optimization of button placement and the organization of Farsi alphabet characters by phonetic similarity. These changes aimed to minimize cognitive load and make the learning tools more intuitive. Adjustments were made to ensure that interactions within the application were straightforward to reduce potential frustration and optimizing learning outcomes. This responsive approach to design highlights the project's focus on user-centered development and continuous improvement.

*Contributions and Practical Implications*

The Spellingual application made noteworthy contributions to educational technology and foreign language learning by highlighting the effects of gamification and multimedia on foreign language acquisition through web-based applications. Though Spellingual was intended as a game to improve spelling skills in multilingual second-grade children verbally fluent in Farsi, it did more than anticipated. This was seen in the individual improvements among test participants in their letter recognition and vowel differentiation. By providing access to a means to enhance these skills at a young age, it prepares multilingual children during a period in their life that encourages the life-long process of learning and retaining a foreign language in a positive and attractive manner. This approach highlights the value of engaging educational content tailored specifically to the linguistic and cognitive needs of second-grade multilingual children. It improve the understanding of effective language teaching methodologies and offers a unique perspective on the design of educational applications through the use of gamification elements demonstrated in other gamified educational applications.

The success of this project in integrating educational and entertainment elements provides a model that could be replicated and adapted for various educational contexts,

promoting better engagement and learning outcomes in young learners through increased intrinsic motivation. By demonstrating effectiveness of integrating gamification elements and multimedia content into educational applications, the project addressed a significant gap in existing research in regards to spelling proficiency in a second language. Additionally, it enhanced other areas of foreign language learning such as letter recognition and vowel differentiation. This project laid the groundwork for future educational tools tailored for various linguistic context, emphasizing the importance of engaging content to improve the motivation of young learners. Its success could inspire similar approaches in other educational settings, potentially incorporating its successful elements into language education for second-grade foreign language education.

*Recommendations and Future Work*

The project identifies a need for further research on the long-term impacts of gamification and multimedia elements on foreign language acquisition with a focus on spelling proficiency. This is crucial as the initial findings suggest positive outcomes, but comprehensive studies could provide deeper insights into sustained impacts and learning retention. It is recommended to explore similar applications across different languages or grade levels to broaden the scope and usage of technology-enhanced language learning to improve the educational tools available globally. For future projects, extending the capabilities of Spellingual is suggested, such as incorporating a broader vocabulary set that spans a larger range of elementary grades and could be integrated into academic institutions. Simpler enhancements could include the addition of gamification elements like badges for progression milestones, custom content for improved user interaction, more animations to increase engagement, and a friend system to encourage collaborative learning experiences.

The development process of Spellingual offered a deeper understanding of language learning dynamics, and educational technology design. This growth highlights the potential of the application to become an effective educational tool in language learning

for young multilingual learners by contributing to broader goals of inclusive and accessible education. Future work could also focus on refining the application based on feedback from user testing, such as ensuring the hints are more visible and intuitive, adjusting the interface for better usability on different devices, and modifying the application to enforce a more pronounced use of parental guidance for younger users. Insights from user testing suggest the application would benefit from features that allow for more personalized learning paths, such as adaptive difficulty levels or content that adjusts to a user's existing language proficiency. Additionally, connecting with educational institutions for broader feedback and integration into school curricula could provide a more structured learning environment using Spellingual.

The user testing phase of Spellingual provided essential insights and feedback that have been essential in identifying potential enhancements and refining the application's features. Participants highly valued the hint system, suggesting that expanding this feature could significantly enhance learning efficiency. For example, introducing an option for users to "buy" letters as hints with points was proposed to make the learning experience more interactive. Additionally, feedback led to recommendations for practical interface adjustments, such as relocating buttons for easier identification, increasing button sizes on modals for better accessibility, and reorganizing the Farsi alphabet display by phonetic similarities to speed up learning.

Improvements were also suggested for the pronunciation guides within the application, such as implementing tap-to-hear sound features for each letter to aid in distinguishing similar sounds. Expanding the use of Spellingual in educational settings by incorporating it into school curricula, particularly for languages like Farsi, was proposed to make language learning more engaging compared to traditional methods. These recommendations and the outlined future work highlight the project's potential for evolving and adapting based on user interactions and academic guidance, ensuring that Spellingual remains viable among educational innovations for language learning.

In conclusion, the development and implementation of the Spellingual application proves to be a significant advancement in the field of educational technology and language learning. By integrating gamification and multimedia elements effectively, Spellingual fills a notable gap in current educational offerings for multilingual children and provides a suggested development model for engaging educational content. The insights gained from user testing have been essential, highlighting the application's potential to enhance spelling proficiency in a second language through a user-friendly and interactive platform. These findings identify the necessity for further research to explore the long-term effectiveness of such technologies in educational settings and extend their capabilities to a broader demographic within elementary education. Looking forward, the ongoing development of Spellingual based on academic guidance and user feedback promises to inform educational innovations, potentially transforming language learning for young multilingual learners across the globe and making education more inclusive and accessible.

