Designing an Interactive Educational Game for Class IV Students of Cahaya Azhari Primary School

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Article Info

ABSTRACT

One of the main problems in mathematics learning at the elementary level, especially in fourth grade, is the low learning motivation of students. *Game-based learning* using interactive media is believed to enhance students' engagement and understanding through appealing visuals and enjoyable game mechanics. This study aims to design and develop an interactive educational game based on GameMaker Studio 2 as a mathematics learning medium for fourth-grade students at SD Cahaya Azhari, aligned with the learning outcomes of the *Merdeka Curriculum*. The research employed the *Research and Development (R&D)* method with stages including needs analysis, design, development, implementation, and evaluation. Research instruments consisted of expert validation, student and teacher response questionnaires, and *pretest–posttest* assessments. Validation results showed an excellent category (material 94.5%, media 96.2%). Student and teacher responses reached 92.8% and 94.1%, respectively. Effectiveness testing indicated an improvement in learning outcomes with an N-Gain value of 0.78 (high category). Thus, the developed educational game is declared feasible and effective as an engaging and interactive mathematics learning medium for fourth-grade students.

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1. INTRODUCTION

The development of information technology has had a significant impact on the field of education, particularly in the delivery of learning materials. One innovation that attracts students' attention is the use of interactive educational games, which not only provide entertainment but also enhance learning motivation and understanding.

At the fourth-grade elementary school level, traditional teaching methods are often less effective because students tend to be more interested in visual and interactive media. This research shows that the use of educational games can significantly increase elementary students' learning motivation [1].

This study employs the Research and Development (R&D) method to develop digital learning media that align with the curriculum and the characteristics of students. SD Cahaya Azhari was selected as the research site due to students' high interest in technology, despite the absence of suitable digital learning media.

By utilizing GameMaker Studio 2, this research aims to design and implement an interactive educational game for fourth-grade students at SD Cahaya Azhari and to evaluate their responses to the developed game.

2. METHOD

This research employs the Research and Development (R&D) method based on the Borg and Gall model, which is suitable for developing technology-based educational products. This method consists of several stages: potential and problems, data collection, product design, design validation, design revision, product testing, product revision, usage testing, and final product.

The R&D model is highly relevant in this context because the main focus of the study is to design and develop an educational game that can be directly implemented in the elementary school environment [2].

2.1 Game

Games are activities with specific rules that involve players for purposes of entertainment, training, or learning. In education, games can be developed into educational games that deliver learning materials in a more engaging and enjoyable way.

Games are potential learning media because they combine entertainment and education (edutainment), allowing students to be more active, focused, and motivated. further explain that educational games can enhance critical thinking, logical reasoning, and problem-solving skills through gameplay challenges [3],[4].

With technological advancements, games have increasingly been developed in digital form, offering visualization, interactivity, and multimedia integration. emphasize that digital games positively influence students' motivation and independence by providing immersive and interactive virtual learning experiences [5].

Overall, digital educational games play a significant role in 21st-century learning. They are not merely entertainment but serve as tools to boost motivation, deepen conceptual understanding, and develop higher-order thinking skills. At the elementary school level, educational games can be adapted to subjects such as mathematics, making the learning process more active, creative, and enjoyable.

2.2 Game Studio Maker

GameMaker Studio 2 is an integrated development environment (IDE) designed for creating 2D games, suitable for both beginners and professionals. It supports multiple platforms (Windows, Android, iOS, HTML5) and offers drag-and-drop features as well as the GameMaker Language (GML), enabling users to design game logic without complex programming skills.

GameMaker Studio 2 is highly suitable for developing educational games due to its user-friendly interface and multimedia integration capabilities (sprites, audio, animations), which are appropriate for elementary students [6]. Note that the drag-and-drop feature allows teachers or novice developers to create structured games quickly [7]. Emphasize that GameMaker Studio 2 is ideal for thematic games because it can combine storytelling, content, and learning visualization into one cohesive experience [8].

2.3 Mode Game

Educational games are designed to provide learning experiences through interactive engagement. educational games are effective in increasing students' interest and understanding, especially at the elementary school level [9].

Mathematics is often perceived as difficult and boring for elementary students. Therefore, a game-based approach can serve as an enjoyable alternative. found that educational games help students understand mathematical concepts through interactive exploration [10].

