Memory Game: An Innovative Approach to Foreign Language Education with Mobile Technology

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Abstract **– Learning vocabulary units can be one of the most challenging activities for students, especially when a foreign language is involved. Modern children are motivated to actively participate in the learning process when using information and communication technologies. According to studies, playing games improves children's concentration, visual memory, analytical thinking, and algorithmic thinking and coding skills. The purpose of the presented study is to develop a mobile game application "My Memory" designed to assist students in memorizing English lexical items, through interaction with a programmable device. The mobile app was developed using Unity IDE and Botley® robot under experimental design conditions.**

Incorporating the developed app will improve students' motivation, vocabulary acquisition, algorithmic thinking, linguistic and cognitive development at an early stage of education.

Keywords **– Mobile technologies, coding, memory games, gamification, foreign language education, Unity Engine.**

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1. Introduction

Coding has become a familiar part of children's lives worldwide. Children should be introduced to programming in ways that suit their developmental stage and make the experience genuinely enjoyable. Although the word "coding" is still fairly new in early-childhood education, young children already encounter and apply algorithms in everyday routines-for example, when they master tying their shoelaces by following a precise series of steps. These daily routines represent the required coding principles to follow or determine a step-by-step task completion procedure [1]. Over the past decade, interest in using computational thinking as a foundation for developing creative problem-solving and spatial thinking skills has increased significantly [2].

Recently, computational thinking and coding fields have been identified as essential 21st-century skills for computer professionals and all individuals [3]. Coding has become a modern form of literacy. Children who acquire coding skills early will be prepared not only to take part in the economy, but also to speak up and be heard as active citizens [4]. Coding ensures the appearance of new ways of thinking and expressing new ideas [5].

In the early-childhood years, the educational pay-offs of coding-improvements in maths skills and problem-solving, for instance-tend to be less immediately visible than gains in areas like language, reasoning, and social understanding [6]. These results broaden the still-limited research on coding's cognitive effects by clarifying the benefits of weaving computational thinking into the early-years curriculum [7].

Learning through games is not a new concept in education [8]. Creative teaching is a powerful way to motivate children and guide them toward meaningful, productive learning [9].

Children seem to possess an innate curiosity about coding, and when they are placed in environments that nurture this interest, they become genuinely happy and engaged [10], [11]. Teaching coding to young kids should be integrated into their daily activities and routines. This includes using games, puzzles, and hands-on activities to help children understand the basic concepts of coding [1]. Puzzles related to coding require children to apply visualization skills, spatial reasoning, and problem-solving thinking to analyze codes and see what the coded game or activity will do. The results of this learning practice improve children's working memory and problem-solving abilities [2].

Moreover, coding games can create an especially fertile setting for dynamic parent-child interaction, giving parents a chance to nurture their children's dimensional thinking [12]. Digital games have taken an important place in people's lives due to evolving gaming technologies [13]. Intellectual games can meaningfully shape children's growth in cognitive, emotional, and social domains [14].

Considering the characteristics and capabilities of educational computer games to improve and make education effective for modern students, it seems that one of these methods is the use of educational games as an effective strategy in learning systems [15]. Numerous studies have documented that playing video and board games can bolster a range of cognitive abilities [16].

Of all educational stages, primary school is viewed as the ideal setting for integrating digital learning games [17]. A wide array of games has been created expressly to boost memory capacity [18]. Gamification works as an enhancement for students to help increase teacher-student and student-student interaction. It is an effective educational strategy to promote student attention and engagement [19], [20].

The dynamic games used in class are meant to spark students' thinking, focus, memory, and creativity in a playful atmosphere where no one fears having their ideas dismissed. Every attempt to invent new dynamic games is welcomed, rewarded, and encouraged [21].

Computer games are now widely employed to train cognitive skills such as working memory and attention. Although most training titles fine-tune difficulty, offer rewards, and use appealing visual themes to boost engagement and effectiveness, researchers have yet to study—in a systematic way—how varying degrees of player control over these features influence training outcomes [22]. Memory games offer an enjoyable yet effective way to strengthen memory, focusing particularly on sharpening children's visual recall skills [23]. Digital games often channel learning into playful distractions and can lessen the cognitive effort required for problem-solving.

In contrast, analogue memory games remain squarely on task, cultivating children's mnemonic skills and strategies without diverting their attention [24].

