Sam Houston State University

Software Engineering Group 1

Final Report

Base Blocks

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April 30th, 2020

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1 Gantt Charts

Project: Base Blocks

Start: January 16th, 2020

End: May 4th, 2020

Organization: Sam Houston State University - Department of Computer Science

Date: April 30th, 2020

Task List

Name	Start Date	End Date	Milestone	% Complete	Resources	Notes
Group formation	1/30/2020	1/30/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Prepared questions for our client meeting.
Project Selection	1/30/2020	02/02/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Selected modules to implement. - Picked application name.
Client meeting	2/3/2020	2/3/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Discussed client requirements.
Group meeting	2/11/2020	2/11/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Refined app functionality.
Group meeting	2/18/2020	2/18/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Prepared for proposal presentaion.
Registered for Undergrad Research Symposium	2/19/2020	2/19/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	
Proposal presentation	2/19/2020	2/19/1010	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	
Group meeting	2/23/2020	2/23/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Discussed feasibility report. - Divide task between team.
Discord group meeting	2/24/2020	2/24/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Begin work on main menu prototype. - Discuss feasibilty report.
Base Blocks v 1.0	3/10/2020	3/23/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Implemented a main menu prototype utilizing Unity engine 3D sprites and assests.
Base Blocks v 2.0	3/20/2020	3/23/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Switched to 2D. Tradeoff to focus on perfecting core functionality of the game first.
Base Blocks v 2.1	3/20/2020	3/25/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Implemented main menu and settings.
Base Blocks v 2.2	3/23/2020	3/25/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	
Base Blocks v 2.3	3/23/2020	3/25/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez	- Created login scence and an account scene.

Base Blocks v 2.4	3/24/2020	3/27/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Connected the app to the database and is now able to create accounts
Base Blocks v 2.5	3/31/2020	3/31/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Finished the Identify Base 10 game mode.
Base Blocks v 3.0	4/6/2020	4/6/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Reimplemented database connection. Fixed bug causing crash..
Base Blocks v 3.1	4/8/2020	4/8/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Complete base 10 game mode.
Base Blocks v 3.2	4/8/2020	4/8/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Created the game mode scene and started building the Identify Base 5 game mode.
Base Blocks v 3.3	4/10/2020	4/15/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- New features include: reworked Main Menu and Choose Game Mode scene, Base 5 Identify, and base 10 addition.
Base Blocks v 3.4	4/11/2020	4/17/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- New features include: Base 5 addition is now added, and recognizing users to login. Additional sound effects have been added.
Base Blocks v 3.5	4/12/2020	4/20/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- New features include: A scoring system that increments and decrements and updates the scores for accounts in the database; also if logged into a student account, scores are shown on the main menu.
Base Blocks v 3.6	4/15/2020	4/21/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Minor bug fixes to navigating through menus using the back buttons, and readjustments to the Inscript wait time that allows for the database to be accessed.
Base Blocks v 3.7	4/16/2020	4/22/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Adaptive resolution incorporated in the app, Score menu replaced settings menu, updated sprite images and sounds, and minor aesthetic changes.
Base Blocks v 3.8	4/18/2020	4/22/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Implemented a slide bar that changes difficulty value; which in turn affects the random values generated and number of points awarded for each game mode. Due to feed back the one's block was made larger to allow for easier drag. Lastly a bug was fixed where previously if all blocks where dragged down the last block would not reset when the reset button was hit.
Base Blocks v 3.9	4/20/2020	4/23/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Implemented minor aesthetic changes and tweaks to values in the number generator.

Client Meeting	4/23/2020	4/23/2020	FALSE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Final meeting, polishing up details and some of the requirements
Base Blocks v 3.10	4/23/2020	4/23/2020	TRUE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	- Implemented minor bug fixes and aesthetic changes based on feedback from the Meeting with Dr. Emma.
Final presentation	4/24/2020	4/24/2020	TRUE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen.	
Final report	4/30/2020	4/30/2020	TRUE	100	Chris Burns Jake Derkowski Victor Vasquez Toyoabasi Udosen	

Resource List

Name	Default Role	Mail
Chris Burns	Developer	clb149@shsu.edu
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Emma Bullock	Client	exb051@shsu.edu