Also support the use of digital media in mathematics learning, as it encourages students to actively participate in the learning process rather than being passive recipients of information [11].

2.4 Needs Analysis

The research began with a needs analysis through observation and interviews at SD Cahaya Azhari. The results showed that students were more enthusiastic when learning through visual and interactive media.

The game design process included creating user interface (UI) sketches, designing gameplay flow, and selecting educational elements suited to students' age and based on multimedia learning principles.

The game was developed using GameMaker Studio 2 with a drag-and-drop approach and simple scripting, consisting of quizzes, picture-matching, and light adventure games.

A trial test was conducted with 10 fourth-grade students over two learning sessions. Researchers observed student responses and distributed questionnaires. Based on the results, the game was evaluated and revised, particularly in navigation and difficulty levels, to better match students' abilities and learning needs.

2.5 Research Data

The data used in this study were collected through several complementary techniques. First, direct observations were conducted during the teaching and learning process in the fourth-grade classroom at SD Cahaya Azhari to understand the real learning environment. In addition, interviews with classroom teachers were carried out to identify suitable learning materials and the characteristics of students as the end users of the educational game.

Questionnaires were also distributed to students to assess their interest in digital learning media. The school's curriculum documents served as the main reference for designing the educational content included in the game.

This research was further supported by relevant literature on educational game development, elementary-level pedagogy, and multimedia learning. All collected data were used to define system requirements, determine the game's theme and content, and serve as the foundation for evaluating the game's effectiveness as a learning medium [12].

2.6 User Interface Design

The game's user interface (UI) was designed using the Room Editor and Sprite Editor features in GameMaker Studio 2. The UI was created to be child-friendly, featuring bright colors and engaging illustrations suitable for fourth-grade students. Each UI element, such as buttons, text, and icons, was developed using Sprites and Objects.

The interface layout is divided into several Rooms:

Main Menu Room: Displays interactive buttons such as *Start Game* and *Exit*. These buttons are created from responsive sprites that react to clicks.

Gameplay Room: The main area where players answer questions. Question objects display text and images, while answer objects appear as interactive buttons. HUD (Heads-Up Display) elements, such as progress indicators, are managed through separate objects that remain visible on the screen.

