MATH RUN: ENDLESS RUNNER GAME-BASED LEARNING USING MENTAL MATHS TECHNIQUES FOR BASIC MATHEMATICS

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This report is submitted in partial fulfillment of the requirements for the Bachelor of Information Technology (Game Technology) with Honours.

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY
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DECLARATION

I hereby declare that this project report entitled

MATH RUN: ENDLESS RUNNER GAME-BASED LEARNING USING MENTAL MATHS TECHNIQUES FOR BASIC MATHEMATICS

is written by me and is my own effort and that no part has been plagiarized without citations.

STUDENT : _____ Date : 26/09/23
(NUR FITRIYAH BINTI ABDULLAH)

I hereby declare that I have read this project report and found this project report is sufficient in term of the scope and quality for the award of Bachelor of Information Technology (Game Technology) with Honours.

SUPERVISOR : _____ Date : 26/09/23
(PROF. TS. DR. SAZILAH SALAM)

DEDICATION

I dedicate my final year project (FYP) to my supervisor, Prof. Ts. Dr. Sazilah Salam, whose unwavering support and guidance have been invaluable throughout my academic journey. Thank you for your patience, encouragement, and for always challenging me to do better.

I would also like to express my sincere gratitude to Mr. Hazmin for his cooperation and for generously sharing his knowledge and expertise on the Atavism game engine. Your contribution and dedication to this project were essential to its success.

Finally, I would also like to extend my heartfelt appreciation to my friends who have been my pillars of strength throughout this journey. Your unwavering support, encouragement, and belief in me have been crucial in helping me overcome challenges and achieve my goals.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my supervisor, Prof. Ts. Dr. Sazilah Salam, for her invaluable guidance and support throughout the completion of my final year project (FYP). Her knowledge, experience, and patience have been indispensable in helping me develop my skills and knowledge in the field. I am also grateful for her constant encouragement and for pushing me to explore new ideas and approaches.

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I would also like to acknowledge the contribution of my friends, who have been a constant source of motivation and support throughout this journey. Your encouragement and belief in me have kept me motivated, and I am grateful for your friendship.

Finally, I would like to thank my family for their unwavering support and encouragement throughout my academic journey. Their love and support have been my source of strength, and I am forever grateful for their presence in my life.

Once again, I express my heartfelt thanks to everyone who has contributed to the successful completion of this project.

ABSTRACT

This report focuses on the development and evaluation of "Math Run: Endless Runner Game-Based Learning," a game designed to improve mental math skills in primary school children. The study aimed to address the problem of students struggling with mental math calculations and the subsequent impact on problem-solving abilities. By incorporating mental math techniques into an endless runner genre, the game provided an engaging platform for children to practice quick calculations in a virtual environment. Usability testing was conducted to assess the game's effectiveness, resulting in positive outcomes, showcasing its potential as an educational tool for enhancing mental math proficiency and problem-solving skills in primary school children.

ABSTRAK

Laporan ini memberi tumpuan kepada pembangunan dan penilaian "Math Run: Endless Runner Game-Based Learning," sebuah permainan yang direka untuk meningkatkan kemahiran matematik mental dalam kalangan murid-murid sekolah rendah. Kajian ini bertujuan untuk menangani masalah pelajar yang menghadapi kesulitan dalam pengiraan matematik mental dan kesan berikutnya terhadap kebolehan menyelesaikan masalah. Dengan menggabungkan teknik matematik mental dalam genre endless runner, permainan ini menyediakan platform menarik bagi kanak-kanak untuk berlatih pengiraan pantas dalam persekitaran maya. Ujian kebolehgunaan telah dijalankan untuk menilai keberkesanan permainan, menghasilkan hasil yang positif dan memperlihatkan potensi permainan sebagai alat pendidikan untuk meningkatkan kecekapan matematik mental dan kemahiran menyelesaikan masalah dalam kalangan murid-murid sekolah rendah.

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LIST OF ABBREVIATIONS

FYP	**-**	**Final Year Project**
SUS	**-**	**System Usability Scale**
GDLC	**-**	**Game Development Life Cycle**
ECS	**-**	**Entity-Component-System**
BGM	**-**	**Background Music**
WAV	**-**	**Waveform Audio**
OG	**-**	**Ogging**
AYG	**-**	**Adab Youth Garage**

LIST OF ATTACHMENTS

CHAPTER 1: INTRODUCTION

1.1 Project Background

Project MATH RUN is a learning initiative that aims to improve problem-solving skills in basic mathematics by incorporating mental math exercises through a game-based approach. The project recognizes the importance of mental math as a problem-solving technique and aims to provide an engaging and interactive way for students to practice and improve their mental math abilities. The project involves the development of an endless runner game elements to engage students in an interactive and collaborative learning experience. The game is designed to provide an entertaining and challenging platform for students to practice their math skills and improve their problem-solving abilities.

This game requires players to be able to perform quick mental math calculations to solve the problem on the road. They can practice mental math techniques like addition, subtraction, multiplication, and division to improve their skills. This game can serve as a valuable tool to help elementary school students improve their problem-solving abilities in mathematics.

1.2 Problem Statement

Many primary students struggle with problem-solving in mathematics, particularly with mental math calculations. They may lack confidence and proficiency in performing quick calculations, which can hinder their ability to solve problems in a timely and efficient manner. To address this issue, there is a need for a game that can provide students with a fun and engaging way to practice mental math skills, improve their confidence, and enhance their problem-solving abilities. The game should incorporate visual and interactive elements to capture students' attention and cater to different skill levels. The goal of this game is to empower primary students

to become more proficient in mental math and better equipped to solve mathematical problems.

1.3 Objectives

The objectives of this project are:

- To identify appropriate game mechanics and elements to apply mental math techniques in basic Mathematics.
- To develop an endless runner game-based learning using mental math techniques for basic mathematics within Unity game engine.
- To evaluate the usability of the endless runner game in assisting children to solve basic Mathematics.

1.4 Goals and Genre

Math Run is a game that combines running and math problem-solving, with the main goals of improving mental math skills and providing a fun and engaging learning experience for players. By presenting players with math problems to solve while running through a virtual environment, Math Run helps players practice and improve their mental math calculations in a fun and interactive way. This not only helps to develop their math skills but also improves their overall cognitive ability.

Moreover, Math Run seeks to provide a fun and engaging learning experience for players. By using game-based learning principles, the game aims to engage players with mathematics in a new and exciting way. The game has a leader board, allowing players to progress at their own pace and challenge themselves to improve their skills.

Math Run is an educational game that falls under the genre of an endless runner game. It combines elements of running games with math problem-solving to provide a fun and engaging way for players to practice and improve their math skills. Educational games like Math Run are designed to teach and reinforce academic concepts in a way that is interactive, enjoyable, and memorable.

1.5 Game Features

Game features refer to the various elements and mechanics that make up a video game. In the case of Math Run, the game features include:

- **Target Players:** Primary school students.
- **Rules of the Game:** Solve math questions using mental math skills.
- **Victory Condition:** Answer all the questions correctly.
- **Termination Condition:** Game ends if a question is answered incorrectly.
- **Gameplay:** Engage in an endless runner-style game while answering math questions, aiming to achieve the highest score possible.

1.6 Conclusion

The output of the project is the development of Math Run, an educational game designed to improve students' problem-solving skills in basic mathematics. The chapter provided an overview of Math Run's goals and features. In the next chapter, a literature review will be conducted, and the research methodology will be discussed.

CHAPTER 2: LITERATURE REVIEW AND PROJECT METHODOLOGY

2.1 Introduction

In this chapter, provide a brief overview of the literature review and project methodology that underpin for the study on "Math Run: Endless Runner Game-Based Learning." It explores existing research on game mechanics and elements that enhance learning, focusing on mental math techniques in basic Mathematics. The methodology employed in the project to design and evaluate the game's effectiveness is also outlined. This chapter sets the stage for detailed discussions in the subsequent sections.

2.1.1 Literature Review Study

The aim of this table is to conduct a literature review to achieve project objective 1, which is to identify appropriate game mechanics and elements that can be applied to enhance mental math techniques in basic Mathematics. Table 2.1 provides a comprehensive overview of various game mechanics and elements discussed in the selected references, along with supporting descriptions and examples, to aid in understanding their potential in improving learning outcomes in educational games.

Table 2.1: Game Mechanics and Elements in Enhancing Mental Math Techniques in Basic Mathematics

Game Mechanics/Elements	Supporting References (with descriptions)	Example	Enhancement of Mental Math Techniques in Basic Mathematics
Progression	Smith et al. (2021): "Advancing through levels/stages as players improve mental math skills."	In an endless runner game, players unlock new levels as they master different math concepts.	Reinforces and expands understanding of basic math concepts and operations.
Achievement Badges	Garcia et al. (2020): "Visual representations of accomplishments or milestones achieved by players."	Players earn badges for completing specific mental math challenges, such as earning a badge for solving 100 equations correctly.	Motivates and rewards players for practicing and mastering mental math skills.
Speed	Lee & Smith (2017): "Focuses on the element of time and challenges players to solve mental math problems quickly."	Players are given a time limit to solve each equation, encouraging quick thinking and mental agility.	Improves mental calculation speed and accuracy.

Score Feedback	Chen & Garcia (2019): "Provides players with information about their performance in the game."	After solving each equation, players receive feedback on their accuracy, speed, and points earned.	Helps players identify areas for improvement and track progress in mental math skills.
Operation Selection	Rodriguez & Nguyen (2020): "Allows players to choose the type of mathematical operations they want to practice."	Players can select addition, subtraction, multiplication, or division to tailor the game to their specific learning needs.	Develops proficiency in specific math operations and strengthens overall computational skills.
Leaderboards	Williams & Brown (2018): "Display scores and rankings of players, creating a competitive environment."	Players can see how their scores compare to others and strive to achieve a top ranking on the leaderboard.	Fosters a sense of competition and motivation to excel in mental math abilities.
Problem-Solving	Martinez & Wang (2021): "Involves presenting players with challenging mental math problems that require critical thinking and problem-solving strategies."	Players encounter complex equations that require logical reasoning and strategic thinking to solve.	Enhances problem-solving skills and encourages application of mathematical concepts in real-life scenarios.

In-Game Rewards	Nguyen & Wang (2018): "Virtual rewards received for achieving specific goals or milestones."	Players earn coins or power-ups for reaching certain score thresholds or completing challenging levels.	Reinforces positive reinforcement and provides incentives for continuous engagement and improvement.
Challenges	Lee et al. (2019): "Introduce new and increasingly difficult mental math tasks."	Players face progressively harder equations or time constraints to keep the game challenging and engaging.	Builds resilience, adaptability, and the ability to handle more complex mental math problems.
Customizable Avatars	Brown & Williams (2022): "Allows players to personalize and customize their in-game characters."	Players can choose from various avatars, change their appearance, or unlock new customization options.	Adds personalization and engagement, which can increase motivation and enjoyment in practicing mental math.

2.2 Genre

Math Run is an educational game designed for primary school students. It falls under the genre of educational games, specifically an endless runner. In Math Run, players engage in an endless running experience while solving math problems. The game focuses on providing an enjoyable and interactive way for students to practice and improve their mental math skills. By incorporating math challenges into the endless runner gameplay, Math Run aims to make learning math fun and engaging for young players.

2.3 Existing Games

The existing game under consideration is a math-themed endless runner. It combines the excitement of endless running with educational math challenges, creating an engaging gameplay experience that helps players improve their math skills while having fun.

In the market, there are several similar games that have been developed, offering a combination of endless running and math learning. Here are a few notable examples:

i. Math Run

Math Run is an exhilarating endless runner game that incorporates math challenges into its gameplay. Players navigate through various obstacles while solving math problems to progress in the game. With its fast-paced gameplay, power-ups, and engaging math exercises, Math Run provides an entertaining and educational experience.

Figure 2.1: Math Run Game.

ii. Math Run: Panda Chase

Panda Chase is another math-themed endless runner that takes players on a delightful panda-themed adventure. As players control a cute panda character running through obstacle-filled levels, they are tasked with solving math problems along the way. With vibrant graphics, unique level design, and a fun math learning experience, Panda Chase offers an enjoyable and educational gameplay journey.

Figure 2.2: Math Run: Panda Chase Game.

iii. Toon Math: Math Games

Toon Math: Math Games is a colorful and captivating math game set in a cartoon world. It seamlessly blends the endless runner genre with math exercises, providing players with an engaging learning experience. By running, jumping, and sliding through challenging levels while solving math problems, Toon Math offers an appealing visual style and an effective way to practice math skills.

Figure 2.3: Toon Math: Math Games.

Table 2.2 compares Math Run with similar educational math games in terms of their shared features and unique elements.

Table 2.2: Comparison of existing games with Math Run in terms of similarities and differences

Game Title	Similarities	Differences
Math Run by TapSim Game Studio	- Educational focus on improving math skills. - Incorporation of math problems into gameplay. - Integration of an endless running element.	- Different visual design and art style. - Unique game mechanics and features. - Specific target audience (primary school students)
Math Run: Panda Chase by Greenhill Games	- Educational nature with a focus on math learning. - Inclusion of math problems and equations. - Endless running gameplay.	- Different level design and obstacles. - Unique power-ups and bonuses. - Unique character and setting.
Toon Math: Math Games by EducaGames	- Educational content centered around math learning. - Integration of math problems and equations.	- Variety of math-related mini-games. - Unique visual style and characters. - Unique power-ups and rewards

	- Endless running gameplay.	

Table 2.3 showcases the game mechanics used, game design principles employed, the hardware used (mobile devices), and the development software (Unity) utilized for each game.

Table 2.3: Game Mechanics, Game Design Principles, Hardware, and Software Used in Similar Games

Game	Game Mechanics	Game Design Principles	Hardware Used	Development Software
"Math Run by TapSim Game Studio"	Endless running, math problem solving.	Gamification, interactive learning.	PC/laptop, keyboard, mouse.	Unity game engine
"Math Run: Panda Chase by Greenhill Games"	Endless running, math challenges, power-ups.	Engagement, skill progression, player feedback.	Mobile devices (iOS, Android)	Unreal Engine
"Toon Math: Math Games by EducaGames"	Endless running, math exercises, cartoon visuals	Colorful visuals, captivating gameplay, educational content	Mobile devices (iOS, Android)	Cocos2d-x

2.3.1 Comparison of Existing Games

Table 2.4 compares the game features, gameplay, game mechanics, and other relevant components of Math Run and existing games in the same genre.

Table 2.4: Comparison of Existing Games

Game	Game Features	Gameplay	Game Mechanics	Relevant Components
Math Run by TapSim Game Studio	Endless running, math problem solving, score tracking	Dodge obstacles, collect power-ups, solve math questions	Speed-based challenges, score-based progression, power-ups	Player character, obstacles, math questions, score tracker
Math Run: Panda Chase by Greenhill Games	Endless running, math challenges, power-ups	Chase the panda character, solve math challenges	Power-ups, obstacle avoidance, math problem-solving	Player character, obstacles, math challenges, power-ups
Toon Math: Math Games	Endless running, math exercises, colorful visuals	Run, jump, and slide through levels, solve math problems	Math exercises, level progression, cartoon visuals	Player character, levels, math problems

In comparison, Math Run and Math Run: Panda Chase also feature endless running gameplay and math challenges. However, Math Run: Panda Chase introduces the panda character and focuses on specific math challenges. Toon Math stands out with its distinct visual style and emphasis on level progression and cartoon visuals, creating a unique and visually appealing experience for players.

2.4 Project Methodology

The project methodology encompasses the techniques employed in a particular field of study, involving systematic and theoretical analysis. In this case, the chosen methodology is the Waterfall Methodology. Waterfall game development follows a sequential and linear approach, where each stage is completed before moving on to the next. The process is structured and allows for meticulous planning and execution. The focus is on delivering high-quality games within the specified time.

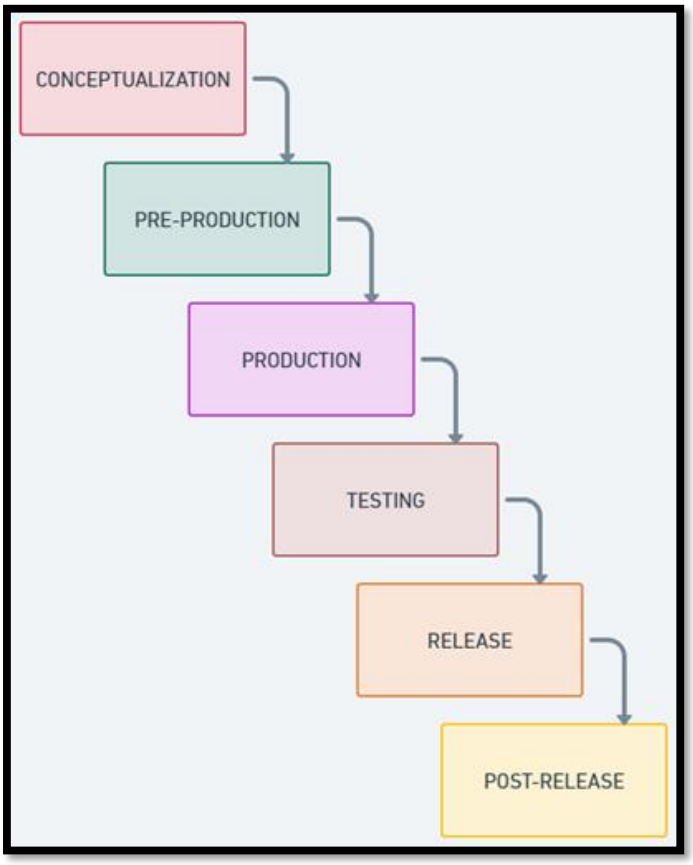


Figure 2.4 Waterfall Development Cycle

Table 2.5 provides a brief overview of the different stages in the game development life cycle for game. It outlines the key activities and descriptions associated with each stage, offering a concise summary of the overall game development process.

Table 2.5 Waterfall Development Cycle Descriptions

Steps	Description
Conceptualization	Brainstorming ideas and developing a concept for Math Run, including defining the game's goals, mechanics, target audience, and educational objectives.
Pre-Production	Creating a game design document outlining features such as game mechanics, level design, and math problem types. Conducting research on educational game design and age-appropriate math concepts.
Production	Developing the game by creating assets, programming gameplay mechanics, artwork, sound effects, and music. Designing levels and preparing the game for release.
Testing	Conducting extensive testing to identify and fix bugs, ensuring the game functions as intended, and optimizing performance. Conducting user testing with children to gather feedback.
Release	Releasing the game to the primary student, potentially involving education and promotion activities.
Post-Release	Providing ongoing support by addressing user feedback, and potentially developing additional levels or math problems for the game.

2.5 Conclusion

In this chapter, an overview of the literature review and project methodology for "Math Run: Endless Runner Game-Based Learning" was provided. The existing research on game mechanics and elements that enhance learning in mental math was explored. In the next activities that will be discussed in Chapter 3: Analysis.

CHAPTER 3: ANALYSIS

3.1 Requirement Analysis

The requirement analysis is a critical phase in the game development process that involves identifying and understanding the needs and expectations of the stakeholders. In this section, we will delve into the process of gathering and analyzing requirements for the game, ensuring that all necessary functionalities, features, and constraints are considered. Through a comprehensive requirement analysis, we aim to lay the foundation for a successful and well-aligned game development project.

3.1.1 Project Requirement

The project requirement section will analyze and discuss the differences in similar games as seen in Table 3.1: Existing Game Analysis. The analysis will focus on key game features like player roles, gameplay, victory conditions, core mechanics, level progression, user interface features, camera models, and, if applicable, a brief storyline. This comprehensive examination of existing games will inform the development of our game, guaranteeing the incorporation of relevant and effective elements from games within the chosen genre.

Table 3.1 Existing Game Analysis

Game Feature	Math Run by TapSim Game Studio	Math Run: Panda Chase	Toon Math: Math Games
Player Roles	Player character	Player character	Player character
Gameplay	Endless runner	Endless runner	Endless runner
Victory Condition	Survive as long as possible	Survive as long as possible	Achieving high scores
Core Mechanic	Collecting power-ups	Collecting bamboo sticks	Collecting coins
Level Progression	Progressing through levels	Progressing through levels	Progressing through levels
User Interface	On-screen controls, score display	On-screen controls, power-up indicators	On-screen controls, coin counter
Camera	Third-person perspective	Third-person perspective	Third-person perspective

3.1.2 Technical Requirement

The technical requirements section, as detailed in Table 3.2: Technical Requirement, sets the foundation for the project by specifying the hardware and associated technologies, including game engines, to be employed. This serves the purpose of defining the fundamental technical capabilities and estimating the development cost, effort, and potential consequences.

Table 3.2 Technical Requirement

Requirement	Tools/Platforms
Hardware Platform	Aspire V5-473G laptop
Input Devices	Keyboard and mouse
Game Engine	Unity Game Engine
Script Programming Language	C# (Visual Studio)
3D Character Resources	Mixamo and Unity Asset Store
Graphic Resources	Freepik

3D Asset Creation	Unity Asset Store
Sound Effects	Mixkit and Unity Asset Store
Background Music	Unity Asset Store

3.1.3 Software Requirement

Throughout the Math Run development process, a range of essential software tools and resources played pivotal roles. These tools fall into three main categories: the game engine, game development tools, and game art resources. The selected software tools include Unity as the game engine, Visual Studio for coding, the Unity Asset Store for game assets, Google Chrome for web-based research, Freepik and Mixkit for graphic and audio resources, and Microsoft Office 16 for documentation and project management. For a detailed breakdown, please refer to Table 3.3: Software Requirements.