The classic memory-matching card game is a beloved pastime enjoyed by people of all ages around the globe [25] This traditional card-matching game, renowned for sharpening short-term memory, is familiar worldwide under names such as Pexeso, Pelmanism, Shinkei-suijaku, Pairs, and Concentration [26]. It is possible to choose from a variety of options and the number of pairs of cards can also vary. In a game used by young children, the number of playing cards is usually limited (e.g., six pairs of cards), whereas in games for teenagers and adults, the number of cards is usually much greater (e.g., 32 pairs of cards) [27]. Another advantage lies in the memory game's broad appeal: It is equally popular with both boys and girls [28]. Card games further encourage learners to actively interact and collaborate with others as well as learn to find effective solutions to any problem they are faced with [29].

Video game training has been studied extensively in recent years for its effects on cognitive functions, specifically visual working memory, attention, and executive function. Numerous studies have shown that such treatments are beneficial for people of all ages [30]. Thoughtful game design is vital: It should entice students to play willingly and leave them eager to return [17].

A memory card game can also help motivate young students to learn vocabulary. Competition is a strong motivator for younger pupils. The urge to out-perform their classmates draws them into the game, sparks enthusiasm, and keeps them engaged, because they naturally want their team to come out on top. As they play, they have fun and genuinely enjoy the experience [31]. Because memory capacity varies from one individual to another, teachers should spark students' interest in new vocabulary so that the words are more readily stored in long-term memory [32].

Like every other sphere of human activity, foreign-language education today has been profoundly shaped by the latest advances in information and communication technologies [33]. Mobile learning is rapidly becoming a central pillar of education: It offers a remarkable opportunity and a significant leap forward that deserves active support—especially because of the advantages it brings to language learning [34]. Nowadays, studying a foreign language with the assistance of information technology looks relevant [35].

The main objective of this article is to propose a memory game mobile application that will help students memorize new words in English and beyond.

2. Technologies

The following software programs were used to develop the mobile memory game:

- *Unity Engine* version 2022.3.19f1 - Used to develop the memory game mobile application. It is popular for building multiplatform 2D and 3D games and interactive content [36].
- *Visual Studio* version 2022 - Used as an integrated development environment (IDE) for the Unity and C# programming language [37].
- Canva - A free online graphic design tool used to edit photos generated for this mobile application [38].
- *ShareX v*ersion 16.1.0.0 – A free and open-source program used for capturing screenshots of the visuals in the game [39].
- *Botley® The Coding Robot* is a small cubic robot with two side wheels and LED lights. Children can use it to create step-by-step coding [40].

3. Mobile Application Developing

The developed mobile application is like a game named "My Memory". It is an interactive and captivating Unity-based project designed to enhance players' memory and attention skills through an immersive gameplay experience.

To implement the idea, the 4th grade in primary education in Bulgaria was chosen because this is the stage at which students are introduced to programmable devices. In addition, they have enough vocabulary items to memorize in the subject of English. The combination of working with programmable devices and the memory game aims to help students memorize new vocabulary items and improve their logical and algorithmic thinking.

Students at this stage have enough vocabulary units to learn English, and the combination of work with programmable devices and a game of the "memory game" type aims to support the memorization of new vocabulary and to improve their logical and algorithmic thinking.

For this purpose, an electronic application was developed, a memory game that can be used both on a computer and on portable or mobile devices. In addition, a cardboard panel was made with the same number of squares as those in the application, with suitable dimensions corresponding to one step of the programmable device. The game aims to move the robot to the corresponding square on the paper panel when a selected square is opened in the memory game (on the computer/ phone/ tablet screen). In this case, the student must do everything in one attempt, with one sequence of commands - or in other words, it has to create the correct algorithm before sending everything to the robot.

The project centers around a unique memory game concept, challenging players to test their ability to recall and match various elements within a given time frame. In the developed app, players are presented with a grid of cards, each containing distinct visual elements. The objective is to uncover and match pairs of cards by flipping them over, relying on their memory and concentration to remember the positions of different cards. The game offers an engaging and visually appealing interface, captivating players and encouraging them to delve into the exciting world of memory challenges. Through the seamless integration of various scripts, "My Memory" efficiently manages the gameplay mechanics, user interface, and audio elements.

The GameControl script handles card creation, matching logic, and overall game progression. The HomePageControl script governs the main menu functionality, allowing players to start the game or exit the application. The SoundControl script ensures a cohesive and immersive audio experience throughout the game.

