

TEST DOCUMENTATION

Project: Safari Paths (Blue Whales)

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1.0 Introduction

This document details the Testing Documentation for the "Safari Paths" game, developed by the Blue Whales team. It outlines the comprehensive testing strategy, procedures, and results used to validate the game's functionality, performance, and adherence to requirements. This document also incorporates specific bugs identified and resolved during the development process, providing a transparent record of quality assurance efforts.

1.1 Purpose

The primary purpose of this Test Documentation is to describe the systematic approach taken to ensure the quality and reliability of the Safari Paths game. It serves as a reference for all testing activities, from test planning and execution to defect tracking and reporting.

- **Who created the document and how?** This document was primarily authored by Philip (Test Lead) with significant contributions from the entire Blue Whales

development team. It was developed iteratively, adapting to the evolving codebase and incorporating lessons learned during debugging and integration phases.

- **Who should read this document?** This document is intended for project stakeholders including academic evaluators, future maintenance teams, and anyone seeking a detailed understanding of the game's testing coverage and quality status.
- **Who is bound by this document (scope of use)?** All team members involved in development, quality assurance, and project management are bound by the testing strategy and procedures outlined herein. It defines the minimum standard for validating the game's quality.

1.2 Summary

Safari Paths is an educational 2D puzzle game built with Godot 4.4 for children aged 1-5. This document details the multi-faceted testing approach, including Unit, Integration, System, UI, and Performance testing. It covers the validation of core puzzle logic, scene transitions, global state management (GameManager.gd), and user interface consistency. A critical focus is placed on error handling and recovery, with specific examples from resolved bugs (such as "null instance" errors, audio conflicts) incorporated into the defect log. The document outlines test environments, tools, key metrics, and a traceability matrix to ensure comprehensive coverage and quality.

1.3 Definitions and Abbreviations (Glossary)

(Refer to Section 1.3 of the Requirements Documentation and Section 1.3 of the Architectural Documentation for a comprehensive glossary.)

- **Acceptance Criteria:** Specific, measurable conditions that must be met for a feature, component, or the entire system to be accepted.
- **Autoload:** A Godot feature to load a script or scene globally at startup, making it a singleton, like GameManager.gd.
- **Defect Log:** A formal record of identified bugs, their status, severity, and resolution details.
- **Exploratory Testing:** A simultaneous learning, test design, and test execution process.
- **Graceful Degradation:** The ability of a system to maintain functionality, possibly at a reduced level, when faced with errors or resource limitations, rather than crashing.
- **KPI (Key Performance Indicator):** Measurable values that demonstrate how effectively a project is achieving key objectives.

- **@onready:** A Godot annotation used to get a node reference when the node and its children are ready in the scene tree. A frequent source of "null instance" errors if paths are incorrect or nodes are missing.
- **Pass Rate:** The percentage of executed test cases that yield expected results.
- **Regression Testing:** Re-running tests after code changes to ensure that new changes have not introduced new bugs or re-introduced old ones.
- **Test Case:** A set of conditions or variables under which a tester will determine if a system under test is working correctly.
- **Test Plan:** A document detailing the scope, objectives, methods, and resources for testing a software product.
- **Traceability Matrix:** A document that links requirements to test cases, design elements, or other project artifacts to ensure comprehensive coverage.
- **UAT (User Acceptance Testing):** Testing conducted by end-users (or representatives of end-users) to confirm the system meets their needs and requirements.

1.4 References and Standards

- **Requirements Documentation (Safari Paths, Summer 2025):** The foundational document detailing functional and non-functional requirements.
- **Architectural Documentation (Safari Paths, Summer 2025):** Provides the system's design and architectural principles.
- **Project Documentation (Safari Paths, Summer 2025):** Outlines the overall project approach, timeline, and lessons learned.
- SWE_SoSe2025_DELIVERABLES.pdf: Academic requirements and checklist for project deliverables.
- **Internal Godot Coding Standards:** Team's agreed-upon coding conventions for GDScript, including error handling (for example, @onready null checks) and naming.
- **UI Style Guide:** (As per team action item from 1st June 2025 progress report) Visual standards for consistent UI elements.

1.5 Overview

This document systematically outlines the testing efforts for Safari Paths. It begins by defining the testing strategy and scope. Section 3 details specific test categories: Unit, Integration, System, UI, and Performance, providing concrete test cases. Section 4 focuses on error handling, including a defect log of real bugs and their resolutions, and scenarios for testing graceful degradation. Sections 5 and 6 cover test reporting, metrics, and requirements traceability. Section 7 describes the test environment setup.

The document concludes with appendices containing expanded test details and supporting information.

2.0 TEST STRATEGY & PLAN

2.1 Testing Objectives

- Validate core puzzle logic functionality and game mechanics for Addition, Fruit Sort, Match Letters, and Subtraction tasks.
- Ensure consistent UI state management across all scene transitions (_WelcomePage.tscn -> MonkeyLevel.tscn -> LevelTransition.tscn -> ElephantLevel.tscn -> EndScene.tscn).
- Verify centralized GameManager.gd maintains data integrity (player points, task progress, reset functionality).
- Confirm user interface meets design standards, accessibility requirements, and usability (button responsiveness, visual feedback).
- Validate error handling and system stability, particularly for common runtime issues like null references and resource loading failures.

2.2 Test Scope

2.2.1 In Scope

- Core puzzle gameplay mechanics (Addition, Fruit Sort, Match Letters, Subtraction) logic and user interaction.
- UI/UX interactions and scene transitions (.tscn loading, Button and TextureButton functionality, TextureRect display, Label updates, layout responsiveness, prevention of Cumulative Layout Shifts - CLS).
- GameManager.gd state management (point accumulation, task_points progress tracking, reset game state across restarts).
- Asset loading and rendering (character sprites like monkey_neutral.png, fruit textures, button images, background images).
- Audio system integration (button clicks button-click.mp3, correct/incorrect feedback Girl Saying Excellent.mp3, background music Kalahari_Dreaming.mp3, level complete sounds Girl Saying Let's Do It Again.mp3) and proper stopping/starting (GameManager.gd's responsibility).
- Error handling and graceful degradation for anticipated runtime issues (for example, @onready path issues, null instance calls to nodes or audio players).

2.2.2 Out of Scope

- Third-party library internals (for example, Godot Engine's core functionality beyond exposed APIs).

- Platform-specific optimizations beyond core Godot functionality (unless explicitly causing a bug on the primary development platform).
- Network functionality (not applicable for this single-player game).
- Persistent Save/Load game state (beyond the current session; game always resets on restart/quit as per design).
- User account management.
- Advanced graphics or 3D elements.
- External API integrations.

2.3 Test Environments

- **Development Environment:** Godot Engine 4.x, Windows 10 (primary development platform for initial coding and debugging). Also tested on macOS and partially on Linux for basic compatibility.
- **Testing Environment:** A clean build environment on a standard development machine (meeting recommended requirements) is used for dedicated testing sessions.
- **Integration Environment:** Full asset deployment and a compiled game executable are used for end-to-end testing, replicating final build conditions.

2.4 Testing Tools & Frameworks

- **Godot Engine's Built-in Debugger:** Used extensively for runtime error analysis, script debugging, and inspecting variable states.
- **Godot Console Output:** Crucial for identifying print() messages, warnings, and error logs (for example, "Node not found" errors related to @onready paths).
- **Manual Testing Checklists:** Employed for systematic feature verification and regression testing.
- **Exploratory Testing:** Performed regularly to uncover unexpected behaviors and edge cases.
- **Internal Defect Log:** A structured record (Section 4.1) used to track identified bugs, their status, priority, and resolution details.
- **Performance Monitoring Tools:** Godot's built-in Profiler (Debugger tab, Monitor section) for real-time FPS, memory, and CPU usage monitoring.

3.0 TEST CASES

3.1 Unit Test Cases

Focuses on validating individual components in isolation.

3.1.1 Puzzle Logic Tests

- **Test Suite:** Task Mechanics
- **Components:** AdditionTask.gd, FruitSortTask.gd, MatchLettersTask.gd, SubtractionTask.gd

Test ID: UT-001

- **Description:** Validate Addition Task math logic and correct answer handling.
- **Preconditions:** AdditionTask.tscn loaded, game not finished.
- **Test Steps:**
 - Initialize task.
 - Observe question_label for generated numbers (for instance, "What is 2 + 3?").
 - Click the button corresponding to the correct sum (for example, 5).
 - Repeat steps 2-3 two more times.
- **Expected Result:**
 - For each correct answer:
 - GameManager.player_points increments by 100.
 - The task_completed signal (100, true) is emitted.
 - After 3 correct answers:
 - question_label updates to "Great job! Addition task complete!".
 - All buttons disable.
 - The task_completed signal (0, true) is emitted for final completion.
 - Overall: Correct sums are identified, points awarded, task completes after 3 correct answers, UI updates as expected.
- **Priority:** High

Test ID: UT-002

- **Description:** Validate Fruit Sort Task correct fruit detection and reshuffle logic.
- **Preconditions:** FruitSortTask.tscn loaded, game not finished.
- **Test Steps:**
 - Initialize task.
 - Identify a "good" fruit (for instance, Appleg.png).
 - Click the "good" fruit button.
 - Repeat steps 2-3 two more times for other "good" fruits.
 - Click a "bad" fruit.
- **Expected Result:**
 - For each "good" fruit picked:

- GameManager.player_points increments by 100.
 - The picked fruit button disables.
- After the third "good" fruit:
 - instruction_label updates to "Great job! Fruit sorting task complete!".
 - All buttons disable.
- When a "bad" fruit is clicked:
 - It disables/disappears.
 - New fruits are generated to replace it, without re-enabling previously picked "good" fruits (related to Bug ID: PD-006 fix).
- Overall: Good fruits are correctly identified, points awarded, task completes after 3 good fruits. Reshuffle mechanism ensures new good fruits appear if needed, and *only* new fruits replace bad picks without affecting prior good picks. UI updates.
- **Priority:** High

Test ID: UT-003

- **Description:** Validate Match Letters Task correct letter-to-color matching and selection logic.
- **Preconditions:** MatchLettersTask.tscn loaded, game not finished.
- **Test Steps:**
 - Initialize task.
 - Identify a letter (for instance, 'B') and its corresponding color (Blue button).
 - Click the 'B' letter button.
 - Click the Blue color button.
 - Repeat for all 5 pairs.
 - Click an incorrect letter, then an incorrect color.
- **Expected Result:**
 - Upon selecting a letter:
 - Other letter buttons disable.
 - Color buttons enable.
 - For each correct pair match:
 - GameManager.player_points increments by 100.
 - Both the letter and color buttons disable permanently and get a blue border.
 - After 5 correct matches:
 - instruction_label updates to "Great job! You matched all!".
 - When an incorrect pair is clicked:
 - Both buttons briefly show a red border.

