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Gamification of Speech Therapy with Pronunciation Pal

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Honors Capstone Report

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Gamification of Speech Therapy with Pronunciation Pal

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Abstract

This capstone report examines the theory and implementation behind applying game design principles to educational applications, and explores their implementation in an educational game through the Pronunciation Pal application. The gamification of learning tools aims to increase learners' engagement and attentiveness with a subject by restructuring content using game design principles of challenges, rewards and feedback. Feedback can be delivered via visuals and/or sounds, as well as regular indicators of player progress and accomplishment. In addition, a successful game implementation establishes challenges to facilitate a player's intrinsic desire to continue playing and improving at the skills presented by the game. This motivation is often assisted by the delivery of meaningful and immediate or near-immediate rewards directly tied to player accomplishment. Pronunciation Pal's game implementation restructures the delivery of the application's standard speech therapy tools, in which a user's performance in the game is based upon their success in pronouncing a given word.

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1 Introduction

Video games are an incredibly popular hobby enjoyed by millions of people worldwide, and with that popularity comes an increased attention towards the application of gamification principles into other areas of art, education, work and science. The gamification of learning and educational tools aims to increase learners' engagement and attentiveness with a given subject using established game design principles of goals, rewards, and immediate feedback. Gamification introduces an additional level of interactivity and personal stake within one's learning, and can enhance the experience of a subject when applied effectively.

Our Capstone project, Pronunciation Pal, is a web-based application designed to allow a variety of user groups facing speech or vocalization challenges to practice and improve their pronunciation of English words through simple and engaging tools and exercises. Users are given a word and guided on how to correctly pronounce it using illustrated diagrams and/or reference images. The user is then prompted to record themselves pronouncing the word and is scored based on accuracy.

The Honors extension portion of the project is designed to provide a gamification extension to the tools offered by the base application to explore and apply successful methods of educational gamification through goals, rewards, and feedback. This report aims to examine the contemporary landscape of education gamification, as well as to illustrate the established concepts of game design that are shown to be able to be applied successfully to aspects of effective teaching strategies. The report will also touch on the scope of accessibility within educational video games for players with physical or cognitive disabilities. Additionally, this report will synthesize these key findings and provide insight into the development choices and strategies of the game features found within Pronunciation Pal.

2 Summaries

2.1 Game Accessibility: A Survey

This article (Yuan et al., 2011) aims to provide an overview of the current state of accessibility features in both current research and their implementation in the video game industry. By detailing the steps of a generalized model of the processes involved within a player's interaction with a video game, the authors are able to examine several examples of popular video games under the same framework for their efficacy in accounting for players with disabilities in different areas. With these findings, the authors then propose a number of different solutions and frameworks with research that supports closing this accessibility gap.

The article's formation of a generalized video game interaction model follows that of models used in a human-computer interaction context, allowing for a rich analysis of the individual factors in a game that may create obstacles for a player with a disability. Separation of the interaction model into receiving stimuli, processing stimuli, and responding to stimuli (usually with an input device) differentiate issues caused by hardware versus software elements of a game, and by extension, the different types of disabilities that may be affected by one or more of these interaction steps.

The article develops these findings through an analysis of several top-selling video games representative of multiple player demographics and genres. The accessibility accommodations found within are contrasted with those of lesser-known specialty games specifically developed with disabilities in mind. The research reviewed within the article reveals that nearly one tenth of the United States population is affected by a disability when trying to play video games, and supports the conclusion that increased industry attention and development towards the topic would serve to close the accessibility gap.

2.2 Gamified Pedagogy: Examining how a Phonetics App Coupled with Effective Pedagogy can Support Learning

The purpose of this article (Shroff et al., 2020) is to illustrate the findings that a partially or completely gamified pedagogy in an educational context supports learning for the students involved. The gamification of learning in a digital environment serves to augment the intrinsic motivation and attentiveness of students engaging with the system. Gamified learning applications marry effective concepts found in both strategies for game design and effective teaching, namely the presentation of motivational rewards and player feedback. When integrated successfully, the medium of a digital game can greatly amplify the benefits of the educational pedagogy.

