



An-Najah National University
Faculty of Engineering and Information Technology
Computer Engineering Department.

Graduation Project 2

KiddieCloset

Prepared by:

Dima Shanti

Nour Sabri

Supervised by:

Dr. Emad Natsheh

Presented in partial fulfillment of the requirements for
Bachelor's Degree in Computer Engineering
Jan 2026

Acknowledgment

We begin by remembering our brothers and sisters in Gaza and all across Palestine who continue to face hardship every day under occupation. This work is dedicated to their strength, resilience, and unbroken spirit.

We express our sincere gratitude to Allah, whose blessings and guidance gave us the strength and perseverance to complete this project.

We would also like to deeply thank our parents and family members for their unwavering support and encouragement, which kept us motivated throughout this journey.

Our sincere appreciation goes to our supervisor, Dr. Emad Natsheh, for his continuous guidance, valuable recommendations, and constructive feedback.

Finally, we extend our gratitude to the Computer Engineering Department at An-Najah National University for their ongoing assistance.

Disclaimer

This report was written by students Dima Shanti and Nour Sabri at the Computer Engineering Department, Faculty of Engineering, An-Najah National University. It has not been altered or corrected, other than editorial corrections, as a result of assessment, and it may contain language as well as content errors. The views expressed in it, together with any outcomes and recommendations, are solely those of the students. An-Najah National University accepts no responsibility or liability for the consequences of this report being used for a purpose other than the purpose for which it was commissioned.

Table Of Contents

Acknowledgment	2
Disclaimer	3
Abstract:	10
Chapter 1: Introduction	11
1.1 <i>General background:</i>	11
1.2 <i>Objectives:</i>	11
1.3 <i>Significance of the work:</i>	11
1.4 <i>Organization of the report:</i>	12
Chapter 2: Theoretical Background and Previous Work	13
Chapter 3: Methodology.....	14
3.1 <i>Hardware components:</i>	14
3.1.1 ESP32.....	14
3.1.2 Arduino Mega	14
3.1.3 Nextion Screen (NX8048P070, 7.0 inch)	15
3.1.4 Computer Power Supply	15
3.1.5 Ultrasonic Sensor.....	15
3.1.6 NEMA23 Stepper Motor	16
3.1.7 DFPlayer Mini MP3 Module, SD Card, and Speaker	16
3.1.8 12V DC Pilot Lamp LED (22 mm)	16
3.1.9 LED Strip (1 m, 12V DC Blue and 3K).....	17
3.1.10 5V Relay Module (8-Channel).....	17
3.1.11 MFRC522 RFID Module and Tags	17
3.1.12 Hall Effect Sensor Module.....	18
3.1.13 Microstep Driver (3.5A).....	18
3.1.14 Load Cell Sensor (20 kg) and HX711 module.....	18
3.1.15 Limit Switches.....	19
3.1.16 Spotlight (220V) with 2-Channel Relay	19
3.1.17 Intercom, Speaker, and Arduino Wires	19
3.1.18 8 mm Lead Screw Rail (T8, 2 mm Pitch).....	20
3.1.19 Shaft Coupler (8 mm to 8 mm).....	20
3.1.20 Bearing Housing.....	20
3.2 <i>System Structure:</i>	21
3.2.1 Closet Structure.....	21
3.2.2 User Interfaces.....	26
3.2.2.1 Nextion touchscreen:	26
3.2.2.1.1 Choosing outfit option screens:.....	26
3.2.2.1.1.1 Rotary Hanger:.....	27

3.2.2.1.1.2	Side Hanger.....	28
3.2.2.1.1.3	Drawer 1.....	29
3.2.2.1.1.4	Drawer 2.....	30
3.2.2.1.1.5	Shoe Shelf.....	31
3.2.2.1.2	Missing Items option screens:.....	32
3.2.2.1.2.1	Rotary Hanger.....	33
3.2.2.1.2.2	Shoe Shelf.....	34
3.2.2.1.2.3	Other Section:.....	35
3.2.2.1.3	Get Outfit Ideas option screens:.....	36
3.2.2.2	Application:.....	38
3.2.2.2.1	Setup screens.....	38
3.2.2.2.1.1	Location.....	39
3.2.2.2.1.2	Blue Light.....	40
3.2.2.2.1.3	Rotary Hanger.....	41
3.2.2.2.1.4	Side Hanger.....	42
3.2.2.2.1.5	Drawer 1.....	43
3.2.2.2.1.6	Drawer 2.....	44
3.2.2.2.1.7	Shoe Shelf.....	45
3.2.2.2.2	Management Screens.....	46
3.2.2.2.2.1	Confirmation.....	47
3.2.2.2.2.2	Rotary Hanger.....	48
3.2.2.2.2.3	Drawers 1 and 2, Side Hanger, and Shoe Shelf.....	49
3.3	<i>System Operation and Workflow</i>	50
3.3.1	Parent Setup.....	50
3.3.2	Child Interaction.....	50
3.3.2.1	Choosing Outfit:.....	50
3.3.2.1.1	Rotary Hanger.....	52
3.3.2.1.2	Side Hanger.....	52
3.3.2.1.3	Drawer 1.....	52
3.3.2.1.4	Drawer 2.....	53
3.3.2.1.5	Shoe Shelf.....	53
3.3.2.2	Missing Items:.....	54
3.3.2.2.1	Rotary Hanger.....	55
3.3.2.2.2	Shoe Shelf.....	55
3.3.2.2.3	Drawer1.....	55
3.3.2.2.4	Drawer2.....	56
3.3.2.2.5	Side Hanger.....	56
3.3.2.3	Get Outfit Ideas:.....	57
3.3.3	Parent interaction.....	59
3.3.3.1	Adding.....	59
3.3.3.1.1	Rotary Hanger:.....	60
3.3.3.1.2	Shoe Shelf.....	60
3.3.3.1.3	Drawer1.....	60
3.3.3.1.4	Drawer2.....	60
3.3.3.1.5	Side Hanger.....	61

3.3.3.2	Removing	61
3.3.3.2.1	Rotary Hanger.....	62
3.3.3.2.2	Shoe Shelf	62
3.3.3.2.3	Drawer 1.....	62
3.3.3.2.4	Drawer 2.....	63
3.3.3.2.5	Side Hanger.....	63
3.3.3.3	Confirming	64
3.4	<i>Constraints:</i>	66
Chapter 4: Results and Discussion:		67
Chapter 5: Conclusions and Future Work		68
5.1	<i>Conclusion:</i>	68
5.2	<i>Future Work:</i>	68
Chapter 6: References		69