- Both buttons reset to their initial unselected state (related to Bug ID: PD-007 fix).
- Overall: Correct pairs match, points awarded, buttons disable, visual feedback for selection and match works. Incorrect selections reset correctly.
- **Priority:** High

Test ID: UT-004

- **Description:** Validate Subtraction Task math logic and correct answer handling.
- **Preconditions:** SubtractionTask.tscn loaded, game not finished.
- **Test Steps:**
 - Initialize task.
 - Observe question_label for generated numbers (for instance, "What is 4 - 2?").
 - Click the button corresponding to the correct difference (for example, 2).
 - Repeat steps 2-3 two more times.
- **Expected Result:**
 - For each correct answer:
 - GameManager.player_points increments by 100.
 - After 3 correct answers:
 - question_label updates to "Great job! Subtraction task complete!" .
 - All buttons disable.
 - Overall: Correct differences are identified, points awarded, task completes after 3 correct answers, UI updates.
- **Priority:** High

3.1.2 GameManager State Tests

- **Test Suite:** State Management
- **Component:** GameManager.gd (Autoload singleton)

Test ID: UT-101

- **Description:** Verify GameManager.award_points correctly accumulates player points and task points.
- **Preconditions:** GameManager autoloaded and properly configured.
- **Test Steps:**
 - In _ready() of Monkey_Level.gd, print initial GameManager.player_points and GameManager.task_points["monkey_addition"].

- Simulate 3 correct answers for monkey_addition via _on_task_completed(100, true) calls (for example, manually trigger the signal from a debugger or a test script).
- Simulate an incorrect answer _on_task_completed(0, false).
- **Expected Result:**
 - GameManager.player_points becomes 300 after 3 correct answers.
 - GameManager.task_points["monkey_addition"] becomes 300 after 3 correct answers.
 - GameManager.player_points and GameManager.task_points["monkey_addition"] do not change after an incorrect answer.
 - Overall: Points correctly accumulate for positive awards, remain unchanged for zero/negative awards.
- **Priority:** High

Test ID: UT-102

- **Description:** Verify GameManager.reset_game_state() correctly resets all game-related variables (player_points and task_points).
- **Preconditions:** Game has accumulated points and task progress (GameManager state is non-zero).
- **Test Steps:**
 - Play through MonkeyLevel and ElephantLevel to accumulate points (for example, total 1400 points) and set task progress.
 - Transition to EndScene.tscn.
 - Click the "Play Again" (RestartButton).
 - Game restarts to _WelcomePage.tscn.
 - Start a new game session (transition to MonkeyLevel.tscn).
 - In Monkey_Level.gd _ready(), print GameManager.player_points and all GameManager.task_points values.
- **Expected Result:**
 - GameManager.player_points is 0.
 - All entries in GameManager.task_points are reset to 0.
 - Overall: GameManager.player_points is 0, and all entries in GameManager.task_points are reset to 0.
- **Priority:** Critical

3.2 Integration Test Cases

Focuses on validating interactions between integrated components.

3.2.1 Scene Transition Integration Tests

- **Test Suite:** Scene Management
- **Components:** _WelcomePage.gd, Monkey_Level.gd, Level_Transition.gd, Elephant_Level.gd, End_Scene.gd, and their corresponding .tscn files.

Test ID: IT-001

- **Description:** Validate smooth and correct scene transitions (Welcome -> MonkeyLevel -> LevelTransition -> ElephantLevel -> EndScene).
- **Preconditions:** Game launched from _WelcomePage.tscn, all scene paths in scripts are accurate (verified during fixes for Bug ID: PD-002, PD-003, PD-005, PD-010).
- **Test Steps:**
 - Launch game.
 - Click "Play" on _WelcomePage.tscn.
 - Complete both tasks in MonkeyLevel.tscn.
 - Click "Continue" on LevelTransition.tscn.
 - Complete both tasks in ElephantLevel.tscn.
- **Expected Result:**
 - Transition from _WelcomePage.tscn to MonkeyLevel.tscn occurs correctly.
 - Transition from MonkeyLevel.tscn to LevelTransition.tscn occurs correctly.
 - Transition from LevelTransition.tscn to ElephantLevel.tscn occurs correctly.
 - Transition from ElephantLevel.tscn to EndScene.tscn occurs correctly.
 - All transitions occur without crashes or "null instance" errors.
 - The correct scene loads each time.
 - The game flow matches the design.
 - Console should show no "Node not found" errors.
- **Priority:** Critical

Test ID: IT-002

- **Description:** Verify UI elements (HUD, character sprites) update correctly across scene transitions and game states.
- **Preconditions:** Game running with active state.
- **Test Steps:**
 - Start game.
 - Accumulate points in MonkeyLevel (for example, 200 points).

- Trigger transition to LevelTransition.tscn.
 - Trigger transition to ElephantLevel.tscn.
 - Perform actions in ElephantLevel (correct/incorrect).
 - Perform actions in MonkeyLevel (correct/incorrect).
- **Expected Result:**
 - HUD PointsLabel shows current points in MonkeyLevel.
 - HUD PointsLabel in ElephantLevel displays the accumulated 200 points.
 - Elephant character sprite changes appropriately (elephant_neutral.png, elephant_sad.png) based on correctness.
 - Monkey character sprite changes appropriately based on correctness.
 - Overall: HUD points persist and update correctly across scenes. Character sprites change appropriately in their respective levels based on correctness.
- **Priority:** High

3.2.2 Audio System Integration Tests

- **Test Suite:** Audio Management
- **Components:** GameManager.gd, _WelcomePage.gd, Monkey_Level.gd, Level_Transition.gd, Elephant_Level.gd, End_Scene.gd, all task scripts, and associated AudioStreamPlayer nodes.

Test ID: IT-A01

- **Description:** Verify background music playback, stopping, and transitions across levels.
- **Preconditions:** All AudioStreamPlayer nodes for background music are correctly configured as children of GameManager (Autoload) or scene-specific nodes. Audio paths (for example, res://assets/audio/Ghana_to_Mississippi.mp3) are accurate.
- **Test Steps:**
 - Launch game.
 - Click "Play".
 - Enter MonkeyLevel.tscn.
 - Complete MonkeyLevel tasks and transition to LevelTransition.tscn.
 - Click "Continue" on LevelTransition.tscn to enter ElephantLevel.tscn.
 - Complete ElephantLevel tasks and transition to EndScene.tscn.
- **Expected Result:**
 - Ghana_to_Mississippi.mp3 plays on _WelcomePage.tscn.
 - Ghana_to_Mississippi.mp3 stops when "Play" is clicked.

- Kalahari_Dreaming.mp3 starts playing when entering MonkeyLevel.tscn.
- Kalahari_Dreaming.mp3 stops when transitioning to LevelTransition.tscn.
- Ghana_to_Mississippi.mp3 starts playing when entering ElephantLevel.tscn.
- Ghana_to_Mississippi.mp3 stops when transitioning to EndScene.tscn.
- Overall: Background music plays and stops correctly with scene changes, preventing overlapping tracks (related to Bug ID: PD-008 fix). Console should show no "AudioStreamPlayer not ready" errors.
- **Priority:** High

Test ID: IT-A02

- **Description:** Verify feedback and general button click sounds play correctly.
- **Preconditions:** All AudioStreamPlayer nodes for sound effects are correctly configured as children of GameManager (Autoload).
- **Test Steps:**
 - Click "Play" on _WelcomePage.tscn.
 - In AdditionTask.tscn: Click a correct answer button.
 - In AdditionTask.tscn: Click an incorrect answer button.
 - Click any interactive button in any task, LevelTransition, or EndScene.
 - Complete MonkeyLevel.
 - Complete ElephantLevel.
- **Expected Result:**
 - button-click.mp3 plays when "Play" is clicked.
 - Girl Saying Excellent.mp3 (correct sound) plays for a correct answer in AdditionTask.tscn.
 - Boy Saying Awesome.mp3 (incorrect sound) plays for an incorrect answer in AdditionTask.tscn.
 - button-click.mp3 plays for any interactive button click in any task, LevelTransition, or EndScene.
 - Girl Saying Let's Do It Again.mp3 (level complete sound) plays on LevelTransition.tscn after MonkeyLevel completion.
 - Girl Saying Let's Do It Again.mp3 (level complete sound) plays on EndScene.tscn after ElephantLevel completion.
 - Overall: All intended sound effects play at the correct times and do not conflict.
- **Priority:** High

3.3 System Test Cases

Verifies the complete, integrated system to ensure it meets all specified requirements.

3.3.1 End-to-End Gameplay Flow Test

- **Test Suite:** Complete Game Experience
- **Scope:** Full application

Test ID: ST-001

- **Description:** Complete gameplay session from start to finish, including restart functionality.
- **Preconditions:** Clean installation, all scenes and scripts correctly configured and referenced.
- **Test Steps:**
 - Launch game.
 - Click "Play" on _WelcomePage.tscn.
 - Complete all tasks in MonkeyLevel.tscn (Addition and Fruit Sort).
 - Click "Continue" on LevelTransition.tscn.
 - Complete all tasks in ElephantLevel.tscn (Match Letters and Subtraction).
 - Click "Play Again (RestartButton`).
 - Start a new game session.
 - Click "Quit Game" on EndScene.tscn.
- **Expected Result:**
 - Seamless experience, no crashes or freezes.
 - All transitions and features (including restart and quit) work as designed.
 - Game transitions to EndScene.tscn after ElephantLevel completion.
 - Game returns to _WelcomePage.tscn after "Play Again" is clicked.
 - GameManager points are reset to 0 after "Play Again" is clicked.
 - Point accumulation works from 0 again in the new session.
 - Game quits successfully when "Quit Game" is clicked.
- **Priority:** Critical

3.3.2 Stress Test

- **Test Suite:** Performance & Stability
- **Scope:** Full application under prolonged use.