Table 3.3 Software Requirements

Category	**Software**
Game Engine	Unity Game Engine
Game Development Tools	Visual Studio
Game Art Resources	Unity Asset Store, Freepik, Mixkit, Microsoft Office 16, Google Chrome

3.1.3.1 Hardware Requirement

In the development and player interaction aspects of Math Run, specific hardware components play vital roles. These can be categorized into two main areas: development hardware and player interaction hardware. For development purposes, a laptop with the specifications of an Aspire V5-473G is utilized, complemented by essential peripherals like a mouse, headphones, and a keyboard. For a detailed breakdown, please refer to Table 3.4.

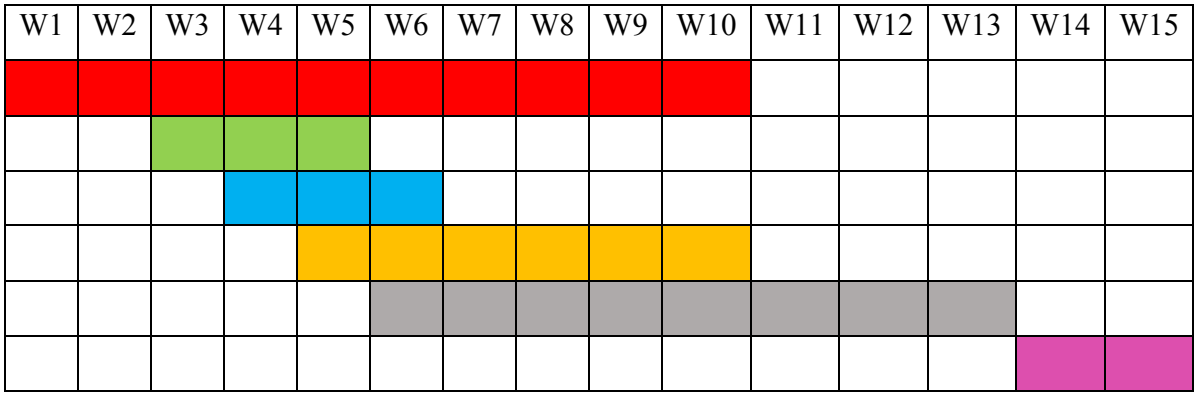
Table 3.4 Hardware Requirements

Category	**Hardware**
Development Hardware	Brand: Laptop Acer Aspire V5-473G Laptop RAM: 8GB Processor: Intel(R) Core(TM) i5-4200U CPU @ 1.60GHz 2.30 GHz
Player Interaction Hardware	Mouse, Headphone, Keyboard

3.2 Project Schedule and Milestone

Table 3.5 provides an overview of the project timeline and activities, guiding the planning and tracking of project progress.

Table 3.5 Project Gantt Chart



- **Research**

Collecting data and conducting research related to the topic, such as similar games, problem statements and other else, using sources such as articles, journals, internet, books, etc.

- **Concept Work**

Developing the initial concept and vision for the game. This include defining the game's genre, setting, characters, and key gameplay mechanics.

- **Block-Out/ Mock-Up Work**

Creating a basic, low-fidelity prototype of the game that can be used to test and refine the game's gameplay mechanics, pacing, and overall feel of the game.

- **Asset Modelling**

Developing the game's final 3D models, textures, animations, and other audio and visual assets.

- **Game Design**

Process of creating the rules, mechanics, objectives, and overall structure of a video game.

- **Finishing Touches**

Final details and modifications performed to a game before it is released or published.

Table 3.6 highlights key project milestones and their status, applying project management principles and including visual representations such as milestone and Gantt charts.

Table 3.6: Project Milestone

Week	Activity	Date
W1	• Select a suitable project topic and potential Supervisor	(20/03 - 24/03)
W1 Meeting 1	• Proposal PSM: Discussion with Supervisor • Proposal assessment & verification • Proposal Correction/Improvement • Proposal Approval • Proposal Submission **Proposal [PRJ-1]**	(20/03 - 24/03)
W2	• List of students with project title versus supervisor and evaluator	(27/03 - 31/03)
W3 Meeting 2	• Chapter 1	(03/04 - 07/04)
W4	• Chapter 1 **Report Writing Progress 1 [PRJ-3]**	(10/04 - 14/04)
W5	• Chapter 2	(17/04 - 21/04)
W7 Meeting 3	• Chapter 2 **Report Writing Progress [PRJ-3]** • **Project Progress 1 [PRJ-2]**	(01/05 - 05/05)
W8	• Chapter 3	(08/05 - 12/05)
W9	• Chapter 3 **Report Writing Progress 1 [PRJ-3]**	(15/05 - 19/05)
W10 Meeting 4	• Chapter 4 • **Project Progress 2 [PRJ-4]**	(22/05 - 26/05)
W11	• Chapter 4 **Report Writing Progress 2 [PRJ-5]**	(29/05 - 02/06)

	• PSM1 Draft Report Preparation	
W12 & W13 Meeting 5	• PSM1 Draft Report preparation	(05/06 - 16/06)
W14	• PSM1 Draft Report submission to SV & Evaluator **Report Evaluation [PRJ9] [PRJ-10]**	(19/06 - 23/06)
W15 FINAL PRESENTATION	• Demonstration **Supervisor [PRJ-6]** **Evaluator [PRJ-7]** • **Presentation Skill [PRJ-8]**	(26/06 - 30/06)

3.3 Conclusion

Chapter 3 discussed the requirements analysis for the project, including project requirements, technical requirements, software requirements, and hardware requirements, as well as the project schedule and milestones; in Chapter 4, the focus will be on the design phase, including the game mechanics, user interface, and visual design of the project.

CHAPTER 4: DESIGN

4.1 Introduction

This chapter will go over the design parts of math run game. Creating a unified and engaging experience for players entails incorporating different factors such as game architecture, gaming mechanics, level advancement, user interface, game art, and more. This chapter will investigate each of these elements in order to provide a thorough grasp of how the game will be constructed and experienced by the players.

4.2 Game Architecture

In Math Run, please see Figure 4.1 for an illustration of the Entity-Component-System (ECS) architecture. Here are some example components and systems that can be part of my game architecture.

Components:

- **Player Character Component:** Stores data related to the player character, such as position, movement, and collision properties.
- **Math Question Component:** Contains information about the math questions, including the operation type, operands, and correct answer.
- **Score Component:** Keeps track of the player's score and high score.
- **User Interface Component:** Manages the game's user interface elements, such as menus, score display, and game over screens.

Systems:

- **Input System:** Handles user input from the keyboard and updates the player character component accordingly.

- **Game Logic System:** Manages the progression of operations, generates math questions, checks for correct answers, and updates the score component.

- **Collision Detection System:** Detects collisions between the player character and boxes, triggering game over events or score updates.

- **Rendering System:** Renders the player character, math questions, and user interface elements based on the component data.

- **Audio System:** Plays background music, sound effects for correct answers, wrong answer feedback, and other audio cues based on game events.

- **Data Management System:** Manages the storage and retrieval of player scores, high scores, and game settings.

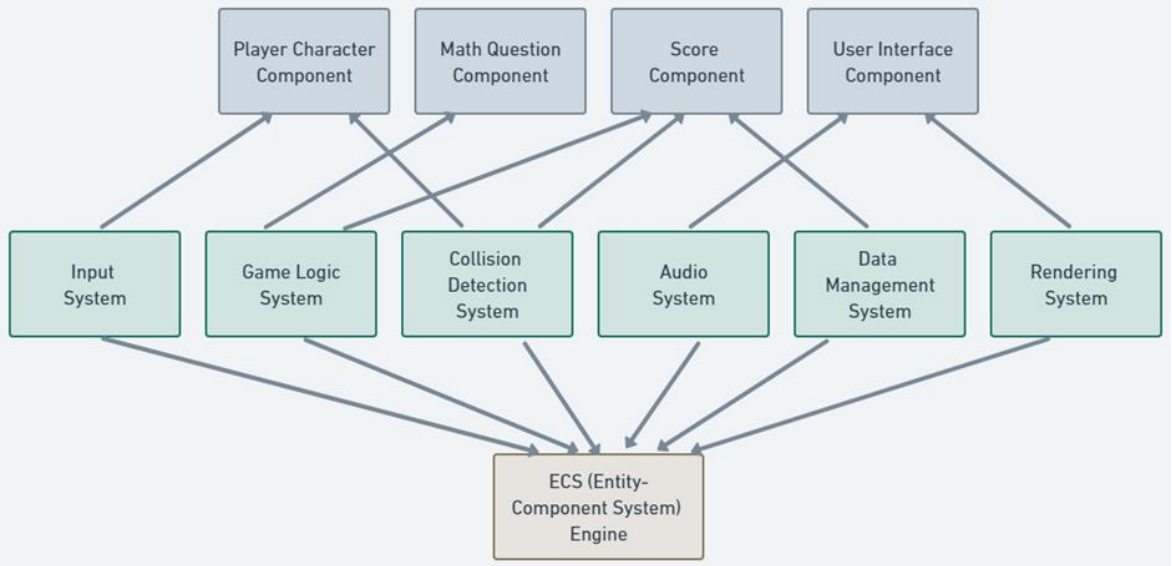


Figure 4.1 Entity-Component-System (ECS) Architecture

4.3 Game Design

The game design section explores the creative process and elements involved in crafting an engaging and enjoyable gaming experience.

4.3.1 Gameplay

The Gameplay section delves into the structure and components of the game, including challenges, player roles, rules, victory/termination conditions, and the level of difficulty.

- **Player Roles**

In the game, players take on the role of controlling animal characters such as sheep, cats, and ducks, according to the operations they choose. They solve math questions using mental math skills and choose the correct answer by hitting the corresponding box, earning scores for each correct response.

- **Game Rules**

i. Player needs to solve math questions using their mental math skills.

ii. Player must answer all the questions correctly to win the game.

iii. Incorrect answers will result in the player losing the game.

iv. To earn points, the player must select the correct answer by hitting the corresponding box.

v. The game progresses by controlling animal characters (such as sheep, cats, and ducks) based on the chosen operations.

- **Victory Conditions**

The player wins the game by providing the correct answers to all the math questions using their mental math skills.

- **Termination Conditions**

The player will lose the game if they hit the box with the wrong answer. When the game is over, they have the option to either restart the game or go back to the main menu.

- **Operation of Difficulty**

The difficulty in the game is designed to gradually increase, challenging the player with math problems while also introducing faster gameplay as they progress.

4.3.2 Core Mechanics

The Core Mechanics section examines the fundamental interactive elements that drive the gameplay experience.

- **Operation Selection**

The player chooses the specific operation or type of math problem they want to solve, such as addition, subtraction, multiplication, or division.

- **Mental Math Solving**

The player utilizes their mental math skills to solve the math problems presented to them within the game.

- **Answer Selection**

The player selects the correct answer among multiple options by hitting the corresponding box.

- **Scoring System**

The game incorporates a scoring system that rewards points for correctly answered math problems, allowing the player to track their progress and performance.

- **Progression and Difficulty Scaling**

The game gradually increases the difficulty of the math problems and may introduce faster gameplay as the player progresses.

4.3.2.1 Application of Mental Math Techniques

Here's a table that relates the mental math techniques discussed in Table 4.1 to how they are designed and applied in Math Run, along with the corresponding design principles:

Table 4.1: Application of Mental Math Techniques in Math Run

Mental Math Techniques	Design in Math Run	Design Principle
Speed	-The speed will increase when a certain score is reached which challenges the player to solve quickly.	-Improve mental calculation speed and encourage quick thinking
Operation Selection	-In Main Menu, Players can choose addition, subtraction, multiplication, or division	-Tailor the game to players' specific learning needs and develop proficiency in specific math operations.
Problem-Solving	-mathematics questions that require critical thinking and problem-solving strategies.	-Enhance problem-solving skills and encourage application of mathematical concepts
Challenges	Introduction of progressively harder equations or time constraints (questions have in 2–3-digit numbers)	Build resilience, adaptability, and the ability to handle more complex mental math problems

Score Feedback	-Detailed feedback on points earned after each equation	-Help players identify areas for improvement and track progress in mental math skills

4.3.3 Flowboard

The Flowboard, as shown in Figure 4.2, is a visual representation that illustrates the flow and progression of the game's levels or stages. It provides a concise overview of the sequence of challenges, events, and player interactions throughout the game. By examining the Flowboard, game designers and developers can gain a better understanding of the game's structure and ensure a smooth and engaging player experience.

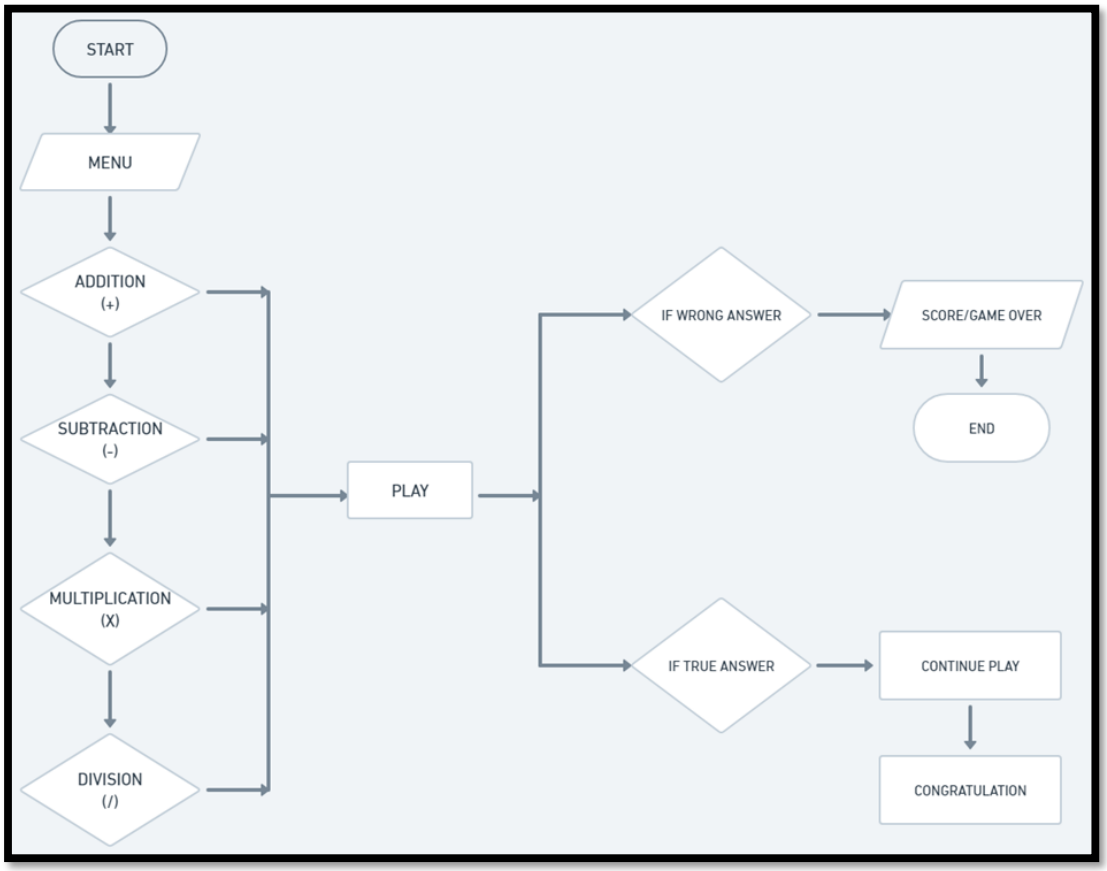


Figure 4.2: Flowboard Game

- **Start**

Upon launching the program, the game will automatically start and direct the player to the Main Menu.

- **Main Menu**

In the Main Menu, players are presented with options to play the game, access instructions on how to play, or quit the game.

- **Operations Selection**

- The operation selection feature offers four choices: addition, subtraction, multiplication, and division. Players can choose which operations they want to choose.

- If the player selects the addition operation, the game will commence, presenting addition questions for the player to solve.

- If the player chooses the subtraction operation, the game will begin and present subtraction questions.

- If the player selects the multiplication operation, the game will start and display multiplication questions.

- If the player opts for the division operation, the game will initiate and show division questions.

- **Wrong Answer**

If the player hits the box with the wrong answer, the game over menu will appear on the screen.

- **True Answer**

When the player selects the box with the correct answer, the game will continue. A congratulations menu will be displayed on the screen when player answer all the questions.

- **Game Over Menu**

Display score and high score players, it also has a restart button and main menu to give players the option to select ether to restart the game or go back to the main menu.

4.3.4 Operations Progression

- The game incorporates four operations, namely addition, subtraction, multiplication, and division.

- The math questions involve both single-digit and two-digit numbers, providing a range of difficulty for the players.

- Players are required to solve math questions using their mental math skills, without the use of calculators or external aids.

- As the game progresses, the speed of the questions will gradually increase, challenging the player to solve them more quickly.

- To earn points, players need to select the box that corresponds to the correct answer for each math question.

4.3.5 User Interface

The game platform is computer/laptop, as depicted in Figure 4.3. Players will access and play the game on their personal computers or laptops. The game will be specifically designed and optimized to run on these platforms, taking advantage of their hardware capabilities and providing an immersive gaming experience.

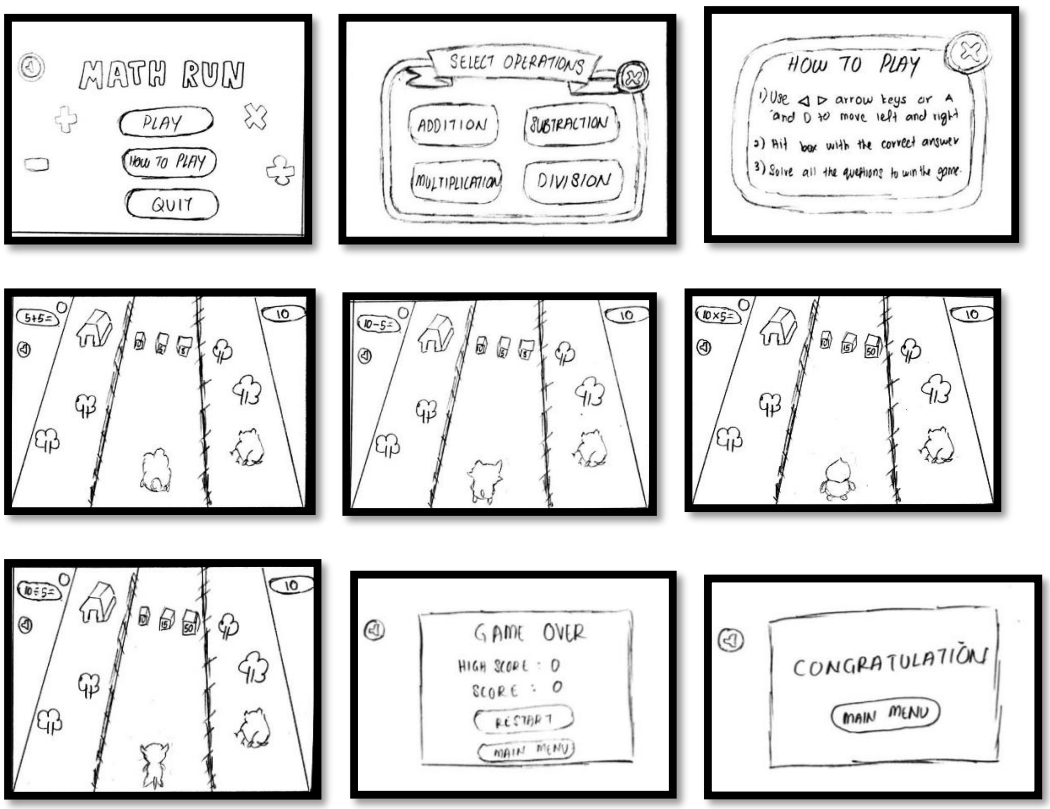


Figure 4.3: Early sketch of the UI

- **Menu UI**

Upon launching the game on a computer or laptop, as shown in Figure 4.4 the main menu will be displayed. Players can navigate through the main menu options using the mouse. They can use mouse cursor to highlight their desired option, and then click the mouse to select it. The main menu provides three options: starting the game, accessing the instructions, or quitting the game. This user-friendly interface allows players to easily navigate and interact with the game using their mouse inputs.

Figure 4.4: Main Menu

- **Operations Selection UI**

Players can select their desired math operation to play and solve the questions by clicking on the corresponding button using the mouse as shown in Figure 4.5.

