South East Technological University

Project Report

Bridge Puzzle Game App for Elementary OS

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Introduction

This project report outlines the development process, achievements, challenges, and insights from the creation of the Bridge Puzzle Game Application. Designed to function seamlessly across mobile platforms, this application aims to deliver a stimulating puzzle-solving experience that challenges users to think critically and strategize effectively.

Description of the Bridge Puzzle Game Application

The Bridge Puzzle Game is a logic puzzle where players aim to connect islands (represented as circles with numbers) with bridges, following specific rules to complete a fully connected network. The number on each island dictates how many bridges can connect to it, and bridges must be either vertical or horizontal, never crossing or overlapping. The game is designed to be intuitive yet challenging, providing an engaging mental exercise for players of all ages.

The application features a clean, user-friendly interface that allows players to interact with the game effortlessly on both desktop and mobile devices. Core functionalities include user registration and login, a real-time leaderboard, comprehensive tutorials, and dynamic puzzle generation. This ensures a fresh challenge with each session, enhancing replay value and user engagement.

Developed using Flutter for the front end and Firebase for the back end, the application leverages the strengths of these platforms to offer a robust, scalable, and secure gaming experience. Real-time data synchronization, seamless user authentication, and efficient data storage are just some of the technical highlights that make the Bridge Puzzle Game a state-of-the-art digital puzzle platform.

This report will delve into various aspects of the project, from the initial design and development phases through to deployment and user feedback integration, highlighting the collaborative efforts that made this application a reality.

Achievements In Core Functionality Implementation

1. **User Authentication**

   A robust user authentication system was developed to safeguard user information, providing a secure and private experience. The implementation involved the Firebase Firestores Database to support authentication via email, username and password.

2. **Real-time Leaderboard System**

   Created a live leaderboard that updates in real-time as players submit new scores. This feature was designed to motivate players by fostering a competitive atmosphere, using real-time database updates to ensure accuracy and immediacy.

3. **Game Knowledge Integration**

   An extensive repository of game mechanics and strategies was developed to assist players. This knowledge base is accessible within the app, providing users with tutorials, tips, and strategies to improve their gameplay.

4. **Feedback Mechanisms**

   Implemented a user feedback system within the app, enabling users to easily report issues and offer suggestions. Admin page was also developed to efficiently manage and respond to user feedback, ensuring swift resolution and maintaining user satisfaction.

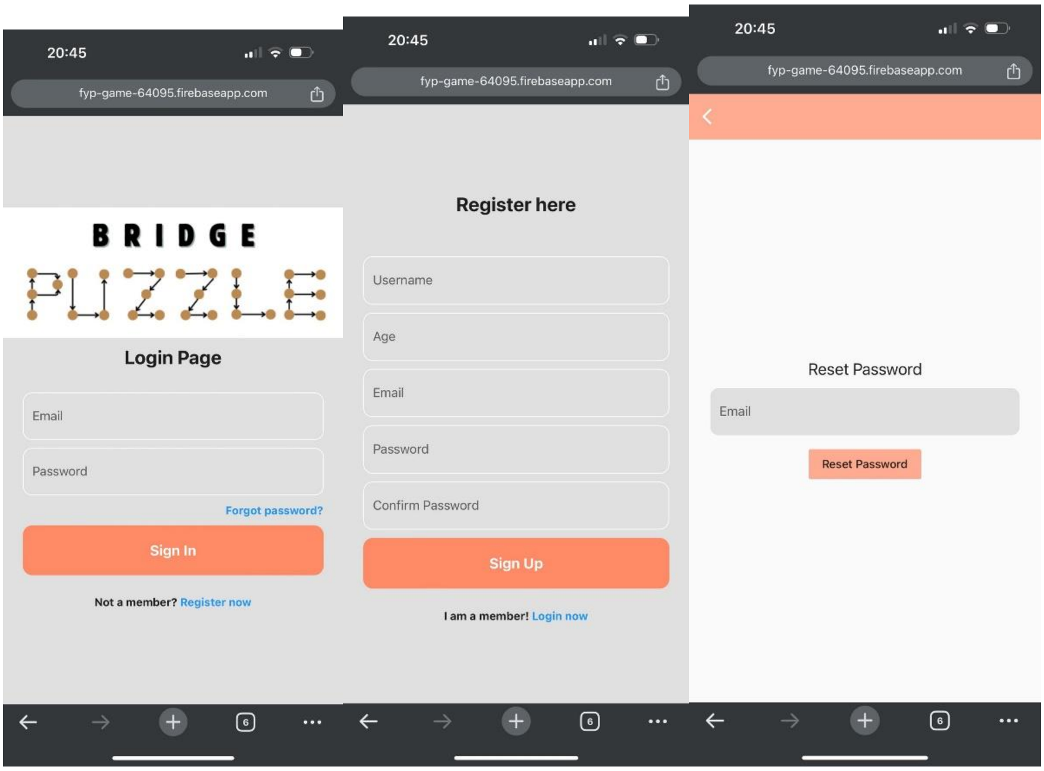
5. **Application Deployment**

   Leveraging Firebase Hosting, the Bridge Puzzle Game Application was deployed efficiently, ensuring high availability and reduced downtime. The use of Firebase's distributed infrastructure guaranteed improved performance and a seamless user experience worldwide.