Table Of Figures

Figure 1: ESP32.....	14
Figure 2: Arduino Mega.....	14
Figure 3: Nextion Screen (NX8048P070, 7.0 inch)	15
Figure 4: Computer Power Supply	15
Figure 5: Ultrasonic Sensor	15
Figure 6: NEMA23 Stepper Motor	16
Figure 7: DFPlayer Mini MP3 Module	16
Figure 8: 12V DC Pilot Lamp LED (22 mm)	16
Figure 9: 12v Blue LED Strip	17
Figure 10: 12v 3K LED Strip	17
Figure 11: 5V Relay Module	17
Figure 12: MFRC522 RFID Module and Tags	17
Figure 13: Hall Effect Sensor Module.....	18
Figure 14: Microstep Driver (3.5A).....	18
Figure 15: Load Cell Sensor (20 kg) and HX711 module	18
Figure 16: Limit Switch	19
Figure 17: Spotlight (220V) with 2-Channel Relay	19
Figure 18: Arduino Wires	19
Figure 19: Intercom Wires.....	19
Figure 20: Speaker Wires	19
Figure 21: 8 mm Lead Screw Rail	20
Figure 22: Shaft Coupler.....	20
Figure 23: Bearing Housing.....	20
Figure 24: Assembled smart closet structure	21
Figure 25: Nextion screen displaying the home page	22
Figure 26: Interior view of the rotary hanger	22
Figure 27: Interior view of the first drawer.....	23
Figure 28: Load cell and ultrasonic sensor inside the first drawer	23
Figure 29: Interior view of the second drawer.....	23
Figure 30: Side view of the side hanger	24
Figure 31: Front view of the side hanger	24
Figure 32: Shoe shelf assembly.....	24
Figure 33: Speaker used for audio prompts.....	25
Figure 34: Nextion screen home page with main wardrobe options.	26
Figure 35: Choosing Outfit page showing all clothing sections.	26
Figure 36: Rotary Hanger - Three sections.....	27

Figure 37: Rotary Hanger - Clothing inside section.....	27
Figure 38: Rotary Hanger - Selecting clothing to retrieve.....	28
Figure 39:Side Hanger - Five sections	28
Figure 40: Side Hanger - Selecting items to retrieve.....	29
Figure 41: Drawer 1 - Two sections.....	29
Figure 42: Drawer 1 - Selecting section to retrieve.....	30
Figure 43: Drawer 2 - Three sections	30
Figure 44: Drawer 2 - Selecting section to retrieve.....	31
Figure 45: Shoe Shelf - Three sections.....	31
Figure 46: Shoe Shelf - Selecting a shoe to retrieve.....	32
Figure 47: Missing Items page showing all clothing sections.	32
Figure 48: Rotary Hanger - Missing clothes.	33
Figure 49: Rotary Hanger - Selecting clothing to return.	33
Figure 50: Shoe Shelf - Missing Shoes.....	34
Figure 51: Shoe Shelf - Selecting the shoe to return.	34
Figure 52: Other Sections - Missing items.	35
Figure 53: Other Sections – Selecting section to return item.....	35
Figure 54: Get Outfit Ideas - Occasions.....	36
Figure 55: Get Outfit Ideas - Entering a Custom Occasion.....	36
Figure 56: Get Outfit Ideas - Selecting an occasion screen.....	37
Figure 57: Get Outfit Ideas – Generated Outfit and Confirmation Screen.	37
Figure 58: Setup - Home screen.....	38
Figure 59: Setup - Location.	39
Figure 60: Setup - Blue Light	40
Figure 61: Setup – Rotary Hanger (1).....	41
Figure 62: Setup – Rotary Hanger (2).....	41
Figure 63: Setup – Side Hanger (1).....	42
Figure 64: Setup – Side Hanger (2).....	42
Figure 65:Setup – Side Hanger (3).....	42
Figure 66: Setup - Drawer 1 (1).....	43
Figure 67: Setup - Drawer 1 (2).....	43
Figure 68: Setup - Drawer 1 (3).....	43
Figure 69: Setup - Drawer 2 (1).....	44
Figure 70: Setup - Drawer 2 (2).....	44
Figure 71: Setup - Drawer 2 (3).....	44
Figure 72: Setup - Shoe Shelf (1).....	45
Figure 73: Setup - Shoe Shelf (2).....	45
Figure 74: Management - Home screen	46

Figure 75: Management - Confirmation (1).....	47
Figure 76: Management - Confirmation (2).....	47
Figure 77: Management - Rotary Hanger (1).....	48
Figure 78: Management - Rotary Hanger (2).....	48
Figure 79: Management - Rotary Hanger Adding Cloth (1).....	48
Figure 80: Management - Rotary Hanger Adding Cloth (2).....	48
Figure 81: Management - Drawers 1 and 2.....	49
Figure 82: Management -Side Hanger.....	49
Figure 83: Management - Shoe Shelf.....	49
Figure 84: Management - Shoe Shelf Adding	49
Figure 85: Child Interaction - Choosing Outfit option Flowchart.....	51
Figure 86: Child Interaction - Missing Items option Flowchart.....	54
Figure 87: Child Interaction - Get Outfit Ideas Flowchart	57
Figure 88: Parent Interaction - Adding Flowchart.....	59
Figure 89: Parent Interaction - Removing Flowchart	61
Figure 90: Parent Interaction - Confirming Flowchart	64

Abstract:

Children naturally seek independence and enjoy making their own choices, even in simple daily tasks like selecting outfits. However, in today's fast-paced world, parents often struggle to find the time to guide and support them in these routines. This creates a need for solutions that help children become more self-reliant while easing the parents' responsibilities. KiddieCloset is a smart closet designed for children, aimed at organizing clothing and making selection easy and interactive.

The closet features a **rotating circular hanger** divided into three sections, each categorized by clothing type, such as dresses, school uniforms, and suits. The hanger is mechanically driven by a stepper motor, allowing automatic rotation to present the appropriate section. Each piece of clothing is equipped with an RFID tag for identification, and the selected item is highlighted with an indicator light to help the child make an easy choice.

Additionally, the closet features a **pull-out hanger** section for items such as backpacks and scarves, which is also mechanically operated, displaying the last hanger as the selected piece. **Two shelves** can be mechanically moved, opening either halfway or fully, depending on the item to pick. The last section is dedicated to **shoes**, where indicator lights help in identifying which pair to choose.

The entire system is controlled using **an Arduino Mega, an ESP32, and various sensors** that provide feedback and ensure accuracy. The child interacts with the system through a **Nextion touchscreen**, making the experience simple and age-appropriate. A built-in **speaker** delivers smooth and clear audio instructions to guide the child. Meanwhile, the closet sections are managed by the parent through a **mobile application** developed using Flutter. Both the hardware system and the mobile application share a common database hosted on Google Firestore.

KiddieCloset is more than just a system of mechanical moving parts; it helps children select the right outfits for school, birthday parties, and other activities. It also assists them in keeping their closet organized and well-presented.