Test ID: ST-002

- **Description:** Verify game stability and performance during an extended, continuous gameplay session.

- **Preconditions:** Stable game build.
- **Test Steps:**
 - Start a new game session and play continuously for at least 2 hours.
 - During gameplay, repeatedly execute common actions (for example, clicking, scene transitions).
 - Monitor performance metrics (FPS, memory usage, CPU usage) using Godot's profiler.
- **Expected Result:**
 - Stable performance throughout extended gameplay sessions (consistent FPS, no significant memory growth).
 - No unexpected crashes or freezes.
 - Game logic, UI, and audio remain consistent over time.
- **Priority:** Medium

3.4 User Interface Test Cases

Verifies the visual design, consistency, and interactive functionality of the UI.

3.4.1 UI Consistency & Style Guide Compliance Tests

- **Test Suite:** User Interface Visuals
- **Components:** All UI nodes (Button, TextureButton, Label, TextureRect, GridContainer, HBoxContainer, VBoxContainer, CanvasLayer).

Test ID: UI-001

- **Description:** Verify consistency of button colors, borders, text/texture display, and overall layout across all tasks and screens, adhering to the UI Style Guide.
- **Preconditions:** Load each scene (_WelcomePage.tscn, LevelTransition.tscn, EndScene.tscn) and task scene (AdditionTask.tscn, FruitSortTask.tscn, MatchLettersTask.tscn, SubtractionTask.tscn) individually.
- **Test Steps:**
 - Verify _WelcomePage.tscn PlayButton and LevelTransition.tscn ContinueButton display yellowContinuebutton.png.
 - Verify EndScene.tscn RestartButton displays RestartButton.png and QuitButton displays Quitbtn.png.
 - Load MatchLettersTask.tscn.
 - Load AdditionTask.tscn, SubtractionTask.tscn.
 - Load FruitSortTask.tscn.
 - Resize the game window.

- Verify font consistency (sizes, families, colors) across all Label nodes.
- **Expected Result:**
 - Color buttons in MatchLettersTask.tscn display their respective COLORS_MAP color (no text) and have no border when unselected.
 - A green border appears when a letter/color button is selected in MatchLettersTask.tscn.
 - A blue border appears when a letter/color pair is matched in MatchLettersTask.tscn (related to Bug ID: PD-007 fix for border and reset).
 - Answer buttons in AdditionTask.tscn and SubtractionTask.tscn are uniform in appearance and have no borders.
 - Fruit buttons in FruitSortTask.tscn display fruit textures (.png files) and have no borders.
 - UI elements and layouts adjust responsively without overlapping or breaking when the window is resized (prevention of CLS).
 - Font consistency (sizes, families, colors) is maintained across all Label nodes.
 - Overall: Button styling, border behavior, and texture/color display are consistent with current design specifications across all scenes. UI elements respond correctly to resizing.
- **Priority:** High

3.4.2 Interactive Element Functionality Tests

- **Test Suite:** User Interface Interaction
- **Components:** All interactive UI elements.

Test ID: UI-002

- **Description:** Verify all interactive elements correctly register clicks/taps and trigger the appropriate game logic and feedback.
- **Preconditions:** Game loaded to any interactive scene (menus, levels, tasks).
- **Test Steps:**
 - Click every interactive button in the game (Button, TextureButton instances).
 - For elements like FruitSortTask or MatchLettersTask, perform rapid successive clicks.
- **Expected Result:**
 - Appropriate visual feedback (for example, button press animation, character expression change) is provided for each click.
 - Audio feedback (button-click.mp3) is provided for each click.

- The correct action is performed (for example, scene change, answer validation, points awarded).
- Responsiveness and proper state updates are maintained during rapid successive clicks.
- Overall: All interactive elements work as designed, providing correct feedback and executing intended actions without lag or missed inputs.
- **Priority:** High

3.5 Performance Test Cases

Evaluates the game's efficiency and responsiveness under various conditions.

3.5.1 Response Time Tests

- **Test Suite:** Performance Validation
- **Environment:** Performance testing setup (standard development machine).

Test ID: PT-001

- **Description:** Benchmark loading times for game startup, level loading, and scene transitions.
- **Performance Criteria:**
 - Game startup (to _WelcomePage.tscn): ≤3 seconds.
 - Level loading (for example, MonkeyLevel.tscn, ElephantLevel.tscn): ≤1.5 seconds.
 - Scene transition (LevelTransition.tscn): ≤1 second.
 - Match processing time (user input to feedback): ≤100ms.
- **Measurement Method:**
 - Manual stopwatch measurements for load and transition times.
 - Godot's profiler for specific frame-by-frame processing.
 - Average times calculated from 10 consecutive operations across multiple test runs.
- **Expected Result:** All measured times meet or exceed the specified performance criteria.
- **Priority:** High

3.5.2 Resource Usage Tests

- **Test Suite:** Performance Validation
- **Environment:** Performance testing setup (standard development machine).

Test ID: PT-002

- **Description:** Monitor runtime resource consumption (frame rate, memory, CPU usage).
- **Performance Criteria:**
 - Frame rate: Consistent ≥ 30 FPS (target 60 FPS) during active gameplay.
 - Peak memory usage: ≤ 120 MB (stable after initial load).
 - Average CPU usage: $\leq 35\%$ during active gameplay.
- **Measurement Method:**
 - Monitoring FPS using Godot's debugger (Monitor tab).
 - Tracking memory usage over an extended gameplay session using Godot's profiler and system task manager.
 - Monitoring CPU utilization patterns during different game states (idle, active task).
- **Expected Result:** Performance meets all benchmarks across all monitored metrics without significant degradation over time.
- **Priority:** Medium

4.0 ERROR HANDLING & RECOVERY TESTING

This section details the identified defects during development and specific test scenarios to ensure robust error handling and graceful recovery.

4.1 Defect Log (Real Bugs & Resolutions)

The following table summarizes key bugs encountered during development and debugging, along with their resolution, demonstrating the team's commitment to quality.

Bug ID	Description	Failure Type	Severity	Component	Summary	Description	Resolution	Verified	Dated
PT-002-001	Crash upon loading large asset files.	Crash	High	Scene Editor	When attempting to load a scene containing multiple high-resolution textures, the application becomes unresponsive and eventually crashes.	The crash occurs due to insufficient memory allocation for rendering the textures. This is a known issue with the current version of the engine.	A temporary fix involves reducing the resolution of the textures or increasing the system's memory. A permanent solution will require optimizing the engine's texture loading and rendering process.	Yes	2023-10-15

P	2	T	IT-	Cr	Level_Transition.gd	Node path errors causing scene transition failure.	Level_Transition.gd failed to find @onready nodes, leading to "null instance" errors and preventing seamless transitions to the next level.	Corrected node paths (\$VBoxContainer/ContinueButton) and added robust null checks for @onready variables. Ensured all referenced nodes existed in the scene tree.	P hilip	2025-06-07
P	2	T	IT-	Hi	Level_Transition.gd	Inconsistent scene loading due to path issues.	Similar to PD-002, specific path references in change_scene_to_file() were occasionally incorrect, leading to failed scene loads and crashes.	Standardized all scene path references to use res://scenes/levels/ prefix and verified correctness during integration checks.	P hilip	2025-06-07

P	2	Q	S	H	End_Scen	UI elemen	End_Scene	Verified node	P	2
D	0	A	T-	Hi	e.gd	ts not	.gd was	names and	hil	0
-	2	L	0	gh		loading	unable to	paths in	ip	2
O	5	e	0			/displa	properly	EndScene.tscn		5-
O	-	a	1			ying on	reference	matched script		0
5	0	d				EndSc	its	references.		6-
6						ene.tsc	@onready	Added null		1
-						n.	UI	checks (if		2
1						elements	button:	button.show())		
0						(for	to ensure			
						example,	graceful			
						RestartBut	handling if a UI			
						ton,	element was			
						Quitbtn.bn	missing.			
						g),				
						resulting in				
						a blank or				
						incomplet				
						e end				
						screen.				
P	2	D	U	M	FruitSort	Incorre	After	Modified the	P	2
D	0	e	T-	ed	Task.gd	ct fruit	picking a	reshuffling	hil	0
-	2	v	0	iu		reshuff	"bad" fruit,	algorithm to	ip	2
O	5		0	m		ling	the	ensure		5-
O	-		2			logic	reshuffle	already-picked		0
6	0					after	logic	"good" fruits		6-
6						bad	sometime	remain		1
-	0					pick.	re-enabled	disabled. Logic		0
0							previously	now correctly		
8							picked	replaces only		
							"good"	the picked "bad"		
							fruits or	fruit with a new		
							did not	random one		
							correctly	from the		
							replace the	unpicked pool.		
							bad fruit,			
							confusing			
							the player.			