Authenticity to Design Vision

The design implementation was meticulously executed, adhering closely to the specifications laid out in the Design Manual. Key design achievements include:

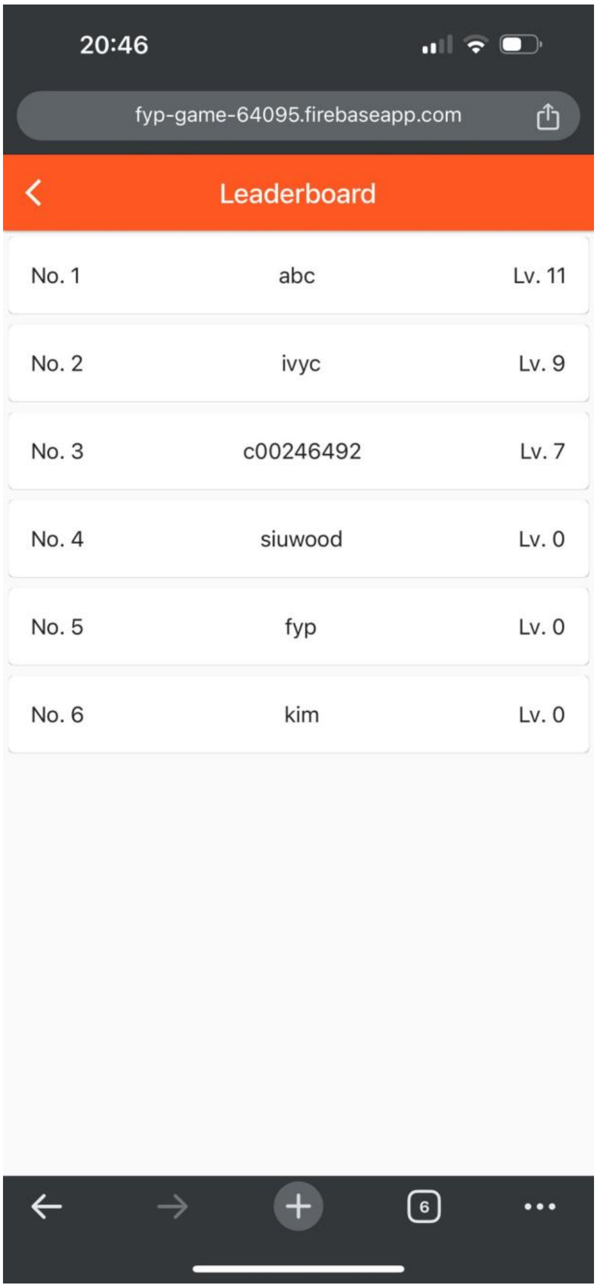
1. User Authentication



– picture of login, register, logout and reset password

Implemented a secure authentication system with a clear interface for login, registration, password reset, and logout, enhancing user trust and application security.

2. Real-Time Leaderboard

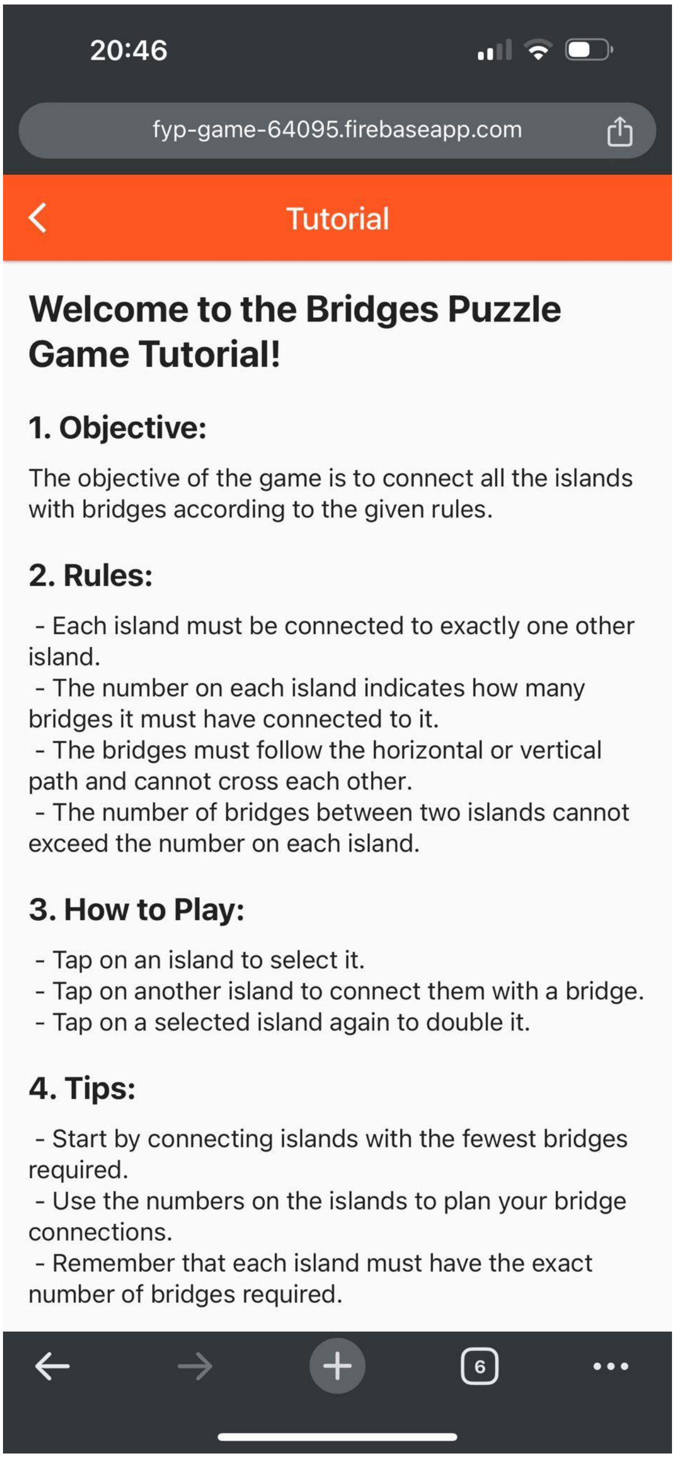


No. 1	abc	Lv. 11
No. 2	ivyc	Lv. 9
No. 3	c00246492	Lv. 7
No. 4	siuwood	Lv. 0
No. 5	fyp	Lv. 0
No. 6	kim	Lv. 0

– picture of the leaderboard

Featured a leaderboard that updates in real-time to display player rankings, fostering a competitive environment and encouraging continuous play.