Chapter 1: Introduction

1.1 General background:

In today's rapidly modernizing world, children, especially those belonging to Generation Alpha, are increasingly surrounded by and engaged with technology in their everyday lives. They frequently interact with smart devices, making technology a natural part of their daily routines. This raises an important question: why not integrate technology into one of the daily activities children repeat multiple times a day, such as using their closet?

At the same time, parents today are often busier than in the past and may not always have the time to assist their children with routine tasks like organizing clothes or suggesting suitable outfits. As a result, closet organization and outfit selection are no longer priorities in daily schedules.

From this need, the idea of a smart closet emerged. What if children no longer needed reminders to return their clothes to their place, or to ask their parents for help in choosing what to wear? KiddieCloset provides a solution by combining technology with everyday clothing routines, encouraging independence in children while reducing the burden on parents.

1.2 Objectives:

The main objectives of the KiddieCloset project are:

- 1) To design a smart closet that enables children to independently select appropriate outfits.
- 2) To organize clothing into clearly categorized sections for easy access.
- 3) To provide visual and audio guidance that is age-appropriate and easy to follow.
- 4) To assist children in identifying missing items and returning them to their proper place.
- 5) To allow parents to manage clothing data (add or remove items) and configure closet sections through a mobile application.
- 6) To integrate hardware and software components into a unified cloud-based system.

1.3 Significance of the work:

KiddieCloset illustrates the integration of technology into everyday furniture, transforming a traditional closet into an interactive system that promotes independence and organization in children. By targeting a critical age group, the project supports the development of autonomy and good habits through engaging visual, audio, and mechanical feedback.

The system effectively combines mechanical hardware, sensors, and software to provide a practical, user-friendly solution. KiddieCloset also highlights new possibilities for smart furniture, paving the way for future innovations that enhance daily routines through automation and interactivity.

1.4 Organization of the report:

The report is divided into several chapters, each focusing on a specific aspect of the project.

- **Chapter 1:** Introduction provides the project's general background, objectives, significance, and an overview of the report structure.
- **Chapter 2:** Theoretical Background and Previous Work, reviews existing research and theories relevant to the project.
- **Chapter 3:** Methodology describes the system's hardware, operating mechanisms, and how challenges were addressed during development.
- **Chapter 4:** Results and Discussion presents the project's outcomes and discusses their implications.
- **Chapter 5:** Conclusions and Recommendations summarizes the project and provides suggestions for future improvements.

Chapter 2: Theoretical Background and Previous Work

Previous research has demonstrated the potential of smart wardrobe systems in improving clothing management through automation and intelligent decision support. In (Mun et al., n.d.) A smart closet based on Arduino MEGA integrates weather-based outfit recommendations, temperature and humidity monitoring, and mechanical control of doors and rotating sections. This work highlights the effectiveness of combining sensors, motors, and mobile applications to enhance daily wardrobe organization.

A software-oriented approach was presented in (Na Nakorn & Rakmanee, n.d.) where a Smart Closet mobile application enables users to digitally manage their clothing, track usage frequency, and receive outfit recommendations based on user behavior, weather conditions, and occasions. While this system primarily focuses on application-level intelligence, it highlights the importance of personalization and data-driven recommendations in smart wardrobe solutions.

In (Goh et al., 2011) An RFID-based smart wardrobe system was introduced to track garments and store clothing attributes such as color, style, and occasion. By automating clothing identification and monitoring garment movement, this system reduces user effort and supports intelligent outfit selection, particularly benefiting busy users and individuals with special needs.

Recent studies and market analyses (*Smart Wardrobe Market Size, Outlook, SWOT & Forecast 2033, 2025*) indicate rapid growth in smart wardrobe technologies that integrate IoT devices, embedded controllers, sensors, and mobile applications. These trends underscore the need for systems that integrate hardware automation, such as motors, RFID, and sensors, with software-based control and cloud data management, thereby supporting the development of advanced smart closets, similar to the proposed system.

Recent studies show growing interest in smart wardrobes that integrate technology into furniture; however, most existing systems focus on limited mechanical functions or software-based outfit recommendations without fully matching the mechanical design to the actual closet structure. In addition, current solutions rarely manage the complete clothing process, including taking, returning, and confirming items. Most systems are also designed for general users and do not target specific age groups. This highlights a research gap for a smart closet that combines a structure-aware mechanical system with software tailored for children, enabling organized clothing management and controlled interaction.

Chapter 3: Methodology

3.1 Hardware components

3.1.1 ESP32

The ESP32 is responsible for wireless communication and cloud connectivity. It connects with the mobile application through the Firestore database, retrieving and updating data as needed. Acting as an intermediary, the ESP32 forwards the required data from Firestore to the Nextion touchscreen for display and user interaction. It also controls the shoe shelf component through its digital pins and communicates with the Arduino Mega via serial communication to coordinate overall system operations.



Figure 1: ESP32

3.1.2 Arduino Mega

The Arduino Mega acts as the main controller of the system. It manages motor control, sensor readings, and coordination between different hardware components. It also handles serial communication with the ESP32, the Nextion touchscreen, and the DFPlayer module to ensure synchronized system operation.

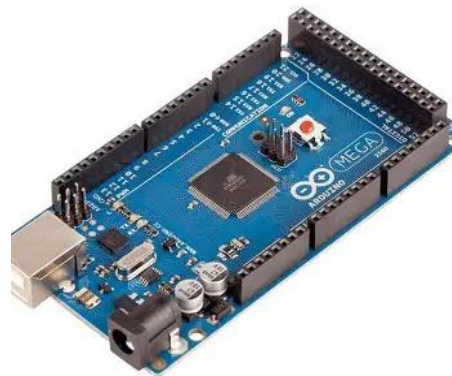


Figure 2: Arduino Mega

3.1.3 Nextion Screen (NX8048P070, 7.0 inch)

The Nextion touchscreen provides a child-friendly user interface for interacting with the system. It displays visual instructions and allows children to easily select clothing items. The screen communicates with the Arduino Mega through serial communication to receive data and send user inputs.



Figure 3: Nextion Screen (NX8048P070, 7.0 inch)

3.1.4 Computer Power Supply

A computer power supply is used to provide stable and sufficient power to the system, supplying different voltage levels required by motors, controllers, and peripherals.



Figure 4: Computer Power Supply

3.1.5 Ultrasonic Sensor

The ultrasonic sensor is used to measure distance and detect the presence of objects, supporting safe and accurate system operation. It is utilized to identify the reference position of the side hanger and to detect the presence of a child's hand inside the drawers, enhancing safety during operation.



Figure 5: Ultrasonic Sensor

3.1.6 NEMA23 Stepper Motor

The NEMA23 stepper motor drives the rotary hanger mechanism, providing precise and controlled rotation of the clothing sections. It is also used to operate the side hanger, allowing accurate positioning for selecting the desired item, and to mechanically move the drawers to the selected section.