The article examines an application utilizing these principles as a case study: "Interactive Phonetics - An Audio-Visual IPA Reference" developed by researchers at Hong Kong Baptist University. Very similar in scope and purpose to Pronunciation Pal, the app aims to provide learners with engaging challenges that instruct and reinforce proper vocalizations of English words. The app delivers repeated exercises through multiple games, centering the mechanics and rules of each game around the elements of the exercise to be connected in the learner's mind, such as pronunciation and spelling. The researchers note the intentional use of a consistent, attractive interface across the application and the delivery of immediate reward gratification to facilitate the increased learning associations provided by the game.

By examining a case study and related research in the field of gamified learning, the authors are able to conclude that effective gamification greatly enhances the retention and potency of educational content. The combination of text, images, and or sound creates an environment that fosters making connections between ideas, and the authors utilize the phonetics app example to highlight particular game design elements that are key in effective gamification.

2.3 Game-based Learning and 21st Century Skills: A Review of Recent Research

The goal of this article (Qian and Clark, 2016) is to provide a literature overview of research articles studying the effectiveness of game-based learning with particular attention towards the acquisition of "21st-century" or meta-cognitive learning skills. The article examines recent literature on game-based learning and outlines the range of game genres and game design elements used within. These are then compared to the set of indicators and measures used to gauge the impact on a student's acquisition of 21st century skills.

Though the literature review findings did not reveal a singular consensus on the effectiveness of gamified learning, but did show that many studies found a positive effect on learning through these methods. The researchers acknowledge that these benefits may not be conclusive across all aspects a student's development until more research is conducted. However, attention towards the topic from researchers and practitioners is growing, and teachers are encouraged to adopt or develop teaching methods in this manner.

The review comprised of 137 articles containing 29 different studies. 37 percent of these articles reported effect sizes in their findings, which the researchers note serves as a more effective indicator than statistical significance. The review stands to provide valuable insights and recommendations to those involved with implementing or designing gamified learning systems, such as researchers and educators.

2.4 Using Challenges to Enhance a Learning Game for Pronunciation Training of English as a Second Language

This article (Tejedor-García et al., 2020) describes the research process behind implementing a gamified learning application designed to assist native Spanish speakers improve their English pronunciation skills. The game was designed using researched gamification strategies of motivation and feedback, with a special emphasis on player competition through

the use of scoring and leaderboards, as well as tracking individual results over time. Through testing of the application, the authors found greater levels of engagement and understanding of the educational content, in comparison to a previous educational game that lacked elements of inter-player competition.

The pedagogical basis for delivering educational content through the application is examined in the form of individual components that can be combined to form mechanically gamified exercises. Learning in the application's context can be defined as exposure, allowing students to develop an initial connection and see the difference between phonemes, perception, reinforcing the exposure in repeatedly identifying differences, and production, or applying the learned perception concepts and articulating a given English word to be evaluated by the application. In addition to the application being similar in function to Pronunciation Pal, the researchers also cite the example of Duolingo, which served as an inspiration for the project in its aesthetic and gamification elements.

This study was conducted on Spanish university students, inviting them to download the game as a mobile application. The researchers found an early abandonment rate of the game in line with most online learning courses, with most students citing a lack of time as the primary reason for quitting. For those who remained involved with the game, the competitive structure facilitated a higher intensity and regularity of play, which in turned resulted in higher pronunciation improvement when evaluated.

3   Synthesis and Discussion

3.1   Effective Game Design and Accessibility Principles

Consistent across all of the findings from the research conducted for this project are key principles of game design and game accessibility that result in enjoyable, effective gamified experiences. These design aspects draw from the processes of interaction between a game and its player (Yuan et al., 2011). They arise primarily in the form of how information

is either initially presented to the player, or presented as a response to a player action. For the most part, these design principles affect the player-facing portions of the game, such as visual presentation and input reactivity, rather than the underlying processes with which the game calculates its given state.

An effective game will facilitate a player's intrinsic desire to keep playing. This can be achieved in multiple ways, such as developing appealing visuals or sound effects, but is chiefly determined by the perceived value of the challenges that the game presents to the player. Challenges that provide an opportunity for players to develop and exercise a skill, without being too challenging to the point of frustration, are the primary vehicle through which a game can achieve player retention and increased play intensity (Tejedor-García et al., 2020). This can be summarized as a game's need to "keep up" with a player as they become more proficient at utilizing the skills needed to play the game.