3. Comprehensive Tutorial



Welcome to the Bridges Puzzle Game Tutorial!

1. Objective:

The objective of the game is to connect all the islands with bridges according to the given rules.

2. Rules:

- Each island must be connected to exactly one other island.
- The number on each island indicates how many bridges it must have connected to it.
- The bridges must follow the horizontal or vertical path and cannot cross each other.
- The number of bridges between two islands cannot exceed the number on each island.

3. How to Play:

- Tap on an island to select it.
- Tap on another island to connect them with a bridge.
- Tap on a selected island again to double it.

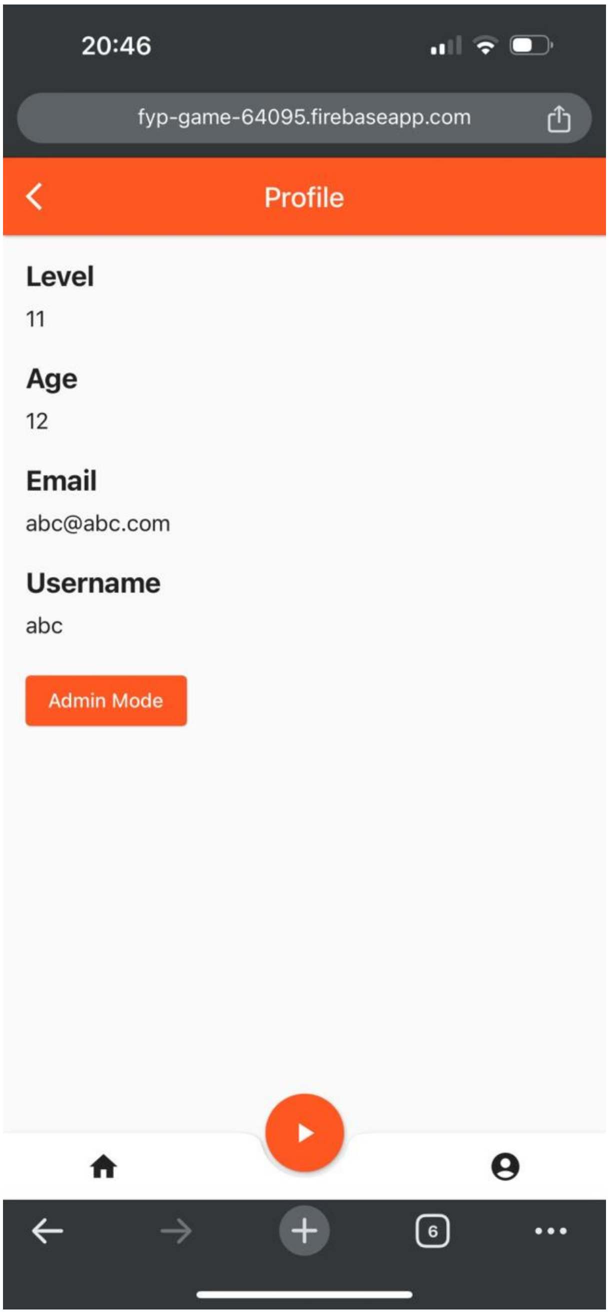
4. Tips:

- Start by connecting islands with the fewest bridges required.
- Use the numbers on the islands to plan your bridge connections.
- Remember that each island must have the exact number of bridges required.

–picture of tutorial

Integrated an easily accessible tutorial section that closely followed the design documentation, providing users with an immediate resource for learning and mastering the game.

4. User Profile



20:46

fyp-game-64095.firebaseapp.com

Profile

Level

11

Age

12

Email

abc@abc.com

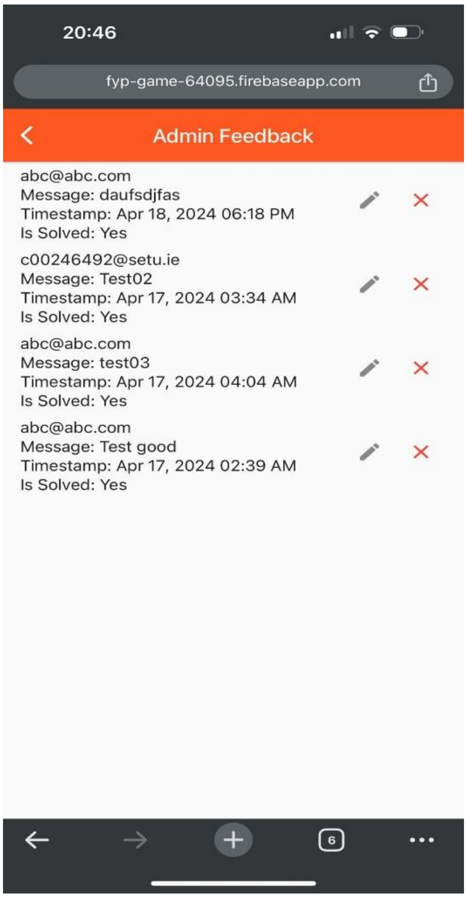
Username

abc

-picture of user profile

Created a personalized user profile page allowing players to view and manage their game details, such as level and age, promoting user engagement.