Figure 6: NEMA23 Stepper Motor

3.1.7 DFPlayer Mini MP3 Module, SD Card, and Speaker

This module is used to play pre-recorded audio instructions stored on an SD card. The speaker provides clear guidance for children during interaction.



Figure 7: DFPlayer Mini MP3 Module

3.1.8 12V DC Pilot Lamp LED (22 mm)

The pilot lamp LED is used as an indicator light to visually highlight the selected shoe, helping the child easily identify the correct pair.



Figure 8: 12V DC Pilot Lamp LED (22 mm)

3.1.9 LED Strip (1 m, 12V DC Blue and 3K)

The 3K LED strip provides general illumination inside the closet to improve visibility. The blue LEDs simulate ultraviolet lighting, which is used for sterilization in the shoe shelf.



Figure 9: 12v Blue LED Strip



Figure 10: 12v 3K LED Strip

3.1.10 5V Relay Module (8-Channel)

The 8-channel relay module is used to control high-power components, such as 12V DC LEDs, using low-voltage signals from the ESP32.



Figure 11: 5V Relay Module

3.1.11 MFRC522 RFID Module and Tags

The RFID module identifies clothing items using RFID tags attached to each hanger, enabling accurate selection and tracking.



Figure 12: MFRC522 RFID Module and Tags

3.1.12 Hall Effect Sensor Module

The Hall effect sensor is used for position detection and rotational reference, ensuring accurate movement and alignment of mechanical parts.

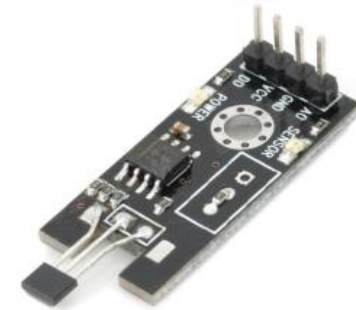


Figure 13: Hall Effect Sensor Module

3.1.13 Microstep Driver (3.5A)

The microstep driver controls the stepper motor, providing smooth motion and precise positioning.



Figure 14: Microstep Driver (3.5A)

3.1.14 Load Cell Sensor (20 kg) and HX711 module

The load cell sensor measures weight to detect the presence or absence of clothing items in the drawer sections, providing feedback on whether an item has been taken or returned. The HX711 module amplifies and converts the sensor signal for accurate processing by the system.

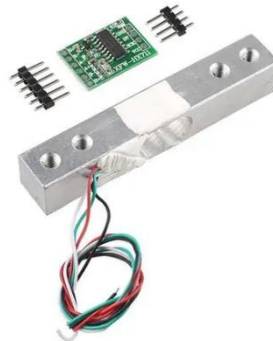


Figure 15: Load Cell Sensor (20 kg) and HX711 module

3.1.15 Limit Switches

Limit switches are used to detect the end positions of moving parts, preventing mechanical overtravel and ensuring safe operation. They also detect the presence or absence of shoe pairs and verify whether a clothing item is present in a slot on the rotary hanger.



Figure 16: Limit Switch

3.1.16 Spotlight (220V) with 2-Channel Relay

The spotlight provides focused illumination for selected closet sections and is controlled through a relay for safe operation.



Figure 17: Spotlight (220V) with 2-Channel Relay

3.1.17 Intercom, Speaker, and Arduino Wires

These components are used for electrical connections and signal transmission between different parts of the system.



Figure 18: Arduino Wires



Figure 19: Intercom Wires



Figure 20: Speaker Wires

3.1.18 8 mm Lead Screw Rail (T8, 2 mm Pitch)

The lead screw converts rotational motion into linear motion for moving shelves and pull-out mechanisms.



Figure 21: 8 mm Lead Screw Rail

3.1.19 Shaft Coupler (8 mm to 8 mm)

The shaft coupler connects the motor shaft to the lead screw, allowing efficient power transmission.



Figure 22: Shaft Coupler

3.1.20 Bearing Housing

Bearing housings support rotating shafts and reduce friction, ensuring smooth and stable motion of the rotary hanger mechanism.



Figure 23: Bearing Housing

3.2 System Structure:

3.2.1 Closet Structure



Figure 24: Assembled smart closet structure



Figure 25: Nextion screen displaying the home page

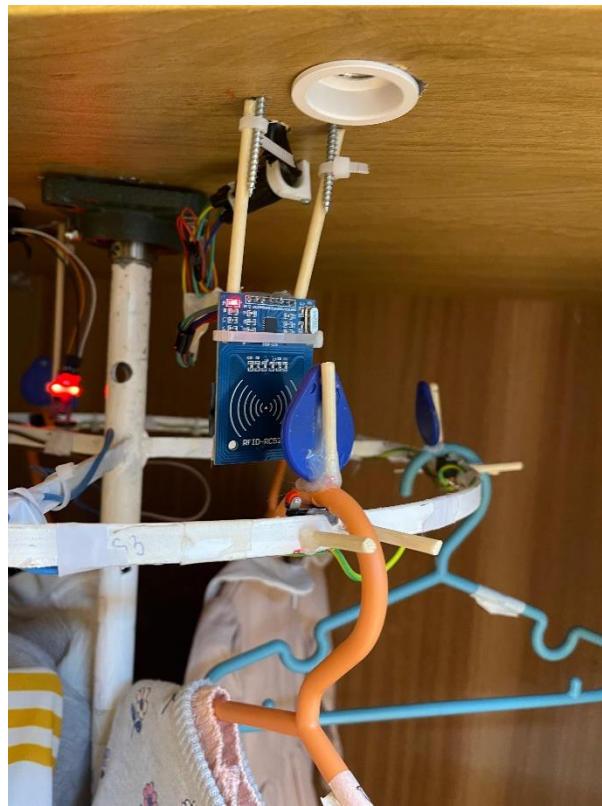


Figure 26: Interior view of the rotary hanger

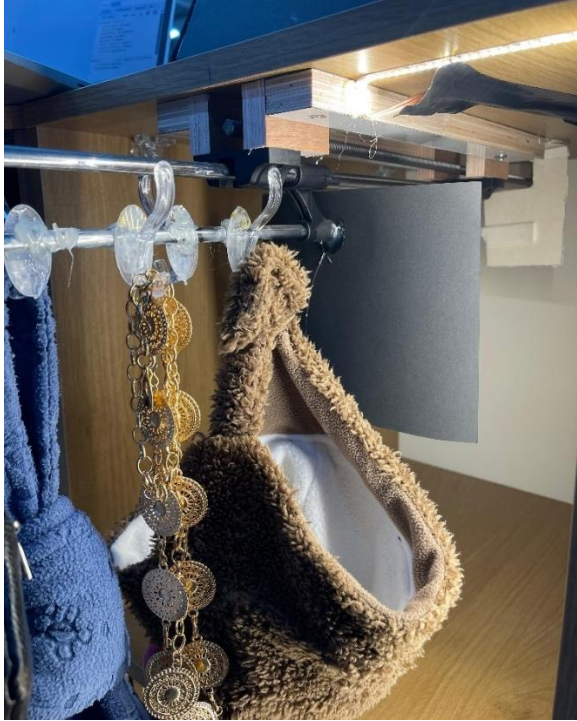


Figure 30: Side view of the side hanger



Figure 31: Front view of the side hanger



Figure 32: Shoe shelf assembly



Figure 33: Speaker used for audio prompts

3.2.2 User Interfaces

3.2.2.1 Nextion touchscreen:

The home page of the screen displays three main options: **Choose Outfit**, **Return Missing Items**, and **Get Outfit Suggestions** based on the occasion and current weather.