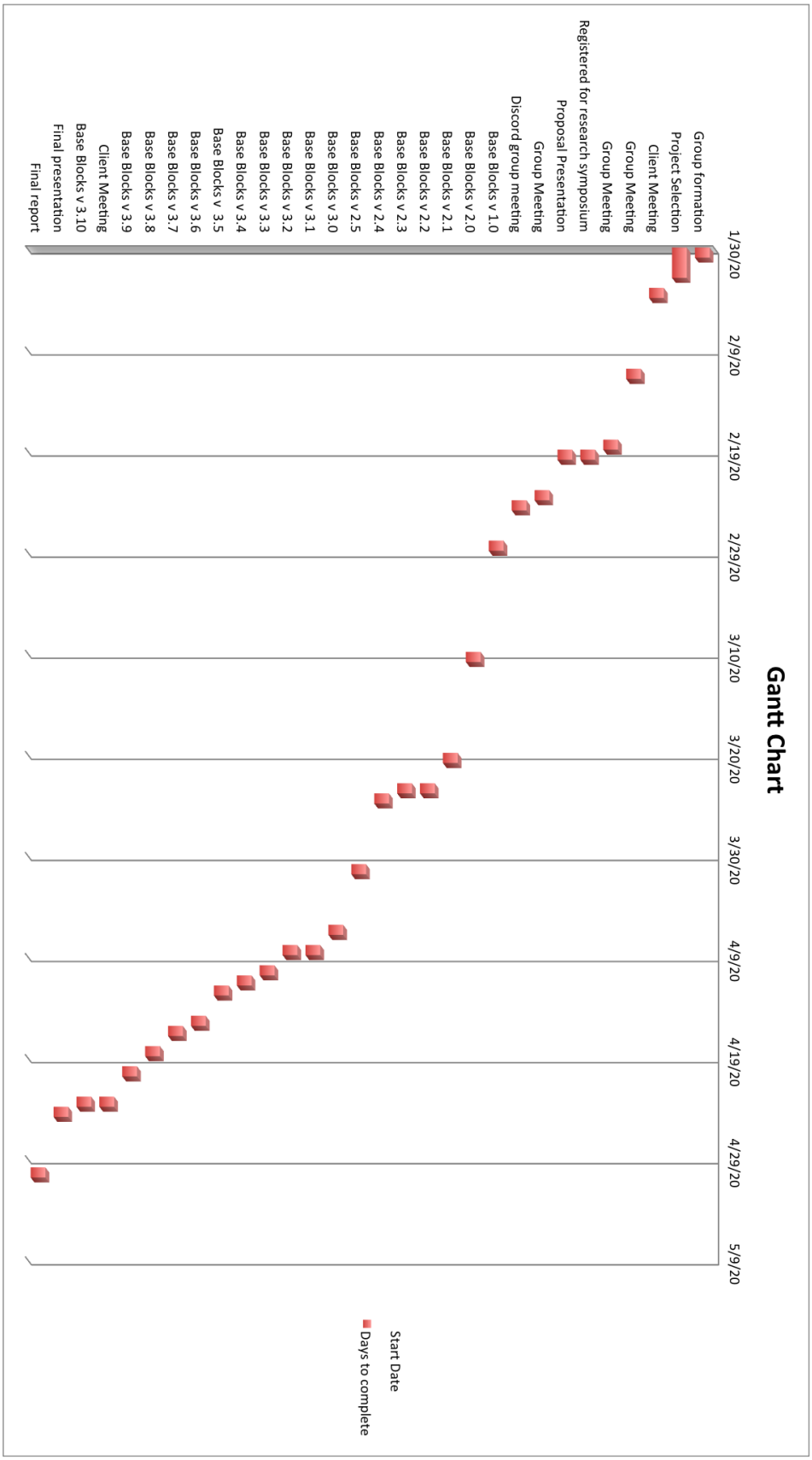

Figure 2: Gantt Chart

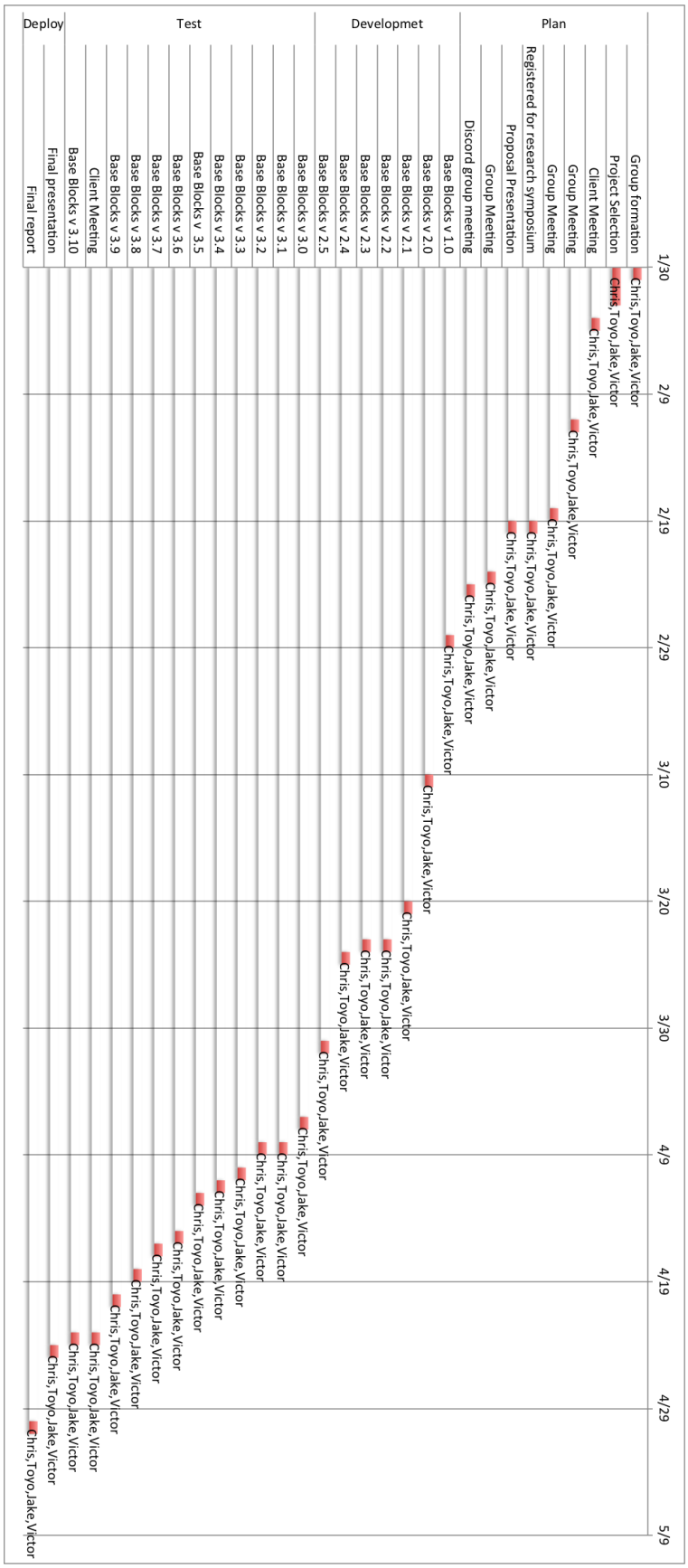

Figure 3: Resource chart

2 Summary of Changes

The key revisions since the last report are as follows:

1. Database implementation
2. Base-5 game module
3. Addition mode of game play
4. Difficulty option
5. Game play flow chart
6. Use case diagrams

3 Glossary of Terms

- ***Number systems*** - Any system of naming or representing numbers, as the decimal system or the binary system
- ***Base*** - The radix or base is the number of unique digits, including the digit zero, used to represent numbers in a positional numeral system.
- ***Scoring*** - A user's score will be kept and updated over time to be accessed in the database.
- ***Touchscreen*** - The application will allow for touch screen navigation throughout all menus and arithmetic operations.
- ***Simultaneous Linking*** - A variety of inputs need to be supported with an arithmetic functionality.
- ***Guiding Feedback*** - Visual and audio feedback will be included to ensure that users do not get overwhelmed or lost through usage.
- ***Aesthetically Appealing*** - The application needs to stand out from competitors as well as keep the attention of the user.

4 Project Overview

Purpose

The purpose of this project is to provide a fun and interactive game that teaches the user about number systems with various bases by providing two game modes, one for representation of a number and another for simple arithmetic. This program is being built as an updated replacement from the current software which lacks modern-day requirements; that will no longer be supported in the near future. The new Base Blocks application will deploy features and functionalities that will make the application more conducive to learning while being more aesthetically pleasing. The new and improved application will also be more "teacher-friendly" by allowing the instructors to view a database of all of their students' progress, in real time.

This learning application will cover the representation and arithmetic of number systems with the base of five and ten which will provide the user with an overall understanding about how values are represented and utilized in each base. The application will include a feature which will keep track of the progress of each student by calculating a "score" based on their accuracy and the difficulty level that they have completed. The scope of this application is not limited to those who are in a mathematics course, but will include additional login options making the game inclusive to any and all who want to play, but will still store their data in case they want to keep track of their own progress.

5 System Requirements

The goal of this project is to recreate and combine two modules of the National Library of Virtual Manipulatives (NLVM) into one updated, effective math learning-game that is easily accessible. This application is designed to benefit both the teacher and the student that are using it by tracking the game progress of the student and to store it for the teacher to view.

5.1 Functional Requirements