Figure 4.5: Operation Selection Menu

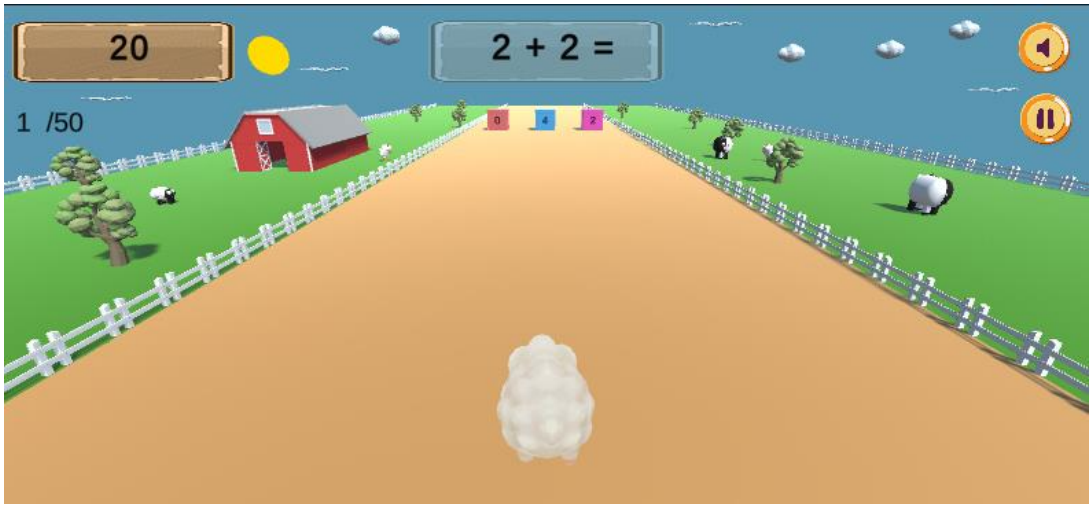
- **How To Play UI**

To access the game rules and guide, players can click on the "How to Play" button in the main menu as shown in Figure 4.6. This will display the instructions and provide guidance on how to play the game. To close the menu, players can simply click on the "Cancel" button.

Figure 4.6: How to Play Menu

- **In-Game UI**

The in-game UI displays the game environment, math questions, score, and answer boxes as shown in Figure 4.7. Players control the animal character using the keyboard as the primary control mechanism.



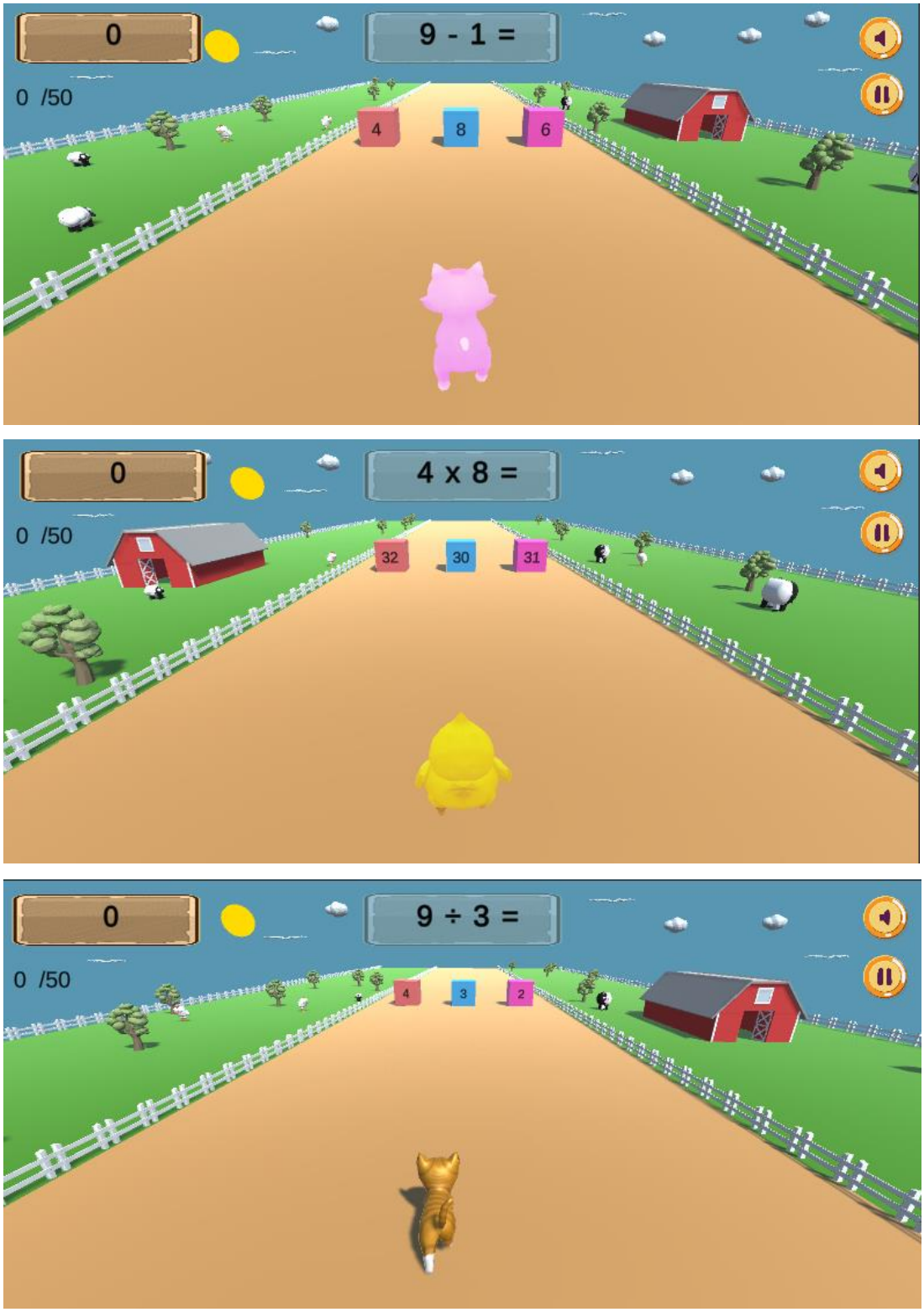


Figure 4.7: In-game Math Run

- **Game Over UI**

If the player hits the wrong answer, the game over menu will appear, showing the player's score and high score as shown in Figure 4.8. It provides two button options: "Restart" to play the game again and "Main Menu" to return to the main menu. Players can click the desired button to either restart the game or go back to the main menu.

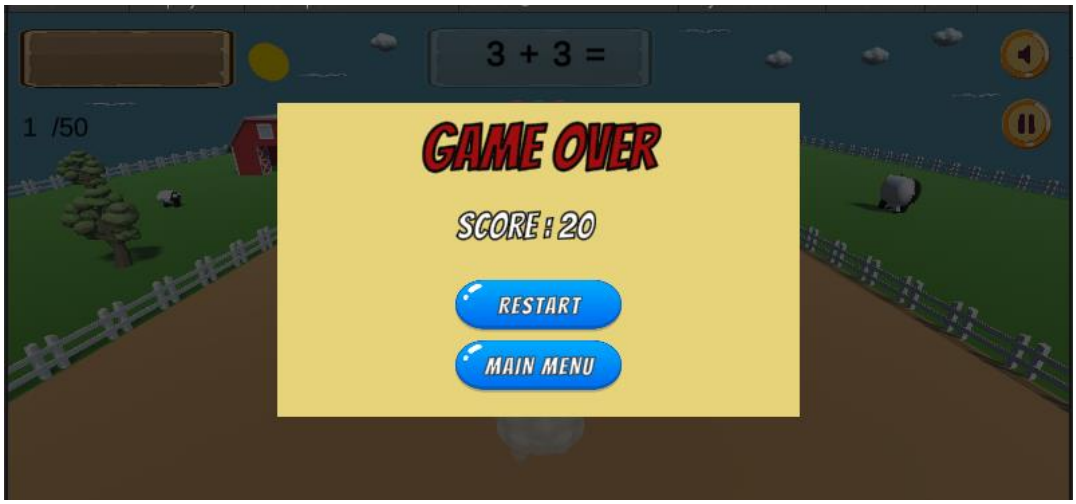


Figure 4.8: Game Over Menu

- **Pause Menu UI**

Players can access the pause feature by clicking the button located in the upper right corner of the screen. While in pause mode, the menu offers two options: the "Continue" button to resume gameplay and the "Main Menu" button to return to the home screen as shown in Figure 4.9.

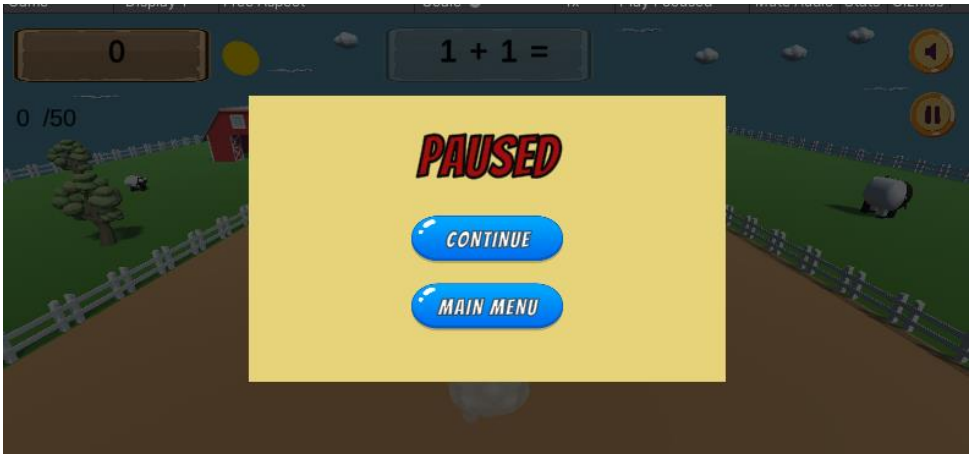


Figure 4.9 Pause Menu

- **Victory UI**

When the player answers all the questions correctly, the congratulations menu will appear. In this menu, players will be presented with a "Main Menu" button, allowing them to go back to the main menu and explore other math operations in the game as shown in Figure 4.10.

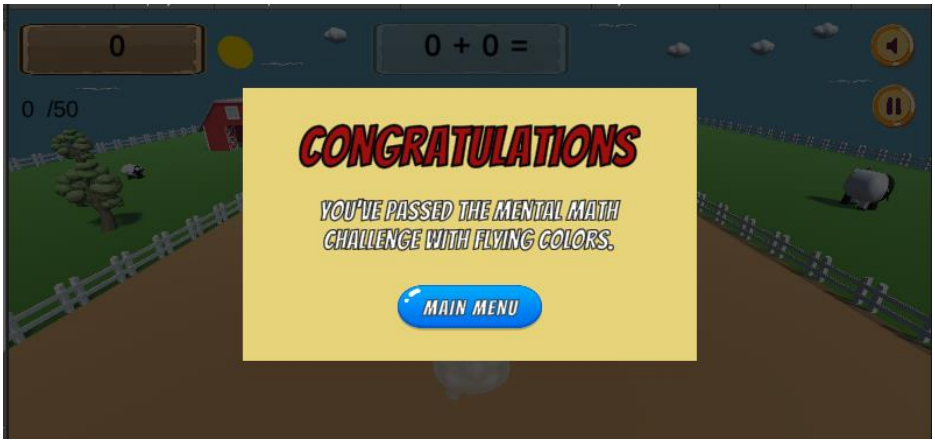


Figure 4.10: Congratulation Menu

The paper-based user interface design has been converted into a digital format using the Unity engine. The Unity Asset Store was utilized to acquire environment assets, which offers a wide range of ready-to-use assets for game development. For the background UI, graphic resources from Freepik were sourced, a website providing free and customizable graphics. By leveraging these resources, the digital assets were seamlessly integrated into Unity, resulting in the creation of a visually appealing and engaging user interface for the game.

4.4 Game Art

The Game Art section explores the visual elements and aesthetics that shape the overall look and feel of the game.

4.4.1 Game World

The game world within the game is situated on a delightful farm. Through the utilization of the Unity engine and the resources available in the Unity Asset Store, the paper sketches were converted into a digital format. A diverse selection of farm-themed assets, including charming barns, fences, and adorable farm animals, were discovered and implemented. The integration of these assets contributed to the development of an immersive and visually captivating farm environment that offers both entertainment and educational value to children.

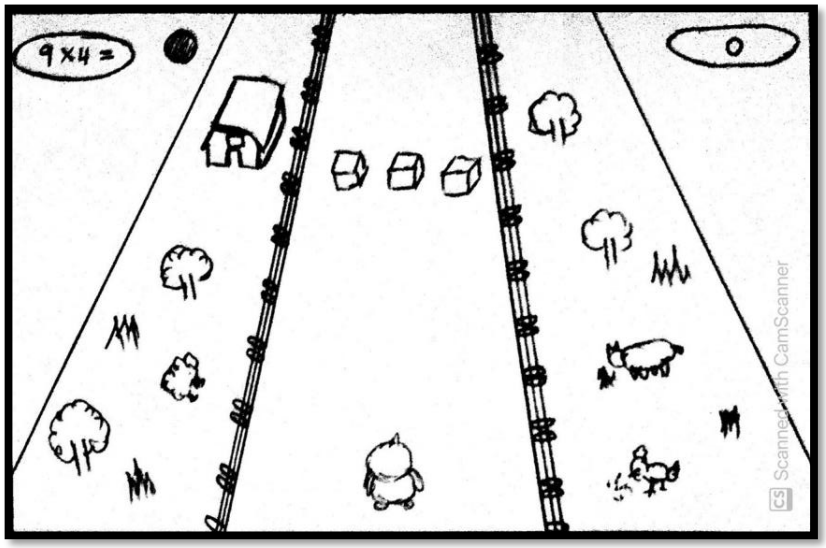


Figure 4.11: Sketch of In-Game Farm Environment

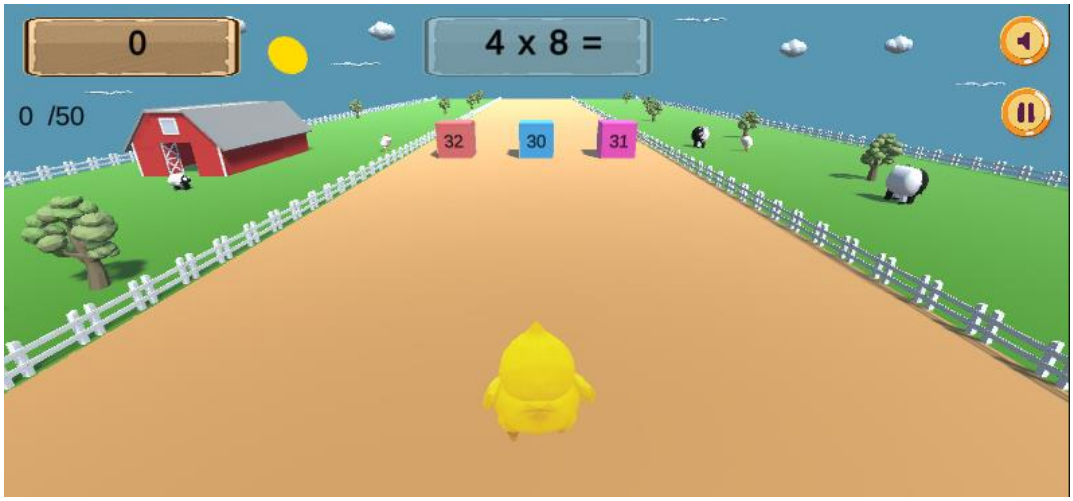
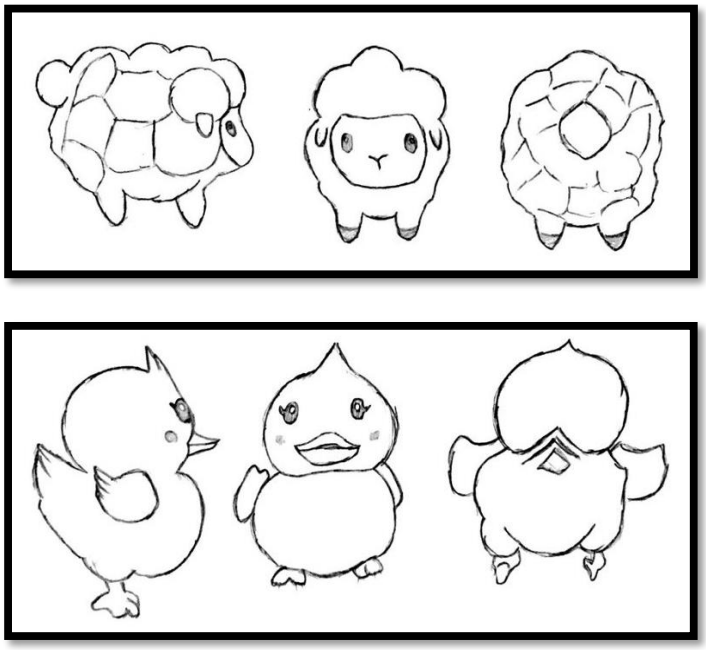


Figure 4.12: In-Game Farm Environment.

4.4.2 Character Design

The game features farm animals as characters, including cats, ducks, and sheep. These characters are depicted in 3D format and are designed to align with the farm theme. I created sketches of the characters from different angles, such as side views, front views, and back views, to showcase their unique features and bring them to life in the game.



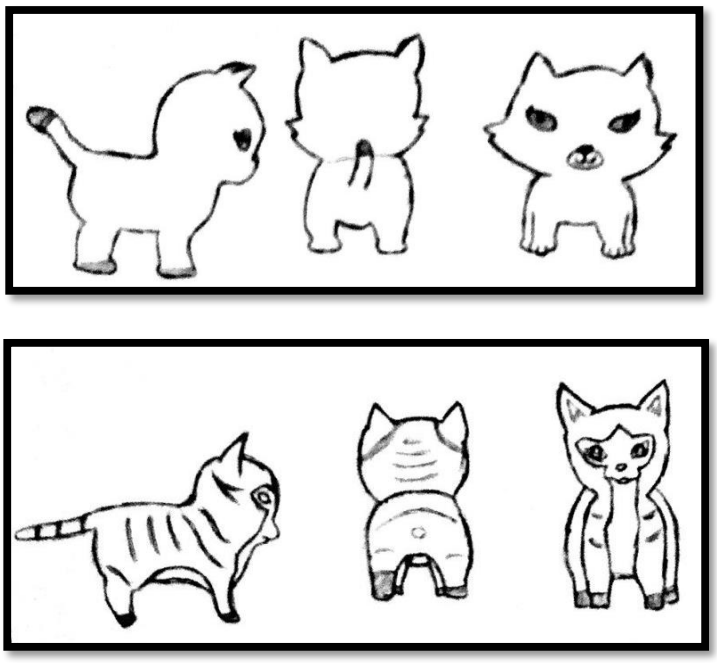


Figure 4.13: Sketches of the character in the game

- **Farm Animals**

To enhance the game experience, farm animal character models were sourced from the Unity Asset Store. These assets offered a wide variety of farm animals that seamlessly aligned with the game's theme. Player control of these charming animals is achieved through keyboard inputs. Each animal character serves a specific mathematical operation: sheep for addition, pink cat for subtraction, duck for multiplication, and orange cat for division. By incorporating these animal characters, the game not only gains a touch of realism in its environment but also captivates children with their adorable and appealing visuals.

Figure 4.14: Farm Animals (cats, duck, sheep)

4.4.3 Camera Model

The Camera Model section explores the different camera perspectives and techniques used in the game.

- **Third-Person Perspective**

    - This camera model positions the camera behind the player's character, allowing them to see the character and the environment they are running through. It provides a dynamic view and allows players to better make precise movements.

    - In math run game, the camera model is a third-person perspective from a slightly elevated angle, allowing players to see their animal character, the math questions, and the game world as they progress.

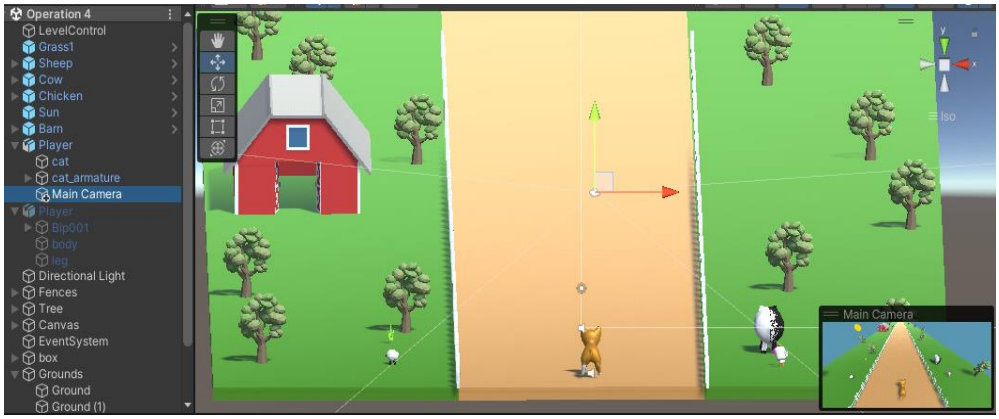


Figure 4.15: Main Camera of The Game.

4.4.4 Audio/Sound Effect

The Audio/Sound Effects section explores the use of sound elements to enhance the game experience.

- **Background Music**

In the game, background music is utilized in the main menu and during the four types of math operations within the game. The audio resources for background music were obtained from the Unity Asset Store, specifically the "Casual Game BGM #5"

file. The audio files used include "BGM_01" for the main menu, "BGM_02" for addition and subtraction operations, "BGM_03" for multiplication operations and division operations. All of the background music tracks are in WAV file format.