## REFERENCES

Anatoli, O., & Cekaite, A. (2023). Child-initiated informings and conversational participation in a bilingual preschool. *Journal of Pragmatics*, *217*, 33–48. https://doi.org/https://doi.org/10.1016/j.pragma.2023.09.007

Barac, R., & Bialystok, E. (2011). Cognitive development of bilingual children. *Language Teaching*, *44*(1), 36–54. https://www.proquest.com/scholarly-journals/cognitive-development-bilingual-children/docview/816191226/se-2

Baumert, J., Fleckenstein, J., Leucht, M., Köller, O., & Möller, J. (2020). The long-term proficiency of early, middle, and late starters learning english as a foreign language at school: A narrative review and empirical study. *Language Learning*, *70*(4), 1091–1135. https://doi.org/https://doi.org/10.1111/lang.12414

Bitrián, P., Buil, I., & Catalán, S. (2021). Enhancing user engagement: The role of gamification in mobile apps. *Journal of Business Research*, *132*, 170–185. https://doi.org/https://doi.org/10.1016/j.jbusres.2021.04.028

Chen, C.-M., Liu, H., & Huang, H.-B. (2019). Effects of a mobile game-based english vocabulary learning app on learners' perceptions and learning performance: A case study of taiwanese efl learners. *ReCALL*, *31*(2), 170–188. https://doi.org/10.1017/S0958344018000228

Elaish, M. M., Ghani, N. A., Shuib, L., & Al-Haiqi, A. (2019). Development of a mobile game application to boost students' motivation in learning english vocabulary. *IEEE Access*, *7*, 13326–13337. https://doi.org/10.1109/ACCESS.2019.2891504

Fan, S. P., Liberman, Z., Keysar, B., & Kinzler, K. D. (2015). The exposure advantage: Early exposure to a multilingual environment promotes effective communication. *Psychological Science*, *26*(7), 1090–1097. https://doi.org/10.1177/0956797615574699

Holz, H., & Meurers, D. (2021). Interaction styles in context: Comparing drag-and-drop, point-and-touch, and touch in a mobile spelling game. *International journal of human-computer interaction*, *37*(9), 835–850.

Klimova, B., & Pikhart, M. (2023). Cognitive gain in digital foreign language learning. *Brain sciences*, *13*, 1074. https://doi.org/10.3390/brainsci13071074

Liberman, Z., Woodward, A. L., Keysar, B., & Kinzler, K. D. (2017). Exposure to multiple languages enhances communication skills in infancy. *Developmental science*, *20*(1).

Luo, Z. (2023). The effectiveness of gamified tools for foreign language learning (fll): A systematic review. *Behavioral Sciences*, *13*(4). https://doi.org/10.3390/bs13040331

Medvedeva, O. D., Rubtsova, A. V., Vilkova, A. V., & Ischenko, V. V. (2022). Digital monitoring of students' soft skills development as an interactive method of foreign language learning. *Education Sciences*, *12*(8), 506. https://www.proquest.com/scholarly-journals/digital-monitoring-students-soft-skills/docview/2706141578/se-2

Mortazavi, M., Nasution, M. K. M., Abdolahzadeh, F., Behroozi, M., & Davarpanah, A. (2021). Sustainable learning environment by mobile-assisted language learning methods on the improvement of productive and receptive foreign language skills: A comparative study for asian universities. *Sustainability*, *13*(11). https://doi.org/10.3390/su13116328

Nam, K. M. (2018). How young children make sense of two different writing systems: Korean written in the hangul alphabet, and english written in the roman alphabet. *Journal of Early Childhood Literacy*, *18*(4), 490–517. https://doi.org/10.1177/1468798416685384

Oga-Baldwin, W. Q., Nakata, Y., Parker, P., & Ryan, R. M. (2017). Motivating young language learners: A longitudinal model of self-determined motivation in elementary school foreign language classes. *Contemporary Educational Psychology*, *49*, 140–150. https://doi.org/https://doi.org/10.1016/j.cedpsych.2017.01.010

Panfilova, V., Spichak, V., & Zhumakhanova, A. (2022). Educational mobile games as a tool for increasing vocabulary when learning a foreign language. *International Journal of Web-Based Learning and Teaching Technologies (IJWLTT)*, *17*(1), 27. https://doi.org/10.4018/IJWLTT.298624

Parkinson, M. M., & Dinsmore, D. L. (2019). Understanding the developmental trajectory of second language acquisition and foreign language teaching and learning using the model of domain learning [Special Issue: New directions for individual differences research in language learning]. *System*, *86*, 102125. https://doi.org/https://doi.org/10.1016/j.system.2019.102125

Pitarch, R. C. (2018). An approach to digital game-based learning: Video-games principles and applications in foreign language learning [Copyright - Copyright Academy Publication Co., Ltd. Nov 2018; Last updated - 2024-02-23]. *Journal of Language Teaching and Research*, *9*(6), 1147–1159. https://www.proquest.com/scholarly-journals/approach-digital-game-based-learning-video-games/docview/2135499078/se-2

Polakova, P., & Klimova, B. (2022). Vocabulary mobile learning application in blended english language learning. *Frontiers in psychology*, *13*, 869055. https://doi.org/10.3389/fpsyg.2022.869055

Pransiska, R. (2016). Benefits of bilingualism in early childhood: A booster of teaching english to young learners. *3rd International Conference on Early Childhood Education (ICECE 2016)*, 390–393.