3.1. Conceptual Model

The application "My Memory" is a Unity Engine-based game designed to enhance players' memory and cognitive skills, while also providing educational value. The game introduces children to various objects and their corresponding names in English as they progress through different levels. Each level focuses on a specific category of objects, with 10 objects to be matched in each level (Table 1). The key additions to the conceptual model are as follows:

Object Learning: Each level of the game aims to teach children about different categories of objects and their names. The first level introduces the food category, where each card contains an image of a food item along with its name written in English.

Progressive Levels: The game follows a progressive learning approach. After completing the food level, players advance to the second level, which focuses on the furniture category. Similarly, the third level introduces the fashion category.

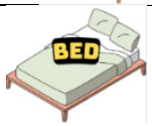
Object Recognition and Matching: Players need to match pairs of cards with identical objects and their corresponding names. By flipping cards and finding matches, children reinforce their memory of objects and their associated English names.

Educational Value: "My Memory" integrates educational elements into the gameplay, providing a fun and interactive way for children to learn vocabulary and object recognition in English. Each level expands its knowledge and vocabulary by introducing new objects within a specific category.

Cognitive Skills Development: The game exercises children's memory, concentration, and cognitive abilities as they memorize object placements and recall them during gameplay. The progressive difficulty of larger grids and time constraints challenges and enhances their cognitive skills.

Animations: The game incorporates animations to enhance the gameplay experience. The enhanced conceptual model of "My Memory" focuses on combining memory improvement gameplay with educational content, providing an engaging and educational experience for children. By introducing new objects and their English names at each level, the game promotes vocabulary acquisition, object recognition, and cognitive skill development.

Table 1. Examples of objects in each category used in the app

Food	Furniture	Fashion
Bread 	Sofa 	Shirt 
Tuna 	Chest of drawers 	T-shirt 
Cheese 	Armchair 	Blouse 
Butter 	Bookcase 	Sweatshirt 
Olives 	Tv cabinet 	Jacket 
Ham 	Cabinet 	Jeans 
Sweet corn 	Wardrobe 	Tracksuit 
Bacon 	Coffee table 	Dress 
Chicken breast 	Bed 	Skirt 
Eggs 	Table 	Leggings 

The game was developed using Unity Engine [36], a popular game development platform, and C# programming language. The gameplay involves user interactions such as tapping to flip cards and matching pairs, which Unity's touch input system handles. The game also features an animated User Interface and sound effects to make the experience more engaging. The pseudocode of the algorithm of the developed mobile application is presented in Table 2.

The game logic is controlled by various scripts in C#. These scripts manage the game's state, handle user inputs, and control the game's flow, such as starting a new level, handling game-over conditions, and tracking the player's progress. The pseudocode of the developed modules is presented in the following Table 2, Table 3, Table 4, and Table 5.

Table 2. Pseudocode of the algorithm of the mobile application

```
1. Initialize Game:
2. Set up the grid of cards
3.  Shuffle the cards
4.    Set the timer
5. Game Loop:
6.    While the game is running:
7.   Check for user input
8.  If the user selects a card:
9.    Flip the card over
10.   If two cards are selected:
11.       If the cards match:
12.         Mark the pair as matched
13.  Else:
14.     Flip both cards back over
15.          Check if all pairs are matched
16.   If all pairs are matched:
17.      End the level
18.          Update the timer
19.   If the timer reaches zero:
20. End the game and show Game Over
```

Table 3. Pseudocode of the GameControl module

```
1. Initialize GameObject array variable Levels
2. Initialize GameObject array variable FactButtons
3. Initialize GameObject array variable Facts
4. function Start ():
5.   Set Time.timeScale to 1
6.    end function
7. function LevelsClicked ():
8.    for each GameObject obj in FactButtons:
9.       Deactivate obj
10. for i=0 to the value of the player preference variable L_Completed:
11.       Activate Levels[i]
12.    end for
13.    end function
14. function FactsClicked ():
15.    for each GameObject obj in Levels:
16.       Deactivate obj
17. if the value of the player preference variable L_Completed > 1:
18.  for i=0 to the value of the player preference variable PuzzlesCompleted:
19.          Activate FactButtons[i]
20.       end for
21.    end if
22.    end function
23. function PlayLevel (LevelName):
24.   Load the scene specified by LevelName in single mode
25.    end function
26. function EiffelButtonClicked(OpenObj):
27.   Activate OpenObj
28.    end function
29. function Close (CloseObj):
30.   Deactivate CloseObj
31.    end function
32. function Exit ():
33.   Quit the application
34.    end function
```