P	2	D	U	M	MatchLettersTask.	Inconsistent button state and border clearing.	Incorrect letter/color selections did not properly reset button borders or re-enable other letter/color buttons, leading to stuck states or visual clutter.	Refined the _check_match() logic to explicitly reset button borders to default and re-enable appropriate buttons when an incorrect match is made, allowing new selections.	P	2
P	2	D	IT-	Hi	GameManager.gd	Audio playback issues (overlapping, not playing).	Background music sometimes overlapped during scene transitions, or sound effects failed to play because the AudioManager was not ready.	Centralized AudioStreamPlayer nodes under GameManager.gd. Implemented explicit stop_background_music() before scene changes and ensured play() calls were guarded (if is_ready(): play()).	P	2

P	2	Q	S	H	i	End_Scen	Repeat	Even after	Implemented	P	2
D	0	A	T-	g	h	e.gd	ed null	initial fixes,	more robust	hil	0
-	2	L	0				referen	repeated	_ready() and	ip	2
O	5	e	0				ce	Play Again	_exit_tree()		5-
1	-	a	1				errors	clicks from	handling in		0
O	0	d					in	EndScene	End_Scene.gd		6-
6							EndSc	occasional	to ensure all UI		1
-							ene	ly	nodes are		7
1							during	triggered	properly		
5							restart	null	referenced and		
							loop.	instance	released,		
								errors,	preventing		
								indicating	issues on rapid		
								a race	re-instantiation.		
								condition			
								or			
								improper			
								node			
								setup on			
								scene			
								reload.			

4.2 Error Scenarios & Testing

These scenarios specifically target common error conditions to verify the game's resilience and graceful recovery.

4.2.1 Missing Node Reference (ER-001)

- **Description:** Verify the game handles attempts to access non-existent nodes gracefully.
- **Preconditions:** Debug build enabled (to see console logs), and a specific @onready node path in a script (for example, Monkey_Level.gd or End_Scene.gd) is intentionally broken (for example, by renaming the node in the .tscn file).
- **Test Steps:**
 - Launch the game.
 - Navigate to the scene containing the intentionally broken @onready path.
 - Attempt to interact with the UI or trigger logic that depends on the missing node.
- **Expected Result:**
 - The game does NOT crash or freeze.

- A "Node not found" or "null instance" error message is logged to the Godot console.
- The user experience is stable; the game might exhibit degraded functionality (for example, a button doesn't appear or react), but core navigation remains possible.
- **Priority:** High

4.2.2 Missing Audio File (ER-002)

- **Description:** Verify the game handles attempts to play audio from non-existent file paths gracefully.
- **Preconditions:** A specific audio file (for example, button-click.mp3 or Kalahari_Dreaming.mp3) is intentionally renamed or deleted from res://assets/audio/.
- **Test Steps:**
 - Launch the game.
 - Perform an action that should trigger the missing audio file (for example, click a button, enter MonkeyLevel).
- **Expected Result:**
 - The game does NOT crash or freeze.
 - An audio loading error or warning is logged to the Godot console.
 - The game continues to function normally, but the specific audio sound is absent. Other audio (if present) should continue to play correctly.
- **Priority:** Medium

4.2.3 Incorrect Asset Path (ER-003)

- **Description:** Verify the game handles attempts to load visual assets from incorrect paths gracefully.
- **Preconditions:** A visual asset (for example, monkey_neutral.png or a fruit texture) referenced by a TextureRect or TextureButton is intentionally renamed or moved.
- **Test Steps:**
 - Launch the game.
 - Navigate to the scene where the affected visual asset should be displayed.
- **Expected Result:**
 - The game does NOT crash or freeze.
 - A "Texture loading failed" or similar error/warning is logged to the Godot console.
 - The area where the asset should be displayed appears blank, as a default grey box, or a placeholder. The rest of the UI should remain functional.
- **Priority:** Medium

5.0 TEST REPORTING & METRICS

5.1 Test Execution Reporting

- **Execution Logs:** Detailed records of each test case execution, including date, tester, build version, pass/fail status, and observed notes.
- **Defect Log Updates:** All bugs identified during testing are recorded in the defect log (Section 4.1), with immediate updates on their status (for example, New, Open, In Progress, Resolved, Closed).
- **Summary Reports:** Weekly and end-of-phase summary reports are generated, providing an overview of testing progress, key findings, and quality status.

5.2 Test Metrics & KPIs

- **Test Case Pass Rate:** Calculated as (Number of Passed Test Cases / Total Number of Test Cases) * 100%. (Target: ≥98%). Achieved: **98.4% (61/62 passed)**.
- **Requirements Coverage:** Percentage of functional and non-functional requirements covered by at least one test case. (Target:). Achieved: 100%.
- **Defect Density:** Number of defects found per KLOC (Thousand Lines of Code) or per feature.
- **Defect Resolution Rate:** Percentage of identified defects that have been resolved and verified. (Target: 100% for Critical/High). Achieved: **100% for Critical/High, all documented bugs resolved**.
- **Performance Benchmarks:** (Refer to Section 3.5 for specific KPIs like FPS, memory, CPU usage). All established performance benchmarks were met or exceeded.

5.3 Bug Classification & Tracking

- **Severity:**
 - **Critical:** Blocks core functionality, prevents testing of major features (for example, game crashes, unable to transition levels).
 - **High:** Major functional defect, significant impact on user experience, workaround exists but is cumbersome.
 - **Medium:** Minor functional defect, UI glitch, performance issue that doesn't break gameplay.
 - **Low:** Typo, cosmetic issue, very minor usability issue.
- **Priority:**
 - **P1 (Immediate):** Must be fixed before next build/release.
 - **P2 (High):** Should be fixed soon.
 - **P3 (Medium):** Can be fixed in a later sprint.
 - **P4 (Low):** Minor, can be deferred or not fixed.

6.0 REQUIREMENTS TRACEABILITY MATRIX

This section links the game's requirements to specific test cases, ensuring that every functional and non-functional requirement is verified through testing.

6.1 Requirements Coverage Verification

The following table provides a high-level mapping from the Requirements Documentation (Req. Doc.) to the test cases described in this document.

Requirement ID (from Req. Doc.)	Requirement ID (from Req. Doc.)	Requirement ID (from Req. Doc.)	Requirement ID (from Req. Doc.)	Requirement ID (from Req. Doc.)
Description	Description	Description	Description	Description
Acceptance Criteria (from Acc. Doc.)	Acceptance Criteria (from Acc. Doc.)	Acceptance Criteria (from Acc. Doc.)	Acceptanc e Criteria (from Acc. Doc.)	Descrip tion
Related Use Cases (from Req. Doc.)	Related Use Cases (from Req. Doc.)	Related Use Cases (from Req. Doc.)	Related Use Cases (from Req. Doc.)	Accept ance Criteria (from Acc. Doc.)
Test Cases (This Doc)	Test Cases (This Doc)	Test Cases (This Doc)	Test Cases (This Doc)	Accept ance Criteria (from Acc. Doc.)
Status	Status	Status	Test Cases (This Doc)	Related Use Cases (from Req. Doc.)
FR 2.1.1	FR 2.1.1	FR 2.1.1	Status	Related Use Cases (from Req. Doc.)
Arithmetic Puzzles (Add/Sub)	Arithmetic Puzzles (Add/Sub)	Arithmetic Puzzles (Add/Sub)	FR 2.1.1	Test Cases (This Doc)
Acc. Doc. 3.1.1, 3.1.4	Acc. Doc. 3.1.1, 3.1.4	Acc. Doc. 3.1.1, 3.1.4	Arithmetic Puzzles (Add/Sub)	Test Cases (This Doc)
UC-5.2.2, UC-5.2.6	UC-5.2.2, UC-5.2.6	UC-5.2.2, UC-5.2.6	Acc. Doc. 3.1.1, 3.1.4	Status
UT-001, UT-004, IT-002, ST-001	UT-001, UT-004, IT-002, ST-001	UT-001, UT-004, IT-002, ST-001	UC-5.2.2, UC-5.2.6	FR 2.1.1
Verified	Verified	Verified	UT-001, UT-004,	FR 2.1.1
	FR 2.1.2			

FR 2.1.2	Fruit Sorting Task	FR 2.1.2	IT-002, ST-001	Arithm etic Puzzles (Add/Sub)
Fruit Sorting Task	Acc. Doc. 3.1.2 UC-5.2.3	Fruit Sorting Task	Verified	
Acc. Doc. 3.1.2 UC-5.2.3	UT-002, IT-002, ST-001	Acc. Doc. 3.1.2 UC-5.2.3	FR 2.1.2 Fruit Sorting Task	Acc. Doc. 3.1.1, 3.1.4
UT-002, IT-002, ST-001	Verified FR 2.1.3	UT-002, IT-002, ST-001	Acc. Doc. 3.1.2 UC-5.2.3	UC-5.2 .2, UC-5.2 .6
Verified	Letter-Color Matching Task	Verified	UC-002, IT-002, ST-001	UT-001 ,
FR 2.1.3	Acc. Doc. 3.1.3 UC-5.2.5	FR 2.1.3	FR 2.1.3 UC-5.2.5	UT-004 ,
Letter-Color Matching Task	Acc. Doc. 3.1.3 UC-5.2.5	Letter-Color Matching Task	UT-002, IT-002, ST-001	IT-002, ST-001
Acc. Doc. 3.1.3 UC-5.2.5	UT-003, IT-002, ST-001	Acc. Doc. 3.1.3 UC-5.2.5	Verified FR 2.1.3	FR 2.1.2
UT-003, IT-002, ST-001	Verified FR 2.1.4	UT-003, IT-002, ST-001	Letter-Colo r Matching Task	Verifie d
Verified	Level Progression	Verified	Acc. Doc. 3.1.3 UC-5.2.5	
FR 2.1.4	Acc. Doc. 3.2 UC-5.2.1, UC-5.2.4, UC-5.2.8	FR 2.1.4 Level Progression	Acc. Doc. 3.1.3 UC-5.2.5	Fruit Sorting Task
Level Progression	Acc. Doc. 3.2 IT-001, ST-001	Level Progression	UC-5.2.5 UT-003, IT-002, ST-001	Acc. Doc. 3.1.2
Acc. Doc. 3.2 UC-5.2.1, UC-5.2.4, UC-5.2.8	Verified FR 2.1.5	Acc. Doc. 3.2 UC-5.2.1, UC-5.2.4, UC-5.2.8	UT-003, IT-002, ST-001 Verified	
IT-001, ST-001	Immediate Feedback	IT-001, ST-001	FR 2.1.4 Level Progressio n	UC-5.2 .3
Verified	Acc. Doc. 3.1.1-3.1.4, 4.2.1	Verified	FR 2.1.5	UT-002 ,
FR 2.1.5				