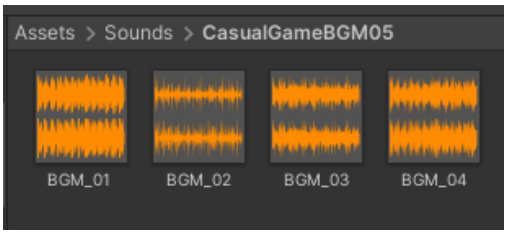


Figure 4.16: Background Music

- **Sound Effect**

The sound effects used in the game, obtained from YouTuber “Akhbar Project”, are in OGG file format. There are three types of sound effects employed: the correct answer sound, which plays when the player collides with the box containing the true answer; the wrong sound, which is played when the game over menu is displayed; and the star sound, which is used in the congratulation menu when the player wins the game.

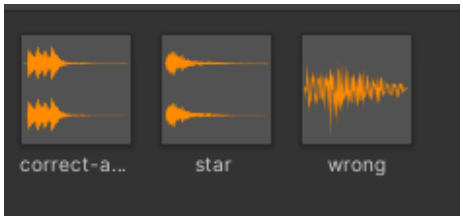


Figure 4.17: Sound Effect

4.5 Conclusion

In conclusion, this chapter provided an overview of the game design elements, including the gameplay, mechanics, progression, user interface, and audio resources, setting the foundation for the next chapter which will discuss the implementation of these elements.

CHAPTER 5: IMPLEMENTATION

5.1 Introduction

In this chapter, the focus shifts to the critical implementation phase of game development. The spotlight centers on the conversion and integration of game art, expanding upon the concepts detailed in 4.4 Game Art. The upcoming sections will delve into the technical processes needed to bring these creative elements to life within the game engine. These elements play a vital role in shaping the final product and ensuring a smooth development process, ultimately resulting in a high-quality, stable game.

5.2 Creation of Game Art

This section delves into the process of creating game art that elevates gameplay and enhances visual aesthetics. It explores various techniques for designing and producing graphics for concept art and asset creation. Additionally, it emphasizes the importance of sound design and its potential to enrich the player experience. Please refer to Table 5.1 for the creation of game art for Math Run, using a 3D pipeline, involves several key steps:

Table 5.1 Streamlined Art Pipeline in Math Run

Key Steps	Descriptions
Character Selection and Animation Integration	Animals character selection and animation integration involve acquiring pre-made characters from the Unity Asset Store, along with their respective animations. These animals' character is then integrated directly into the Unity project.

Custom 3D Object Creation	Custom 3D object creation is a part of the process where 3D objects, such as boxes used for answer options, are crafted within Unity to suit the specific requirements of the game.
Custom Animations for Objects	Custom animations for objects are created using the Unity Animator. These animations are designed for 3D objects like boxes and fences, adding interactive elements to the game.
Asset Fences	Asset fences, on the other hand, are obtained from the Unity Asset Store and seamlessly integrated into the game.
Testing and Integration	Testing and integration are critical phases where all elements, including characters, boxes, fences, and their animations, are rigorously examined to ensure smooth cohesiveness within the game environment.
Optimization	Optimization comes into play to fine-tune these assets, ensuring optimal performance across different devices.

5.2.1 Production of Graphics

This section explores the process of creating visual elements that bring a game to life, including character design and world-building.

5.2.1.1 3D Asset Models

In Math Run, 3D asset models are the digital creations that shape various objects, including animal characters and the game's environments. These models are crafted within Unity, giving life and dimension to the game. Some of the 3D models, such as animal characters, are acquired from the Unity Asset Store, streamlining the development process while maintaining visual quality and consistency.

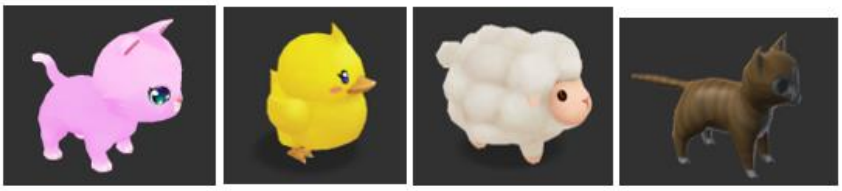


Figure 5.1 Animals Character Design Concept from Unity Asset Store

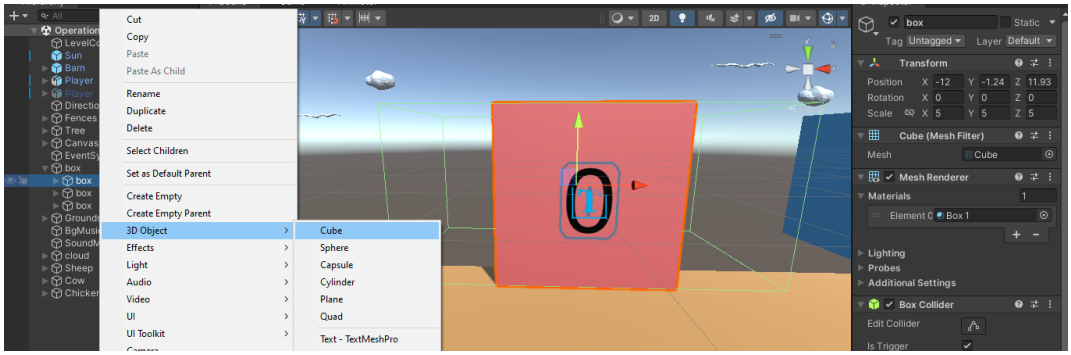


Figure 5.2 The Creation of 3D Boxes in Unity

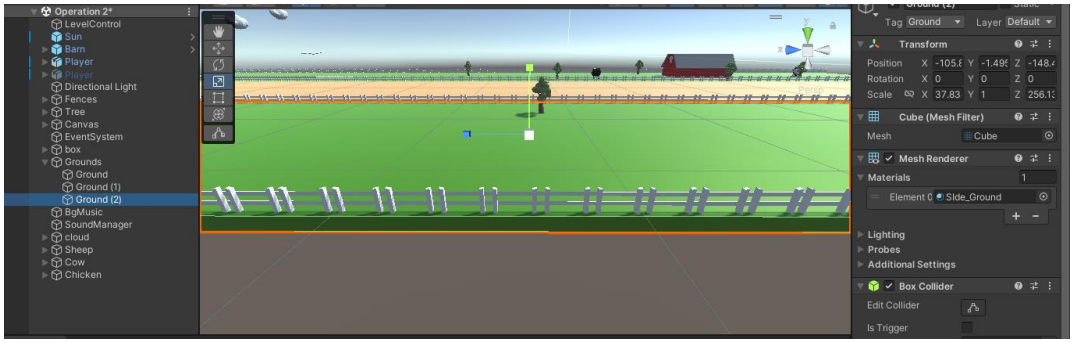


Figure 5.3 The Creation of 3D Grounds in Unity

5.2.1.2 User Interface (UI) Design

UI Design in Math Run focuses on making the game easy to use. It matches the farm theme with a background from Freepik Website and includes math symbols. Buttons come from the Unity Asset Store for a clean and functional interface.

Figure 5.4 Crafting the Main Menu (UI Design)

5.2.1.3 Game World

In Math Run, the Game World is a lively farm setting. It includes a barn, fences, and farm animals, all sourced from the Unity Asset Store to enrich the environment. The ground, fitting the farm theme, was constructed directly within Unity.

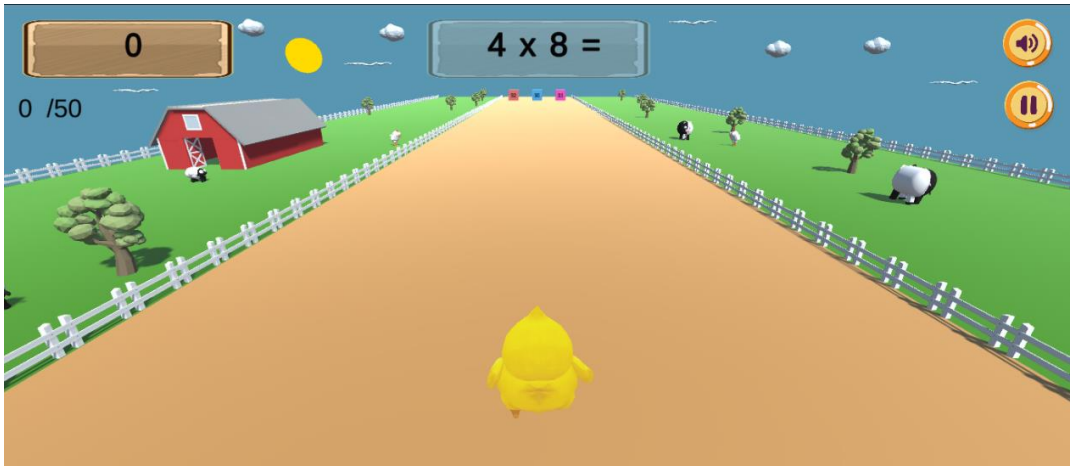


Figure 5.5 Farm Game World

5.2.2 Production of Audio

This section covers how captivating game audio is created, taking a closer look at the world of game soundscapes. For a detailed breakdown, please refer to Table 5.2 and 5.3.

Table 5.2 Audio Production and Integration

Step	Description
Audio Formats	OGG for in-game sound effects (interactions, game over, congratulations) and WAV for background music during gameplay.
Select Audio Assets	- **Unity Asset Store:** Visit the Unity Asset Store to find and acquire suitable audio assets in the chosen formats. Ensure they match the intended in-game use. - **Mixkit:** Explore Mixkit for royalty-free music and sound effects that enhance the Math Run experience.
Download Audio Assets	- For Unity Asset Store assets, follow provided instructions to download and import them into your Unity project. - For Mixkit, download selected audio tracks and save them to a location accessible from your Unity project.
Import into Unity	Import the downloaded audio assets into Unity by selecting "Assets" then "Import New Asset" and locating the downloaded files.
Audio Implementation	Attach audio assets to relevant game elements and scenes using Unity's Audio Source component. Implement simple code to trigger audio playback as needed, such as during player interactions, game over, or gameplay scenes.

Table 5.3 Audio Production List

Audio Format	Example of Usage
OGG	The sound effects that occur when the player interacts with both correct and incorrect answer boxes, as well as during the game over and congratulations scenes.
WAV	Background music played in a gameplay.

5.3 Integration of Game Component

The process of integrating art components with the technical aspects of game development varies based on the game engine used.

5.3.1 Operation Selection Integration

In Math Run, players choose mathematical operations (addition, subtraction, multiplication, division) to practice mental math. The figures below show the implementation of the design concept into Unity with C# scripting.

Figure 5.6 Implementation Game Design, Assets and Environment on Unity

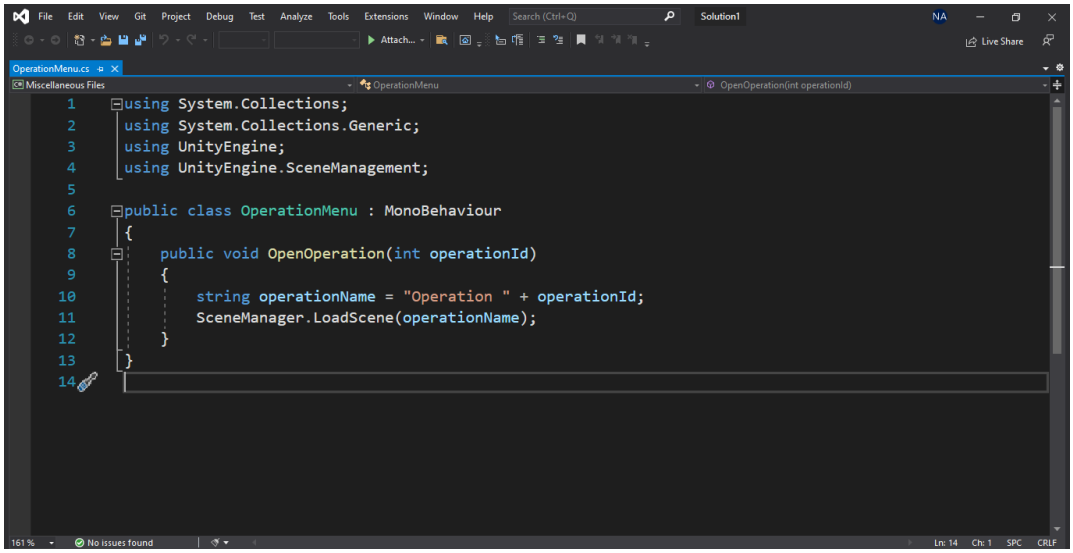


Figure 5.7 C# Script for Operation Menu

5.3.2 Score Integration

The score is a numerical representation of a player's performance in the game. It increases as the player answers math questions correctly. The score serves as a measure of progress and motivating players to improve their math skills and gameplay. The figures below show the implementation of the design concept into Unity with C# scripting.

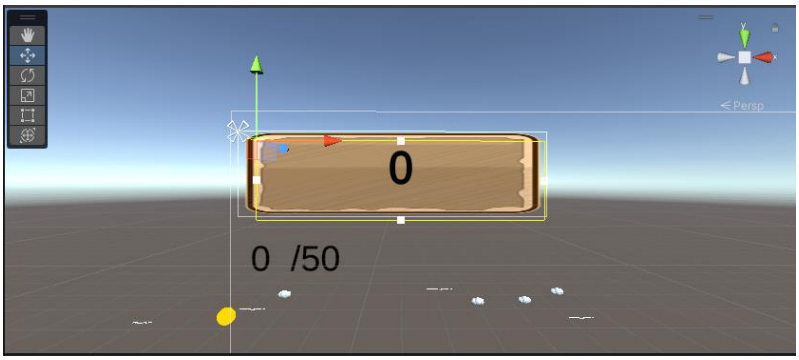


Figure 5.8 Implementing Score Assets

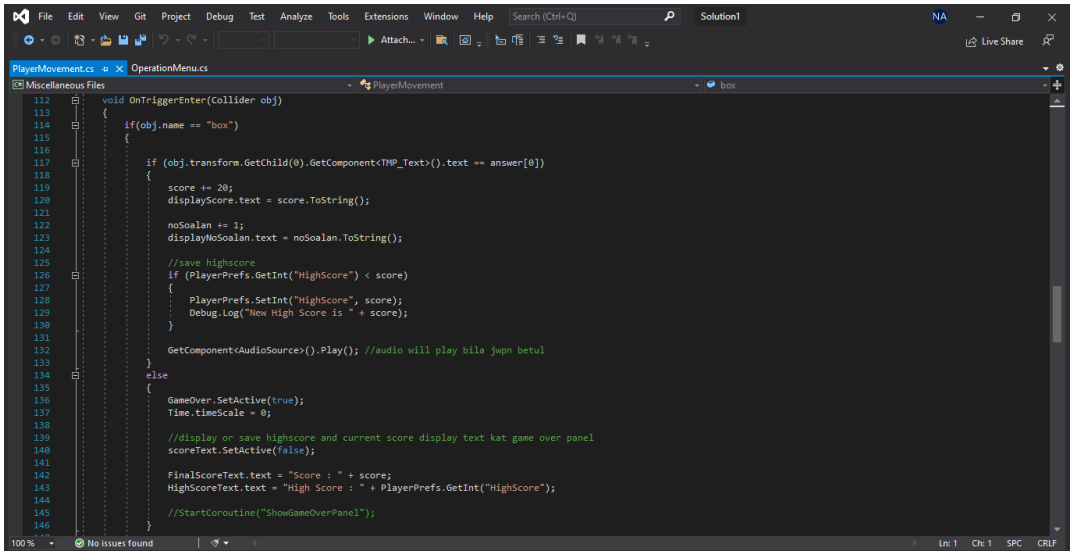


Figure 5.9 C# Script for Scoring Logic

5.3.3 Speed Integration

Speed is how quickly the answer boxes move. It gets faster as player's score rises, adding a challenge that tests their math skills. The figures below show the implementing speed increase in box animations in Unity with C# scripting.

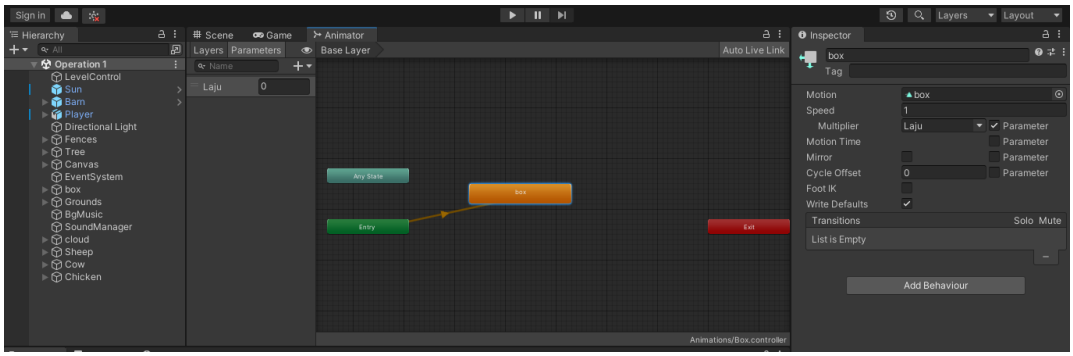


Figure 5.10 Implementing Speed Increase in Box Animations

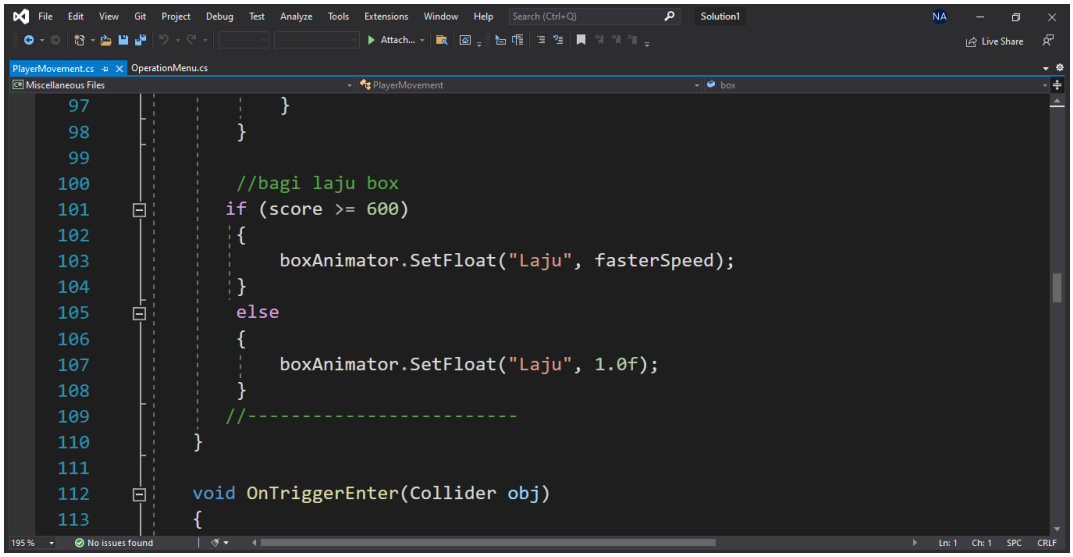


Figure 5.11 C# Script for Speed Enhancement

5.3.4 Character Movement Integration

Determines how the player's character interacts with and navigates the game world. The figures below show the implementing character movement in Unity with C# scripting.

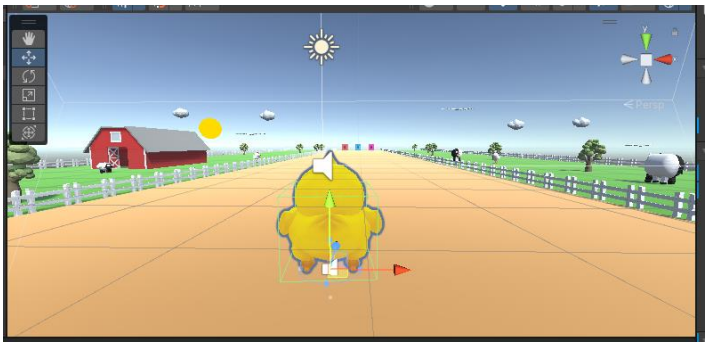


Figure 5.12 Implementing Character Movement in Unity

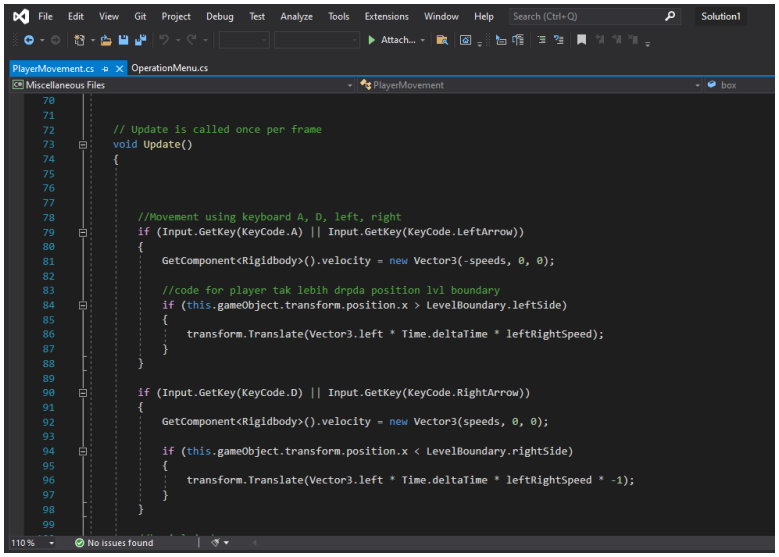


Figure 5.13 C# Script for Character Movement

5.3.5 Math Question Implementation

In Math Run, math questions are the core challenge. As players play, these questions test their math skills while they run, making learning fun and exciting. The figures below show the implementing math question in Unity with C# scripting.