1. The success of this application depends on its touch screen compatibility.
2. Random number generation for the presented question, according to the current difficulty.
3. User login and authentication.
4. Include number systems other than the Base-10

5.2 Non-Functional Requirements

- *Accessibility* - The application will be supported on android, with functionality to be ported to others platforms at a later date. With touchscreen being a main required functionality, portable devices are the intended devices to be used. This allows users to use the software anywhere, not just in the classroom.
- *Scalability* - The software will be developed to add more functionality such as multiplication and division without sacrificing the initial functionality.

5.3 Goals and Features

This application will feature two different modules, the Base Blocks and Base Blocks Arithmetic module, in which different number bases will be available. Base Blocks has the user drag and drop blocks representing specific numbers into their respective fields to match a given random number. Arithmetic requires the same interactions as Base Blocks but the objective is to answer the given arithmetic problem. These modules will tie into a database that keeps track of the user's activity and score. To accomplish this, the software needs to be web-based keeping accessibility and portability in mind.

1. Increased learning value of the game by utilizing the techniques that the touch screen compatibility offers. These include, but are not limited to, Simultaneous Linking and Guiding Feedback.

2. User friendly, allowing for the user to adapt the game settings, change the difficulty of the game play, and view their current scores with ease in an aesthetically appealing environment.

3. A separate scoring system for each mode of game play for all registered users that is updated by the accuracy of the student's submitted answers. Therefore, a student will only be presented with questions that match the knowledge level permitting them to grow them to learn at their own pace.

4. A backend database that is updated when new accounts are created and when there are updates in the user's score. This system allows for students to not lose the progress that they have made when they come back to the application and allows for their teacher to view the progress that they have made.

5.4 Actors and Goals

Format - [Actor: Goal]

- *Student (user):* Playing and generating the game data that relfects their knowledge of the presented topic.
- *Guest User:* User that plays the game just as the Student User does, but does not interact with the Firebase.
- *Teacher (Administrator):* Monitor the progress of their students by viewing the scores in the database.
- *Firebase:* Store the game data and login credentials for the users and their teachers, and display the scores for each student through game play.
- *Base Blocks:* The main game objects that the user will be *dragging* and *dropping*. The blocks will reflect the number system that is currently in use and will generate the User's score for the particular game mode that is currently being played.