Figure 1. Game Desing

2.7 Game and Fllowchard

The player controls the main character who explores a fantasy world with a mathematics theme.
Each level represents a specific topic (for example: the multiplication forest).
To progress in the game, the player must solve math problems presented as mini-games or puzzles.
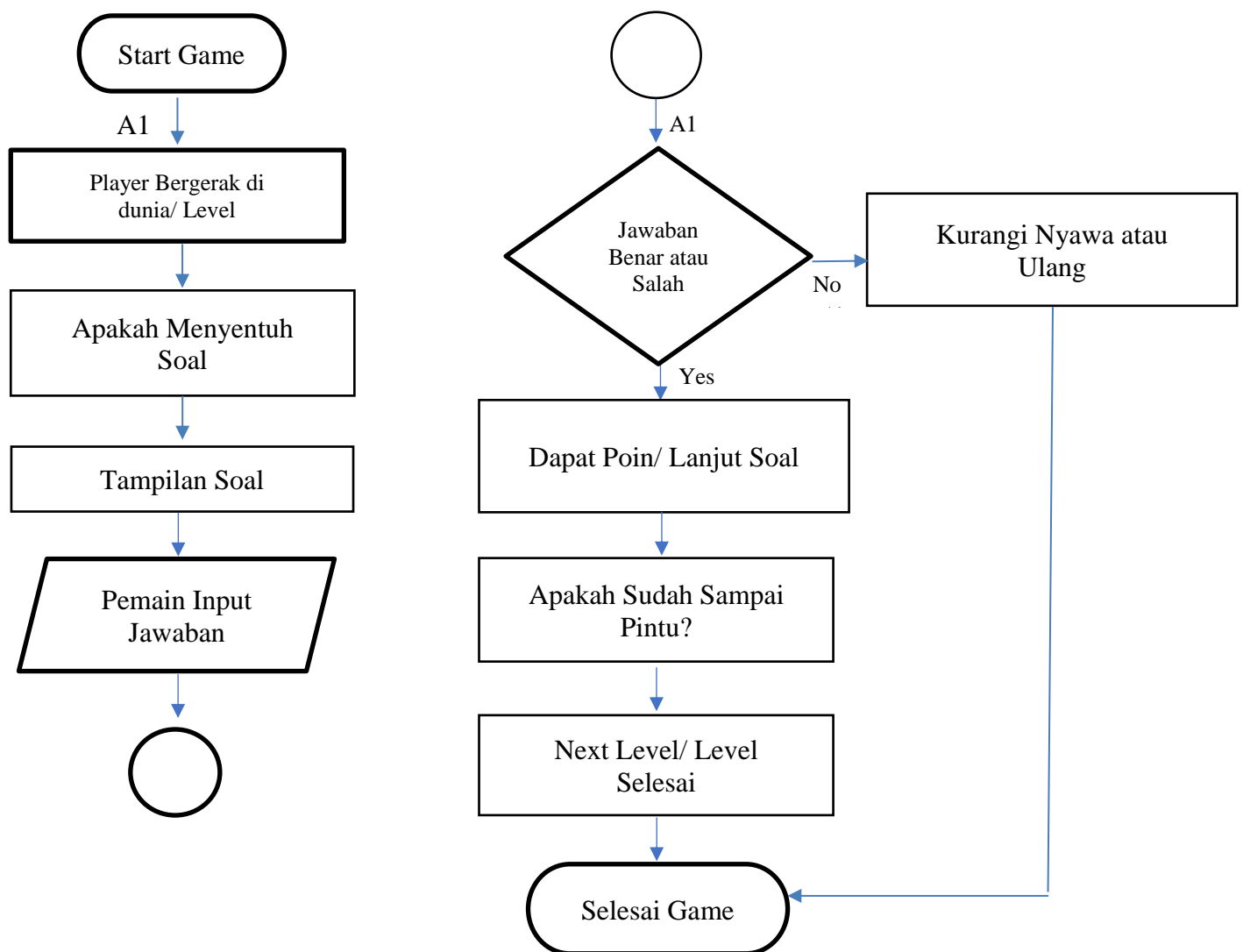As the level increases, the math problems become more complex.

```
Start Game
   │ A1
   ▼
Player Bergerak di
dunia/ Level
   │
   ▼
Apakah Menyentuh
Soal
   │
   ▼
Tampilan Soal
   │
   ▼
Pemain Input
Jawaban
   │
   ▼
  ( )

        A1
         │
         ▼
    Jawaban
    Benar atau  ──No──►  Kurangi Nyawa atau
    Salah                      Ulang
         │                        │
        Yes                       │
         ▼                        │
Dapat Poin/ Lanjut Soal           │
         │                        │
         ▼                        │
Apakah Sudah Sampai               │
       Pintu?                     │
         │                        │
         ▼                        │
Next Level/ Level                 │
    Selesai                       │
         │                        │
         ▼                        │
   Selesai Game  ◄────────────────┘
```

Figure 2. Flowchart

2.8 Game Creation Process

The design of this educational game was developed using Game Maker Studio 2 (GMS2) with its programming language, Game Maker Language (GML). The core logic of the game revolves around a question-and-answer system managed through objects and events. Each learning module, such as Mathematics and Indonesian Language, is handled by separate objects with their own scripts and events. This approach simplifies the management of content and game logic.

For example, the obj_controller object is responsible for loading question and answer data, which can be stored in text files or spreadsheets. In its Create Event, the question data is loaded, while in the Step Event, the program monitors player interactions (such as clicking on answer choices). When a player selects an answer, the Mouse Left Button Event on the answer object triggers a function to check correctness. These structured GML scripts ensure smooth gameplay, from question selection to scoring, in accordance with the design objectives.
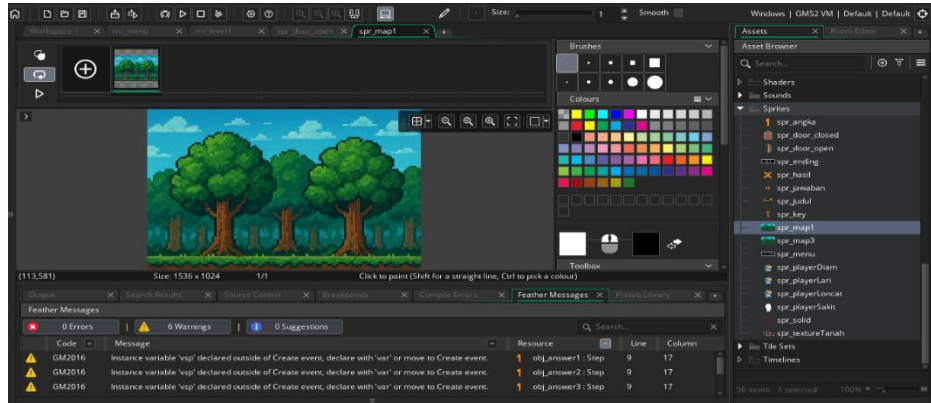
Figure 3. Game Creation Process