Another important aspect of developing an engaging game that is often used in tandem with intrinsically motivating challenges is a consistent and reactive delivery of rewards to the player. Rewards in games are versatile in the forms they can take; games can provide tangible rewards such a new or improved in game ability, or rewards that can serve to bolster a player's intrinsic desire to keep playing, like a high score or a cosmetic visual upgrade. The timing of rewards is crucial; their delivery must occur as close to the accomplishment of a goal as possible to be effective (Shroff et al., 2020). Reward structuring in gaming is just as important if not more as establishing motivation. Many game developers now dedicate employees or entire departments to this role, especially in free-to-play mobile gaming.

Accessibility is another key factor in making a game approachable to as many players as possible. Accessibility can sometimes refer to broader concepts of player retention, such as the perceived initial complexity of a game and a player's willingness to learn it. In the context of this report, however, accessibility refers to a player's ability to successfully and effectively interface with a game, under the generalized model of game interaction. This can occur at a software level, as a player interprets and processes visual, audible, or tactile

information relayed by the game, or at a hardware level as a player physically interacts with any kind of input device (Yuan et al., 2011). The wide range of technical implementation possibilities makes accessibility standards more difficult to generally define, but most findings point to making a game's input and output interfaces as abstract as possible, so it can be compatible with the widest range of input and output devices accounting for different types of player disabilities.

3.2   Applying Game Design Principles to Gamification of Learning

Effective aspects of game design mesh well with researched, effective learning strategies. Design choices made for a gamified learning application can utilize game design and teaching strategies that overlap in tandem, such as establishing an intrinsic motivation to continue learning or playing, or in other cases a game design theory can be used to bolster a facet of educational theory (Shroff et al., 2020). Reward delivery is a common example of this, as the reception of rewards can reinforce a desire to continue learning when rewards are tied to mastery or understanding, especially in a context where intrinsic desire may be lower outside of an application of gamification. The repetitive nature of most educational pedagogues also serves the "game loop" structure of video games well, in which challenges can keep occurring until some kind of specified end condition is met.

4   Game Implementation

These game design principles are embodied in a game that I created as an extension to the base Pronunciation Pal application. Using the researched findings of effective learning strategies and my existing understanding of engaging game design, I aimed to create an interactive component of Pronunciation Pal that could extend its educational potential in a fun and enjoyable way.

As Pronunciation Pal was developed as a TypeScript web application, I elected to develop the game as a TypeScript component, in order to ensure compatibility and performance across all web browsers, and to integrate with the API services already included in the base Pronunciation Pal application. I initially scoped out and planned three distinct games, to test speed, accuracy, and word range in user vocalization respectively. However, the nature of native browser game development led to some difficult challenges as I did not have access to a traditional game engine. As such, the three games initially planned were reduced to one playable game, with the other two existing as example concepts. This development environment also meant limitations in graphical and gameplay complexity, however, this also assisted in ensuring the game was simple and approachable enough to all potential players. This was further facilitated by the inclusion of a friendly mascot character, Otto the parrot, to explain the rules of the game in an easily accessible manner, partially inspired by other successful gamified learning applications such as Duolingo (Figure 1, Figure 2).