6 System Architecture

6.1 Architecture Diagram

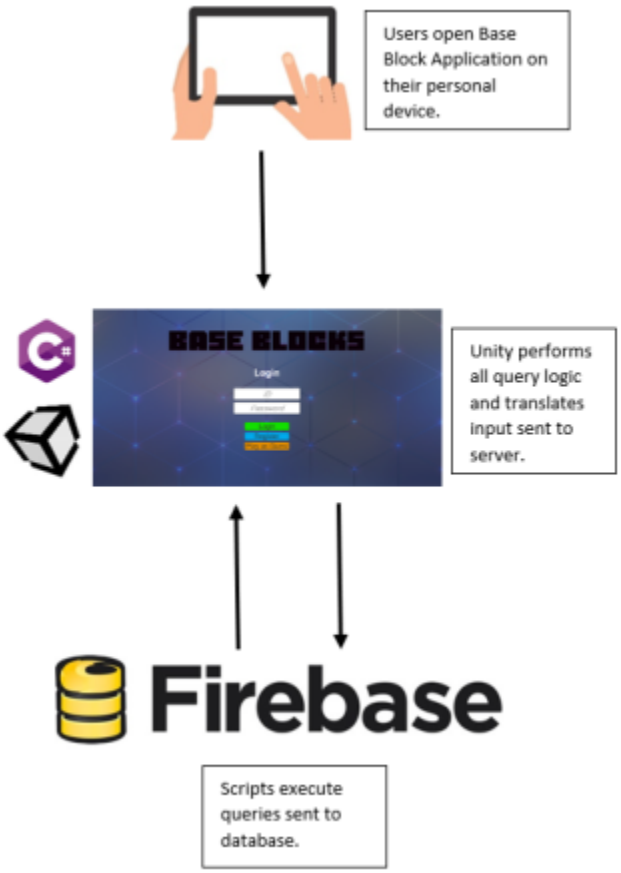

Figure 4: Architecture Diagram

6.2 Unity Game Engine

Unity is currently the most popular game development engine in the world, and therefore there exists a lot of documentation and assistance which will help us in creating exactly what our client is looking for. Unity is well documented, supported and is a platform that will allow easy development of our intended application. Unity introduces assets and other prefabrications which are composed of models, textures and other components. Once assets are built they can be easily manipulated with components also known as properties. When assets have been completed, interactivity is implemented and incorporated utilizing the C# language to create scripts. Unity also allows for real time rendering of changes being made during application development. This powerful software will allow us to seamlessly deploy our application on a wide range of devices in order to target varying audiences with different technology.

6.3 Firebase Database

Firebase, a nonrelational, cloud storage database that stores all information in the JSON file format will be used for our database. Firebase is easily integrated into the Unity Game development environment via plugins which include Authentication, Analyzing, and a RealTime database allowing remote configuration and reliable data handling.

7 Algorithm for "Random Number" Generator

For each game mode there is a randomly generated number that the user needs to reach in order to successfully complete the game. This random number is generated based on the difficulty level the user sets prior to starting the game mode. The difficulty level directly influences the random number such that as the difficulty level increases the number of place values also increases. For example on medium difficulty, the 1's and 10's place will generate a number for base 10. While the 1's and 5's place will generate a number for base 5. To accomplish this a C# random number generator that have varying ranges depending on the base and difficulty.

Identify: Base-10

- **Easy:** The range of the random number is 1 - 9.
- **Medium:** The range of the random number is 10 - 99.
- **Hard:** The range of the random number is 100 - 999.

Addition: Base-10

- **Easy:** The range of random number one is 0 - 4, and the range of random number two is 1 - 5.
- **Medium:** The range of random number one is 0 - 54, and the range of random number two is 1 - 55.
- **Hard:** The range of random number one is 0 - 549, and the range of random number two is 1 - 550.

Identify: Base-5

- **Easy:** The range of the random number is 1 - 4.
- **Medium:** The range of the random number is 5 - 24.
- **Hard:** The range of the random number is 25 - 124.

Addition: Base-5

- **Easy:** The range of random number one is 0 - 2, and the range of random number two is 1 - 2.
- **Medium:** The range of random number one is 0 - 12, and the range of random number two is 1 -12.
- **Hard:** The range of random number one is 0 - 68, and the range of random number two is 1 - 68.

After the random number is generated the random number(s) are then used to compare against the user's inputed number. For base 10 game modes the random and inputed numbers are compared at a 1:1 ratio. For base 5 game modes the random and inputed numbers are compared at a 4:1 ratio for the 25 block, a 2:1 ratio for the 5 block, and a 1:1 ratio for the 1 block. After the random number and inputed number are equal then the user is given a score value dependent on the difficulty level. 1 point for easy, 2 points for medium, and 3 points for hard.

8 Use-Case Diagrams

8.1 Case One: Create Student User Account

- **Initiating actor**: Student user.
- **Actor's Goal**: To create a new student account.
- **Participating Actors**: Student user, Base Blocks, Firebase.
- **Preconditions**: Base Blocks is installed, and an account is not already created.
- **Trigger**: Create account button is pressed.
- **Postconditions**: The account is created, and scores are set to 0.

Main Success Scenario:

1. The Create Account button initiates creation of a student account.
2. Base Blocks reads Firebase to check if an account already exists.
3. Firebase returns a value that states no account already exists.
4. Base Blocks copies the input information into Firebase to create a student account and sets the scores to 0.