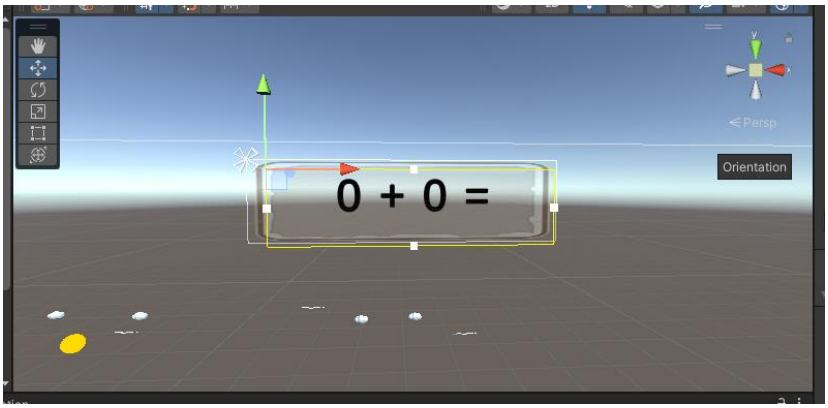


Figure 5.14 Implementing Math Question

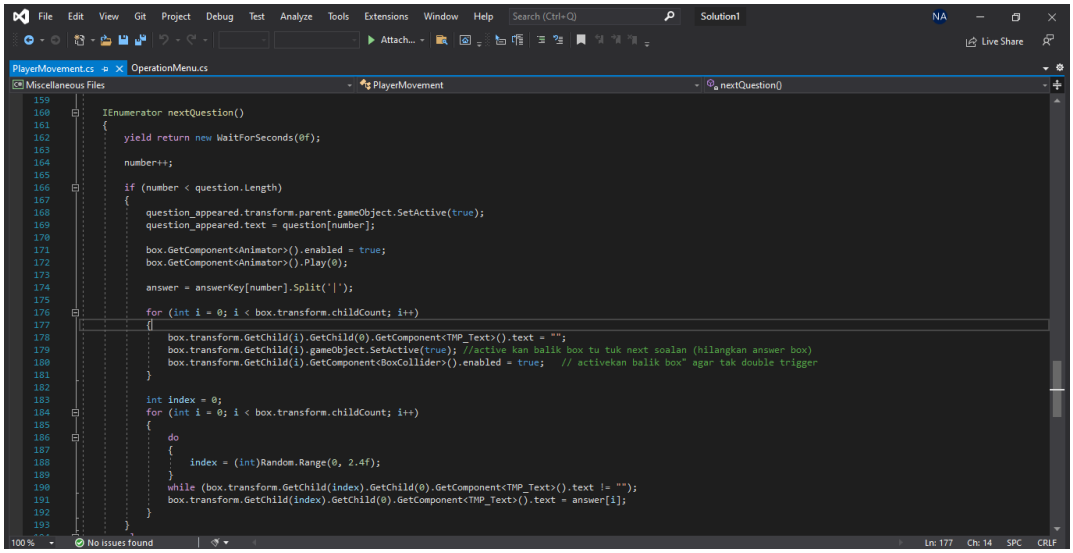


Figure 5.15 C# Script for Math Question and Answer

5.4 Game Configuration Management

Game Configuration Management is a critical aspect of game development that focuses on how the game is prepared, published, and maintained. This section explores how the game is prepared, delivered, and maintained for players' seamless experiences.

5.4.1 Configuration Setup

In this section, the process of publishing Math Run will be described, along with step-by-step guidance on setting up and installing the game. This includes any necessary configurations or installations. Rest assured, there are no special plugins or complex requirements involved, ensuring a straightforward experience for testers. Let's proceed with the key steps as shown in Table 5.4 and 5.5:

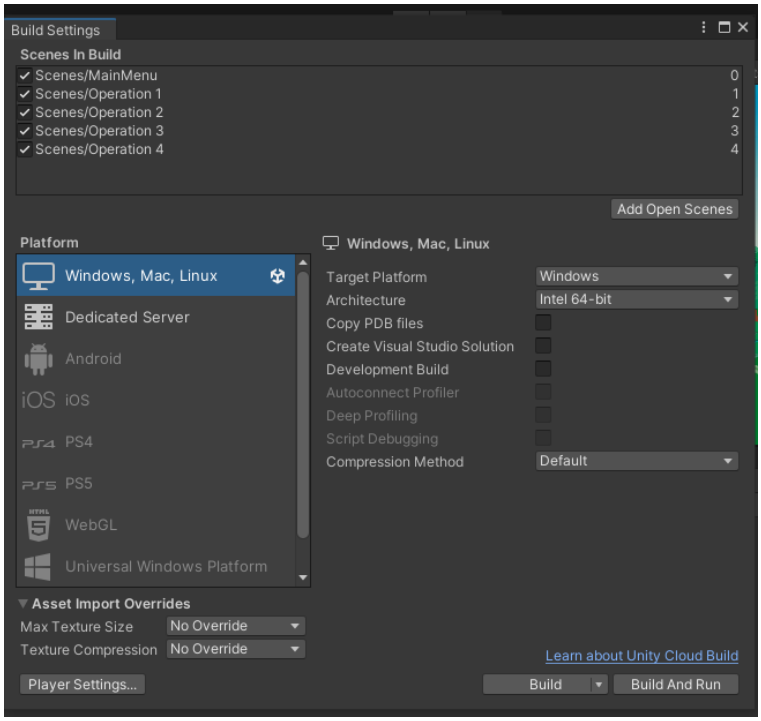


Figure 5.16 Build Setting for Game Publishing

Table 5.4 Game Publish On PC

Key Steps	**Descriptions**
Build the Game	To publish Math Run for PC, begin by building the game for the PC platform. In Unity, access the "File" menu and choose "Build Settings." Select "Windows, Mac & Linux" as the target platform.
Configuration Settings	Configure game settings like resolution and graphics quality to match the PC version.
Build Process	Click the "Build" button within the Build Settings menu. This action creates an executable file, often with a .exe extension, for the game.
Installation Package	Compile a compressed installation package with the game executable, vital assets, and any relevant instructions or documentation.
Distribution	Share the installation package with the testing audience through file-sharing services, email, or other appropriate distribution methods.

Table 5.5 Game Setup and Installation (for PC)

Key Steps	Descriptions
Download the Installation Package	Testers must download the installation package of Math Run provided by the developer.
Run the Installer	After downloading, testers locate the installation package file and execute the installer.
Follow Installation Instructions	Testers are guided through the installation process by the installer, including specifying the installation directory or creating desktop shortcuts.
Launch the Game	Upon successful installation, testers can initiate Math Run by clicking the desktop shortcut or launching the game from the installation directory.
Testing and Feedback	Testers interact with Math Run on their PC, offering feedback based on their experience and reporting encountered bugs, issues, or suggestions.

5.4.2 Version Control Procedure

Managing game versions entails implementing specific control measures at various development stages. During the Alpha stage, the focus is on core features and stability, with limited internal testing and version control. In the Beta stage, external testing broadens, and feedback is gathered to identify and fix bugs. Finally, the Release Candidate 1 stage involves finalizing all features, extensive testing, user acceptance testing, and polishing the user interface. Refer Table 5.6 for more detailed.

Table 5.6 Version Control Table

Version Stage	Description	Activities and Control
Alpha	Initial development stage, often unstable.	- Core gameplay mechanics and features are developed. - Internal testing to identify critical issues.
Beta	Expansion of features and content.	- External testing with a selected group of testers. - Collection of user feedback for improvements.
Release Candidate 1 (RC1)	Game is near completion and polished.	- Final testing to ensure stability. - Preparing for official release.

5.5 Implementation Status

The "Implementation Status" section in game documentation provides an overview of the current progress and status of the implementation phase in a game development project. It includes details about the work that has been accomplished, specifics about the implementation process, estimated time required to complete remaining tasks, and the overall status of the implementation effort. Table 5.7 furnishes descriptions for each component.

Table 5.7 Implementation Status List

Implementation	Description	Duration to Complete	Status
Game Prototype	Basic mechanic of the game	2 weeks	In Time
Game Asset	Designing 3D objects, and user interface	1 week	On Time
Game World	Environment Design and operation progression	2 weeks	On Time
Implementation of User Interface	Designing user interfaces in Unity Game Engine	1 week	On Time
Game Mechanics Implementation	Implementation of all functions, mechanics, gameplay rules	7 weeks	Delay (expected 6 weeks)
Game Polishing	Fixing bug, errors and making adjusment	2 weeks	In Time

5.6 Conclusion

This chapter covered the essential steps in the implementation phase, which includes creating game art, putting together different parts of the game, and managing its configuration. As the project moves forward, we will keep a close eye on how development is progressing and ensure that all the pieces fit together smoothly. In the next phase, the focus will be on testing and improving the game to get it ready for release.

CHAPTER 6: TESTING

6.1 Introduction

The testing phase in Math Run takes place after the completion of the implementation phase. In this chapter, the project involves planning and conducting tests to achieve the third objective which is evaluating the usability of the endless runner game as a tool to assist children in solving basic Mathematics.

6.2 Test Plan

Following the game's complete development and necessary adjustments, a series of tests are undertaken to evaluate its usability and functionality. To ensure the effectiveness of these tests and obtain optimal results, thorough preparation is diligently managed. The preparation including identifying the test users, test environment, test schedule, test implementation and test result and analysis.

6.2.1 Test Organization

In this chapter, the organizational structure of the testing process for Math Run is detailed. Key roles include the game developer responsible for unit testing, a math teacher serving as the subject matter expert for specialized testing, collaboration with other game developers and game experts for functionality testing, and, significantly, the target audience for usability testing.

These four distinct types of tests collectively contribute to ensuring the quality and effectiveness of Math Run. To provide a clear overview of roles and responsibilities, a summary is presented in Table 6.1.

Table 6.1 Test Organization

Type of Test	Person Involved	Responsibilities
Unit Testing	Game Developer (1 person)	Thoroughly test individual game components and logic.
Subject Matter Expert Testing	Math Teacher (1 person)	Assess the game's educational value and alignment.
Functionality Testing	Game Developers, Game Expert (3 persons)	Evaluate overall game performance and functionality.
Usability Testing	Children (10-12 years old) (35 persons)	Provide feedback on user-friendliness and experience.

6.2.2 Test Environment

The Test Environment encompasses the essential elements required to conduct tests for Math Run. It includes the location where testing is conducted, as well as the necessary hardware and software components.

The testing primarily occurs at an educational institution known as "Adab Youth Garage," situated in Butterworth, Penang. Additionally, some face-to-face testing sessions are held in a lecture room at FTMK, UTeM. Online testing is facilitated through downloadable executable files. During testing sessions, children are provided with guidance from the developer.

i. **Hardware Requirements**

Testers utilize personal computers (PCs) or laptops equipped with a mouse to play Math Run. These devices may either be provided by the institution for in-person testing or owned by individual testers for online evaluations.

ii. **Software Requirements**

For online individual testers, Math Run game files are made available for download. In the case of children's institutions, the developer preconfigures the game for immediate access by the children.

6.2.3 Test Schedule

A predefined schedule has been established to ensure the orderly execution of tests within the planned timeframe. Table 6.2 provides details of the schedules for each test phase.

Table 6.2 Test Schedule

Test	Start Date	End Date
Unit	20 August 2023	27 August 2023
Subject Matter Expert	28 August 2023	29 August 2023
Functionality	1 September 2023	5 September 2023
Usability (Lecturer Rooms)	7 September 2023	8 September 2023
Usability (Adab Youth Garage (AYG))	11 September 2023	12 September 2023
Usability (Online Platform)	13 September 2023	16 September 2023

6.3 Test Implementation

In the testing phase of Math Run, a comprehensive strategy was employed to ensure the game's quality and effectiveness across various dimensions. Four distinct types of testing were conducted, each serving a specific purpose and involving different groups of evaluators.

i. Unit Testing

This phase involved rigorous testing of individual components and mechanics within Math Run by the game developer. It aimed to ensure that each element, such as math questions, character movement, and game logic, functioned as intended. The developer thoroughly examined the game's code and mechanics to identify and resolve any issues or bugs.

ii. Subject Matter Expert Testing

Subject Matter Expert (SME) Testing was conducted by math teachers who evaluated Math Run's educational effectiveness. These experts assessed how well the game aligned with educational objectives and whether it effectively supported students in improving their math skills. Feedback from math teachers provided valuable insights into the game's suitability as an educational tool.

iii. Functionality Testing

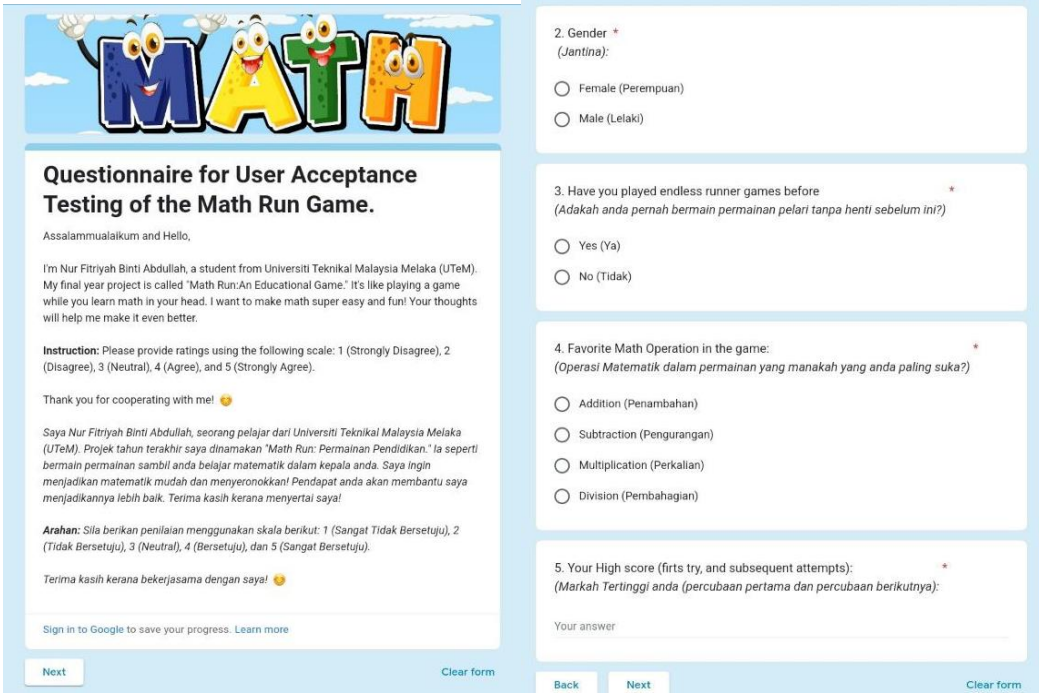
Functionality Testing was carried out by game experts and developers who examined the overall performance and functionality of Math Run. They assessed various aspects, including user interface, character movements, and gameplay mechanics. This comprehensive evaluation ensured that all features worked seamlessly and identified any areas for improvement.

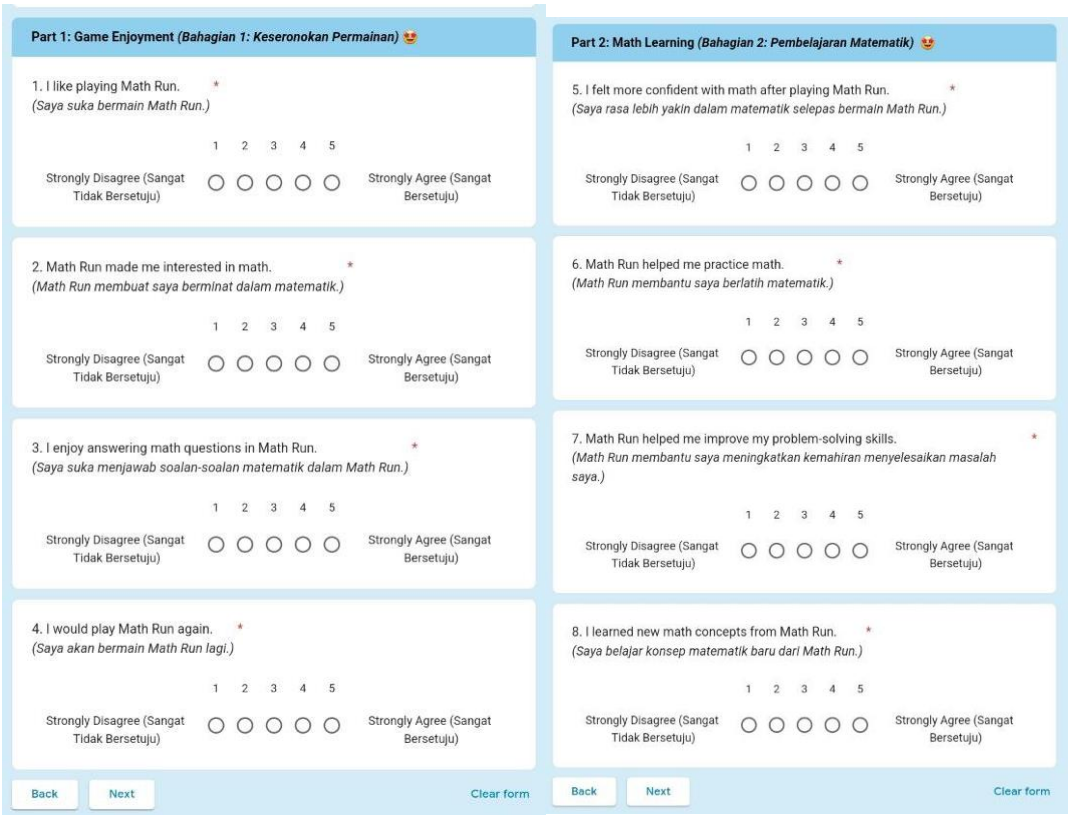
iv. Usability Testing

Usability Testing targeted the game's primary audience, children aged 10-12 years old, through a questionnaire distributed via Google Docs. This questionnaire collected valuable feedback on the game's user-friendliness, ease of navigation, and overall user experience. Testers provided insights into the game's intuitiveness, controls, and their overall enjoyment of Math Run.

6.3.1 Test Data

To achieve the third objective, which is evaluating Math Run's usability as a tool for helping children solve basic Mathematics, detailed data documentation was carried out. This involved the use of questionnaires distributed via Google Forms, specifically tailored for primary school students aged 7 to 12. These questionnaires aimed to gather insights into the students' gameplay experiences and educational interactions with Math Run. Below is an example of the questionnaire used for this purpose.