Sandberg, J., Maris, M., & Hoogendoorn, P. (2014). The added value of a gaming context and intelligent adaptation for a mobile learning application for vocabulary learning. *Computers  Education*, *76*, 119–130. https://doi.org/https://doi.org/10.1016/j.compedu.2014.03.006

Sari, D., Sahardin, R., Yani, V., & Yusuf, Y. (2022). Scrabble game technique: A game changer for english vocabulary learning. *Englisia: Journal of Language, Education, and Humanities*, *10*, 1. https://doi.org/10.22373/ej.v10i1.12388

Schön, E. M., Thomaschewski, J., & Bader, F. (2017). Heuristics considering ux and quality criteria for heuristics. *International Journal of Interactive Multimedia and Artificial Intelligence*, *4*(6), 48–53. https://doi.org/10.9781/ijimai.2017.05.001

Siegal, M., Surian, L., Ayumi, M., Geraci, A., Iozzi, L., Okumura, Y., & Itakura, S. (2010). Bilingualism accentuates children's conversational understanding. *PLoS ONE*, *5*(2), e9004. https://doi.org/10.1371/journal.pone.0009004

Wang, F.-L., Zhang, R., Zou, D., Au, O. T. S., Xie, H., & Wong, L.-P. (2021). A review of vocabulary learning applications: From the aspects of cognitive approaches, multimedia input, learning materials, and game elements. *Knowledge Management and E-Learning*, *13*(3), 250–272. https://doi.org/10.34105/j.kmel.2021.13.014

Zainuddin, Z., Chu, S. K. W., Shujahat, M., & Perera, C. J. (2020). The impact of gamification on learning and instruction: A systematic review of empirical evidence. *Educational Research Review*, *30*, 100326. https://doi.org/https://doi.org/10.1016/j.edurev.2020.100326

Zeybek, N., & Saygı, E. (2024). Gamification in education: Why, where, when, and how?—a systematic review. *Games and Culture*, *19*(2), 237–264. https://doi.org/10.1177/15554120231158625

# APPENDIX A: PROJECT DOCUMENTATION

Table 4. Vocabulary Words for Dictionary

| English | Definition |
|---|---|
| bird | An animal that has wings and can fly. |
| cat | A small animal that people often keep as a pet. |
| dog | A furry animal that barks and is a good friend to humans. |
| fish | An animal that lives in water and swims. |
| mouse | A small animal with a long tail, often found in houses. |
| arm | The part of your body that stretches from your shoulder to your hand. |
| back | The part of your body from your shoulders to your hips that is on the opposite side of your chest. It helps you stand up straight. |
| ear | The part of your body on the side of your head that you hear with. |
| eyebrow | The line of hair above each of your eyes. |
| eye | The part of your body you see with. |
| foot | The part of your body at the end of your leg that you stand and walk on. |
| hair | The thin strands that grow on your head. |
| head | The top part of your body that has your eyes, nose, mouth, and brain. |
| knee | The part of your leg that bends so you can sit, jump, and run. |
| lash | The tiny hairs that grow on the edge of your eyelids. |
| lip | The soft edges around your mouth that you use to close it, talk, and eat. |
| neck | The part of your body that connects your head to the rest of your body. |
| nose | The part of your face that you smell with. |
| bag | Something you use to carry things. |
| ball | A round thing you can throw, catch, or kick. |
| book | Pages of stories or information you can read. |
| clock | A device used to measure and show time, found on walls or on the wrist. |
| train | A long line of connected cars that move on tracks and can take people or things from place to place. |
| game | A fun thing to do by yourself or with friends with rules and goals. |
| paint | Using colors to make pictures or designs on a surface. |
| play | Using toys, imagination, or games to have fun. |
| puzzle | A game where you fit pieces together to make a picture or complete a challenge. |
| school | A place where children go to learn. |
| banana | A long yellow fruit that is soft inside. It's sweet and you can peel it to eat. |
| fork | A tool you use to pick up and eat your food. It has a handle and usually four pointy parts called prongs. |
| orange | A round fruit that is orange outside and inside. It is juicy and sweet and can be peeled. |
| plate | A flat round thing you put your food on when you eat. |
| spoon | A tool with a round scoop at the end. You use it to eat soup or cereal. |

Table 5. User Experience Heuristics

| UX Dimension | Description |
|---|---|
| Attractiveness | The design looks and feels appealing. |
| Perspicuity | The ability to understand things quickly and make accurate judgements. |
| Efficiency | The speed at which users can accomplish tasks once they are familiar with the interface. |
| Dependability | The quality and reliability are trustworthy. |
| Stimulation | The sensory stimuli improve user attention. |
| Novelty | The unique experience that differentiates the application from others. |