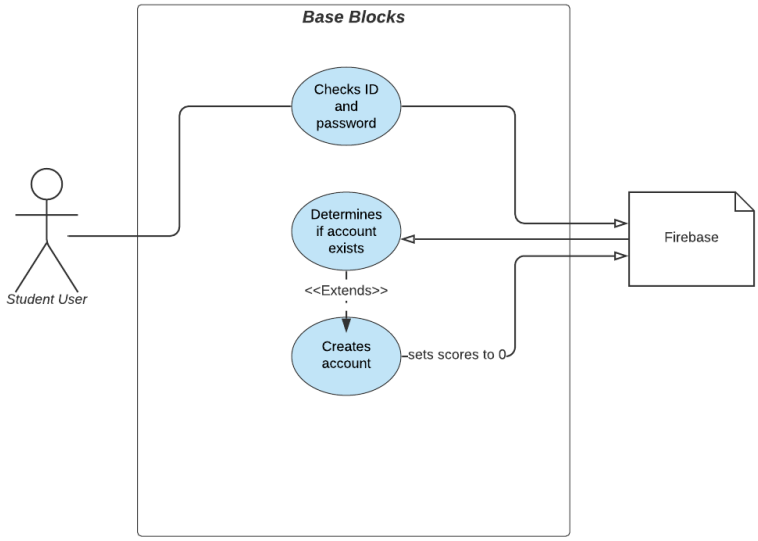

Figure 5: Create Student account

8.2 Case Two: Guest Play the Game

- **Initiating actor**: Guest user.
- **Actor's Goal**: A guest plays the game with no account.
- **Participating Actors**: Guest user and Base Blocks.
- **Preconditions**: Base Blocks is installed.
- **Trigger**: Continue As Guest button is pressed.
- **Postconditions**: The user exits the app and scores are not saved.

Main Success Scenario:

1. Continue As Guest button allows user access to the app.
2. User continues to the game mode menu and selects a game mode to play.
3. The user plays the game mode and accrues a score based on performance.
4. The user quits playing the game mode and the score is not saved.

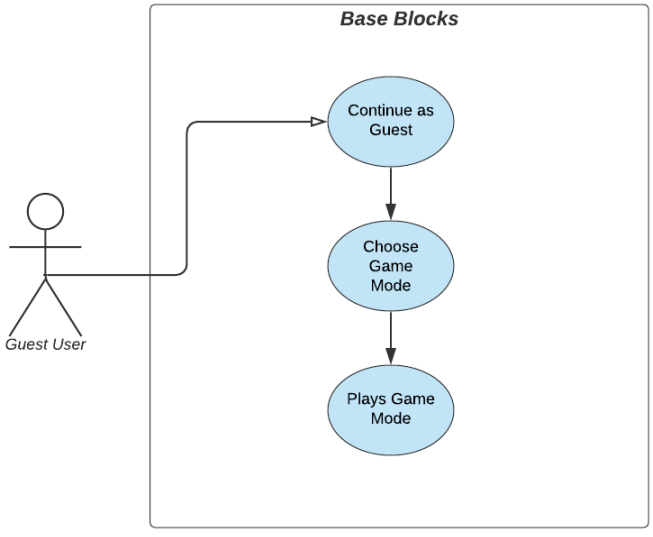

Figure 6: Guest Plays Game

8.3 Case Three: Student User Login, Pick Game Mode

- **Initiating actor**: Student User
- **Actor's Goal**: To play a game mode and update the score in Firebase.
- **Participating Actors**: Student User, Base Blocks, Firebase.
- **Preconditions**: Base Blocks is installed, and an account already exists.
- **Trigger**: User logs into their account.
- **Postconditions**: The student user exists the game, and the score is updated in Firebase.

Main Success Scenario:

1. Student user inputs their id and password and presses the login button that calls Firebase to verify the account.
2. User continues to game mode menu and selects a game mode.
3. The student user plays a game mode and accrues a score based on performance.
4. The user exits the game mode which adds the score from the play session to the existing score and updates Firebase.

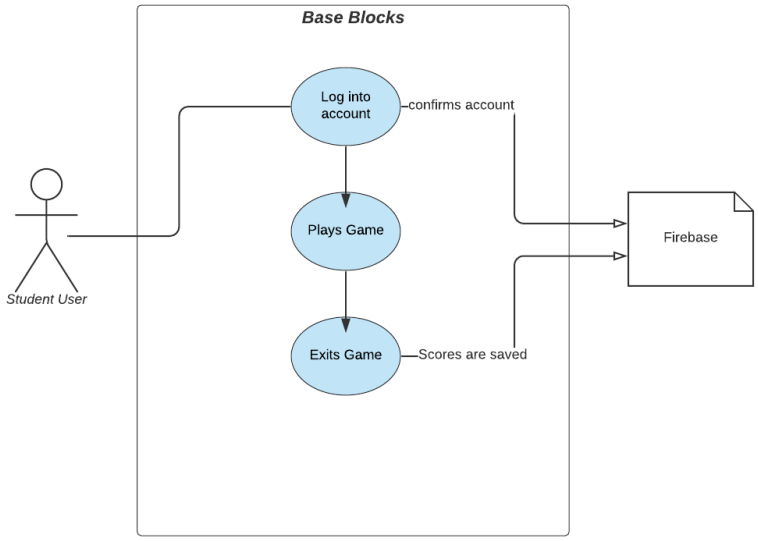

Figure 7: Student Picks Game Mode

8.4 Case Four: Teacher Views Student's Scores

- **Initiating actor**: Teacher User.
- **Actor's Goal**: To view the Student's scores.
- **Participating Actors**: Teacher User, Base Blocks, Firebase
- **Preconditions**: Base Blocks is installed, and an account is already created.
- **Trigger**: Teacher User logs into their account.
- **Postconditions**: The Student's scores are displayed in the scores menu.