MATH
Questionnaire for User Acceptance Testing of the Math Run Game.
Assalammualaikum and Hello,
I'm Nur Fitriyah Binti Abdullah, a student from Universiti Teknikal Malaysia Melaka (UTeM). My final year project is called "Math Run:An Educational Game." It's like playing a game while you learn math in your head. I want to make math super easy and fun! Your thoughts will help me make it even better.
Instruction: Please provide ratings using the following scale: 1 (Strongly Disagree), 2 (Disagree), 3 (Neutral), 4 (Agree), and 5 (Strongly Agree).
Thank you for cooperating with me!
Saya Nur Fitriyah Binti Abdullah, seorang pelajar dari Universiti Teknikal Malaysia Melaka (UTeM). Projek tahun terakhir saya dinamakan "Math Run: Permainan Pendidikan." Ia seperti bermain permainan sambil anda belajar matematik dalam kepala anda. Saya ingin menjadikan matematik mudah dan menyeronokkan! Pendapat anda akan membantu saya menjadikannya lebih baik. Terima kasih kerana menyertai saya!
Arahan: Sila berikan penilaian menggunakan skala berikut: 1 (Sangat Tidak Bersetuju), 2 (Tidak Bersetuju), 3 (Neutral), 4 (Bersetuju), dan 5 (Sangat Bersetuju).
Terima kasih kerana bekerjasama dengan saya!
Sign in to Google to save your progress. Learn more
Next
Clear form
About you (Tentang anda)
1. Age *
(Umur):
10 years old (10 Tahun)
11 years old (11 Tahun)
12 years old (12 Tahun)
Other:
2. Gender *
(Jantina):
Female (Perempuan)
Male (Lelaki)
3. Have you played endless runner games before *
(Adakah anda pernah bermain permainan pelari tanpa henti sebelum ini?)
Yes (Ya)
No (Tidak)
4. Favorite Math Operation in the game: *
(Operasi Matematik dalam permainan yang manakah yang anda paling suka?)
Addition (Penambahan)
Subtraction (Pengurangan)
Multiplication (Perkalian)
Division (Pembahagian)
5. Your High score (firts try, and subsequent attempts): *
(Markah Tertinggi anda (percubaan pertama dan percubaan berikutnya):
Your answer
Back
Next
Clear form


Part 1: Game Enjoyment (Bahagian 1: Keseronokan Permainan)
1. I like playing Math Run. *
(Saya suka bermain Math Run.)
1 2 3 4 5
Strongly Disagree (Sangat Tidak Bersetuju)
Strongly Agree (Sangat Bersetuju)
2. Math Run made me interested in math. *
(Math Run membuat saya berminat dalam matematik.)
1 2 3 4 5
Strongly Disagree (Sangat Tidak Bersetuju)
Strongly Agree (Sangat Bersetuju)
3. I enjoy answering math questions in Math Run. *
(Saya suka menjawab soalan-soalan matematik dalam Math Run.)
1 2 3 4 5
Strongly Disagree (Sangat Tidak Bersetuju)
Strongly Agree (Sangat Bersetuju)
4. I would play Math Run again. *
(Saya akan bermain Math Run lagi.)
1 2 3 4 5
Strongly Disagree (Sangat Tidak Bersetuju)
Strongly Agree (Sangat Bersetuju)
Back
Next
Clear form
Part 2: Math Learning (Bahagian 2: Pembelajaran Matematik)
5. I felt more confident with math after playing Math Run. *
(Saya rasa lebih yakin dalam matematik selepas bermain Math Run.)
1 2 3 4 5
Strongly Disagree (Sangat Tidak Bersetuju)
Strongly Agree (Sangat Bersetuju)
6. Math Run helped me practice math. *
(Math Run membantu saya berlatih matematik.)
1 2 3 4 5
Strongly Disagree (Sangat Tidak Bersetuju)
Strongly Agree (Sangat Bersetuju)
7. Math Run helped me improve my problem-solving skills. *
(Math Run membantu saya meningkatkan kemahiran menyelesaikan masalah saya.)
1 2 3 4 5
Strongly Disagree (Sangat Tidak Bersetuju)
Strongly Agree (Sangat Bersetuju)
8. I learned new math concepts from Math Run. *
(Saya belajar konsep matematik baru dari Math Run.)
1 2 3 4 5
Strongly Disagree (Sangat Tidak Bersetuju)
Strongly Agree (Sangat Bersetuju)
Back
Next
Clear form

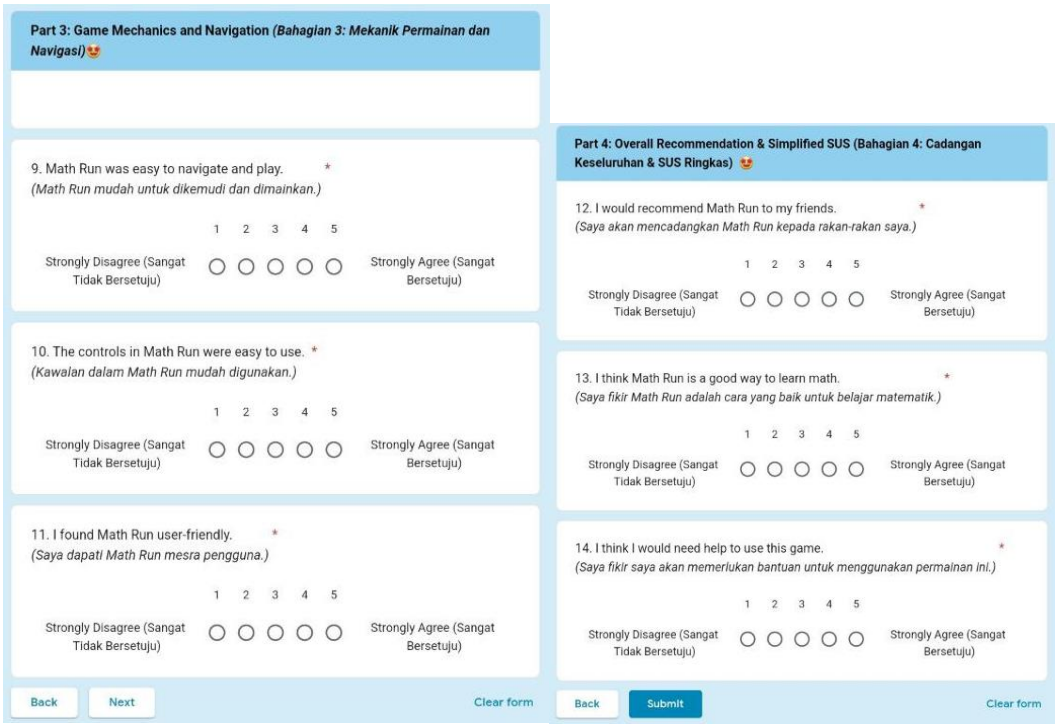


Figure 6.1 Questionnaire for User Acceptance Test

Both the functionality testing and subject matter expert testing phases utilize actual data collected from real users who engaged with Math Run. A comprehensive representation of this data can be found in Appendix C and Appendix D, providing insights and findings derived from these two crucial testing phases.

6.4 Test Results and Analysis

In this part, provides an in-depth examination of the testing outcomes and analyses for the following methodologies: Unit Testing, Subject Matter Expert Testing, Functionality Testing, and Usability Testing.

6.4.1 Unit Test Results and Analysis

During the unit testing phase, led by game developer (myself), Math Run's core components were thoroughly examined for accuracy and functionality. This included testing math question generation, character movements, game logic, and user interface elements. The results were highly positive, with all components operating correctly and without critical errors. This testing phase provided essential insights, ensuring the game's foundation was solid for subsequent testing, contributing to a stable and engaging learning experience for young users.

6.4.2 Subject Matter Expert Test Results and Analysis

Math Run was subjected to thorough scrutiny by a mathematics teacher during the Subject Matter Expert (SME) testing phase, with a focus on its educational value and alignment with basic math learning objectives.

The results from the questionnaire, as filled out by the math teacher, demonstrated that Math Run effectively aligns with essential math educational goals and makes learning math an enjoyable experience for students aged 10-12 years old. The expert also acknowledged the game's endless runner format as a suitable method for learning math, highlighting its potential to engage students while making math fun.

Furthermore, the SME affirmed that Math Run successfully encourages critical thinking and decision-making skills in students, promoting problem-solving abilities. The math questions within the game were found to be appropriate in terms of complexity for the specified age group.

The teacher's feedback also emphasized the game's potential to enhance problem-solving skills among students. Math Run's user-friendly interface, intuitive controls, and overall engagement factor were lauded as positive attributes.

In summary, the Subject Matter Expert testing yielded favorable results, indicating that Math Run effectively supports math education for children aged 10-12 years old, aligns with educational goals, and promotes an enjoyable learning experience.

6.4.3 Functionality Test Results and Analysis

The functionality test for Math Run was conducted to comprehensively evaluate the various components and functions of the game using a questionnaire, as shown in Appendix D. This test involved one game expert, a lecturer, and two game developers who used a questionnaire to assess the game's performance. The results of this evaluation demonstrate that Math Run performed exceptionally well in terms of functionality.

The key components, including buttons such as Play, How to Play, Quit, Sound, Addition, Subtraction, Multiplication, Division, Player Control, Box Collider for both correct and wrong answers, Pause, Continue, Main Menu, and Restart, were all subjected to rigorous testing. The outcomes consistently indicated that these components functioned precisely as intended.

For instance, the Play Button correctly displayed the operation selection, while the How to Play Button provided clear and accurate game instructions. The Quit Button effectively closed the game console, and the Sound Button seamlessly toggled the in-game music on and off.

Furthermore, Math Run flawlessly directed players to the respective math operation games upon clicking the Addition, Subtraction, Multiplication, or Division Buttons. Player control, using either the arrow keys or A and D keys, exhibited responsiveness and ease of use.

The game's core mechanics, such as the Box Collider, accurately awarded points for hitting the correct answer and transitioned to the game over scene when a wrong answer was selected. The Pause, Continue, Main Menu, and Restart Buttons all performed their functions without any issues.

In conclusion, Math Run's functionality test results reflect the game's robust and reliable performance. Its components and functions operate seamlessly, ensuring a smooth and enjoyable gaming experience for its target audience of young learners aged 10-12 years old.

6.4.4 Usability Test Results and Analysis

During Math Run's evaluation phase, a questionnaire survey was conducted using Google Forms and distributed to 35 game testers, primarily comprising primary school students aged 7 to 12. The gathered data is depicted in labeled graphs, unveiling insights into the game's performance and user experience. This feedback is instrumental in optimizing Math Run for improved usability and educational efficacy. Subsequently, the categorized User Acceptance data is presented below.

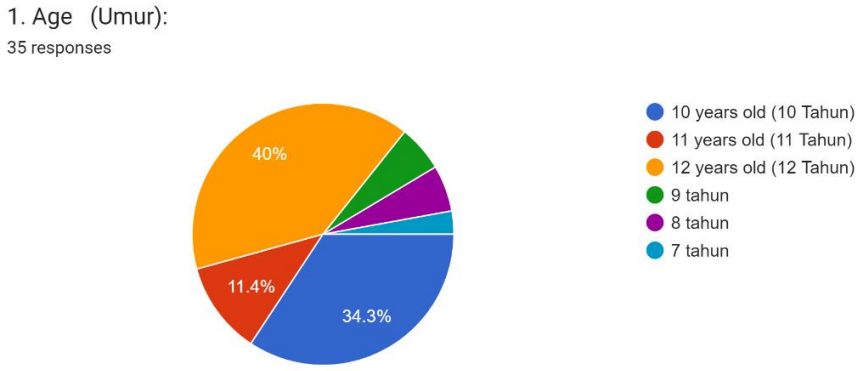


Figure 6.2 Data for Respondents' Age

From Figure 6.2, the data illustrates the distribution of respondents' ages among the 35 participants. Among these respondents, 14 (40%) are 12 years old, indicating the largest age group. Additionally, 12 (34.4%) respondents are 10 years old, while 4 (11.4%) fall into the 11-year-old category. Furthermore, there are 2 (5.7%) respondents each in the 9-year-old and 8-year-old age groups. Finally, 1 (2.9%) respondent is 7 years old. This data provides valuable insights into the age distribution of the participants involved in the evaluation of Math Run.

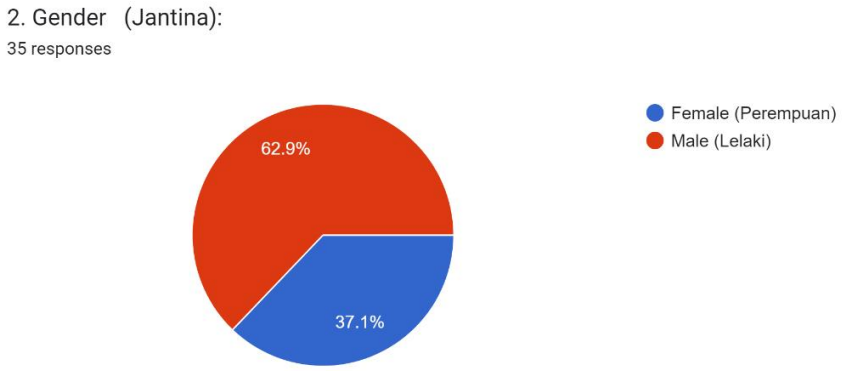


Figure 6.3 Data for Respondents' Gender

In Figure 6.3, the data presents the gender distribution among the 35 respondents who participated in the evaluation. Of these respondents, 22 (62.9%) are male, while 13 (37.1%) are female. This data sheds light on the gender representation within the participant pool, providing context for the evaluation of Math Run.

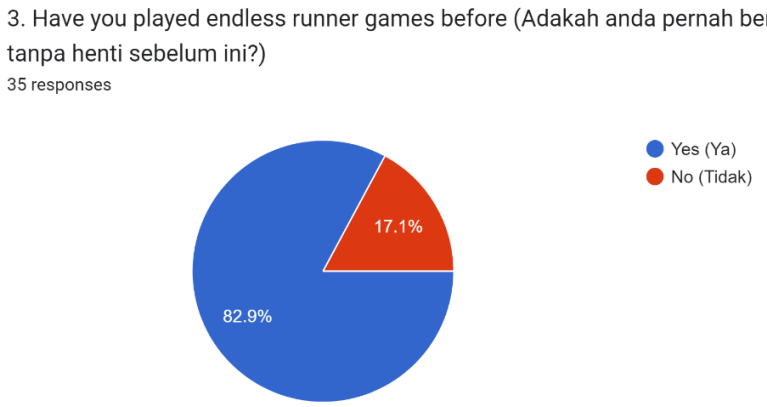


Figure 6.4 Data for Player Experience with Endless Runner Games

In Figure 6.4, the data reflects the players' prior experience with endless runner games among the 35 respondents. A significant majority, 29 respondents (82.9%), indicated that they have experience playing endless runner games. Conversely, 6 respondents (17.1%) reported having no prior experience with this genre of games. This data provides insights into the participants' familiarity with the game genre, which is relevant to understanding their experience with Math Run.

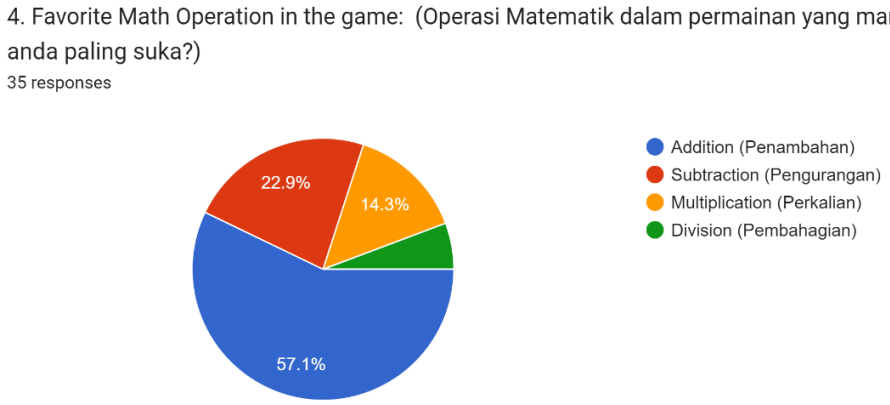


Figure 6.5 Data for Favorite Math Operation

In Figure 6.5, the data reveals the favored math operations among the 35 respondents who engaged in the Math Run evaluation. Among these participants, a majority of 20 individuals (57.1%) showed a preference for addition as their favorite math operation. Subtraction was favored by 8 respondents (22.9%), while 5 participants (14.3%) indicated a preference for multiplication. Division garnered the

least preference, with 2 respondents (5.7%) favoring it. This data offers valuable insights into the participants' preferred math operations, providing potential guidance for tailoring Math Run's educational content to meet individual preferences and learning needs.

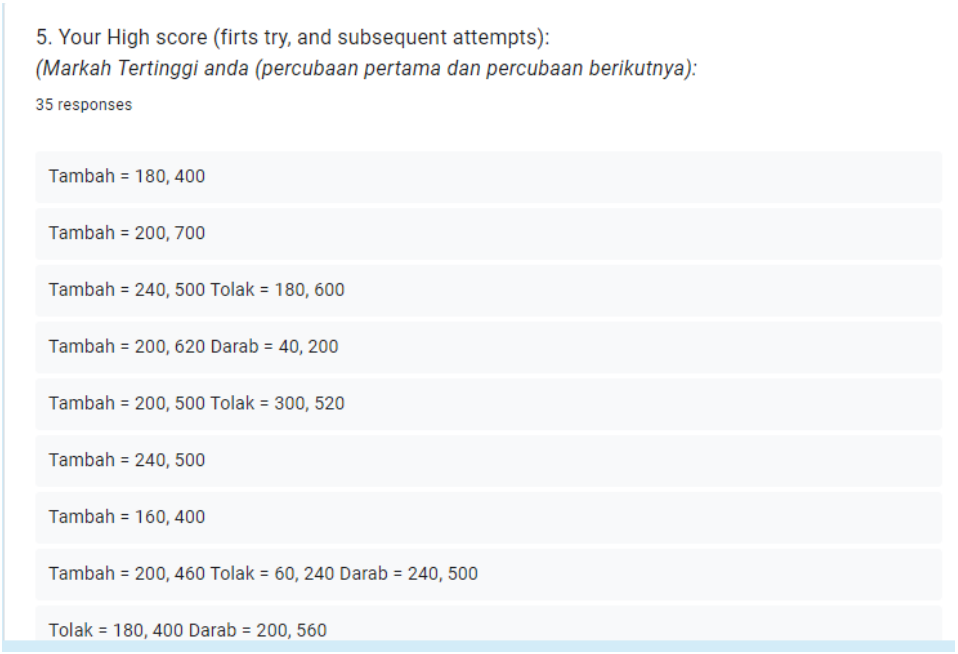


Figure 6.6 High Scores for First and Subsequent Attempts

In figure 6.6 shows the highest scores obtained from 35 respondents based on the operation they chose to solve mathematical problems. These scores were recorded during the 1st attempt and subsequent attempts to observe the differences and improvements achieved. The Test Results and Analysis are presented in the table below.

Table 6.3 Data for High Score

Age	Addition		Subtraction		Multiplication		Division	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
10	180	400	-	-	-	-	-	-
10	200	700	-	-	-	-	-	-
10	240	500	180	600	-	-	-	-
10	200	620	-	-	40	200	-	-
10	200	500	300	520	-	-	-	-
10	240	500	-	-	-	-	-	-
10	160	400	-	-	-	-	-	-
10	200	460	60	240	240	500	-	-
10	-	-	180	400	200	560	-	-
10	220	520	-	-	-	-	60	240
10	300	640	-	-	-	-	-	-
10	-	-	-	-	80	300	-	-
11	-	-	220	700	-	-	-	-
11	320	720	-	-	-	-	-	-
11	-	-	200	540	-	-	--	-
11	500	760	-	-	-	--	-	-
8	220	300	-	-	-	-	-	-
7	80	200	-	-	-	-	-	-
8	200	340	220	380	20	80	20	60
9	280	400	180	240	-	-	-	-
9	440	500	-	-	80	160	-	-
12	400	780	-	-	-	-	-	-
12	440	800	160	600	80	220	40	180
12	400	740	320	480	80	120	20	100
12	260	800	400	620	420	600	80	240
12	240	720	400	600	100	260	40	180
12	300	820	420	540	160	260	60	400
12	320	680	240	580	100	220	80	120

12	300	640	200	440	100	220	20	140
12	460	720	400	600	120	260	40	180
12	320	700	400	620	200	400	80	200
12	300	680	260	420	180	480	40	120
12	420	600	400	580	120	260	100	200
12	320	780	300	520	240	380	200	420
12	420	800	280	500	100	400	80	300

Based on Table 6.3, the results indicate a difference in scores between the first attempt and subsequent attempts, with an increase in scores for all subsequent attempts, as highlighted in blue. This demonstrates the achievement of the third objective, which is to evaluate the usability of the endless runner game in assisting children to solve basic Mathematics. The game has enhanced their problem-solving skills using mental math.

Furthermore, the provision of operation selection is highly suitable for them because several children aged 7, 8, 9, and 10 years old will choose their preferred operations, as shown in the table. Meanwhile, for children aged 12 and some who are 8 years old, they have an inclination to experiment to improve their problem-solving abilities. Therefore, operation selection is highly appropriate as they can choose according to their preferences.

Next, data collected based on four categories based on user acceptance towards Math Run. The score 1 to 5 is identified as:

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

i. Game Enjoyment

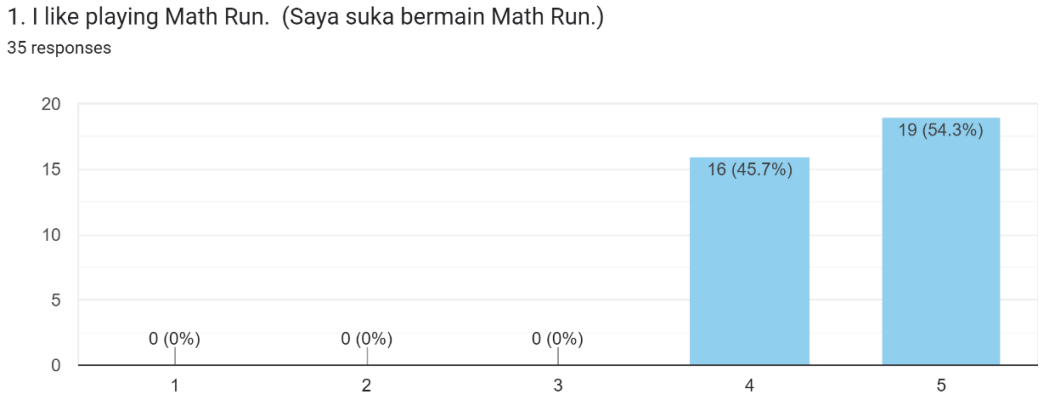


Figure 6.7 Data for Player Sentiment Towards Math Run

In Figure 6.7, based on responses from the 35 participants, the data indicates that 16 respondents (45.7%) rated Math Run with a score of 4 (Agree), while 19 respondents (54.3%) provided the highest rating of 5 (Strongly Agree). This data reveals the positive sentiment of the majority of players towards Math Run.