5. Feedback & Support



20:46

fyp-game-64095.firebaseapp.com

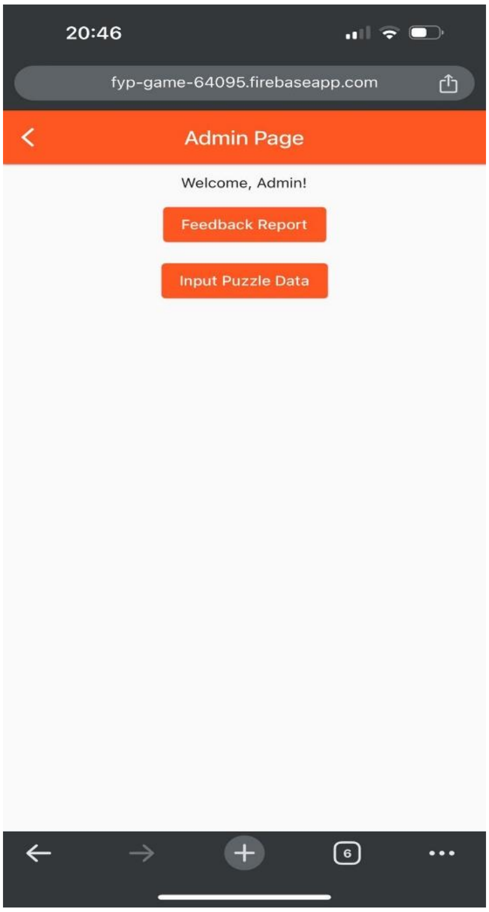
Admin Feedback

abc@abc.com
Message: daufsdjfas
Timestamp: Apr 18, 2024 06:18 PM
Is Solved: Yes

c00246492@setu.ie
Message: Test02
Timestamp: Apr 17, 2024 03:34 AM
Is Solved: Yes