Figure 34: Nextion screen home page with main wardrobe options.

3.2.2.1.1 Choosing outfit option screens:

When the child selects the **Choosing Outfit** option, the interface navigates to a page displaying the clothing category sections: **Drawer 1**, **Drawer 2**, **Rotary Hanger**, **Side Hanger**, and **Shoe Shelf**.

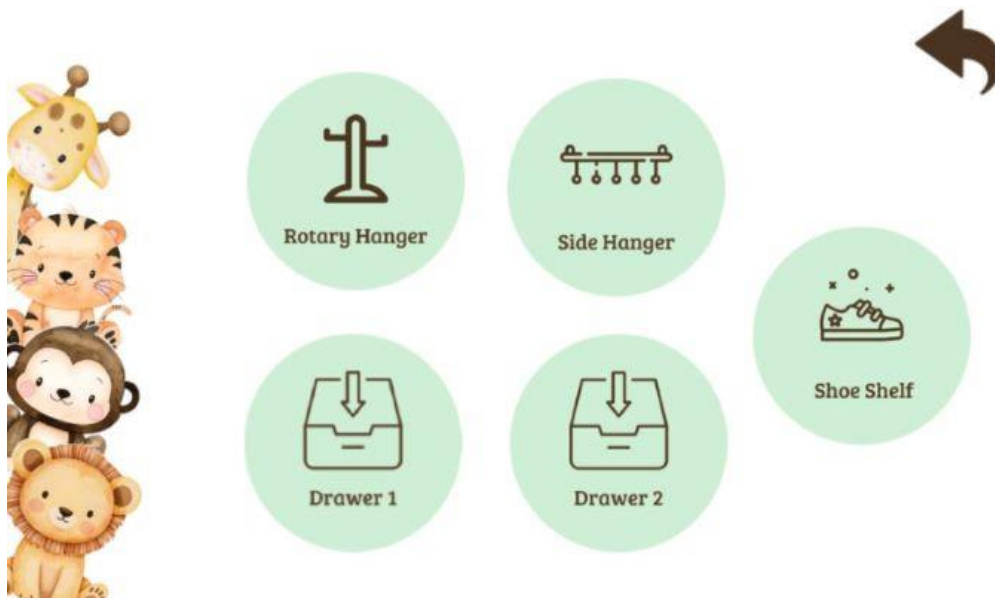


Figure 35: Choosing Outfit page showing all clothing sections.

3.2.2.1.1.1 Rotary Hanger:

If the child selects the **Rotary Hanger** category, the interface navigates to a screen displaying three sections, with each section labeled according to the data retrieved from the Firestore database, as configured by the parent.

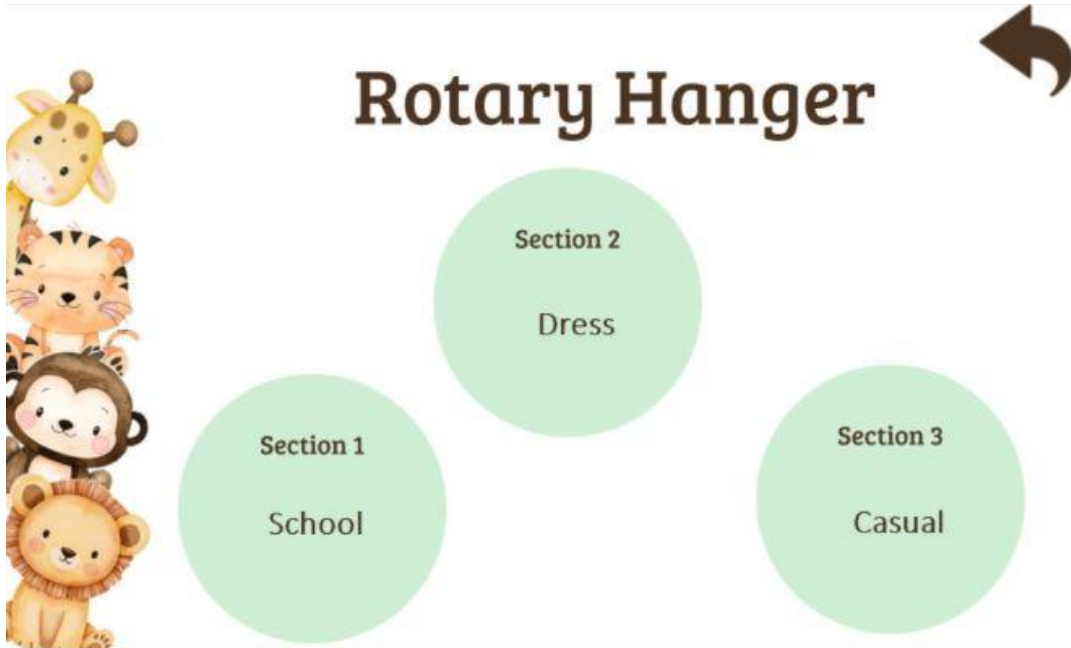


Figure 36: Rotary Hanger - Three sections.

By selecting a section, the information of the clothing items labeled as “in cabinet” is displayed, allowing the child to choose the item they want. The child can select multiple items to retrieve at the same time.



Figure 37: Rotary Hanger - Clothing inside section.