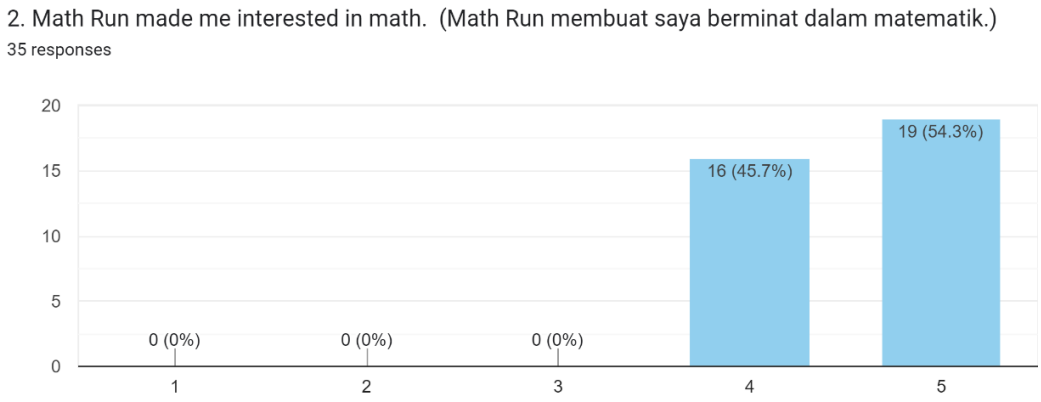


Figure 6.8 Data for Math Interest Impact

In Figure 6.8, the data reveals the influence of Math Run on participants' interest in mathematics, assessed using a scale from 1 to 5, where 1 represents "Strongly Disagree" and 5 signifies "Strongly Agree." Among the 35 respondents, 16 individuals (45.7%) expressed their agreement with a score of 4, while a majority of 19 participants (54.3%) strongly agreed, giving a score of 5. This data underscores the substantial impact of Math Run in enhancing the interest of players in mathematics.

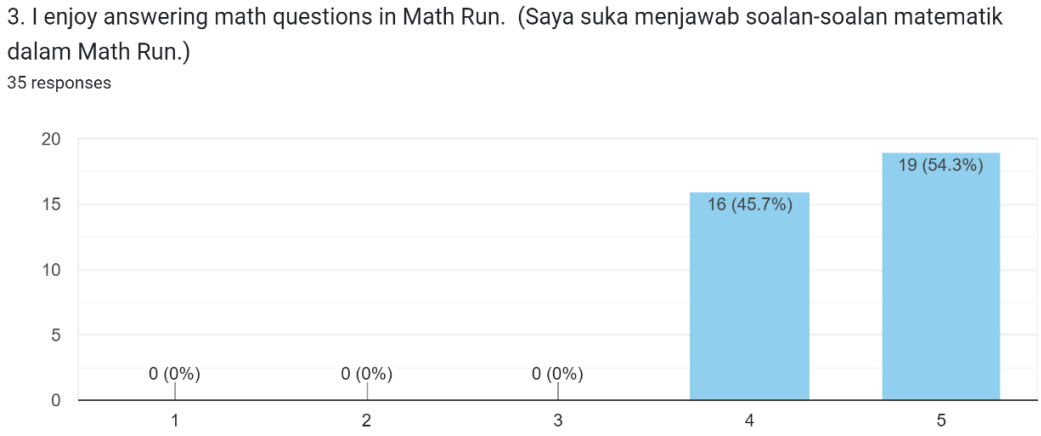


Figure 6.9 Data for Math Question Enjoyment

In Figure 6.9, the data represents the level of enjoyment experienced by participants while answering math questions in Math Run. The data is categorized on a scale of 1 to 5, where 1 signifies "Strongly Disagree" and 5 indicates "Strongly Agree." Among the 35 respondents, 16 individuals (45.7%) expressed their enjoyment

with a score of 4, and a majority of 19 participants (54.3%) reported a high level of enjoyment, giving a score of 5. This data underscores the positive experience of players when engaging with math questions in Math Run.

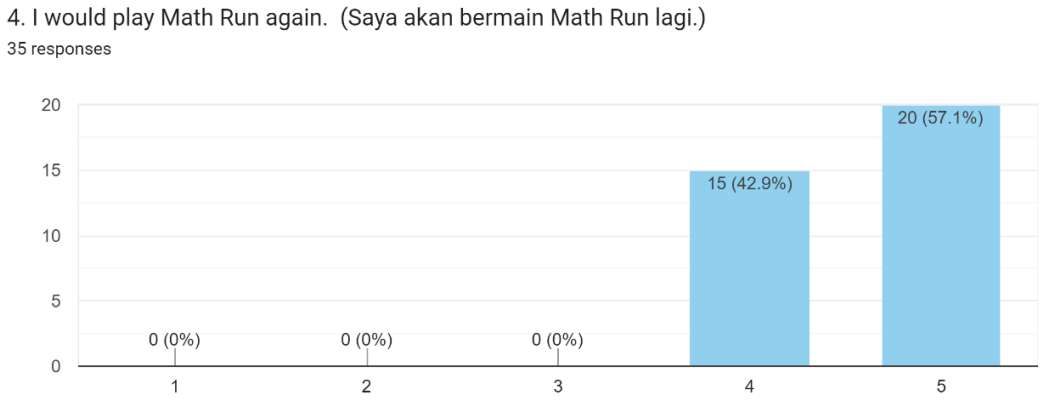


Figure 6.10 Data for Replay Intent for Math Run

In Figure 6.10, the data represents the players' intent to replay Math Run, evaluated on a scale from 1 to 5. Among the 35 respondents, 15 individuals (42.9%) expressed their intent to replay the game, giving it a score of 4. A significant majority of 20 participants (57.1%) indicated a strong intention to replay, with a score of 5. This data suggests that Math Run successfully encourages players to revisit the game for another round of gameplay.

ii. Math Learning

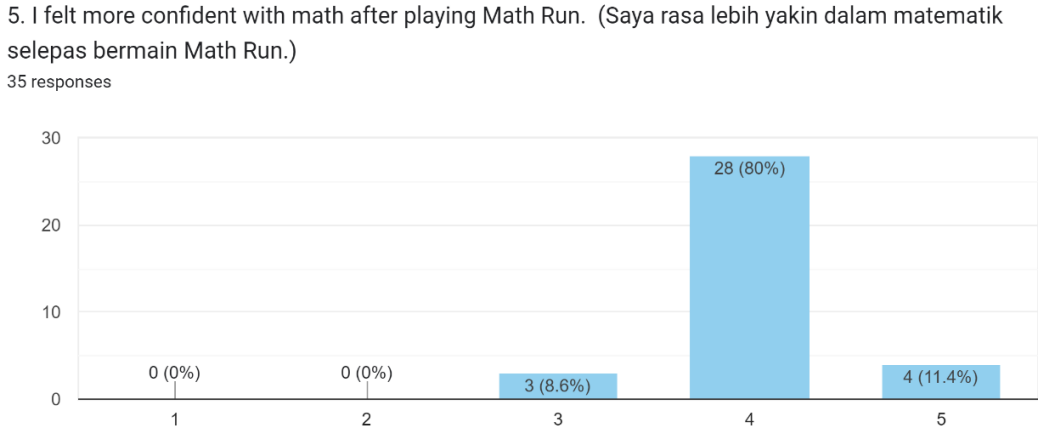


Figure 6.11 Data for Math Confidence Boost

In Figure 6.11, the data illustrates the boost in math confidence experienced by participants while playing Math Run. The data is categorized using a scale from 1 to 5, where 3 represents "Neutral," 4 signifies "Agree," and 5 indicates "Strongly Agree." Among the 35 respondents, 3 individuals (8.6%) reported a neutral boost (score 3), while a substantial majority of 28 participants (80%) expressed a significant confidence boost (score 4). Additionally, 4 respondents (11.4%) strongly agreed that Math Run enhanced their math confidence (score 5). This data underscores the game's positive impact on boosting players' confidence in mathematics.

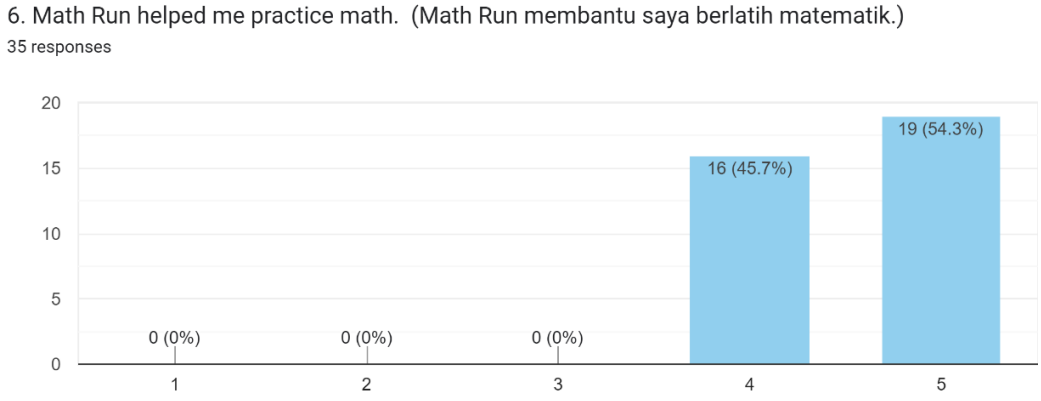


Figure 6.12 Data for Math Practice with Math Run

In Figure 6.12, among the 35 respondents, the data shows that 45.7% (16 participants) indicated a high level of math practice with Math Run, rating it as 4 (Agree), while 54.3% (19 participants) strongly engaged in math practice with a score of 5 (Strongly Agree). This data underscores the game's effectiveness as a tool for practicing math skills.

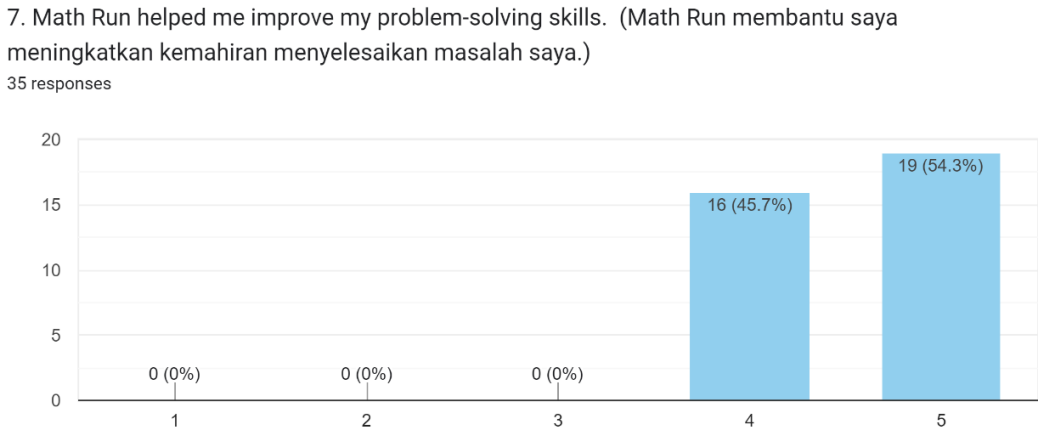


Figure 6.13 Data for Problem-Solving Enhancement

In Figure 6.13, among the 35 respondents, the data shows that 45.7% (16 participants) experienced a significant enhancement in problem-solving skills with Math Run, rating it as 4 (Agree), while 54.3% (19 participants) reported a strong enhancement with a score of 5 (Strongly Agree). This data emphasizes the game's effectiveness in improving players' problem-solving abilities.

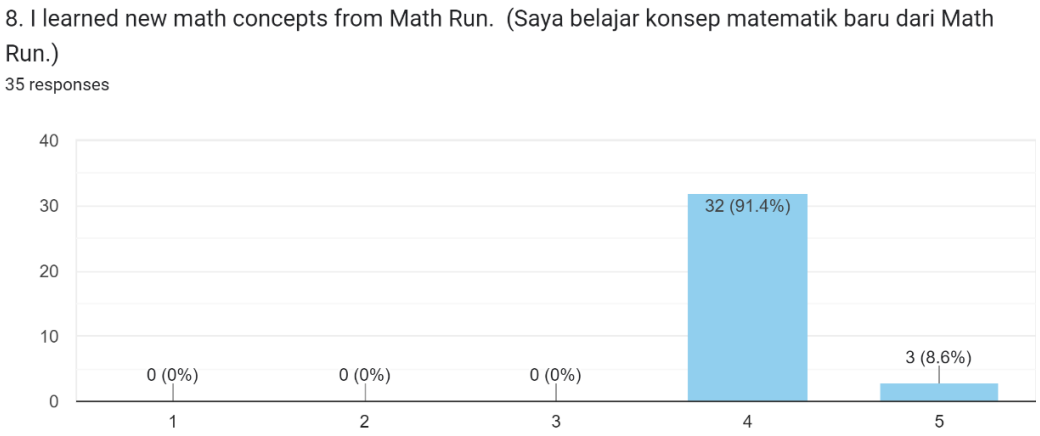


Figure 6.14 Data for Learning New Math Concepts

In Figure 6.14, among the 35 respondents, the data shows that 91.4% (32 participants) reported learning new math concepts with Math Run, rating it as 4 (Agree), while 8.6% (3 participants) indicated a strong learning experience with a score of 5 (Strongly Agree). This data highlights the game's effectiveness in introducing players to new mathematical concepts.

iii. Game Mechanics and Navigation

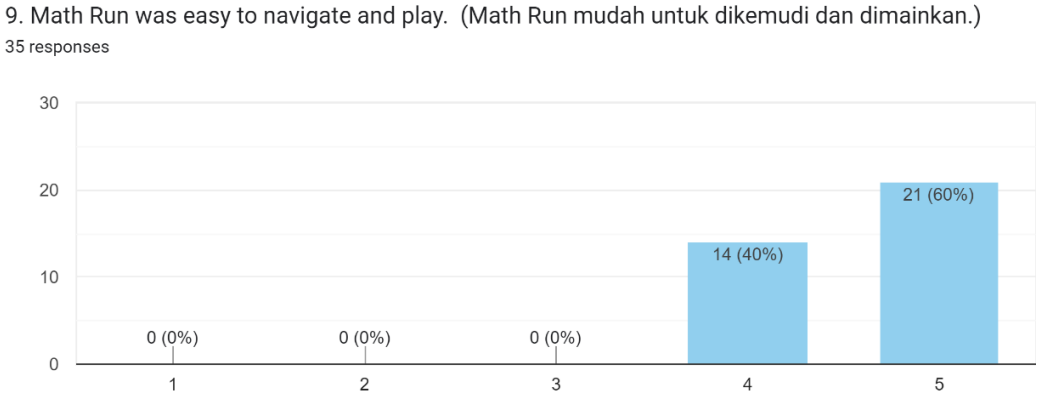


Figure 6.15 Data for Ease of Navigation and Gameplay

In Figure 6.15, among the 35 respondents, the data shows that 40% (14 participants) found Math Run easy to navigate and play, rating it as 4 (Agree), while

60% (21 participants) reported a high level of ease with a score of 5 (Strongly Agree). This data underscores the game's user-friendly design and gameplay.

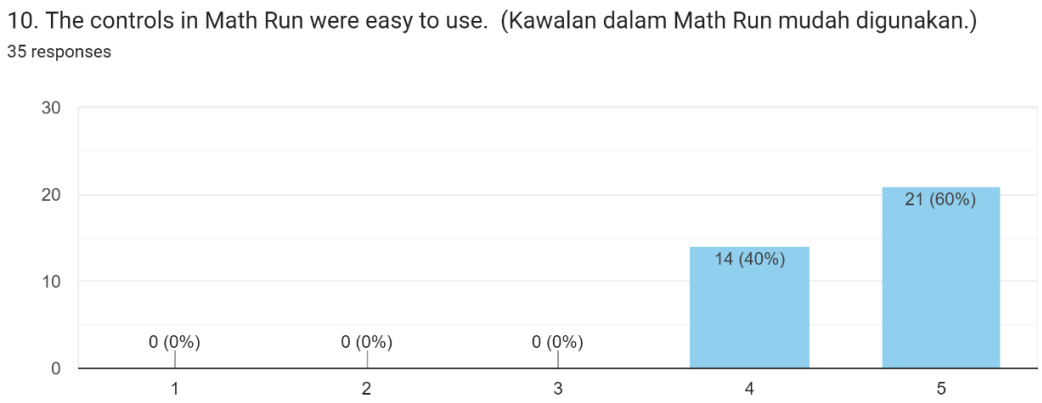


Figure 6.16 Data for Math Run Control Usability

In Figure 6.16, among the 35 respondents, the data shows that 40% (14 participants) found the controls in Math Run easy to use, rating them as 4 (Agree), while 60% (21 participants) reported a high level of usability with a score of 5 (Strongly Agree). This data highlights the game's effective control design, enhancing the overall user experience.

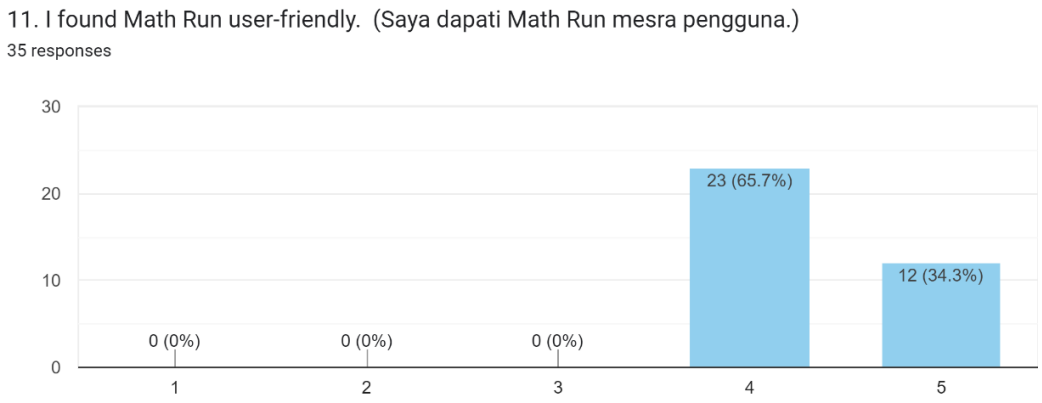


Figure 6.17 Data for Math Run User-Friendliness

In Figure 6.17, among the 35 respondents, the data shows that 65.7% (23 participants) found Math Run to be user-friendly, rating it as 4 (Agree), while 34.3%

(12 participants) indicated a high level of user-friendliness with a score of 5 (Strongly Agree). This data emphasizes the game's overall user-friendly design and interface.

iv. Overall Recommendation & Simplified SUS (System Usability Scale)

Figure 6.18 Data for Recommending Math Run

In Figure 6.18, among the 35 respondents, the data shows that 80% (28 participants) would recommend Math Run, rating it as 4 (Agree), while 20% (7 participants) expressed a strong willingness to recommend with a score of 5 (Strongly Agree). This data underscores the game's potential to receive positive referrals from players.

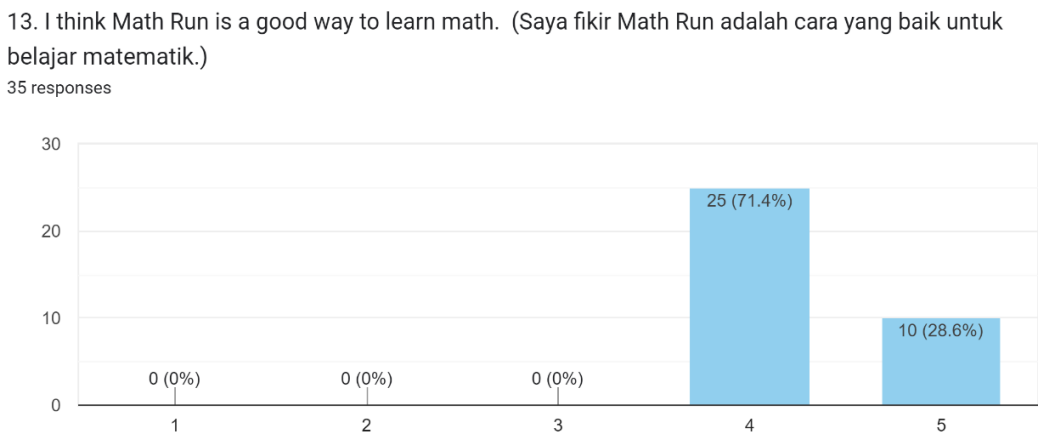


Figure 6.19 Data for Math Run as a Learning Tool

In Figure 6.19, among the 35 respondents, the data shows that 71.4% (25 participants) believed Math Run is a good way to learn math, rating it as 4 (Agree), while 28.6% (10 participants) strongly endorsed it as an effective learning tool with a score of 5 (Strongly Agree). This data underscores Math Run's potential as a valuable educational resource.