abc@abc.com
Message: test03
Timestamp: Apr 17, 2024 04:04 AM
Is Solved: Yes

abc@abc.com
Message: Test good
Timestamp: Apr 17, 2024 02:39 AM
Is Solved: Yes

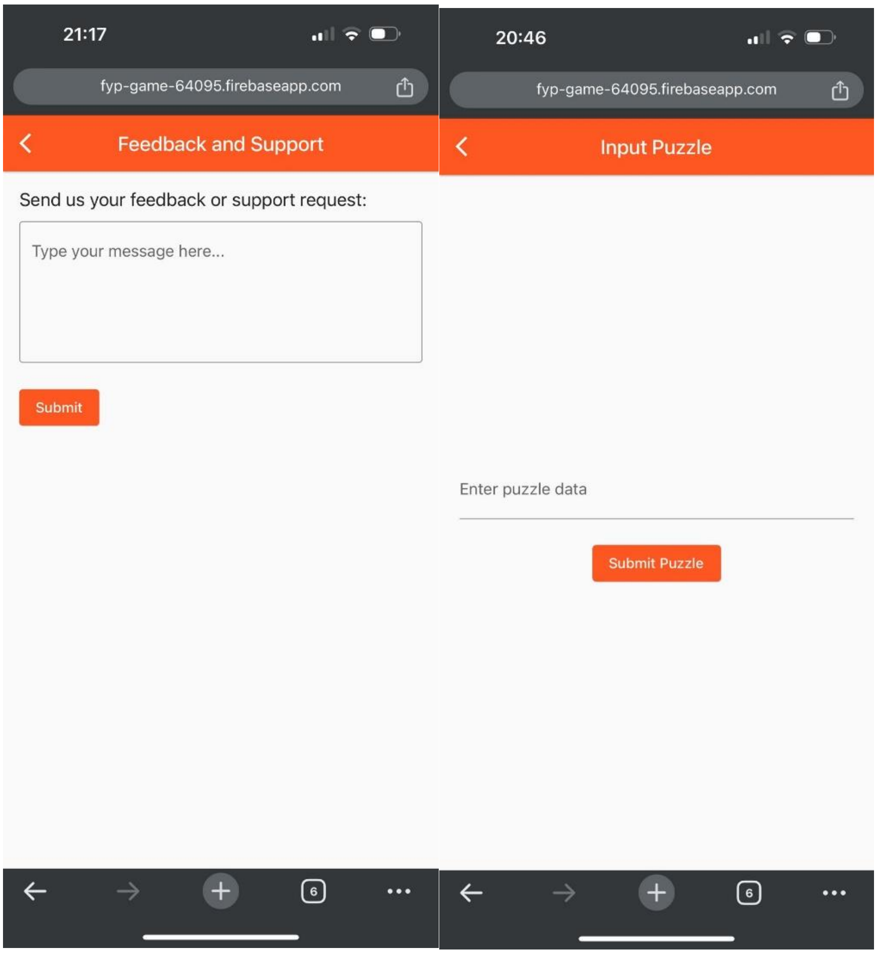


20:46

fyp-game-64095.firebaseapp.com

Admin Page

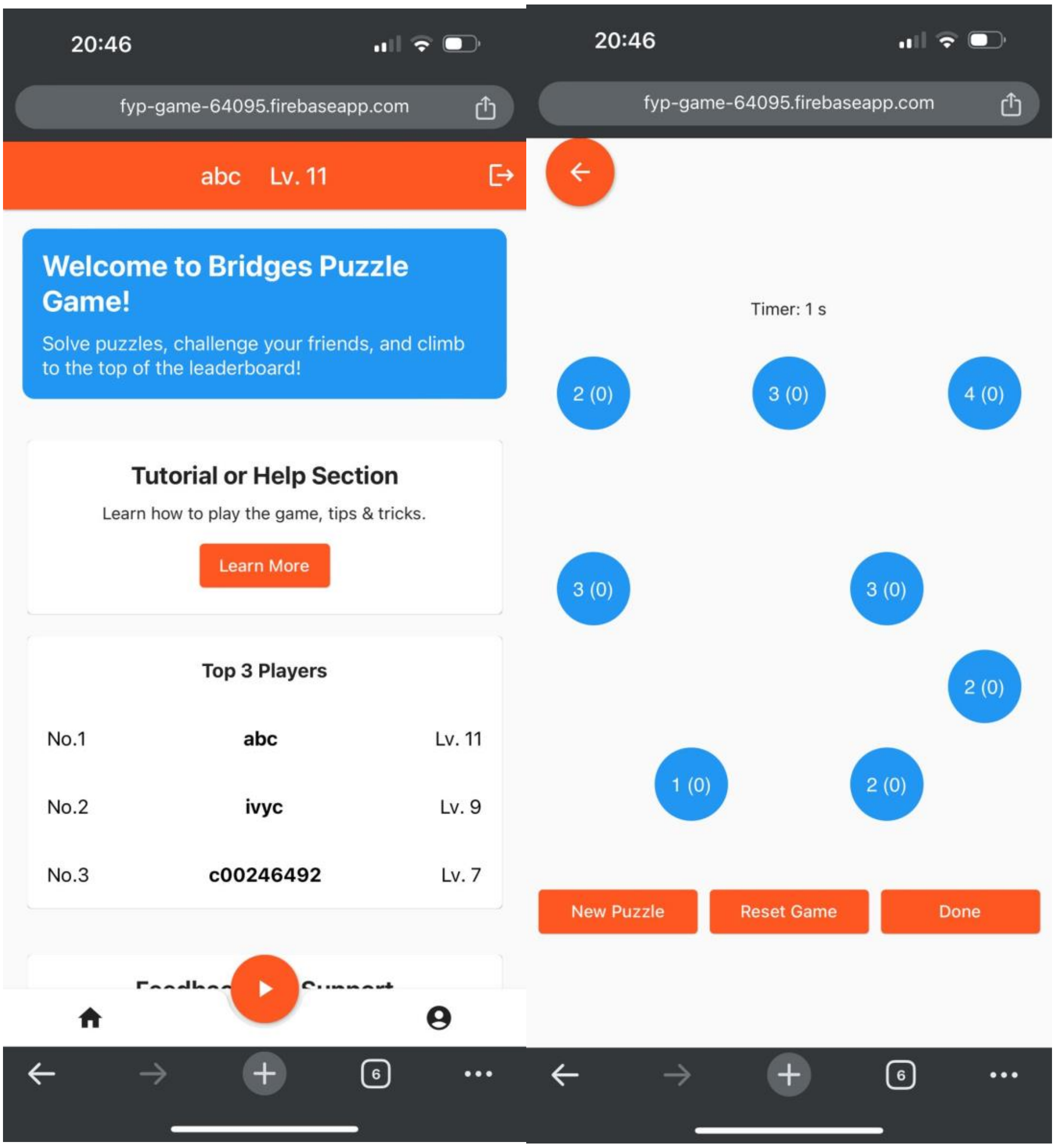
Welcome, Admin!


21:17
fyp-game-64095.firebaseapp.com
Feedback and Support
Send us your feedback or support request:
Type your message here...
Submit
20:46
fyp-game-64095.firebaseapp.com
Input Puzzle
Enter puzzle data
Submit Puzzle

-picture of the feedback page

Developed a dedicated feedback section where players can report issues or suggestions, ensuring their voices are heard and contributing to the game's improvement.

6. Game



Welcome to Bridges Puzzle Game!

Solve puzzles, challenge your friends, and climb to the top of the leaderboard!

Tutorial or Help Section

Learn how to play the game, tips & tricks.

Top 3 Players

No.1	**abc**	Lv. 11
No.2	**ivyc**	Lv. 9
No.3	**c00246492**	Lv. 7

-picture of the game page

Designed and executed a seamless game experience with features like new puzzles on demand, game resets, and straightforward exit functionality.

General Issue and Resolution

1. Complexity in User Authentication

The project aimed to establish a robust and secure authentication system that could protect user privacy and ensure the integrity of their data. Using Firebase Firestore for user authentication posed complexities due to the requirements for secure password handling, account management, and the prevention of unauthorized access.

Impact: These complexities had the potential to impact user trust and the application's credibility if not properly addressed.

Resolution: The complexity of user authentication was tackled by employing Firebase Authentication in tandem with Firestore. This combination provided a secure authentication framework that automatically handled common security issues. I used built-in methods for authentication which simplified the process, and security rules in Firestore to manage user data securely.

2. Incompatibility with Initial Development Environment:

Initially, the project required the use of Elementary OS for its performance and security features, for creating a stable application. However, this choice led me to a steep learning curve due to unfamiliarity with the OS and compatibility issues with needed development tools. This situation significantly slowed the development process, as additional time was required for configuring and adapting the environment for game development.

Impact: Considerable time and resources were spent troubleshooting environment issues rather than focusing on game design and user experience enhancements. The learning and adaptation period significantly slowed progress, causing delays in the development cycle that impacted planned release dates.

Resolution: To address these inefficiencies, I requested to transition to using Flutter, known for its robust cross-platform capabilities and supportive developer community. This switch not only enhanced development speed by leveraging a familiar toolset but also improved the responsiveness and aesthetic flexibility of the application's user interface.