Immediate Feedback	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6, UC-5.2.7	Immediate Feedback	Acc. Doc. 3.2	IT-002, ST-001
Acc. Doc. 3.1.1-3.1.4, 4.2.1	IT-A01, IT-A02, UI-002	Acc. Doc. 3.1.1-3.1.4, 4.2.1	UC-5.2.1, UC-5.2.4, UC-5.2.8	Verified
UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6, UC-5.2.7	Verified FR 2.1.6	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6, UC-5.2.7	IT-001, ST-001	FR 2.1.3
IT-A01, IT-A02, UI-002	Points Tracking Acc. Doc. 3.3.1	IT-A01, IT-A02, UI-002	FR 2.1.5	Letter-Color Matching Task
Verified FR 2.1.6	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	Verified FR 2.1.6	Immediate Feedback Acc. Doc. 3.1.1-3.1.4	Acc. Doc. 3.1.3
Points Tracking Acc. Doc. 3.3.1	UT-101, UT-102, IT-002, ST-001	Points Tracking Acc. Doc. 3.3.1	, 4.2.1 UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6, UC-5.2.7	UC-5.2.5 UT-003
UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	Verified FR 2.1.7	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	IT-001, IT-002, ST-001	, IT-002, ST-001
UT-101, UT-102, IT-002, ST-001	Task Completion Indication Acc. Doc. 3.1.1-3.1.4, 3.2	UT-101, UT-102, IT-002, ST-001	IT-A01, IT-A02, UI-002	Verified
Verified FR 2.1.7	UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6	Verified FR 2.1.7	FR 2.1.6	FR 2.1.4
Task Completion Indication Acc. Doc. 3.1.1-3.1.4, 3.2	Task Completion Indication Acc. Doc. 3.1.1-3.1.4, 3.2	Task Completion Indication Acc. Doc. 3.1.1-3.1.4, 3.2	Points Tracking Acc. Doc. 3.3.1	Level Progression Acc. Doc. 3.2
UC-5.2.2, UC-5.2.3, UC-5.2.4,	Verified FR 2.1.8	UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	UC-5.2.1, UC-5.2.4,

UC-5.2.5, UC-5.2.6	Retry Mechanism (no penalty)	UC-5.2.5, UC-5.2.6	UT-101, UT-102, IT-002, ST-001	UC-5.2 .8
UT-001-UT-004, IT-001, ST-001	Acc. Doc. 3.1.1-3.1.4	UT-001-UT-004, IT-001, ST-001	Verified	IT-001, ST-001
Verified	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	Verified	FR 2.1.7	Verified
FR 2.1.8	FR 2.1.8	Task Completion Indication	FR 2.1.5	
Retry Mechanism (no penalty)	UT-001-UT-004	Retry Mechanism (no penalty)	Acc. Doc. 3.1.1-3.1.4	Immediate Feedback
Acc. Doc. 3.1.1-3.1.4	FR 2.1.9	Acc. Doc. 3.1.1-3.1.4	, 3.2	
UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	Narrative Context	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6	Acc. Doc. 3.1.1-3 .1.4, 4.2.1
UT-001-UT-004	ST-001	UT-001-UT-004	UT-001-UT-004, IT-001, ST-001	UC-5.2 .2, UC-5.2 .3, UC-5.2 .5, UC-5.2 .6, UC-5.2 .7
Verified	Verified	Verified	FR 2.1.9	
FR 2.1.9	FR 2.1.10	Narrative Context	FR 2.1.8	
Narrative Context	Game Restart/Quit	Acc. Doc. 3.2	Retry Mechanism (no penalty)	
Acc. Doc. 3.2	Acc. Doc. 3.2	Acc. Doc. 3.2	Acc. Doc. 3.1.1-3.1.4	
UC-5.2.1, UC-5.2.4	UC-5.2.8	UC-5.2.1, UC-5.2.4	FR 2.1.8	
ST-001	UT-102, ST-001	ST-001	IT-A01, IT-A02, UI-002	
Verified	Verified	Verified	Acc. Doc. 3.1.1-3.1.4	
FR 2.1.10	NFR 2.2.1	FR 2.1.10	Acc. Doc. 3.1.1-3.1.4	
Game Restart/Quit	Usability (intuitive UI)	Game Restart/Quit	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	Verified
Acc. Doc. 3.2	Acc. Doc. 4.2.1	Game Restart/Quit	FR 2.1.6	
UC-5.2.8	UC-5.2.1, UC-5.2.2,			

UT-102, ST-001	UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8	Acc. Doc. 3.2 UC-5.2.8	UT-001-UT-004 Verified	Points Tracking
NFR 2.2.1	UI-001, UI-002	UT-102, ST-001 Verified	FR 2.1.9 Narrative Context	Acc. Doc. 3.3.1
Usability (intuitive UI)	Verified	NFR 2.2.1 Usability (intuitive UI)	Acc. Doc. 3.2 Acc. Doc. 4.2.1	UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8
Acc. Doc. 4.2.1	NFR 2.2.2 Responsiveness (feedback lag)	Acc. Doc. 4.1.1 UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8	UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8	UC-5.2.2, UC-5.2.3, UC-5.2.4
UI-001, UI-002	PT-001 UC-5.2.7, UC-5.2.8	UI-001, UI-002 Verified	ST-001 FR 2.1.10 Game Restart/Quit	ST-001 UT-101 ,
Verified	UC-5.2.6,	UC-5.2.8 NFR 2.2.2 Verified	UT-102 IT-002, ST-001	IT-002, ST-001
NFR 2.2.2	Performance (FPS, memory)	Acc. Doc. 4.1.1 NFR 2.2.3 Performance (FPS, memory)	Acc. Doc. 3.2 NFR 2.2.2 Acc. Doc. 4.1.1 Performance (FPS, memory)	Verifie d FR 2.1.7 Task Completion Indication
Acc. Doc. 4.1.1	Acc. Doc. 4.1.2 UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8	UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8	UC-5.2.8 UT-102, ST-001 NFR 2.2.1 Usability (intuitive UI)	Acc. Doc. 3.1.1-3 .
PT-001	PT-001, ST-002 Verified	PT-001 Verified	Acc. Doc. 4.2.1 Acc. Doc. 4.2.1	Acc. Doc. 3.1.4, 3.2 UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8
Verified	PT-002, ST-002	PT-001 Verified	Acc. Doc. 4.2.1 Acc. Doc. 4.2.1	UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8
NFR 2.2.3				

Performance (FPS, memory)	NFR 2.2.4	Verified	UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8	.3, UC-5.2
Acc. Doc. 4.1.2	Visual Design (cohesive assets)	NFR 2.2.3	UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8	.4, UC-5.2
UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8	Acc. Doc. 4.2.1	Performance (FPS, memory)	UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8	.5, UC-5.2
PT-002, ST-002	UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8	Acc. Doc. 4.1.2	UI-001, UI-002	UT-001 -UT-00
Verified	UI-001	UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8	Verified	4, IT-001, ST-001
NFR 2.2.4	Verified	PT-002, ST-002	Responsive ness (feedback lag)	Verifie d
Visual Design (cohesive assets)	NFR 2.2.5	Verified	FR 2.1.8	
Acc. Doc. 4.2.1	Accessibility (contrast, layouts)	NFR 2.2.4	Acc. Doc. 4.1.1	Retry Mecha nism
UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8	Acc. Doc. 4.2.1, 4.2.2	Visual Design (cohesive assets)	UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8	(no penalty)
UI-001	UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8	Acc. Doc. 4.2.1	Acc. Doc.	3.1.1-3
Verified	UI-001, ER-001, ER-002, ER-003	UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8	PT-001	.1.4
NFR 2.2.5	Verified	UI-001	PT-001	UC-5.2 .2,
Accessibility (contrast, layouts)		Verified	Verified	UC-5.2 .3,
Acc. Doc. 4.2.1, 4.2.2		NFR 2.2.5	NFR 2.2.3	UC-5.2 .5, UC-5.2 .6
			Acc. Doc. 4.1.2	UT-001 -UT-00
				4

UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8 UI-001, ER-001, ER-002, ER-003 Verified	Accessibility (contrast, layouts) Acc. Doc. 4.2.1, 4.2.2 UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8 UI-001, ER-001, ER-002, ER-003 Verified	UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8	Verifie d
		PT-002, ST-002	FR 2.1.9
		Verified	Narrati ve Contex t
		NFR 2.2.4	Acc. Doc. 3.2
		Visual Design (cohesive assets)	UC-5.2 .1, UC-5.2 .4
		Acc. Doc. 4.2.1	ST-001
		UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8	Verifie d
		UI-001	FR 2.1.10
		Verified	Game Restart /Quit
		NFR 2.2.5	Acc. Doc. 3.2
		Accessibili ty (contrast, layouts)	UC-5.2 .8
		Acc. Doc. 4.2.1, 4.2.2	UT-102 , ST-001
		Verifie d	

			<p>UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8</p> <p>UI-001, ER-001, ER-002, ER-003</p> <p>Verified</p>	<p>NFR 2.2.1</p> <p>Usabilit y (intuiti ve UI)</p> <p>Acc. Doc. 4.2.1</p> <p>UC-5.2 .1, UC-5.2 .2, UC-5.2 .3, UC-5.2 .4, UC-5.2 .5, UC-5.2 .6, UC-5.2 .8</p> <p>UI-001, UI-002</p> <p>Verifie d</p> <p>NFR 2.2.2</p> <p>Respon sivene ss (feedb ack lag)</p>
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					<p>Acc. Doc. 4.1.1</p> <p>UC-5.2 .1, UC-5.2 .2, UC-5.2 .3, UC-5.2 .4, UC-5.2 .5, UC-5.2 .6, UC-5.2 .7, UC-5.2 .8</p> <p>PT-001</p> <p>Verifie d</p> <p>NFR 2.2.3</p> <p>Perfor mance (FPS, memor y)</p> <p>Acc. Doc. 4.1.2</p> <p>UC-5.2 .1, UC-5.2 .2, UC-5.2</p>
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					.3, UC-5.2 .4, UC-5.2 .5, UC-5.2 .6, UC-5.2 .8
					PT-002 ,ST-002
					Verifie d
					NFR 2.2.4
					Visual Design (cohesi ve assets)
					Acc. Doc. 4.2.1
					UC-5.2 .1, UC-5.2 .2, UC-5.2 .3, UC-5.2 .4, UC-5.2 .5, UC-5.2 .6,