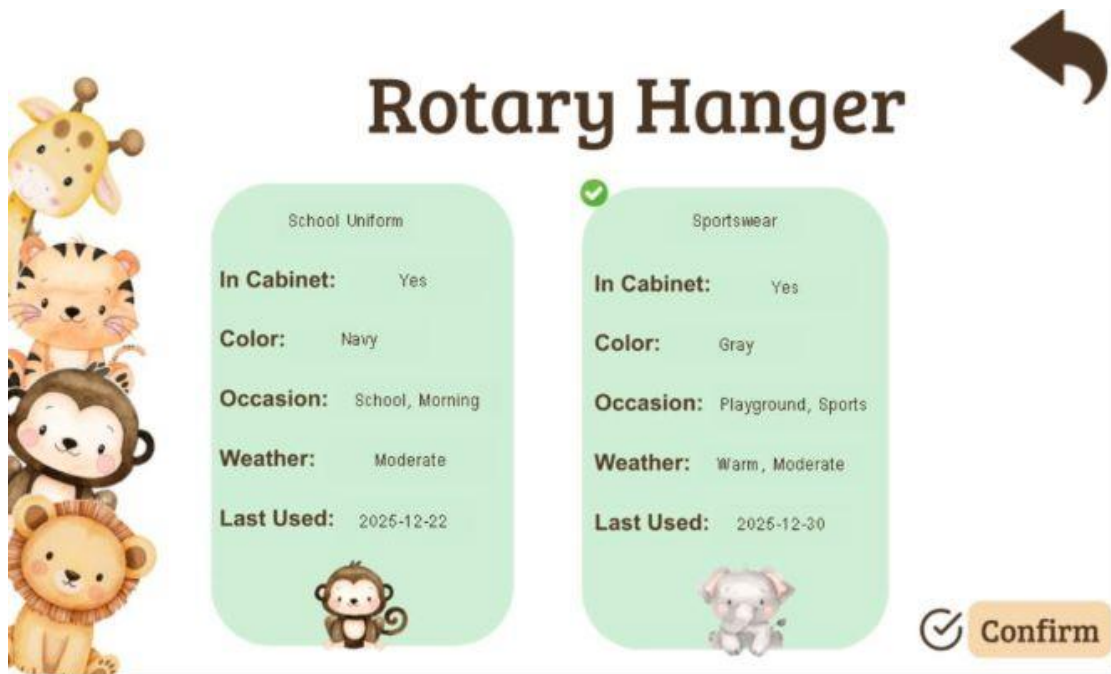


Figure 38: Rotary Hanger - Selecting clothing to retrieve.

3.2.2.1.1.2 Side Hanger

If the child selects the **Side Hanger** category, the interface navigates to a screen displaying the items placed on it, based on data retrieved from the Firestore database as configured by the parent. The child can select multiple items to retrieve at the same time.



Figure 39: Side Hanger - Five sections



Figure 40: Side Hanger - Selecting items to retrieve.

3.2.2.1.1.3 Drawer 1

If the child selects the **Drawer 1** category, the interface navigates to a screen displaying its two labeled sections, based on data retrieved from the Firestore database as configured by the parent. The child can select multiple items from these sections to retrieve at the same time.



Figure 41: Drawer 1 - Two sections



Figure 42: Drawer 1 - Selecting section to retrieve.

3.2.2.1.1.4 Drawer 2

If the child selects the **Drawer 2** category, the interface navigates to a screen displaying its three labeled sections, based on data retrieved from the Firestore database as configured by the parent. The child can select multiple items from these sections to retrieve at the same time.



Figure 43: Drawer 2 - Three sections



Figure 44: Drawer 2 - Selecting section to retrieve

3.2.2.1.1.5 Shoe Shelf

If the child selects the **Shoe Shelf** category, the interface navigates to a screen displaying the available shoe types, based on data retrieved from the Firestore database as configured by the parent.



Figure 45: Shoe Shelf - Three sections.



Figure 46: Shoe Shelf - Selecting a shoe to retrieve

3.2.2.1.2 Missing Items option screens:

When the child selects the **Missing Items** option, the interface navigates to a page displaying the clothing category sections: **Rotary Hanger**, **Shoe Shelf**, and **Other Sections**.



Figure 47: Missing Items page showing all clothing sections.

3.2.2.1.2.1 Rotary Hanger

If the child selects the **Rotary Hanger** category, the interface navigates to a screen displaying the clothing items that are missing, based on data retrieved from the Firestore database.



Figure 48: Rotary Hanger - Missing clothes.



Figure 49: Rotary Hanger - Selecting clothing to return.

3.2.2.1.2.2 Shoe Shelf

If the child selects the **Shoe Shelf** category, the interface navigates to a screen displaying the shoes that are missing, according to data retrieved from the Firestore database.



Figure 50: Shoe Shelf - Missing Shoes.



Figure 51: Shoe Shelf - Selecting the shoe to return.

3.2.2.1.2.3 Other Section:

If the child selects the **Other Sections** category, the interface navigates to a screen displaying the **Drawer 1, Drawer 2, and Side Hanger** sections.



Figure 52: Other Sections - Missing items.



Figure 53: Other Sections – Selecting section to return item.

3.2.2.1.3 *Get Outfit Ideas option screens:*

If the child selects the **Get Outfit Ideas** option, the interface navigates to a screen displaying different occasions, with an option to enter a custom occasion if it is not listed.



Figure 54: Get Outfit Ideas - Occasions

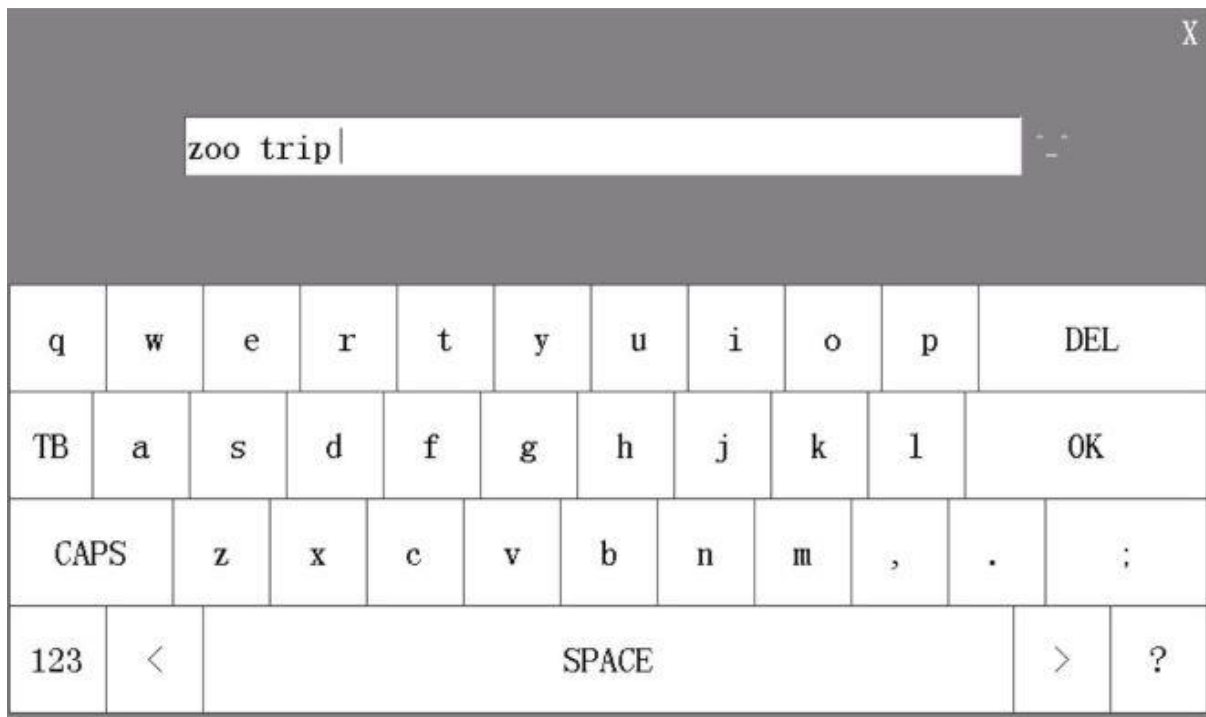


Figure 55: Get Outfit Ideas - Entering a Custom Occasion.