Technical Issues Encountered and Resolutions

1. Auto-generation Puzzle Functionality

The auto-generation of puzzles, intended to provide a unique experience for each user session, presented significant technical difficulties. The initial approach relied on a complex algorithm using a large dataset of pre-generated puzzles, which not only slowed down the application but also complicated the validation of puzzle solvability.

Impact: This functionality was crucial for ensuring replay value and user engagement, as it aimed to continuously provide fresh challenges to players. The performance issues and the complexity of ensuring each puzzle's solvability without extensive manual intervention were major setbacks.

Resolution: After thorough research and testing, I decided to shift from real-time puzzle generation to a model where a curated set of solvable puzzles was pre-generated and stored in Firebase Cloud Firestore. This set is rotated periodically to maintain a fresh challenge aspect while significantly improving load times and application responsiveness. The puzzles are also validated in batches for solvability before being added to the rotation, ensuring quality and playability.

2. Scalability of Real-Time Features

As the user base of the Bridge Puzzle Game Application grew, scalability issues became apparent, particularly with real-time features such as live updates to the leaderboard. The initial architecture struggled to handle concurrent user sessions effectively, leading to delays and performance bottlenecks.

Impact: Scalability challenges can severely limit the growth potential of an application and degrade the user experience, particularly during peak usage times when multiple users are online simultaneously.

Resolution: To address these issues, I redesigned the backend architecture to better support scalability. This included implementing a more robust server infrastructure with load-balancing capabilities and optimizing real-time communication protocols. The use of web sockets for more efficient, bidirectional communication between clients and servers was also introduced to reduce latency in data updates.

3. Device and Platform Compatibility

Inconsistent game performance across different devices and operating systems highlighted compatibility issues. Some users experienced interface misalignments, slow loading times, and even crashes, particularly on older or less common devices.

Impact: Compatibility issues can lead to a poor user experience and reduce the overall satisfaction and retention rates among players.

Resolution: I implemented a series of device-specific optimizations to address these compatibility issues. This included enhancing the responsive design features, performing rigorous testing across a wide range of devices, and optimizing graphics and gameplay elements to accommodate different hardware capabilities.

4. Game Page Functional Shift

The original design manual specified a game page with save and pause functions, allowing players to halt their gameplay and resume at their convenience. However, this posed technical challenges related to state management and user experience consistency across sessions.

Resolution: After considering the implications of these features on the overall game flow and user engagement, the decision was made to replace the save and pause functions with a 'New Game' feature and a 'Restart' option. The 'New Game' function dynamically generates a fresh puzzle, providing immediate value to players seeking a new challenge, while the 'Restart' option allows players to begin the current puzzle anew, offering a seamless way to improve their skills without the need to manage saved states. This adaptation not only simplified the backend complexity but also kept the game experience focused and engaging, ensuring players remained immersed in the gameplay without interruption.

Unimplemented Features from Designed Functional

1. Level Difficulty of Game Mode

Reason for Omission: The intended level difficulty feature, which would allow users to select the complexity of puzzles, was not implemented due to the significant algorithmic complexity and development time required. Balancing a broad range of difficulties to cater to all user skill levels proved to be more resource-intensive than initially anticipated.

Resolution: Given the resource constraints, the initial plan for multiple selectable levels was restructured to focus on delivering a single, robust game mode. I developed an algorithm to automatically select and present puzzles of varying difficulties. This approach maintained gameplay variety and challenge while remaining within the project’s resource limitations.

2. Multiplayer Mode

Reason for Omission: The multiplayer mode, a feature that would enable users to compete or cooperate in real-time, was not completed. This was primarily due to the challenges in establishing a stable and synchronous multiplayer environment that could seamlessly handle real-time interactions and data synchronization across various devices.

3. Awards and Share Function

Reason for Omission: Although planned, the awards system for recognizing player achievements and the function to share these accomplishments on social platforms were not realized. The development of a comprehensive awards system and integration with social media APIs required additional time for implementation and testing, which was not feasible within the project's timeline and scope.

Each of these features, while valuable for enhancing user engagement and gameplay depth, was deemed outside the scope of the initial project release due to technical, resource, and time constraints. Prioritization was given to essential game mechanics and stability, with the possibility of revisiting these features in future updates.

Challenges in UI and UX Design

1. **Responsive & Adaptive User Interface Design:**

   Crafting a user interface that is universally responsive and adapts seamlessly across a wide range of devices posed a significant challenge. Ensuring compatibility from desktop to handheld devices required a thoughtful design approach that maintained functionality and aesthetic quality.

   Solution: By leveraging the versatile widget library of Flutter, a responsive UI was meticulously developed to provide a consistent user experience on any platform. Media queries and flexible layouts were utilized to ensure that UI elements dynamically fit the screens of both smartphones and larger displays without losing their intuitive usability.

2. **Balancing Simplicity with Depth:**

   The design needed to strike a balance between being user-friendly for newcomers and engaging enough for experienced players. The risk was creating a UI that could either overwhelm beginners with complexity or underwhelm experts with oversimplification.

   Solution: The solution was to employ a minimalistic design that straightforwardly presented game features while embedding depth into the gameplay itself. Interactive tutorials and progressive disclosure of advanced features allowed new users to learn as they played, while expert users could dive straight into the rich gameplay without unnecessary UI interference.

Areas for Improvement

1. UI/UX Design Enhancement

The current user interface of the Bridge Puzzle Game Application is functional and responsive but lacks visual appeal and modern design elements that could enhance the user experience.

Improvement Goals: The goal is to overhaul the UI to make it more visually engaging and interactive. Incorporating contemporary design trends, such as minimalism and material design, could significantly improve aesthetic appeal and user engagement.