Drawing on the learning themes of exposure, perception, and then production of an educational concept, the accuracy game was designed to provide repeated input loops through which the player could apply these three concepts in sequence for the duration of the game. The control scheme of the game was kept as simple as possible to avoid any difficulty in controlling the game, and instead keeping the challenge towards the vocalization goals presented by the game. Players are tasked with controlling a spaceship that can move left or right using keyboard keys (Figure 3). Meteorites containing English words fall from above (exposure), which the player can aim towards using the spaceship's laser (perception). Once locked on, the player can use the spacebar to charge a shot, which begins the browser's recording function, indicated by a status bar below the game screen. The player is then expected to pronounce the word contained within the meteorite (production), and if successful, the meteorite is destroyed, and points are awarded. As the player scores more points, the speed of the meteorites, and by extension the difficulty of the game, is increased with each new point threshold. While not implemented, the speed and word range
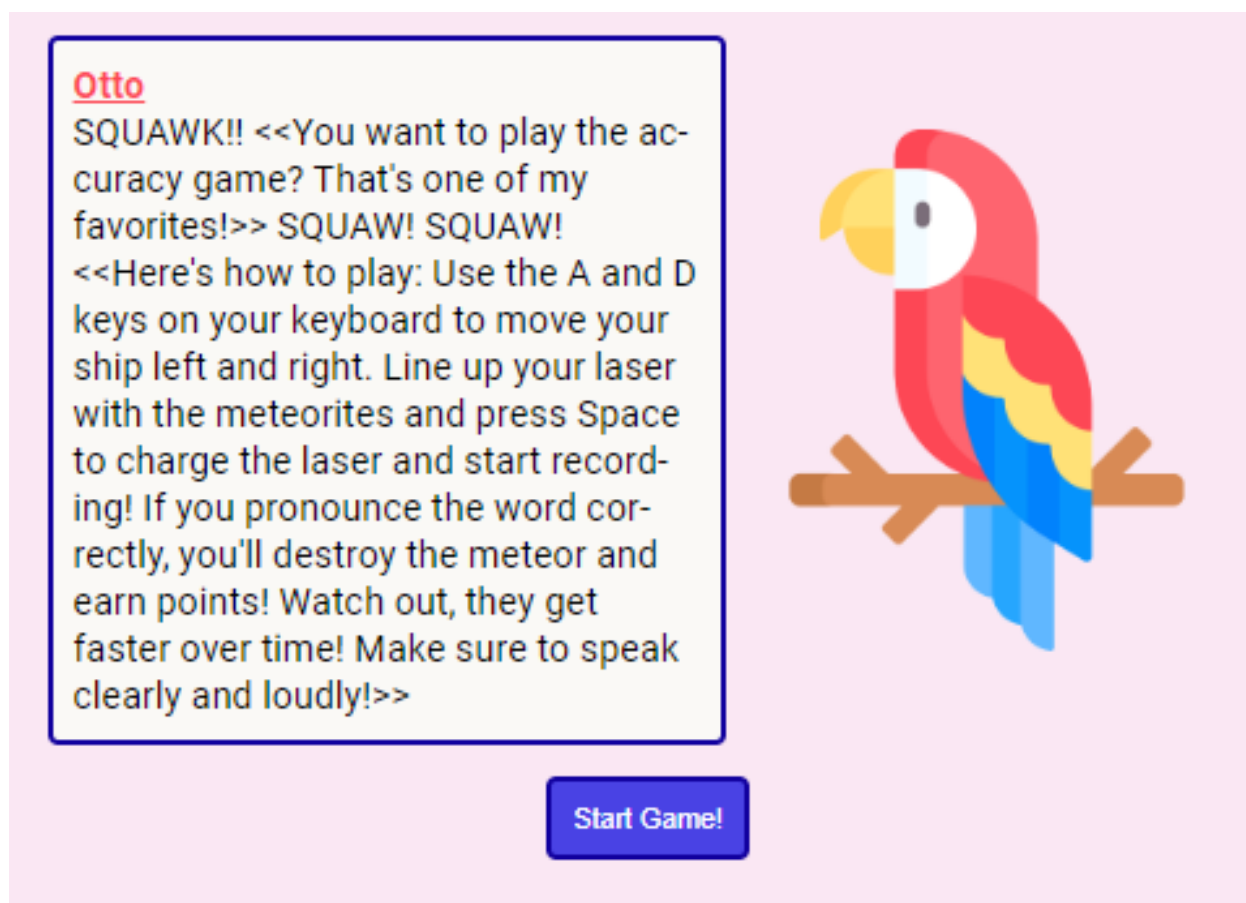
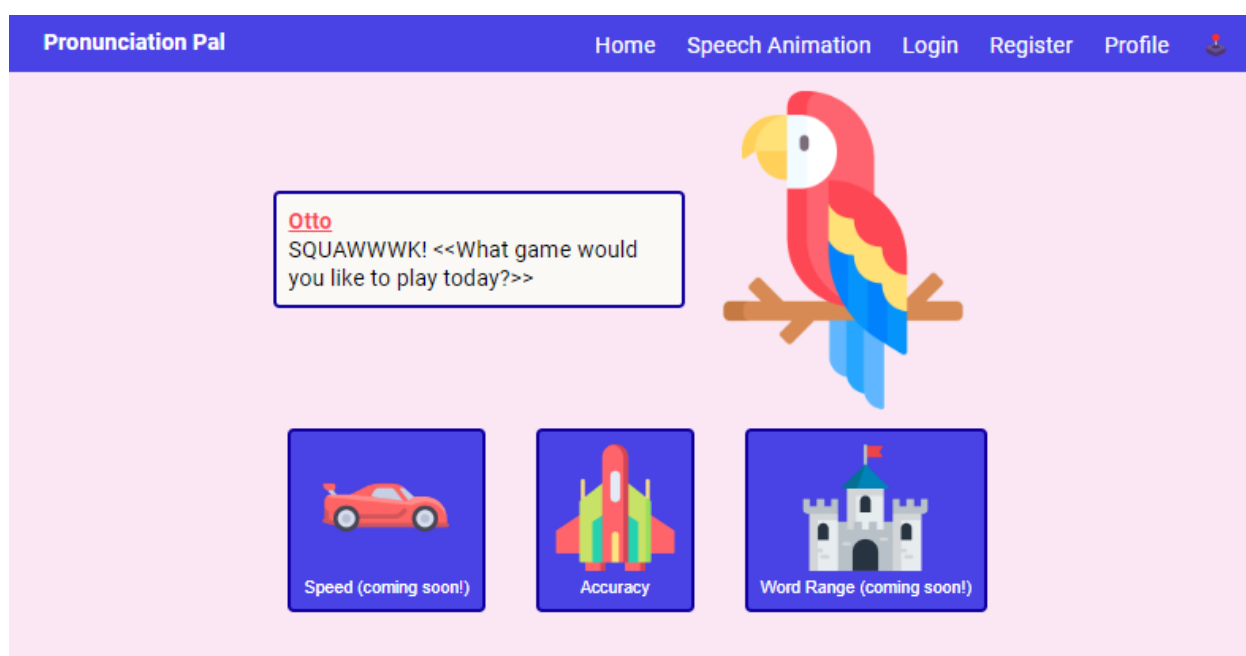**Figure 1:** Otto explaining how to play the accuracy game.