Figure 56: Get Outfit Ideas - Selecting an occasion screen.

Once confirmed, the system navigates to a screen displaying the outfit generated by the AI prompt, based on the clothing items available in the cabinet and the current weather. The child can then either confirm the chosen outfit or cancel it.

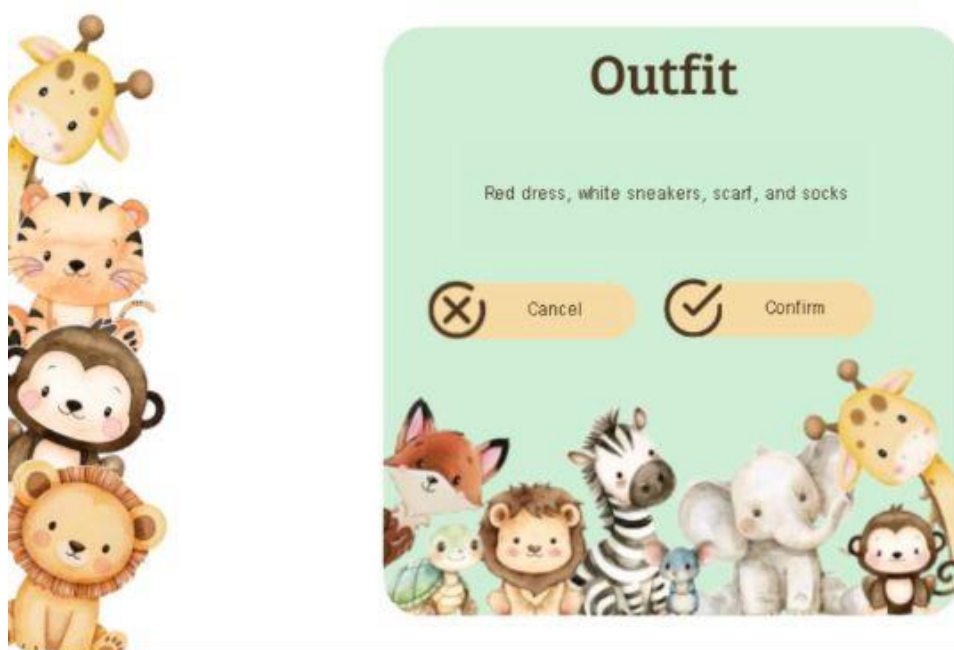


Figure 57: Get Outfit Ideas – Generated Outfit and Confirmation Screen.

3.2.2.2 Application:

3.2.2.2.1 Setup screens

The setup screens allow parents to configure the categories for each closet section, including the rotary hanger, side hanger, drawer 1, drawer 2, and shoe shelf.

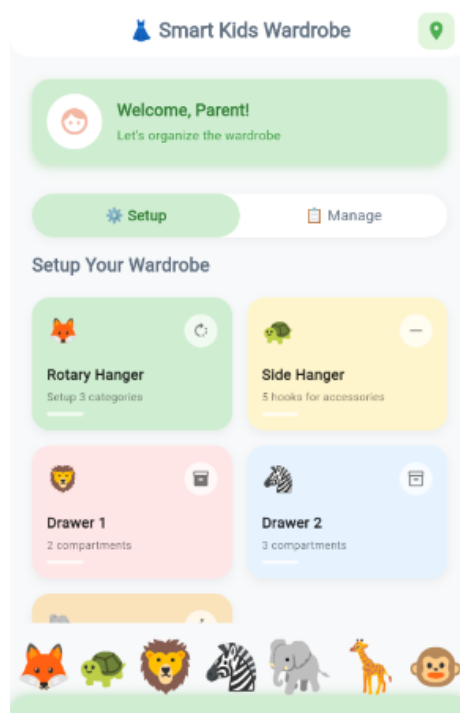


Figure 58: Setup - Home screen.

3.2.2.2.1.1 Location

Parents can also set their location, which is later used by the **Get Outfit Ideas** feature to retrieve the local weather forecast.

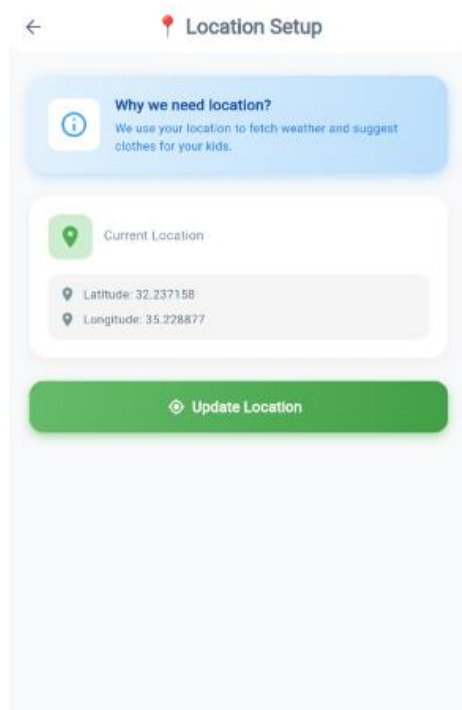


Figure 59: Setup - Location.

3.2.2.2.1.2 Blue Light

Parents can control the blue light of the shoe shelf by selecting a specific activation time period, simulating ultraviolet (UV) light for sterilization purposes.