Table 4. Pseudocode of the HomePageControl module

```
1. Initialize GameObject variable ‘ExitPanel’
2. function Start():
3.    if ‘Time.timeScale’ equals 0:
4.       Set ‘Time.timeScale’ to 1
5.    end function
6. function PlayBtn():
7.    Load the scene with build index 1
8.    end function
9. function ExitGame():
10.   Activate ‘ExitPanel’
11.    end function
12. function Answer(answer):
13.    if ‘answer’ equals "Yes":
14.       Quit the application
15.    else:
16.       Deactivate ‘ExitPanel’
17.    end function
```

Table 5. Pseudocode of the SoundControl module

```
1. Initialize GameObject variable ‘instance’
2. function Awake():
3.   Call ‘DontDestroyOnLoad(gameObject)’ to prevent the game object from being
destroyed when loading a new scene.
4.    If ‘instance’ is null:
5.       Set ‘instance` to ‘gameObject’
6.    Else:
7.       Destroy ‘gameObject’
8.    end function
```

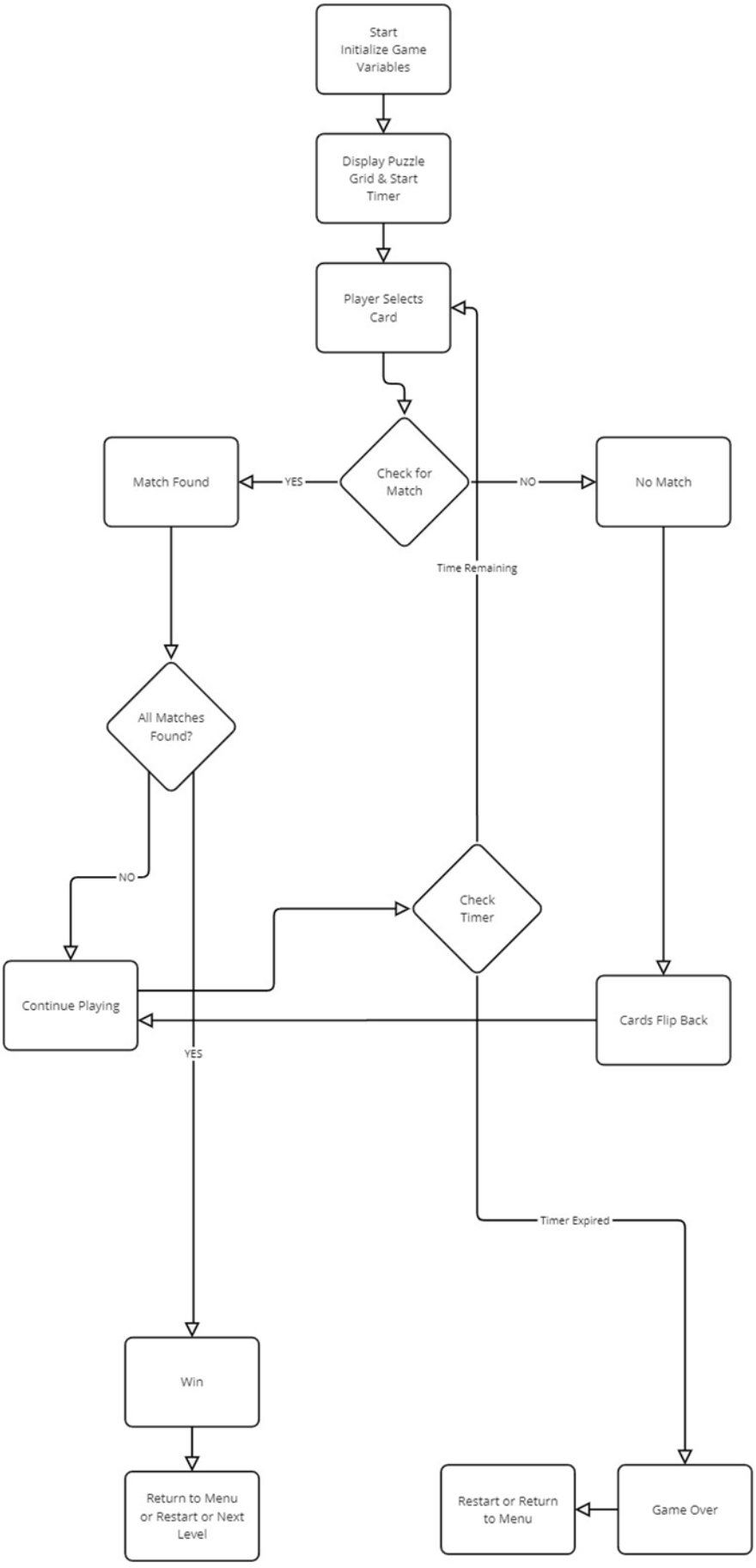
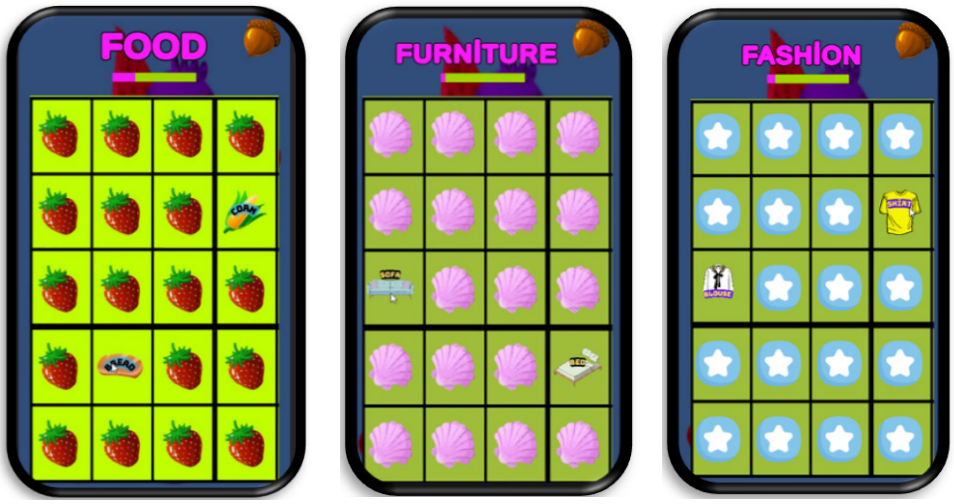