Main Success Scenario:

1. Teacher User inputs their id and password and presses the login button that calls Firebase to verify the account.
2. Teacher user goes to scores menu and Base Blocks calls the student accounts associated with the Teacher User.
3. The scores of the Students are displayed on the score menu.
4. The user exists the application.

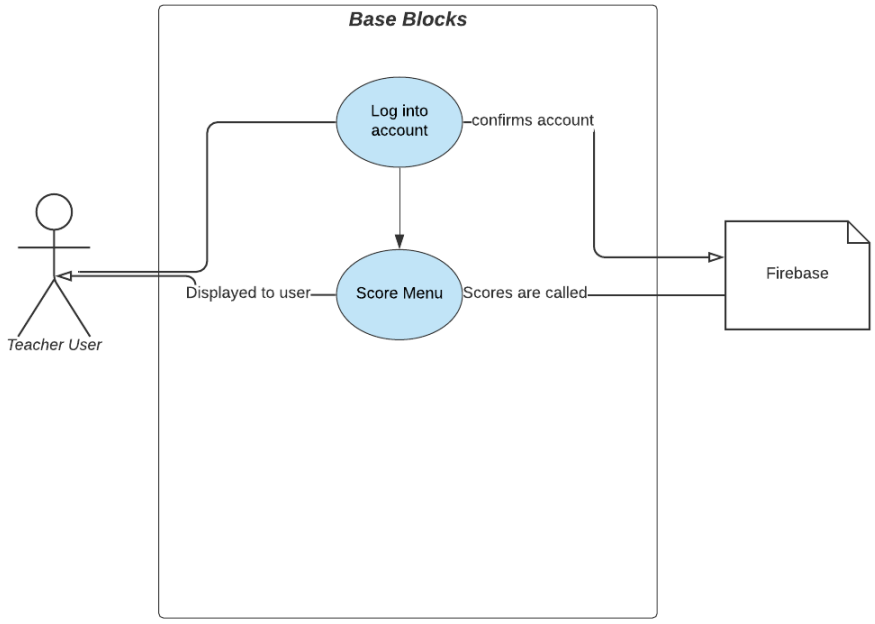

Figure 8: Teacher Views Student scores

9 System Screen Shots

Figure 9: Login Screen

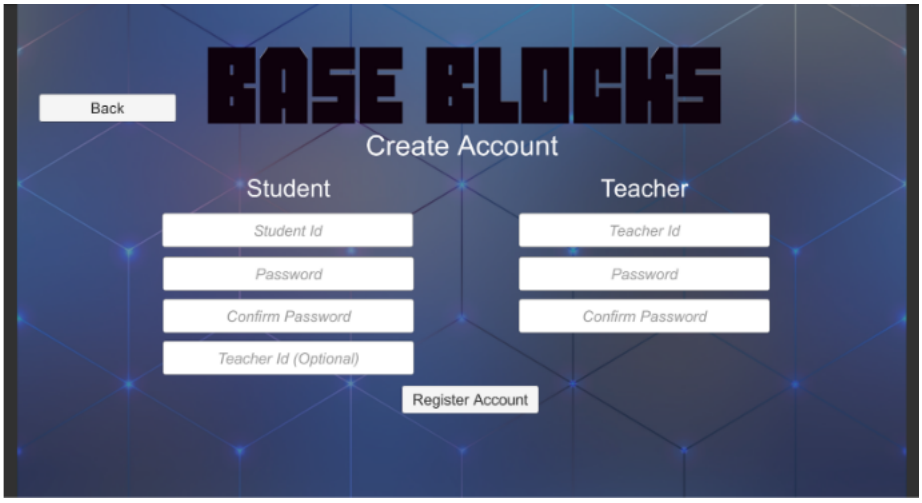

Figure 10: Create Account

Figure 11: Main Menu

Figure 12: Game Mode

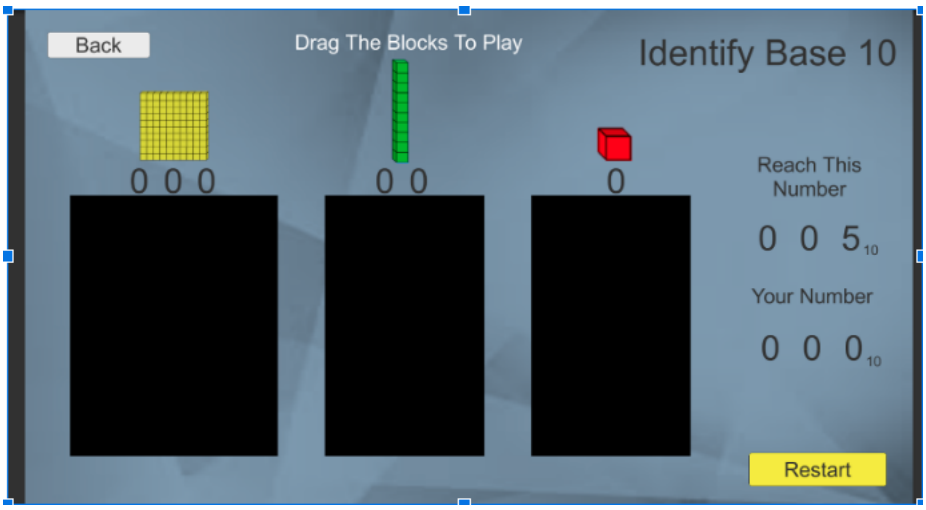

Figure 13: Base-10 Identify

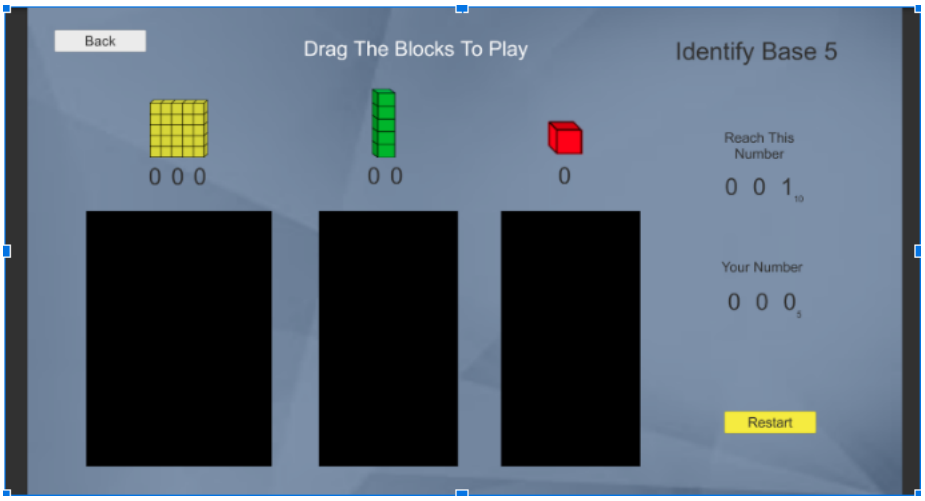

Figure 14: Base-5 Identify

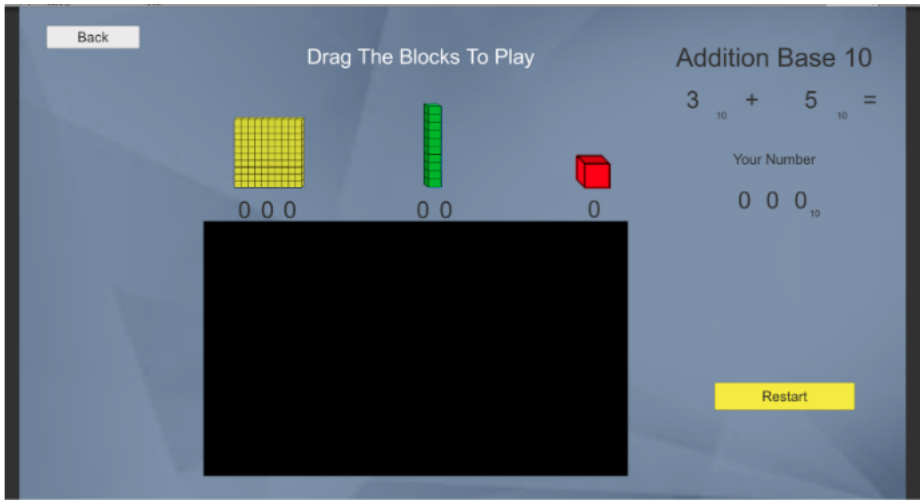

Figure 15: Base-10 Addition

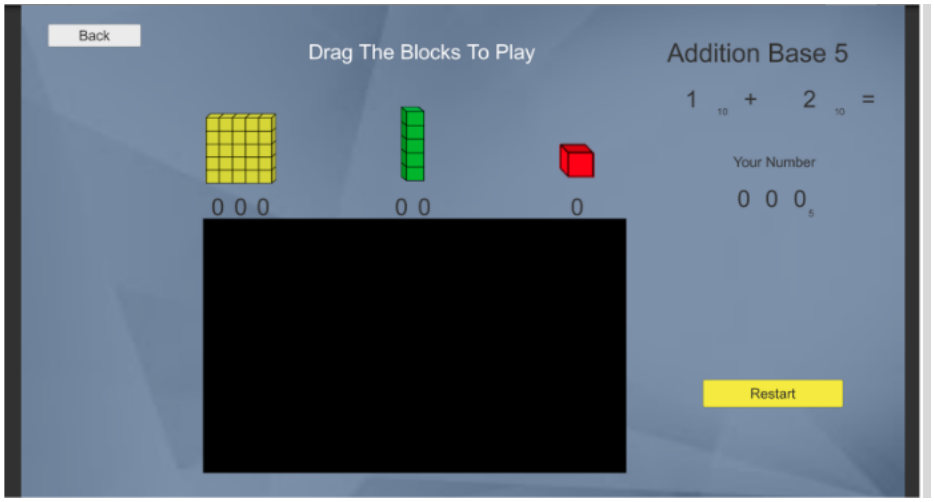

Figure 16: Base-5 Addition

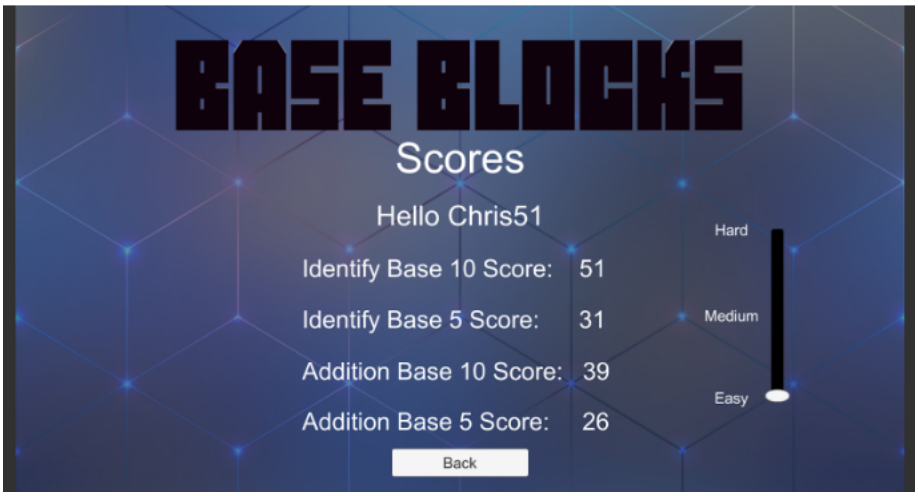

Figure 17: Score Menu

10 Firebase Structure

For the sake of simplicity and to ensure functionality, the structure of the Firebase Database that has been implemented has one main table with a record for each student or user. Each record has the scores for all of the different modes of game play along with the credentials for the given account.

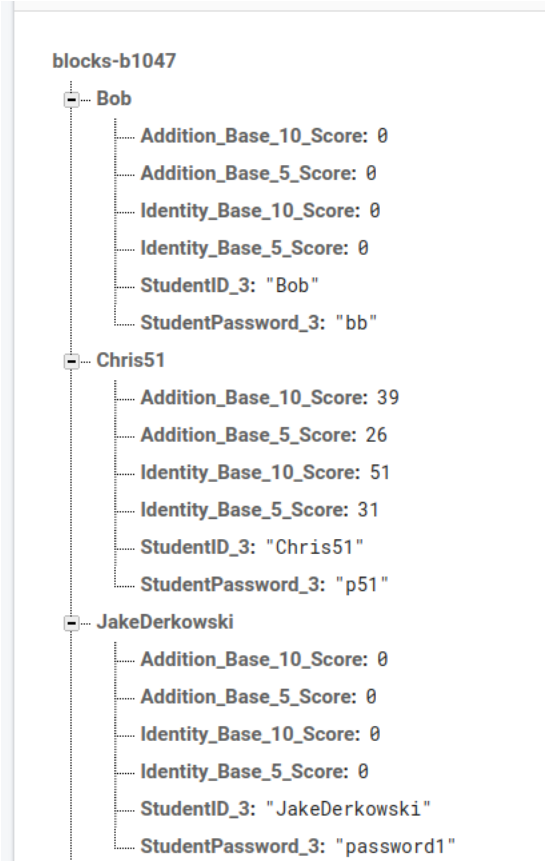