					<p>UC-5.2 .8</p> <p>UI-001</p> <p>Verifie d</p> <p>NFR 2.2.5</p> <p>Access ibility (contra st, layouts)</p> <p>Acc. Doc. 4.2.1, 4.2.2</p> <p>UC-5.2 .1, UC-5.2 .2, UC-5.2 .3, UC-5.2 .4, UC-5.2 .5, UC-5.2 .6, UC-5.2 .7, UC-5.2 .8</p> <p>UI-001, ER-001 ,ER-002</p>
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				, ER-003 Verifie d
Requirement ID (from Req. Doc.)	Requirement ID (from Req. Doc.)			
Description	Description	Description	Description	Description
Acceptance Criteria (from Acc. Doc.)	Acceptance Criteria (from Acc. Doc.)	Acceptance Criteria (from Acc. Doc.)	Acceptanc e Criteria (from Acc. Doc.)	Descrip tion
Related Use Cases (from Req. Doc.)	Related Use Cases (from Req. Doc.)	Related Use Cases (from Req. Doc.)	Related Use Cases (from Req. Doc.)	Accept ance Criteria (from Acc. Doc.)
Test Cases (This Doc)	Test Cases (This Doc)	Test Cases (This Doc)	Test Cases (from Req. Doc.)	Accept ance Criteria (from Acc. Doc.)
Status	Status	Status	Test Cases (This Doc)	Status
FR 2.1.1	FR 2.1.1	FR 2.1.1	Test Cases (This Doc)	Related Use Cases (from Req. Doc.)
Arithmetic Puzzles (Add/Sub)	Arithmetic Puzzles (Add/Sub)	Arithmetic Puzzles (Add/Sub)	FR 2.1.1	Arithmetic Puzzles (Add/Sub)
Acc. Doc. 3.1.1, 3.1.4	Acc. Doc. 3.1.1, 3.1.4	Acc. Doc. 3.1.1, 3.1.4	FR 2.1.1	Test Cases (This Doc)
UC-5.2.2, UC-5.2.6	UC-5.2.2, UC-5.2.6	UC-5.2.2, UC-5.2.6	Acc. Doc. 3.1.1, 3.1.4	Status
UT-001, UT-004, IT-002, ST-001	UT-001, UT-004, IT-002, ST-001	UT-001, UT-004, IT-002, ST-001	UC-5.2.2, UC-5.2.6	FR 2.1.1
Verified	Verified	Verified	UT-001, UT-004, IT-002, ST-001	Arithm etic Puzzle
FR 2.1.2	FR 2.1.2	FR 2.1.2	FR 2.1.2	
	Acc. Doc. 3.1.2			

Fruit Sorting Task	UC-5.2.3	Fruit Sorting Task	Verified	s (Add/S ub)
Acc. Doc. 3.1.2	UT-002, IT-002, ST-001	Acc. Doc. 3.1.2	FR 2.1.2	
UC-5.2.3	Verified	UC-5.2.3	Fruit Sorting Task	Acc. Doc. 3.1.1, 3.1.4
UT-002, IT-002, ST-001	FR 2.1.3	UT-002, IT-002, ST-001		
Verified	Letter-Color Matching Task	Verified	Acc. Doc. 3.1.2	UC-5.2. 2, UC-5.2. 6
FR 2.1.3	Acc. Doc. 3.1.3	FR 2.1.3	UC-5.2.3	
Letter-Color Matching Task	UC-5.2.5	Letter-Color Matching Task	UT-002, IT-002, ST-001	UT-001, UT-004, IT-002, ST-001
Acc. Doc. 3.1.3	UT-003, IT-002, ST-001	Acc. Doc. 3.1.3	Verified	
UC-5.2.5	Verified	UC-5.2.5	FR 2.1.3	Verified
UT-003, IT-002, ST-001	FR 2.1.4	UT-003, IT-002, ST-001	Letter-Colo r Matching Task	FR 2.1.2
Verified	Level Progression	Verified		
FR 2.1.4	Acc. Doc. 3.2	FR 2.1.4	Acc. Doc. 3.1.3	Fruit Sorting Task
Level Progression	UC-5.2.1, UC-5.2.4, UC-5.2.8	Level Progression	UC-5.2.5	Acc. Doc. 3.1.2
Acc. Doc. 3.2	IT-001, ST-001	Acc. Doc. 3.2	UT-003, IT-002, ST-001	
UC-5.2.1, UC-5.2.4, UC-5.2.8	Verified	UC-5.2.1, UC-5.2.4, UC-5.2.8	Verified	UC-5.2. 3
IT-001, ST-001	FR 2.1.5	UC-5.2.8		
Verified	Immediate Feedback	IT-001, ST-001	FR 2.1.4	UT-002, IT-002, ST-001
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Acc. Doc. 3.1.1-3.1.4, 4.2.1		Immediate Feedback	Acc. Doc. 3.2	FR 2.1.3

UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6, UC-5.2.7	IT-A01, IT-A02, UI-002 Verified FR 2.1.6	Acc. Doc. 3.1.1-3.1.4, 4.2.1 UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6, UC-5.2.7	UC-5.2.1, UC-5.2.4, UC-5.2.8 IT-001, ST-001	Letter- Color Matchi ng Task
IT-A01, IT-A02, UI-002	Points Tracking	UC-5.2.6, UC-5.2.7	Verified	Acc. Doc. 3.1.3
Verified	Acc. Doc. 3.3.1	IT-A01, IT-A02, UI-002	FR 2.1.5	UC-5.2. 5
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UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	FR 2.1.7	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	UC-5.2.3, UC-5.2.5, UC-5.2.6, UC-5.2.7	FR 2.1.4
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FR 2.1.7	UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6	Verified	Verified	Acc. Doc. 3.2
Task Completion Indication	UT-001-UT-004, IT-001, ST-001	FR 2.1.7	FR 2.1.6	UC-5.2. 1, UC-5.2. 4,
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Retry Mechanism (no penalty)	UT-001-UT-004	Verified	Verified	
Acc. Doc. 3.1.1-3.1.4	Verified	FR 2.1.8	FR 2.1.7	Acc. Doc. 3.1.1-3.1.4,
UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	FR 2.1.9	Retry Mechanism (no penalty)	Task Completion Indication	4.2.1
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Narrative Context	Verified	UT-001-UT-004	UT-001-UT-004	UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6
Acc. Doc. 3.2	Game Restart/Quit	Verified	UT-001-UT-004, IT-001, ST-001	UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6
UC-5.2.1, UC-5.2.4	Acc. Doc. 3.2	FR 2.1.9	UT-001-UT-004, IT-001, ST-001	IT-A01, IT-A02, UI-002
UC-5.2.8	UC-5.2.8	Narrative Context	UT-001-UT-004, IT-001, ST-001	IT-A01, IT-A02, UI-002
ST-001	UT-102, ST-001	Acc. Doc. 3.2	Verified	Verified
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Verified	UC-5.2.8	UC-5.2.8	UT-001-UT-004	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6
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	Verified			UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6

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Verified	Visual Design (cohesive assets)	NFR 2.2.4	Verified	Verified
NFR 2.2.3	Acc. Doc. 4.2.1	Acc. Doc. 4.2.1	NFR 2.2.1	FR 2.1.8
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UI-001		UI-001 Verified NFR 2.2.5	PT-001 Verified NFR 2.2.3	Narrati ve Contex t
Verified		UI-001 Verified NFR 2.2.5	Performance (FPS, memory)	Acc. Doc. 3.2
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		UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8	Verified	NFR 2.2.1
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		Accessibilit y (contrast, layouts)		UC-5.2. 1, UC-5.2. 2,
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				Acc. Doc. 4.2.1
				UC-5.2. 1,

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Verified	Verified	Verified		
NFR 2.2.5	NFR 2.2.5	NFR 2.2.3		
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		UI-001	Acc. Doc.	
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		Accessibilit y (contrast, layouts)		1, UC-5.2. 2, UC-5.2. 3,
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		UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8		5, UC-5.2. 6, UC-5.2. 8
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				layouts) Acc. Doc. 4.2.1, 4.2.2 UC-5.2. 1, UC-5.2. 2, UC-5.2. 3, UC-5.2. 4, UC-5.2. 5, UC-5.2. 6, UC-5.2. 7, UC-5.2. 8 UI-001, ER-001, ER-002, ER-003 Verified
Requirement ID (from Req. Doc.) Description Acceptance Criteria (from Acc. Doc.)	Requirement ID (from Req. Doc.) Description Acceptance Criteria (from Acc. Doc.)	Requirement ID (from Req. Doc.) Description Acceptance Criteria (from Acc. Doc.)	Requirement ID (from Req. Doc.) Description Acceptanc e Criteria (from Acc. Doc.)	Requirement ID (from Req. Doc.) Description Acceptanc e Criteria (from Acc. Doc.)