Figure 1. Flowchart of the mobile application "My memory"

The flowchart (Figure 1) of the developed application is as follows:

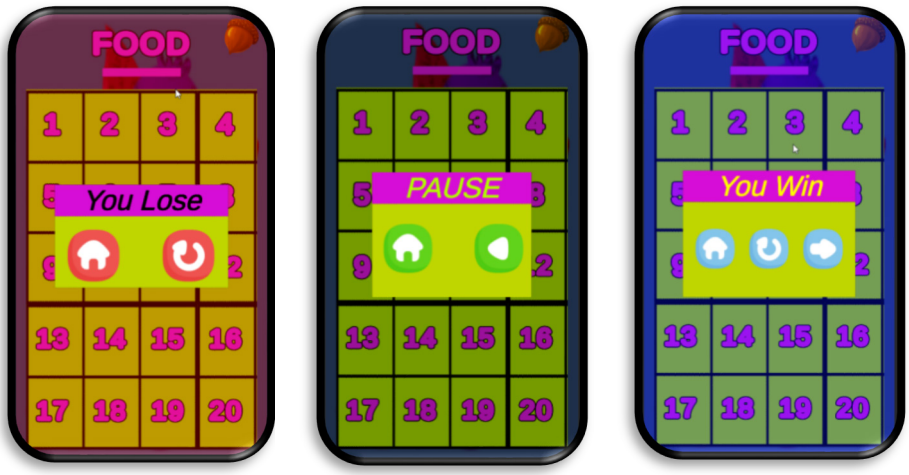
1. **Start:** Initialize the game variables (number of choices, level success count, timer, etc.) and set up the game environment (buttons, grid, levels, etc.)
2. **Game Start:** Display the puzzle grid with hidden items (e.g., food items, animals) and start the timer (Figure 2).
3. **Player Action: Card Selection:** Wait for the player to tap on a card and flip the card to reveal the item (Figure 3).
4. **Check Match:** If two cards are selected, check if they match:
   - **4.1. Yes:** increase the success count; disable both cards; check if the success count reaches the level goal:
     Yes: Trigger the Win condition and move to the next level.
     No: Continue the game.
   - **4.2. No: Flip both cards back over after a short delay or r**eset selection.
5. **Timer Check: Continuously check the timer.** If the timer reaches zero: Trigger the Game Over condition.
6. **Win or Game Over**
   Win: Show the victory panel and proceed to the next level.
   Game Over: Show the game-over panel.
7. **End:** The game ends either when the player wins or loses, with options to restart or return to the home menu (Figure 4).