Action Plan:

- Interactive Elements: Implement interactive components such as custom cursors, hover effects, and dynamic feedback to user interactions, which can make the interface feel more lively and responsive.
- User Testing: Conduct user experience tests to gather feedback on the new designs and iterate based on user preferences and usability issues.

2. Enhancing Game Fun Factor

While the game mechanics are solid, there could be more elements of fun and engagement to keep players coming back. Currently, the game may not offer enough variety or challenge to sustain long-term interest.

Improvement Goals: Increase the game's entertainment value to boost player retention and attract new users. This can be achieved by adding new gameplay elements and enhancing existing features to offer a richer, more diverse gaming experience.

Action Plan:

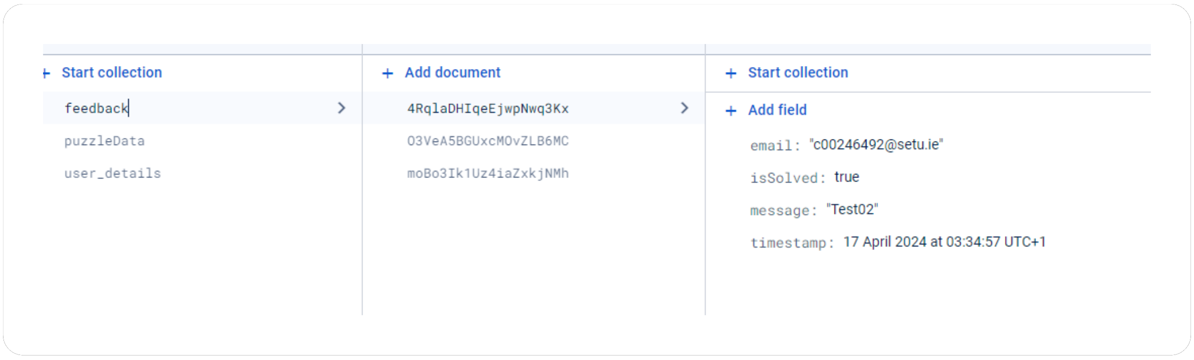
- New Game Modes: Introduce various game modes that challenge players in different ways. For example, multiplayer modes could provide fresh challenges.
- Rewards System: Develop a comprehensive rewards system that recognizes player achievements with in-game currency, badges, or unlockable content. This system could include daily challenges and milestones to keep players engaged.

Firebase Firestore Database Structures

The Bridge Puzzle Game Application utilizes Firebase Firestore, a NoSQL database, to store and manage data in a real-time, efficient, and scalable manner. The structured Firestore database is designed with specific collections to organize the data effectively:

1. Feedback Collection:

This collection holds documents and each document corresponds to a piece of user feedback. Each document contains fields such as \`email\`, \`isSolved\`, \`message\`, and a \`timestamp\`. These fields record the user's contact information, the resolution status of the feedback, the user's message, and the time the feedback was submitted.



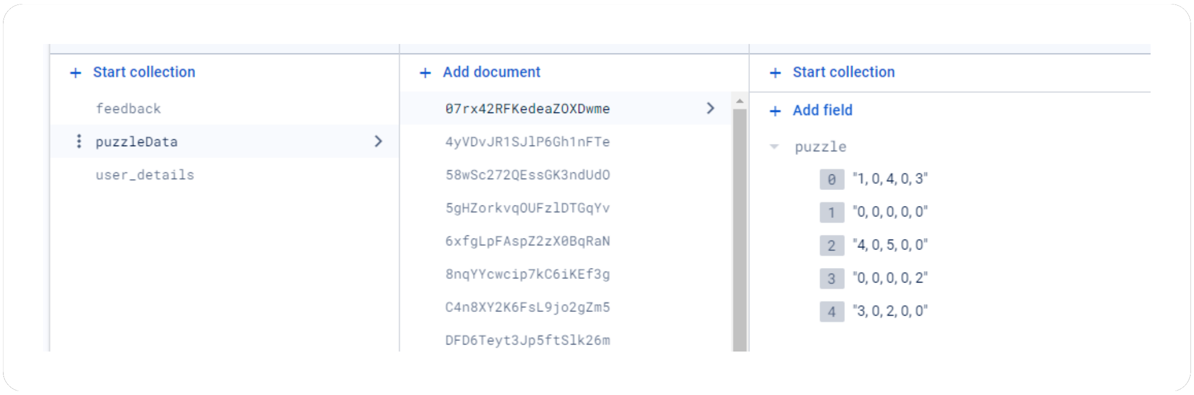
feedback
puzzleData
user_details

4RqlaDHIqeEjwpNwq3Kx
O3VeA5BGUxcMOvZLB6MC
moBo3Ik1Uz4iaZxkjNMh

email: "c00246492@setu.ie"
isSolved: true
message: "Test02"
timestamp: 17 April 2024 at 03:34:57 UTC+1

2. PuzzleData Collection:

Within this collection, individual documents represent unique puzzle configurations available to the users. A document in \`puzzleData\` contains a \`puzzle\` field that holds an array of strings, each representing a row in the puzzle grid, encoding the puzzle structure and state.