Related Use Cases (from Req. Doc.)	Acceptance Criteria (from Acc. Doc.)			
Test Cases (This Doc)				
Status	Status	Status	Status	Related Use Cases (from Req. Doc.)
FR 2.1.1	FR 2.1.1	FR 2.1.1	FR 2.1.1	
Arithmetic Puzzles (Add/Sub)				
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Fruit Sorting Task	Fruit Sorting Task	Fruit Sorting Task	Fruit Sorting Task	
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UT-002, IT-002, ST-001	UT-002, IT-002, ST-001	UT-002, IT-002, ST-001	UT-002, IT-002, ST-001	
Verified	Verified	Verified	Verified	
FR 2.1.3	FR 2.1.3	FR 2.1.3	FR 2.1.3	
Letter-Color Matching Task	Letter-Color Matching Task	Letter-Color Matching Task	Letter-Color Matching Task	
Acc. Doc. 3.1.3	Acc. Doc. 3.1.3	Acc. Doc. 3.1.3	Acc. Doc. 3.1.3	

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UT-003, IT-002, ST-001	Verified	UT-003, IT-002, ST-001	Letter-Color Matching Task	Verified
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IT-001, ST-001	Verified	IT-001, ST-001	Level Progression	UT-002, IT-002, ST-001
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Immediate Feedback	Acc. Doc. 3.1.1-3.1.4, 4.2.1	FR 2.1.5	FR 2.1.3	FR 2.1.3
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Points Tracking	UT-101, UT-102, IT-002, ST-001	UT-101, UT-102, IT-002, ST-001	UC-5.2.2, UC-5.2.3,	

UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	Verified	Acc. Doc. 3.3.1	UC-5.2.5, UC-5.2.6, UC-5.2.7	Verified
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Acc. Doc. 3.1.1-3.1.4, 3.2	UT-001-UT-004, IT-001, ST-001	FR 2.1.7 Task Completion Indication	Points Tracking	UC-5.2. 1, UC-5.2. 4, UC-5.2. 8
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Verified	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	UT-001-UT-004, IT-001, ST-001	Verified	Immedi ate Feedba ck
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Verified	Verified			

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UC-5.2.1, UC-5.2.4	UC-5.2.8	Acc. Doc. 3.2	FR 2.1.8	IT-A01, IT-A02, UI-002
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Verified	Verified	ST-001		FR 2.1.6
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Acc. Doc. 3.2	Acc. Doc. 4.2.1	Game Restart/Quit	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	Acc. Doc. 3.3.1
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Verified	Verified	UC-5.2.5, UC-5.2.6, UC-5.2.8	Verified	FR 2.1.7
NFR 2.2.2	NFR 2.2.3	UI-001, UI-002	FR 2.1.10	Task Completion

Responsiveness (feedback lag)	Performance (FPS, memory)	NFR 2.2.2	Game Restart/Qui t	Indicati on
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Verified	Verified	PT-001	Verified	Usability (intuitive UI)
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Requirement ID (from Req. Doc.)	Requirement ID (from Req. Doc.)	Requirement ID (from Req. Doc.)	Requirement ID (from Req. Doc.)	Requirement ID (from Req. Doc.)
Description	Description	Description	Description	Description
Acceptance Criteria (from Acc. Doc.)	Acceptance Criteria (from Acc. Doc.)	Acceptance Criteria (from Acc. Doc.)	Acceptanc e Criteria (from Acc. Doc.)	Description
Related Use Cases (from Req. Doc.)	Related Use Cases (from Req. Doc.)	Related Use Cases (from Req. Doc.)	Related Use Cases (from Req. Doc.)	Accept ance Criteria (from Acc. Doc.)
Test Cases (This Doc)	Test Cases (This Doc)	Test Cases (This Doc)	Test Cases (This Doc)	Accept ance Criteria (from Acc. Doc.)
Status	Status	Status	Test Cases (This Doc)	Related Use Cases (from Req. Doc.)
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Requirement ID (from Req. Doc.) Description Acceptance Criteria (from Acc. Doc.)	Requirement ID (from Req. Doc.) Description Acceptance Criteria (from Acc. Doc.)	Requirement ID (from Req. Doc.) Description Acceptance Criteria (from Acc. Doc.)	Requirement ID (from Req. Doc.) Description Acceptanc e Criteria (from Acc. Doc.)	Requirement ID (from Req. Doc.) Description Acceptanc e Criteria (from Acc. Doc.)

Related Use Cases (from Req. Doc.)	Acceptance Criteria (from Acc. Doc.)			
Test Cases (This Doc)				
Status	Status	Status	Status	Related Use Cases (from Req. Doc.)
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Description	Description	Description	Description	Description
Acceptance Criteria (from Acc. Doc.)	Acceptance Criteria (from Acc. Doc.)	Acceptance Criteria (from Acc. Doc.)	Acceptanc e Criteria (from Acc. Doc.)	Description
Related Use Cases (from Req. Doc.)	Related Use Cases (from Req. Doc.)	Related Use Cases (from Req. Doc.)	Related Use Cases (from Req. Doc.)	Accept ance Criteria (from Acc. Doc.)
Test Cases (This Doc)	Test Cases (This Doc)	Test Cases (This Doc)	Test Cases (This Doc)	Accept ance Criteria (from Acc. Doc.)
Status	Status	Status	Test Cases (This Doc)	Related Use Cases (from Req. Doc.)
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Test Cases (This Doc)				
Status	Status	Status	Status	Related Use Cases (from Req. Doc.)
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Related Use Cases (from Req. Doc.)	Related Use Cases (from Req. Doc.)	Related Use Cases (from Req. Doc.)	Related Use Cases (from Req. Doc.)	Accept ance Criteria (from Acc. Doc.)
Test Cases (This Doc)	Test Cases (This Doc)	Test Cases (This Doc)	Test Cases (This Doc)	Accept ance Criteria (from Acc. Doc.)
Status	Status	Status	Test Cases (This Doc)	Related Use Cases (from Req. Doc.)
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UC-5.2.5	Verified	UC-5.2.5	Letter-Color Matching Task	FR 2.1.2
UT-003, IT-002, ST-001	FR 2.1.4	UT-003, IT-002, ST-001	Acc. Doc. 3.2	FR 2.1.2
Verified	Level Progression	Verified	FR 2.1.4	
FR 2.1.4	Acc. Doc. 3.2	FR 2.1.4		

Level Progression	UC-5.2.1, UC-5.2.4, UC-5.2.8	Level Progression	Acc. Doc. 3.1.3	Fruit Sorting Task
Acc. Doc. 3.2	IT-001, ST-001	Acc. Doc. 3.2	UC-5.2.5	
UC-5.2.1, UC-5.2.4, UC-5.2.8	Verified	UC-5.2.1, UC-5.2.4, UC-5.2.8	UT-003, IT-002, ST-001	Acc. Doc. 3.1.2
IT-001, ST-001	FR 2.1.5	FR 2.1.5		UC-5.2. 3
Verified	Immediate Feedback	IT-001, ST-001	Verified	
FR 2.1.5	Acc. Doc. 3.1.1-3.1.4, 4.2.1	Verified	FR 2.1.4	UT-002, IT-002, ST-001
Immediate Feedback	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6, UC-5.2.7	FR 2.1.5	Level Progression	
Acc. Doc. 3.1.1-3.1.4, 4.2.1	UC-5.2.7	Immediate Feedback		Verified
UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6, UC-5.2.7	IT-A01, IT-A02, UI-002	Acc. Doc. 3.1.1-3.1.4, 4.2.1	Acc. Doc. 3.2	FR 2.1.3
IT-A01, IT-A02, UI-002	Verified	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6, UC-5.2.7	UC-5.2.1, UC-5.2.4, UC-5.2.8	Letter- Color Matchi ng Task
Verified	FR 2.1.6	IT-001, ST-001		
Points Tracking	IT-A01, IT-A02, UI-002	IT-A01, IT-A02, UI-002	Verified	Acc. Doc. 3.1.3
FR 2.1.6	Acc. Doc. 3.3.1	FR 2.1.5		
Points Tracking	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	Verified	Immediate Feedback	UC-5.2. 5
Acc. Doc. 3.3.1	UT-101, UT-102, IT-002, ST-001	FR 2.1.6		UT-003, IT-002, ST-001
UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	Task Completion Indication	Points Tracking	Acc. Doc. 3.1.1-3.1.4, 4.2.1	
UT-101, UT-102, IT-002, ST-001	Verified	Acc. Doc. 3.3.1		Verified
FR 2.1.7	FR 2.1.6	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6, UC-5.2.7	FR 2.1.4
Task Completion Indication	Acc. Doc. 3.1.1-3.1.4, 3.2	UT-101, UT-102, IT-002, ST-001	UT-101, UT-102, IT-002, ST-001	Level Progre ssion

Verified FR 2.1.7	UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6	Verified FR 2.1.7	IT-A01, IT-A02, UI-002	Acc. Doc. 3.2
Task Completion Indication	UT-001-UT-004, IT-001, ST-001	Task Completion Indication	Verified FR 2.1.6	UC-5.2. 1, UC-5.2.
Acc. Doc. 3.1.1-3.1.4, 3.2	Verified FR 2.1.8	Acc. Doc. 3.1.1-3.1.4, 3.2	Points Tracking	4, UC-5.2. 8
UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6	Retry Mechanism (no penalty)	UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6	Acc. Doc. 3.3.1	IT-001, ST-001
UT-001-UT-004, IT-001, ST-001	Acc. Doc. 3.1.1-3.1.4	UC-5.2.2, UC-5.2.3, UC-5.2.6	UC-5.2.2, UC-5.2.3, UC-5.2.6	Verified FR 2.1.5
Verified FR 2.1.8	UT-001-UT-004	Verified FR 2.1.8	UT-101, UT-102, IT-002, ST-001	Immedi ate Feedba ck
Retry Mechanism (no penalty)	FR 2.1.9	Retry Mechanism (no penalty)	Verified	Acc. Doc.
Acc. Doc. 3.1.1-3.1.4	Narrative Context	Acc. Doc. 3.1.1-3.1.4	FR 2.1.7	3.1.1-3.
UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	Acc. Doc. 3.2	UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6	Task Completion Indication	1.4, 4.2.1
UT-001-UT-004	UC-5.2.1, UC-5.2.4	ST-001	Acc. Doc. 3.1.1-3.1.4, 3.2	UC-5.2. 2, UC-5.2.
Verified FR 2.1.9	FR 2.1.10	UT-001-UT-004	FR 2.1.9	3, UC-5.2. 5, UC-5.2.
Narrative Context	Game Restart/Quit	Acc. Doc. 3.2	Narrative Context	6, UC-5.2. 7
Acc. Doc. 3.2	UC-5.2.8	UC-102, ST-001	Acc. Doc. 3.2	IT-A01, IT-A02, UI-002
			UT-001-UT-004, IT-001, ST-001	