Figure 18: User login and game scores

11 Conclusion

11.1 Obstacles

Throughout the development of this application we encountered many obstacles most of which were overcome, however there were a couple where we had to settle for a compromise. These compromises did not affect the functionality of the finished product, but explicity pointed out the areas in which we need improvement for future projects. We encountered difficulties with the implementation of the database because we were using a foreign system; a NoSQL database. In the future, we will need to understand this structure in a more efficient way or stick to SQL databases. The *Firebase Database* features a user autentication model that was not used in the current version, but would provide more security for future builds. The other main stuggle that we faced with the arithmetic and representation of number bases other than the ones that we have implemented. We had planned to include the Base-2 numbering system, but failed to realized the exponential increase of complexity are this target number increases.

11.2 Acomplishments

This efficient recreation of Base Blocks combines what was once two modules into one fully functional mobile device application; complete with touchscreen compatibility. The teaching has been increased significantly from that of the original application due to the use of digital learning techniques that have been implemented. One very important aspect of the success of this recreation of Base Blocks is that the increased availability. This application is now available to all who own or have access to a mobile device, allowing for the teaching power to reach its utmost potential.

12 Future Work

This is not the end of the road for Base Blocks because the way that it has been designed allows for future scalability. Potential scalability is offered through the modularization of the application development.

1. More number systems, such as Base-2 and Base-3
2. Other mathematical operations such as subtraction, multiplication, and division
3. Inclusion in a new and updated database of the other modules
4. More secure method for storing user credentials

13 References

[1] National Library of Virtual Manipulatives

http://nlvm.usu.edu/en/nav/vlibrary.html

[2] Firebase Database

https://firebase.google.com/docs/

[3] Unity Game Engine

https://docs.unity3d.com/Manual/index.html

[4] Android Studio

https://developer.android.com/guide

[5] Number Systems

https://en.wikipedia.org/wiki/Numeral_system

[6] Positional Systems

https://en.wikipedia.org/wiki/Numeral_system#Positional_systems_in_detail