Step 4: Math Questions and Answers
Create number sprites and math question objects (obj_soal1, obj_soal2, obj_soal3).
Use Create and Step events to display frames and animations.

Step 5: Objects Touched by Player
Create answer objects (obj_answer1, obj_answer2, obj_answer3) with sprites, scaling, and image speed.
Use Step and Collision events to remove objects when touched and spawn keys for the next level.

Step 6: Time Limit for Questions
Create controller object (obj_controller) to manage countdown using room_speed and time_left variables.
Step event decreases time and triggers events when time runs out.
Draw GUI event displays remaining time on screen.

Step 7: Key Objects
Create key sprite and object (obj_key).
Collision with player sets has_key = true and removes the key from the room.

Step 8: Doors to Next Level
Create door sprite and object (obj_door) with open/close frame events.
Step event opens the door if player has key, changing sprite to door open.

Step 9: Wrong Answer / Trap Objects
Create wrong answer objects (obj_salah1, obj_salah2, obj_salah3).
Collision with player decreases health, triggers hurt animation, and prevents repeated damage.

Step 10: Ending Room
Create ending room (rm_ending) with background and ending objects.
Draw GUI displays "GAME OVER" or "GAME COMPLETED" message.
Add a button to return to menu or exit game with mouse events.

Step 11: Background Sound
Import sound file and create sound object.
In obj_controller Create event, play sound in a loop if it is not already playing.

Step 1: Game Menu

```
// obj_menu - Create Event
menu = 1; // default menu selection
image_speed = 0;

// obj_menu - Step Event
if(menu == 1) image_index = 0;
else if(menu == 2) image_index = 1;
```

```
// obj_menu - Left Released Event
if(mouse_check_button_pressed(mb_left)){
    if(point_in_rectangle(mouse_x, mouse_y, x-50, y-20, x+50, y+20)){
        if(menu == 1) room_goto(rm_level1);
        else if(menu == 2){
            if(show_question("Do you want to exit?")) game_end();
        }
    }
}
```

```
// obj_control_help - Draw Event
draw_set_halign(fa_center);
draw_set_valign(fa_middle);
draw_text(room_width/2, room_height-100, "How to Play:\nUse arrows to move and solve math problems");
```

Step 2: Level Room & Background
```
// rm_level1: Add background sprite (spr_map) in Background Layer
// Add floor objects using obj_solid in Instances layer
```

Step 3: Player Character
```
// obj_player - Create Event
spd = 4; jump_spd = -10; gravity = 0.5;
nyawa = 3; lagiSakit = false; has_key = false;
```

```
// obj_player - Step Event
var hMove = keyboard_check(vk_right) - keyboard_check(vk_left);
x += hMove * spd;
```

```
if(keyboard_check_pressed(vk_up) && place_meeting(x, y+1, obj_solid)){
    gerakY = jump_spd;
}
gerakY += gravity;
if(!place_meeting(x, y+gerakY, obj_solid)) y += gerakY;
else gerakY = 0;
```

```
// Check collision with key
if(place_meeting(x, y, obj_key)){
    has_key = true;
    with(obj_key) instance_destroy();
}
```

```
// Check collision with door
if(place_meeting(x, y, obj_door) && has_key) room_goto_next();
```

```
// Check health
if(nyawa <= 0){
    show_message("GAME OVER!");
    game_restart();
}
```