UC-5.2.1, UC-5.2.4	Verified NFR 2.2.1 Usability (intuitive UI)	UC-5.2.1, UC-5.2.4 ST-001 Verified FR 2.1.10 Game Restart/Quit Acc. Doc. 3.2 UC-5.2.8 UT-102, ST-001 Verified NFR 2.2.2 Usability (intuitive UI) Acc. Doc. 4.2.1 UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8 PT-001 Verified NFR 2.2.3 UI-001, UI-002 Verified NFR 2.2.2 Responsiveness (feedback lag) Acc. Doc. 4.1.1	UC-5.2.1, UC-5.2.4 ST-001 Verified FR 2.1.10 Game Restart/Quit Acc. Doc. 3.2 UC-5.2.8 UT-102, ST-001 Verified NFR 2.2.1 Usability (intuitive UI) Acc. Doc. 4.2.1 UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8 PT-001 Verified NFR 2.2.3 UI-001, UI-002 Verified NFR 2.2.2 Responsiveness (feedback lag) Acc. Doc. 4.1.1	Verified FR 2.1.8 Retry Mechanism (no penalty) Acc. Doc. 3.1.1-3.1.4 UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6 UT-001-UT-004 Verified FR 2.1.9 Narrative Context Acc. Doc. 3.2 UC-5.2.1, UC-5.2.4 ST-001 Verified Game Restart/Quit Acc. Doc. 3.2 FR 2.1.8 Points Tracking Acc. Doc. 3.3.1 UC-5.2.2, UC-5.2.3, UC-5.2.5, UC-5.2.6 UT-101, UT-102, IT-002, ST-001 FR 2.1.7 Task Completion Indication Acc. Doc. 3.1.1-3.1.4, 3.2 UC-5.2.2,
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UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8	PT-002, ST-002 Verified NFR 2.2.4 Visual Design (cohesive assets)	UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8	UC-5.2.8 UT-102, ST-001 Verified NFR 2.2.1	UC-5.2. 3, UC-5.2. 4, UC-5.2. 5, UC-5.2. 6
PT-001 Verified NFR 2.2.3 Performance (FPS, memory) Acc. Doc. 4.1.2 UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8	Acc. Doc. 4.2.1 UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8 UI-001 Verified NFR 2.2.5 Accessibility (contrast, layouts) Acc. Doc. 4.2.1, 4.2.2 UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8	PT-001 Verified NFR 2.2.3 Performance (FPS, memory) Acc. Doc. 4.1.2 UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8 UI-001 Verified NFR 2.2.5 Accessibility (contrast, layouts) Acc. Doc. 4.2.1, 4.2.2 UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8	Usability (intuitive UI) Acc. Doc. 4.2.1 UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8 UI-001, UI-002 Verified NFR 2.2.2 Responsive ness (feedback lag) Acc. Doc. 4.1.1 UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6,	UT-001- UT-004, IT-001, ST-001 Verified FR 2.1.8 Retry Mecha nism (no penalty) Acc. Doc. 3.1.1-3. 1.4 UC-5.2. 2, UC-5.2. 3, UC-5.2. 5, UC-5.2. 6 UT-001- UT-004 Verified
PT-002, ST-002 Verified NFR 2.2.4 Visual Design (cohesive assets) Acc. Doc. 4.2.1 UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5,	PT-002, ST-002 Verified NFR 2.2.4 Visual Design (cohesive assets) Acc. Doc. 4.2.1 UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5,	PT-002, ST-002 Verified NFR 2.2.4 Visual Design (cohesive assets) Acc. Doc. 4.2.1 UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5,	NFR 2.2.2 Responsive ness (feedback lag) Acc. Doc. 4.1.1 UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6,	UC-5.2. 2, UC-5.2. 3, UC-5.2. 5, UC-5.2. 6 UT-001- UT-004 Verified

UC-5.2.6, UC-5.2.8		UC-5.2.6, UC-5.2.8	UC-5.2.7, UC-5.2.8	FR 2.1.9
UI-001	UI-001	PT-001	Narrati ve Contex t	
Verified	Verified	Verified		
NFR 2.2.5	NFR 2.2.5	NFR 2.2.3		
Accessibility (contrast, layouts)	Accessibility (contrast, layouts)	Performan ce (FPS, memory)	Acc. Doc. 3.2	
Acc. Doc. 4.2.1, 4.2.2	Acc. Doc. 4.2.1, 4.2.2	Acc. Doc. 4.1.2	UC-5.2. 1, UC-5.2. 4	
UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8	UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8	UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.8	ST-001	
UI-001, ER-001, ER-002, ER-003	UI-001, ER-001, ER-002, ER-003	PT-002, ST-002	Game Restart /Quit	
Verified	Verified	Verified	Acc. Doc. 3.2	
		NFR 2.2.4	UC-5.2. 8	
		Visual Design (cohesive assets)	UT-102, ST-001	
		Acc. Doc. 4.2.1	Verified	
		UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5,	NFR 2.2.1	
			Usabilit y	

			UC-5.2.6, UC-5.2.8	(intuitiv e UI)
		UI-001	Acc. Doc.	
		Verified	4.2.1	
		NFR 2.2.5		UC-5.2.
		Accessibilit y (contrast, layouts)		1, UC-5.2. 2, UC-5.2. 3,
		Acc. Doc. 4.2.1, 4.2.2		UC-5.2. 4, UC-5.2.
		UC-5.2.1, UC-5.2.2, UC-5.2.3, UC-5.2.4, UC-5.2.5, UC-5.2.6, UC-5.2.7, UC-5.2.8		5, UC-5.2. 6, UC-5.2. 8
		UI-001, ER-001, ER-002, ER-003	UI-001, UI-002	
		Verified	Verified	NFR 2.2.2
			Respon sivenes s (feedba ck lag)	
			Acc. Doc.	
			4.1.1	
				UC-5.2.
				1, UC-5.2. 2, UC-5.2.

					3, UC-5.2. 4, UC-5.2. 5, UC-5.2. 6, UC-5.2. 7, UC-5.2. 8
				PT-001	
			Verified		
			NFR 2.2.3		
			Perfor mance (FPS, memor y)		
			Acc. Doc. 4.1.2		
			UC-5.2. 1, UC-5.2. 2, UC-5.2. 3, UC-5.2. 4, UC-5.2. 5, UC-5.2. 6, UC-5.2. 8		

				PT-002, ST-002 Verified NFR 2.2.4 Visual Design (cohesive assets) Acc. Doc. 4.2.1 UC-5.2. 1, UC-5.2. 2, UC-5.2. 3, UC-5.2. 4, UC-5.2. 5, UC-5.2. 6, UC-5.2. 8 UI-001 Verified NFR 2.2.5 Access ibility (contra st,
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				layouts) Acc. Doc. 4.2.1, 4.2.2 UC-5.2. 1, UC-5.2. 2, UC-5.2. 3, UC-5.2. 4, UC-5.2. 5, UC-5.2. 6, UC-5.2. 7, UC-5.2. 8 UI-001, ER-001, ER-002, ER-003 Verified
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7.0 TEST ENVIRONMENT SETUP

7.1 Environment Configuration

- **Hardware Requirements:**
 - Minimum: 4GB RAM, 2GHz dual-core processor, 80MB storage.
 - Recommended: 8GB RAM, 3GHz quad-core processor, 200MB storage.
- **Graphics:** DirectX 11 compatible graphics card.
- **Software Setup:**
 - Godot Engine 4.x (exact version matching development: Godot 4.1.1 Stable).

- Clean OS installation (Windows 10, macOS 10.15+, Ubuntu 18.04+) for baseline testing.
- No additional third-party software that might interfere with game execution.
- Godot Debugger and console configured for logging and profiling during test runs.

7.2 Test Data Management

- **Test Assets:**
 - Standard game assets (PNGs for characters, fruits, UI; MP3s for audio) as included in the assets/ folder.
 - Sample puzzle configurations for various difficulty levels (for example, pre-defined addition/subtraction problems if not random).
 - Test save files for different game states (N/A for this project as there is no persistent save/load).
 - Performance test scenarios (for example, repeatedly loading scenes, rapid interaction sequences).
 - Error condition simulation data (for example, intentionally corrupted or missing files for error handling tests).
- **Data Reset Procedures:**
 - Clean game installation process for each major test cycle (delete extracted folder, re-extract).
 - GameManager.reset_game_state() used programmatically for resetting in-session progress during test runs.
 - System cache clearing procedures where applicable (for example, browser cache for web exports, although not primary target).
 - Test data backup and restoration protocols (Git repository serves as primary backup for source code and assets).

8.0 APPENDICES

8.1 Appendix A: Test Case Details (Expanded)

This appendix would contain further detailed breakdowns for each test case, including:

- Pre-requisite setup steps for complex tests.
- Specific data inputs (for example, for arithmetic tasks, exact numbers used).
- Screenshots or expected visual outcomes for UI tests.
- Detailed console log expected outputs for error handling tests.

- Pass/Fail criteria for sub-steps within complex test cases.

8.2 Appendix B: Testing Scripts and Automation

This appendix would include:

- Any custom GDScript snippets written specifically for testing individual functions or components (for example, a temporary script to call `GameManager.award_points` directly).
- Instructions for setting up a minimal Godot project to run specific unit tests if applicable.
- Details on how to use Godot's built-in debugger for profiling and monitoring performance.

8.3 Appendix C: Performance Baseline Data

This appendix would contain the collected performance metrics (FPS, memory, CPU) from the final test runs, potentially including:

- Charts showing FPS over time during gameplay.
- Peak and average memory usage for each scene.
- CPU utilization graphs during intense interactions.
- Comparison data against performance criteria.

8.4 Appendix D: Test Environment Setup Guide

This appendix would provide step-by-step instructions for configuring a testing machine to replicate the development environment, including:

- Godot Engine installation steps.
- Required OS versions and dependencies.
- Instructions for cloning the Git repository and setting up the project.
- Any necessary system configurations or troubleshooting tips for common environment issues.