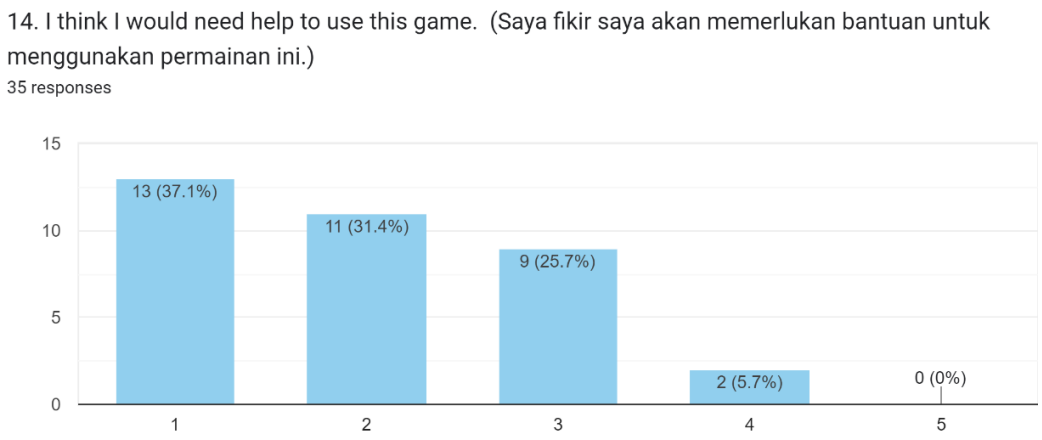


Figure 6.20 Data for Assistance with Math Run

In Figure 6.20, the data illustrates respondents' diverse perspectives regarding the need for assistance when using Math Run. Specifically, 37.1% (13 participants) strongly disagreed, indicating that they felt confident about using the game independently (score 1). Meanwhile, 31.4% (11 participants) disagreed but still had some reservations (score 2). Another 25.7% (9 participants) remained neutral, neither strongly inclined towards independence nor dependence (score 3). Only 5.7% (2 participants) agreed that they would need assistance when using the game (score 4). This data portrays a spectrum of opinions about the game's user-friendliness and ease of use.

6.5 Conclusion

In this chapter, thorough testing was conducted, and insights were gathered through a user questionnaire. The data revealed player sentiments, preferences, and the educational impact of Math Run. These findings are instrumental in refining Math Run further. The upcoming chapter will delve into an analysis of Math Run's strengths and

weaknesses, focusing on opportunities for improvement. The contributions of Math Run as an educational tool will also be highlighted.

CHAPTER 7: CONCLUSION

7.1 Observation of Strength and Weaknesses

In this section, the analysis focuses on observing the strengths and weaknesses of Math Run. Through comprehensive testing and evaluation, valuable insights are gathered for refining and optimizing Math Run, with the ultimate goal of enhancing the game's gaming experience and educational effectiveness.

7.1.1 Strengths

The strengths of Math Run are notable aspects that enhance both the gaming experience and its educational value. Here are three key strengths that contribute to Math Run's effectiveness and appeal.

i. Enhanced Math Learning

Math Run effectively enhances math learning through its engaging gameplay. It encourages players to practice math skills in an enjoyable way, making it an effective educational tool. Players can hone their math skills while having fun, which is a significant strength for educational games.

ii. Improved Decision-Making Skills

The game's mechanics, which require quick thinking and decision-making while answering math questions, help players improve their decision-making skills. This strength is particularly valuable as it aligns with broader educational goals beyond math, promoting critical thinking and problem-solving abilities.

iii. Intuitive and Clear UI Design

Math Run's strength lies in its user-friendly interface. The game offers a straightforward and intuitive design, ensuring that players, particularly children aged 10-12 years old, can easily navigate through menus and access gameplay elements. The simplicity of the interface reduces the learning curve, allowing players to focus on the math challenges without distractions.

7.1.2 Weakness

The weaknesses in Math Run represent areas where improvements can be made to enhance the overall gaming experience and educational effectiveness. Here are three significant weaknesses that require attention and refinement.

i. Less Engagement Mechanism

One weakness of Math Run is its engagement mechanism. Requiring players to hold both the left and right buttons to change lanes may pose a challenge to engagement. It could be more user-friendly to implement a single-tap mechanism, making it easier for players to navigate the game. This improvement would enhance the overall gaming experience.

ii. No Game Continuation

Another identified weakness is the need for players to restart the game entirely if they lose. This can be frustrating and may discourage some players from continuing to engage with Math Run. Implementing a system that allows players to continue from where they left off or providing checkpoints could improve user retention and satisfaction.

iii. Box Colliders Too Large

Due to the colliders being too large, there were instances where players might have unintentionally triggered the selection of an answer that they did not intend to choose. This could result in incorrect answers being registered by the game.

7.2 Proposition for Improvement

The propositions for improvement in Math Run focus on enhancing the game's functionality, usability, and educational impact. Here are three key propositions that aim to address the identified weaknesses and elevate the game's overall quality and effectiveness.

i. Enhance Player Controls

To improve the game's playability, consider refining the player controls to resemble those of popular endless runner games like 'Subway Surfers.' Implement intuitive single-tap controls for actions such as lane changing, jumping, and sliding. Simplifying the controls can make the game more accessible to a wider audience, including younger players, while maintaining a sense of challenge.

ii. Modify Scoring System

Adjust the scoring system to penalize players for selecting incorrect answers. Currently, Math Run may require players to start over upon choosing a wrong answer. Instead, implement a scoring deduction mechanism that subtracts points from the player's score when an incorrect answer is selected. This approach allows players to continue playing without the need to restart, promoting a more seamless and enjoyable gaming experience.

iii. Score Database Persistence

This involves implementing a feature where the game retains a record of players' scores even after they have closed the game application. For example, display high score table. Typically, games reset scores when they are closed, but this suggestion aims to change that behavior.

7.3 Contribution

Math Run significantly contributes to the educational gaming landscape by offering an innovative approach to learning math for children aged 10-12 years old. The game combines engaging gameplay with essential math skills development, fostering critical thinking, problem-solving, and mental math techniques. This contribution is further enhanced by the game's continuous improvement process, driven by testing and user feedback, ensuring its effectiveness as an educational tool.

7.4 Conclusion

In conclusion, this project has effectively met its set objectives. It has successfully identified and implemented appropriate game mechanics and elements that integrate mental math techniques into basic Mathematics, resulting in Math Run, an engaging and educational endless runner game developed using the Unity game engine. Through thorough testing and evaluation, particularly in usability testing involving children aged 10-12 years old, the game has demonstrated its potential as a valuable tool for enhancing math skills while providing an enjoyable gaming experience. The project's commitment to ongoing improvements and its contribution to the educational gaming landscape further emphasize its success in achieving the outlined objectives. Math Run can be an innovative game design in promoting learning and problem-solving among young learners.

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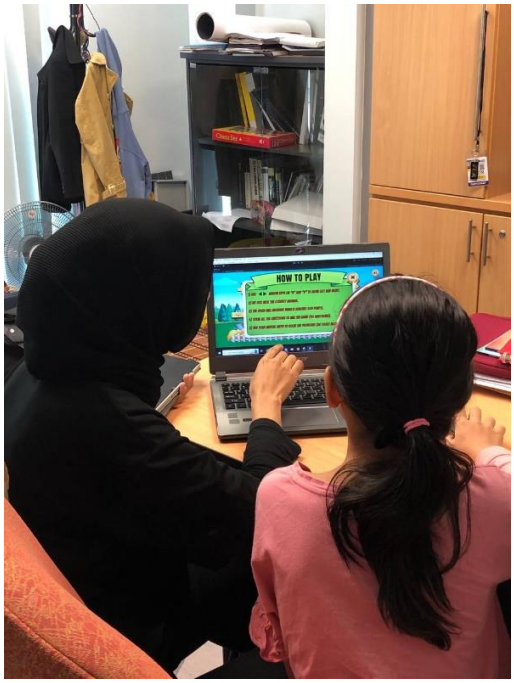
APPENDICES

APPENDIX A: TESTING

- Usability test at Pusat Interaksi Belia Adab Youth Garage (AYG)

- Usability test at Ts. Dr. Norharyati Harum's Room



- Usability Test at Mrs. Khadijah Wan Mohd. Ghazali's Room

APPENDIX B: CODING SCRIPT

➢ Player Movement

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;
using UnityEngine.UI;
using TMPro;

public class PlayerMovement : MonoBehaviour
{

    public GameObject box, GameOver, congratulation, scoreText;

    public TMP_Text question_appeared, displayScore, FinalScoreText,
HighScoreText, displayNoSoalan;

    public float speeds;
    public float leftRightSpeed;
    public string [] question, answerKey;


    //lajukan box
    public float fasterSpeed;
    private Animator boxAnimator;


    private static string playerName;

    string[] answer;

    int number = -1;

    int score = 0;

    int noSoalan = 0;

    void Start()
    {

        // Find the GameObject with the Animator named "Box" in its
children
        GameObject boxObject = GameObject.Find("box");
        if (boxObject != null)
        {
            boxAnimator = boxObject.GetComponentInChildren<Animator>();

        }
        else
        {
            Debug.LogError("Could not find the GameObject with the
Animator named 'Box'.");

        }
```

```
        StartCoroutine(nextQuestion());
    }


    // Update is called once per frame
    void Update()
    {


     //Movement using keyboard A, D, left, right
        if (Input.GetKey(KeyCode.A) || Input.GetKey(KeyCode.LeftArrow))
        {
            GetComponent<Rigidbody>().velocity = new Vector3(-speeds,
0, 0);

            //code for player tak lebih drpda position lvl boundary
            if (this.gameObject.transform.position.x >
LevelBoundary.leftSide)
            {
                transform.Translate(Vector3.left * Time.deltaTime *
leftRightSpeed);
            }
        }

        if (Input.GetKey(KeyCode.D) ||
Input.GetKey(KeyCode.RightArrow))
        {
            GetComponent<Rigidbody>().velocity = new Vector3(speeds, 0,
0);

            if (this.gameObject.transform.position.x <
LevelBoundary.rightSide)
            {
                transform.Translate(Vector3.left * Time.deltaTime *
leftRightSpeed * -1);
            }
        }

        //bagi laju box
       if (score >= 600)
        {
            boxAnimator.SetFloat("Laju", fasterSpeed);
        }
        else
        {
            boxAnimator.SetFloat("Laju", 1.0f);
        }
       //-------------------------
    }

    void OnTriggerEnter(Collider obj)
    {
        if(obj.name == "box")
        {

            if (obj.transform.GetChild(0).GetComponent<TMP_Text>().text
== answer[0])
```

```
            {
                score += 20;
                displayScore.text = score.ToString();

                noSoalan += 1;
                displayNoSoalan.text = noSoalan.ToString();

                //save highscore
                if (PlayerPrefs.GetInt("HighScore") < score)
                {
                    PlayerPrefs.SetInt("HighScore", score);
                   Debug.Log("New High Score is " + score);
                }

                GetComponent<AudioSource>().Play(); //audio will play
bila jwpn betul
            }
            else
            {
                GameOver.SetActive(true);
                Time.timeScale = 0;

                //display or save highscore and current score display
text kat game over panel
                scoreText.SetActive(false);

                FinalScoreText.text = "Score : " + score;
                HighScoreText.text = "High Score : " +
PlayerPrefs.GetInt("HighScore");

                //StartCoroutine("ShowGameOverPanel");
            }


            for (int i = 0; i < obj.transform.parent.childCount; i++)
            {

obj.transform.parent.GetChild(i).GetComponent<BoxCollider>().enabled =
false;   //non activekan box" agar tak double trigger
            }
            obj.gameObject.SetActive(false); //tuk hilangkan box answer
after langgar
            StartCoroutine(nextQuestion());
        }


    }

    IEnumerator nextQuestion()
    {
        yield return new WaitForSeconds(0f);

        number++;

        if (number < question.Length)
        {

question_appeared.transform.parent.gameObject.SetActive(true);
```

```
            question_appeared.text = question[number];

            box.GetComponent<Animator>().enabled = true;
            box.GetComponent<Animator>().Play(0);

            answer = answerKey[number].Split('|');

            for (int i = 0; i < box.transform.childCount; i++)
            {

box.transform.GetChild(i).GetChild(0).GetComponent<TMP_Text>().text =
"";
                box.transform.GetChild(i).gameObject.SetActive(true);
//active kan balik box tu tuk next soalan (hilangkan answer box)

box.transform.GetChild(i).GetComponent<BoxCollider>().enabled = true;
// activekan balik box" agar tak double trigger
            }

            int index = 0;
            for (int i = 0; i < box.transform.childCount; i++)
            {
                do
                {
                    index = (int)Random.Range(0, 2.4f);
                }
                while
(box.transform.GetChild(index).GetChild(0).GetComponent<TMP_Text>().tex
t != "");

box.transform.GetChild(index).GetChild(0).GetComponent<TMP_Text>().text
= answer[i];
            }
        }
        else
        {
            Time.timeScale = 0;
            congratulation.SetActive(true);
        }

    }


    public static string getPlayerName()
    {
        return playerName;
    }

    public static void SetPlayerName(string _playerName)
    {
        playerName = _playerName;
    }

    public void restart()
    {
        Time.timeScale = 1;
        Application.LoadLevel(Application.loadedLevelName);
    }
```

```
}
```

- **Operation Menu**

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class OperationMenu : MonoBehaviour
{
    public void OpenOperation(int operationId)
    {
        string operationName = "Operation " + operationId;
        SceneManager.LoadScene(operationName);
    }

}
```

- **Main Menu**

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class MainMenu : MonoBehaviour
{
    public void PlayGame()
    {
        SceneManager.LoadScene(1);
    }

    public void QuitGame()
    {
        Application.Quit();
    }
}
```

- **Sounds Manager**

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UI;

public class SoundManager : MonoBehaviour
{
    [SerializeField] Image soundOnIcon;
    [SerializeField] Image soundOffIcon;
    private bool muted = false;
```

```
// Start is called before the first frame update
void Start()
{
    if(!PlayerPrefs.HasKey("muted"))
    {
        PlayerPrefs.SetInt("muted", 0);
        Load();
    }

    else
    {
        Load();
    }

    UpdateButtonIcon();
    AudioListener.pause = muted;
}

public void OnButtonPress()
{
    if(muted == false)
    {
        muted = true;
        AudioListener.pause = true;
    }

    else
    {
        muted = false;
        AudioListener.pause = false;
    }

    Save();
    UpdateButtonIcon();
}

private void UpdateButtonIcon()
{
    if(muted == false)
    {
        soundOnIcon.enabled = true;
        soundOffIcon.enabled = false;
    }

    else
    {
        soundOnIcon.enabled = false;
        soundOffIcon.enabled = true;

    }
}

private void Load()
{
    muted = PlayerPrefs.GetInt("muted") == 1;
}

private void Save()
```

```
    {
        PlayerPrefs.SetInt("muted", muted ? 1 : 0);
    }
}
```

- **Game Over Menu**

```
using UnityEngine;
using UnityEngine.SceneManagement;

public class GameOverMenu : MonoBehaviour
{
    [SerializeField] GameObject gameOverMenu;

    public void Home()
    {
        SceneManager.LoadScene("MainMenu");
        Time.timeScale = 1;  //kalau tak dak jadi bug play button
gameplay xfunct

    }
```

- **Background Music**

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class BackgroundMusic : MonoBehaviour
{
    private static BackgroundMusic backgroundMusic;

    void Awake()
    {
        if(backgroundMusic == null)
        {
            backgroundMusic = this;
            DontDestroyOnLoad(backgroundMusic);
        }

        else
        {
            Destroy(gameObject);
        }
    }
}
```

- **Level Boundary**

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
```

```
public class LevelBoundary : MonoBehaviour
{
    public static float leftSide = -17.0f;
    public static float rightSide = 17.0f;
    public float internalLeft;
    public float internalRight;


    // Update is called once per frame
    void Update()
    {
        internalLeft = leftSide;
        internalRight = rightSide;
    }

}
```

- **Pause Menu**

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class PauseMenu : MonoBehaviour
{
    public GameObject PausePanel;

    // Update is called once per frame
    void Update()
    {

    }

    public void Pause()
    {
        PausePanel.SetActive(true);
        Time.timeScale = 0;
    }

    public void Continue()
    {
        PausePanel.SetActive(false);
        Time.timeScale = 1;
    }
}
```

APPENDIX C: SUBJECT MATTER EXPERT TEST DATA

Subject Matter Expert Test

Game: Math Run

Math Teacher: Izzah Hayani binti Saleh

Date: 28/9/2023

No.	Question	Response (Yes/No)	Remarks
1.	Is Math Run aligned with basic math educational goals?	Yes	
2.	Does Math Run make learning math enjoyable for students?	Yes	
3.	Do you think the endless runner format is a good way to learn math?	Yes	
4.	Does Math Run encourage critical thinking and decision-making while making math fun?	Yes	
5.	Does Math Run cover various math operations effectively (addition, subtraction, multiplication, division)?	Yes	
6.	Are the math questions in Math Run suitable in terms of complexity for children aged 10-12?	Yes	Just a note: According to DSKP tahun 4, at least 10 years old students already learn the arithmetic operations involving up to 5 digits number. maybe this is an option for you to increase the number of digits for the higher level. but, if you focus on the speed of

			answering the question, then it is okay to not increasing the number of digits.
7.	Does Math Run help improve problem-solving skills in students?	Yes	
8.	Is Math Run easy to use with an intuitive interface for students?	Yes	
9.	Are the game controls user-friendly and responsive for children in this age group?	Yes	
10.	Does Math Run keep children engaged throughout the game?	Yes	

APPENDIX D: FUNCTIONALITY TEST DATA

- **Functionality Test 1**

Game: Math Run
Game Expert: Mohd Khalid Bin Mokhtar (Lecturer)
Date: 5/9/2024

No.	Component	Execution	Outcome	Function (OK/Error /Failed)	Remarks (If Error)
1.	Play Button	Click button	Display the operation selection	OK	
2.	How to Play Button	Click button	Display the guideline how to play the game	OK	
3.	Quit Button	Click button	Close the console of the game	OK	
4.	Sound Button	Click button	On or off the music	OK	
5.	Addition Button	Click button	Go to the addition game	OK	
6.	Subtraction Button	Click button	Go to the subtraction game	OK	
7.	Multiplication Button	Click button	Go to the multiplication game	OK	
8.	Division Button	Click button	Go to the division game	OK	
9.	Player Control	Use left and right arrow keys or A and D	Move left and right	OK	
10.	Box Collider	Hit the true answer	Get 20 marks	OK	
11.	Box Collider	Hit the wrong answer	Display game over scene	OK	
12.	Pause Button	Click Button	Display Pause Menu	OK	
13.	Continue Button	Click Button	Continue the game	OK	
14.	Main Menu Button	Click Button	Back to the main menu	OK	

15.	Restart Button	Click Button	Restart the game	OK	

1) What are the strengths and weaknesses you observed in Math Run's functionality?

The strengths are it can suitably game play to improve math learning and also encourage to learn math the weakness of this games to make user more engage with the games.

2) Do you have any suggestions to enhance Math Run for a better gaming experience?

Add side games inside this games math to make user maintain their engagement.

- **Functionality Test 2**

Game: Math Run
Game Developer: Ahmad Luqman Bin Adam
Date: 4/9/2023

No.	Component	Execution	Outcome	Function (OK/Error /Failed)	Remarks (If Error)
1.	Play Button	Click button	Display the operation selection	OK	
2.	How to Play Button	Click button	Display the guideline how to play the game	OK	
3.	Quit Button	Click button	Close the console of the game	OK	
4.	Sound Button	Click button	On or off the music	OK	
5.	Addition Button	Click button	Go to the addition game	OK	
6.	Subtraction Button	Click button	Go to the subtraction game	OK	
7.	Multiplication Button	Click button	Go to the multiplication game	OK	
8.	Division Button	Click button	Go to the division game	OK	
9.	Player Control	Use left and right arrow keys or A and D	Move left and right	OK	
10.	Box Collider	Hit the true answer	Get 20 marks	OK	
11.	Box Collider	Hit the wrong answer	Display game over scene	OK	
12.	Pause Button	Click Button	Display Pause Menu	OK	
13.	Continue Button	Click Button	Continue the game	OK	
14.	Main Menu Button	Click Button	Back to the main menu	OK	
15.	Restart Button	Click Button	Restart the game	OK	

1) What are the strengths and weaknesses you observed in Math Run's functionality?

Strengths: Give player an improvement on decision making while answering questions

Weakness: Player need to hold the left and right button to change lane rather than single tap button.

2) Do you have any suggestions to enhance Math Run for a better gaming experience?

Player control need to be more like ‘Subway Surfer’.

- **Functionality Test 3**

Game: Math Run
Game Developer: Mohd Najmie Aiman Bin Shaharruddin
Date: 3/9/2023

No.	Component	Execution	Outcome	Function (OK/Error /Failed)	Remarks (If Error)
1.	Play Button	Click button	Display the operation selection	OK	
2.	How to Play Button	Click button	Display the guideline how to play the game	OK	
3.	Quit Button	Click button	Close the console of the game	OK	
4.	Sound Button	Click button	On or off the music	OK	
5.	Addition Button	Click button	Go to the addition game	OK	
6.	Subtraction Button	Click button	Go to the subtraction game	OK	
7.	Multiplication Button	Click button	Go to the multiplication game	OK	
8.	Division Button	Click button	Go to the division game	OK	
9.	Player Control	Use left and right arrow keys or A and D	Move left and right	OK	
10.	Box Collider	Hit the true answer	Get 20 marks	OK	
11.	Box Collider	Hit the wrong answer	Display game over scene	OK	
12.	Pause Button	Click Button	Display Pause Menu	OK	
13.	Continue Button	Click Button	Continue the game	OK	
14.	Main Menu Button	Click Button	Back to the main menu	OK	
15.	Restart Button	Click Button	Restart the game	OK	

1) What are the strengths and weaknesses you observed in Math Run's functionality?

Strength – Simple but clear interface and instruction, responsive input

Weakness – Some answer colliders were too large, occasionally leading to incorrect answers being selected.

2) Do you have any suggestions to enhance Math Run for a better gaming experience?

To maintain a score database even after the game is closed, which can enhance players' excitement to continue playing and strive for higher scores.