Step 4: Math Questions
```
// obj_soal1 - Create Event
image_speed = 0;

// obj_soal1 - Step Event
image_index = 0; // example to show first number/frame
```

Step 5: Answer Objects
```
// obj_answer1 - Step Event
if(place_meeting(x, y, obj_player)){
   if(is_correct){
      instance_create_layer(x, y-50, "Instances", obj_key);
   }
   instance_destroy();
}
```

Step 6: Time Limit
```
// obj_controller - Create Event
time_left = room_speed * 30; // 30 seconds

// obj_controller - Step Event
if(time_left > 0) time_left -= 1;
else room_goto(rm_menu);

// obj_controller - Draw GUI Event
draw_set_color(c_white);
draw_text(20, 20, "Time: " + string(ceil(time_left / room_speed)));
```

Step 7: Key Object
```
// obj_key - Collision Event with obj_player
other.has_key = true;
instance_destroy();
```

Step 8: Door Object
```
// obj_door - Step Event
if(instance_exists(obj_player) && obj_player.has_key){
   is_open = true;
   sprite_index = spr_door_open;
}
```

Step 9: Wrong Answer
```
// obj_wrong - Collision Event with obj_player
if(!lagiSakit){
   nyawa -= 1;
   lagiSakit = true;
}
```

Step 10: Ending Room
```
// obj_ending - Draw GUI Event
draw_set_color(c_white);
draw_set_halign(fa_center);
```

55

```
draw_set_valign(fa_middle);
draw_text(320, 140, "GAME COMPLETED!");

// obj_kembaliMenu - Left Released Event
if(kembaliMenu == 1) room_goto(rm_menu);
else if(kembaliMenu == 2){
    if(show_question("Do you want to exit?")) game_end();
}
```

Step 11: Background Sound
```
// obj_controller - Create Event
if(!audio_is_playing(backsound)){
    audio_play_sound(backsound, 1, true);
}
```

2.9 Research Testing

The game was tested using functional testing and user acceptance testing (UAT) involving fourth-grade students at SD Cahaya Azhari. Functional testing aimed to ensure that all game features, such as navigation and the question-and-answer system, functioned correctly without bugs or errors.
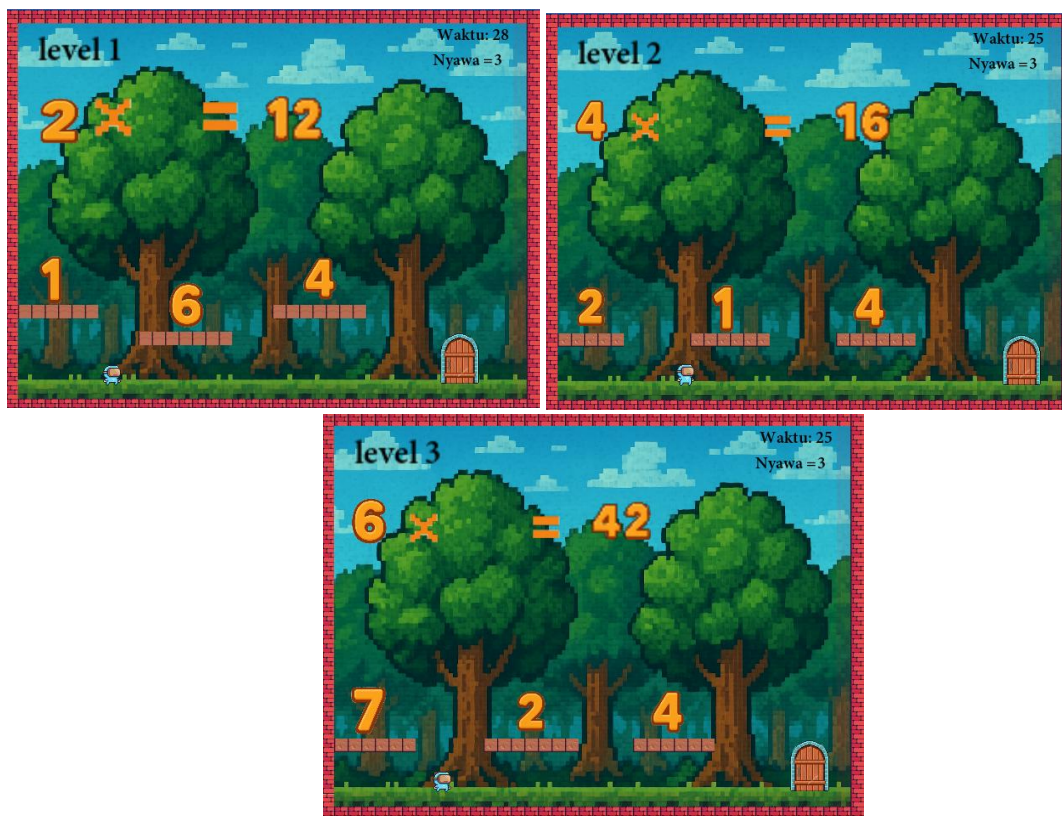
Figure 4.Testing Game