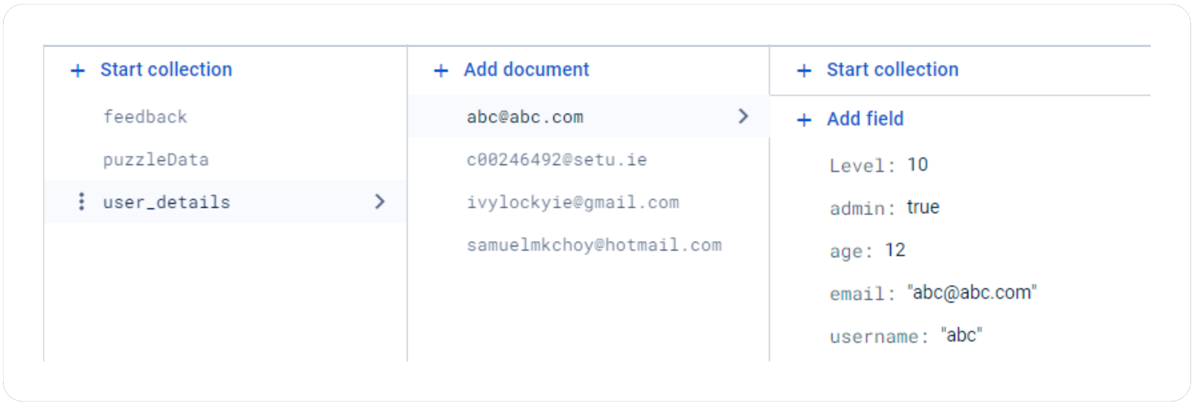
feedback
puzzleData
user_details

07rx42RFKedeaZOXDwme
4yVDvJR1SJlP6Gh1nFTe
58wSc272QEssGK3ndUdO
5gHZorkvqOUFzlDTGqYv
6xfgLpFAspZ2zX0BqRaN
8nqYYcwcip7kC6iKEf3g
C4n8XY2K6FsL9jo2gZm5
DFD6Teyt3Jp5ftSlk26m

puzzle
0 "1, 0, 4, 0, 3"
1 "0, 0, 0, 0, 0"
2 "4, 0, 5, 0, 0"
3 "0, 0, 0, 0, 2"
4 "3, 0, 2, 0, 0"

3. User_details Collection:

This collection stores documents with user-specific information. The fields within a `user_details` document include `Level`, `admin` status, `age`, `email`, and `username`, providing a profile of the user's game progression, administrative privileges if any, demographic data, contact information, and chosen username.



feedback
puzzleData
user_details

abc@abc.com
c00246492@setu.ie
ivylockyie@gmail.com
samuelmkchoy@hotmail.com

Level: 10
admin: true
age: 12
email: "abc@abc.com"
username: "abc"

Development Methodology

An Agile development methodology was employed to manage the creation of the Bridge Puzzle Game Application. This iterative and incremental approach was instrumental in the project's success for several reasons:

- **Adaptability**: Agile practices allowed me to adapt to changes quickly. Whether responding to user feedback or new technical requirements, the methodology ensured that the application evolved to meet these needs efficiently.
- **Continuous Delivery**: By breaking down the project into manageable iterations, I focus on delivering functional increments of the application. This enabled continuous delivery and frequent releases, keeping the project momentum high and stakeholders regularly updated with tangible progress.
- **User-Centric Focus**: Central to Agile is the focus on user needs. By involving user feedback at every stage, the development process ensured that the final product truly resonated with its audience, addressing their preferences and requirements effectively.

Implementing the Agile methodology with the support of Flutter and Firebase's suite of tools enabled to creation of a high-quality application that was well-received by users and met all defined objectives with flexibility and user engagement at its core.

Insights and Lessons Learned

Upon reflecting on the journey of creating the Bridge Puzzle Game Application, many profound insights and valuable lessons have been gleaned.

Adaptability and Problem-Solving:
One of the most significant learnings was the importance of adaptability. The development process was dynamic, with requirements and technical specifications evolving. This necessitated a flexible approach to problem-solving, often requiring on-the-spot innovation, such as reimagining game features like the save and pause functions to align with user engagement strategies.

Technical Proficiency with Firebase:
Gaining a deep understanding of Firebase's Firestore and Authentication services was instrumental. Not only did it involve mastering the technical skills to integrate these services into the application, but also learning how to leverage their full potential to create a secure, efficient, and user-friendly environment.

UI/UX Design Considerations:
The project underscored the importance of user-centric design. Crafting a UI that was intuitive yet engaging required an iterative design process, where user feedback was crucial. Balancing aesthetic appeal with functionality was a delicate dance that enhanced my appreciation for UI/UX design intricacies.

Data Management:
The structuring of the Firestore database was another critical learning curve. Designing data schemas that support real-time updates, scalability, and fast queries was a complex task that improved my understanding of database management and optimization.

Project Management:
Managing the development lifecycle from conception to deployment provided insights into the agile methodology and the importance of milestone tracking, risk management, and time allocation.

In conclusion, this project was a comprehensive learning experience that sharpened my technical skills, enhanced my design thinking, and honed my project management abilities. It was a testament to the idea that the journey of creating is as enriching as the final product itself.

Acknowledgements

Special thanks to the faculty and advisors from Joseph Kehoe whose guidance and expertise provided the foundational knowledge and support necessary to navigate the complexities of game development.

I would also like to thank my early users who participated in the testing phase. Your feedback was invaluable in refining the user experience and ensuring the game met the highest standards.

A big shout-out to the online communities of Firebase and Flutter. The resources, discussions, and shared knowledge within these communities were instrumental in overcoming technical challenges.

Lastly, I extend my thanks to anyone who was indirectly involved in the project. Your indirect contributions, whether as a source of inspiration or a provider of moral support, have not gone unnoticed.

This acknowledgement would be incomplete without recognizing that this project, like many creative endeavours, was built upon the open-source software and libraries that represent the collective ingenuity of the global developer community. Thank you for laying the groundwork that enables developers like myself to innovate and build upon.

With sincere thanks,
Choy Ming Kit