Figure 2. Home page of the mobile app



Level 1: Food. **Level 2:** Furniture **Level 3:** Fashion

Figure 3. Levels of the memory game



Panel 1: Game over. **Panel 2:** Pause. **Panel 3:** Win.

Figure 4. Panels of memory game

The game ends either when the player wins or loses, with options to restart or return to the home menu (Figure 4). The information model outlines the key elements of the game, including the levels, objects, cards, card-matching mechanics, animations, and progression. It provides an overview of how the game is structured and the interactions players have with the objects and cards. In the current research, we use the programmable device a Bootley robot [41] which is low-tech, requires no computer connectivity, and is easy to program using a simple wireless remote. The students have to determine the number of steps and rotations so that they can reach the corresponding position on the cardboard field that matches the one selected on the computer screen in the memory game. In this way, they create a whole algorithm of steps, which teaches them to think logically and to predict the movement of the robot, including the corresponding turns.

The educational puzzle game successfully combines entertainment with cognitive development for children (Figure 5). It is free and available at the following link: https://github.com/AbdulkadirGur/Bulgaria_Robot_Project. By encouraging children to match items and solve puzzles, the game promotes skills such as memory, pattern recognition, and problem-solving [42], [43]. Future improvements may include adding new themes, levels, and adaptive difficulty to further engage children and enhance the educational benefits.

As a next step, we can again recommend a stand-alone robot that does not need an additional smart device (laptop, tablet, phone, etc.) to be programmed but works with the help of a remote control. The use of remote control would help to observe the robot from a different perspective, rather than the proximity required in the previous class of robots.

In this way, the work with the devices becomes more complicated, and upgrades quite smoothly and almost imperceptibly for the students [44].

The use of this type of training robot supports the development of already mastered algorithmic thinking, the skills to solve specific tasks and problems, etc. In the presence of more programmable devices of the same type, we recommend implementing games with a competitive nature, which further increases the motivation of students to participate [43].

According to a survey conducted in 2021 among 61 parents [44], we can conclude that most parents find programming useful and important for their children. They see several positive aspects of its study but still have some concerns about the stage at which it should be included in their children's education. On the one hand, perhaps this doubt is provoked by the fear of the new and the unknown, and on the other hand, we can point to their concerns about the children's health. Parents still want their children to participate in extracurricular activities that teach them how to code, despite these prejudices.

Figure 5. The programmable device: Bootley robot

4. Conclusion

"My Memory" provides not only entertainment but also serves as a valuable tool for cognitive development. By exercising memory and attention skills, players have the opportunity to enhance their mental agility and concentration abilities. Whether enjoyed for leisure or personal growth, the mobile application offers a rewarding experience for players of all ages. In conclusion, the developed tool showcases the versatility of the Unity game development platform and exemplifies the potential for creating engaging and educational gaming experiences. By immersing players in a stimulating memory challenge, "My Memory" aims to foster cognitive enhancement while providing a delightful and memorable gaming experience.

The idea presented in this paper integrates games and educational elements to develop the memory, concentration, and cognitive skills of primary school students. An interactive and engaging experience was created in which children are introduced to new English words and objects structured in different categories such as food, furniture, and fashion.

Key aspects:

Educational value: the game was designed to support the acquisition of new vocabulary and object recognition through play. Each level presents 10 objects, each with a corresponding name in English, which helps enrich children's vocabulary. Progressive levels: The game follows a step-by-step approach where each level adds a new category of objects. Starting with food, moving through furniture, and ending with fashion, children gradually increase their knowledge and skills.

Cognitive skills: The project encourages the development of children's memory, concentration, and cognitive abilities.

Through the mechanics of the game, which involves flipping cards and searching for matches, students practice their memorization and object recognition skills.

Interactive Component: The use of the Botley programmable robot adds physical interaction to the digital experience. Students must program the bot to move to the correct square on the cardboard panel corresponding to the selected square in the game on the screen. This further develops logical thinking and algorithm creation skills.

Combining fun and learning, the game provides a valuable tool for cognitive development and learning new knowledge. Through progressive levels and the integration of the Botley programmable robot, the game offers a holistic and multi-layered approach to education that stimulates both the intellectual and physical development of children.

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