This intuitive interface design is created to ensure that students can use the game easily without confusion, allowing them to focus on the learning process. This design directly supports the thesis objective of creating an effective and enjoyable learning experience.

3.   RESULTS AND DISCUSSION

The test results showed that the game runs smoothly on all tested devices, and all features functioned according to the design.

Next, user testing was conducted by having several fourth-grade students try the game. This testing focused on three main aspects: enjoyment of learning through the game, easier understanding of the material, and willingness to use the game in other subjects.
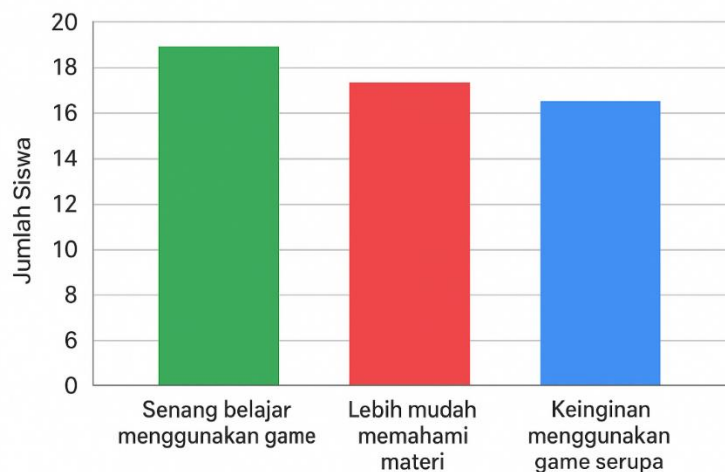

Figure 4. Result

Enjoyment: 90% of students felt happy learning through the game.

Material Understanding: 85% of students reported that they found it easier to understand the material presented in the game.

Willingness to Use in Other Subjects: 80% of students expressed interest in using similar games in other subjects.

This trial demonstrates that the designed math adventure game not only functions well technically but also effectively engages students in learning. These positive results indicate that educational games are a relevant and well-accepted learning medium in the school environment.

4.   CONCLUSION

The study shows that the game is suitable as a learning medium. Material validation reached a very good category, and the media aspect was also rated very good, indicating that both content and design meet educational standards.

Student and teacher responses were highly positive. Students felt more motivated, enthusiastic, and engaged while learning mathematics through the game. Teachers noted that the game made delivering material more interesting and facilitated practice exercises.

Effectiveness testing showed an improvement in student learning outcomes. The N-Gain scores were in the high category, indicating that this interactive educational game effectively enhances understanding of mathematical concepts, particularly basic number operations.

In conclusion, the interactive educational game developed using GameMaker Studio 2 is both feasible and effective as an alternative learning medium for fourth-grade students at SD Cahaya Azhari.

4.1   Recommendations

For Teachers: Teachers can use this game as an additional medium in teaching mathematics, particularly on basic number operations. It is recommended that teachers guide students while using the game to ensure proper understanding of concepts.

For Students: Students are encouraged to use the game not only for entertainment but also as a tool to practice and reinforce mathematical understanding. Regular use of the game can improve retention of multiplication and division concepts.

For Future Researchers: The game is currently limited to basic number operations, so it can be further developed for other mathematics topics. It can also be expanded to platforms such as Android or web-based

applications to make it more accessible outside the school environment. Future research could include automatic evaluation features and analytics to track students' learning progress in more detail.

5.   ACKNOWLEDGEMENTS

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