Figure 2: The menu for Pronunciation Pal's games tab, featuring its mascot, Otto.

games would have operated under similar conditions, but with different tasks and subsequent rewards at each stage of cognition (i.e, vocalizing a word as fast as possible to gain a higher car speed in the speed game, or advancing the character a further number of squares by successfully pronouncing longer, more difficult words in the word range game).

There are many ways through which Pronunciation Pal's games could be expanded upon to increase the potential for learning provided by the application. In addition to completing the implementation of all three games, the complexity of each game could be improved upon with more development time, allowing for a more engaging experience with more appealing graphical presentation. More development time would also be conducive to making the application more accessibility-friendly, such as offering gamepad input support or the option to utilize a screen reader. The base Pronunciation Pal application also serves itself well to be extended through its user accounts feature to potentially allow for individual high score tracking and comparison through leaderboards, adding another vector of competitive player interest. Finally, the rewards offered by the games could be greatly fleshed out in any number of ways, including cosmetic customization of the game elements or Otto, player associated achievement rewards, or player profile personalization elements.

The implementation code for Pronunciation Pal and this extension project can be found here: https://github.com/cttomcak/Team-12-SWAG-Pronunciation-Pal.git

5   Conclusion

Our Pronunciation Pal web application allows for users who face pronunciation or vocalization difficulties to practice saying English words using a variety of interactive and responsive tools. My personal Honors extension of the application presents those tools in a gamified learning context. The choices made in the game's mechanical design and visual presentation are consistent with researched findings on design techniques to effectively facilitate learning through interactive games. Developed as a native TypeScript game, the
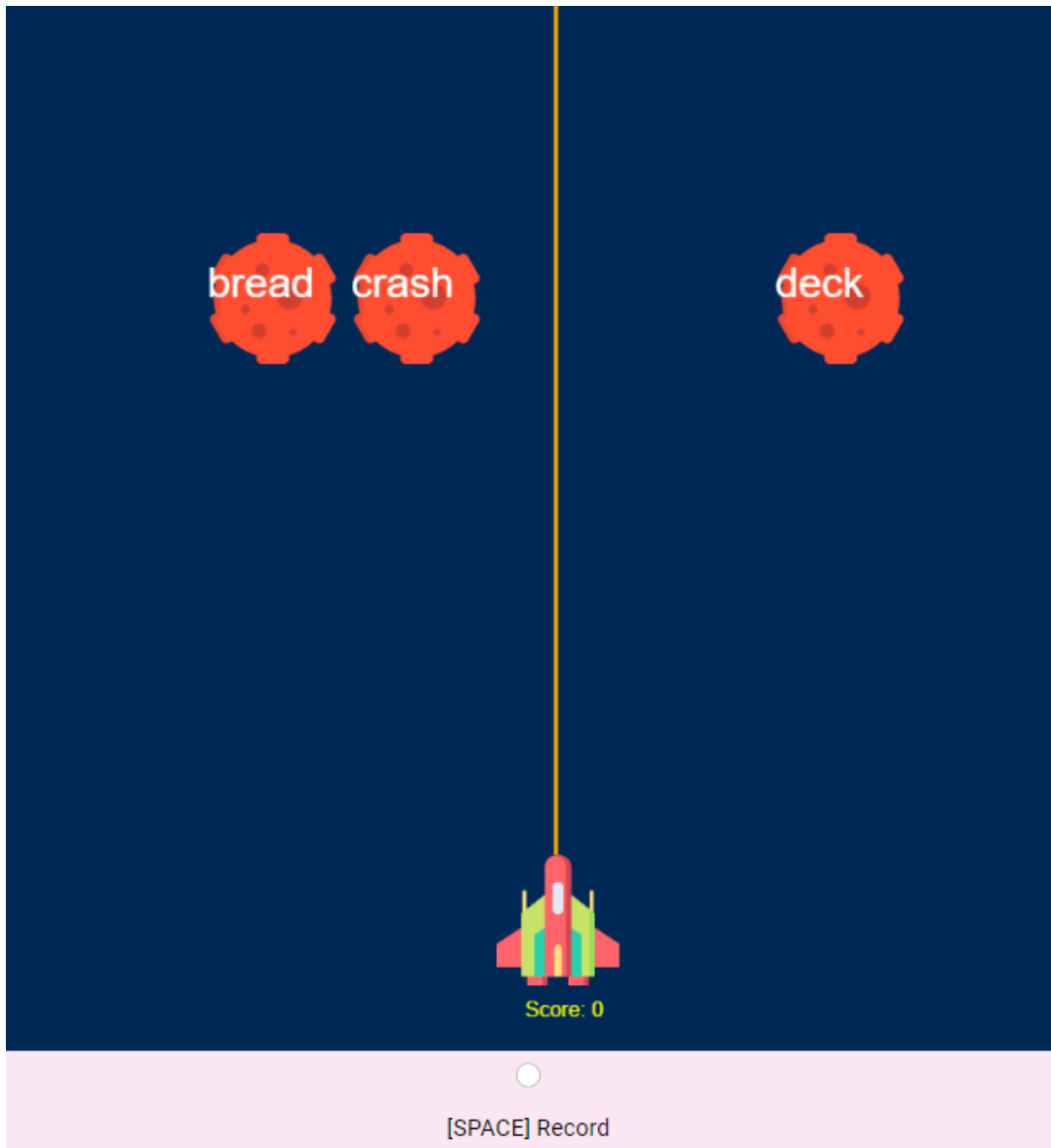
Figure 3: The main game interface for Pronunciation Pal's accuracy game.

project is largely software and hardware agnostic, utilizing a simplistic control scheme to be as accessible as possible for the greatest number of users.

Undertaking this project not only reinforced concepts attained throughout my college career, but also exposed me to new topics I had not seen before. I was able to build upon game architecture and web development concepts learned previously when constructing the core game. However, implementing the extension as well as the base application also required an understanding of the SvelteKit web development architecture, browser recording features, and speech to phonetic conversions, all discovered during the course of this project. The guidance of Mrs. Korey Stading MS of the University of Nebraska Medical Center was instrumental in our group's success.

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