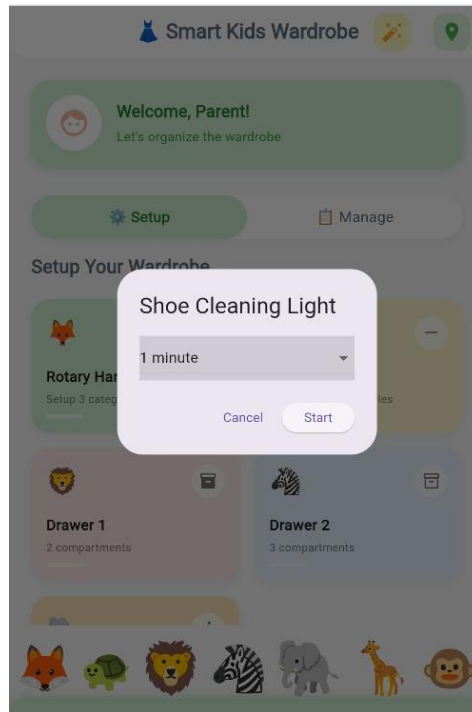


Figure 60: Setup - Blue Light

3.2.2.2.1.3 Rotary Hanger

The rotary hanger setup screens allow parents to define categories for the three sections of the rotary hanger, such as casual or school wear.

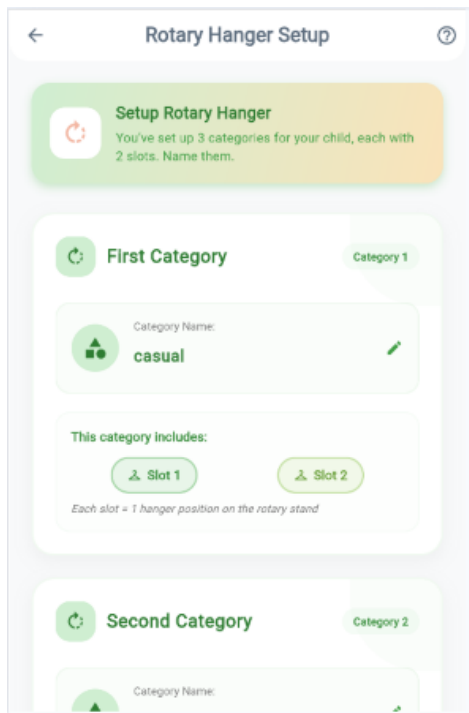


Figure 61: Setup – Rotary Hanger (1).

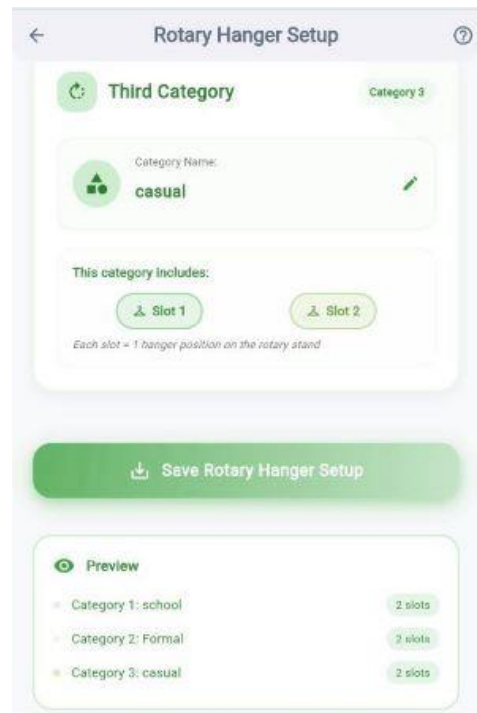


Figure 62: Setup – Rotary Hanger (2).

3.2.2.2.1.4 Side Hanger

The side hanger setup screens allow parents to assign items to each of the five hooks.

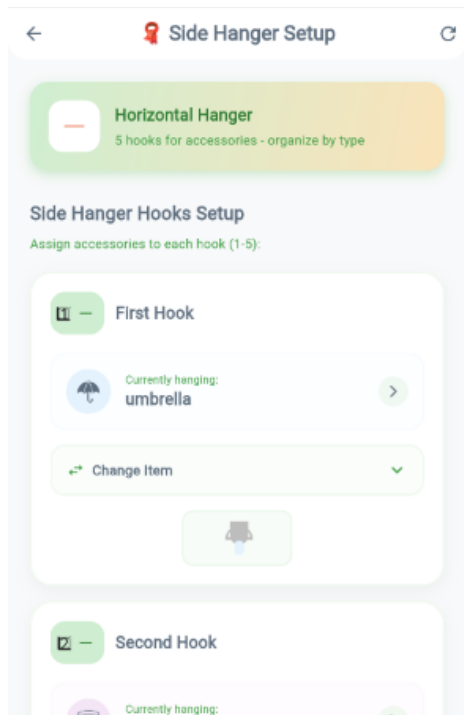


Figure 63: Setup – Side Hanger (1).

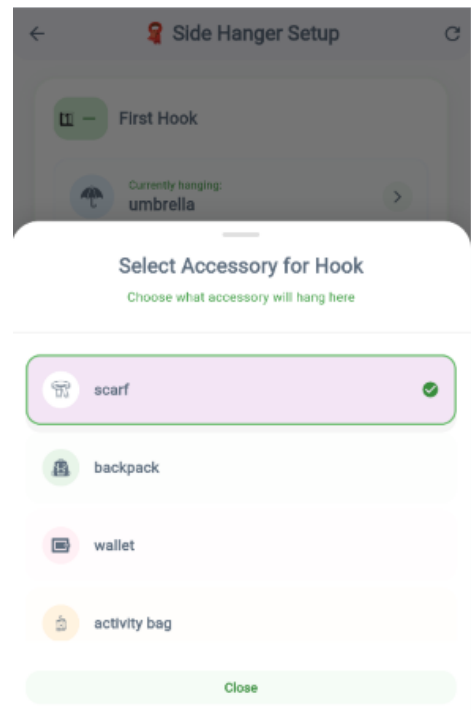


Figure 64: Setup – Side Hanger (2).

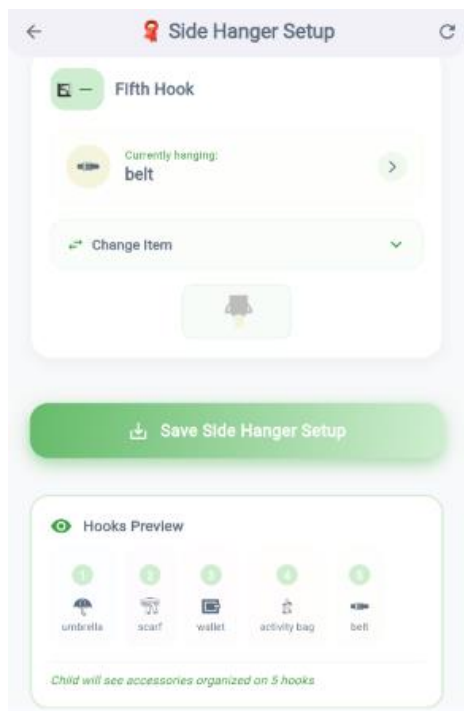


Figure 65: Setup – Side Hanger (3).

3.2.2.2.1.5 Drawer 1

The first drawer setup screens allow parents to assign categories to the first and second halves of the drawer.

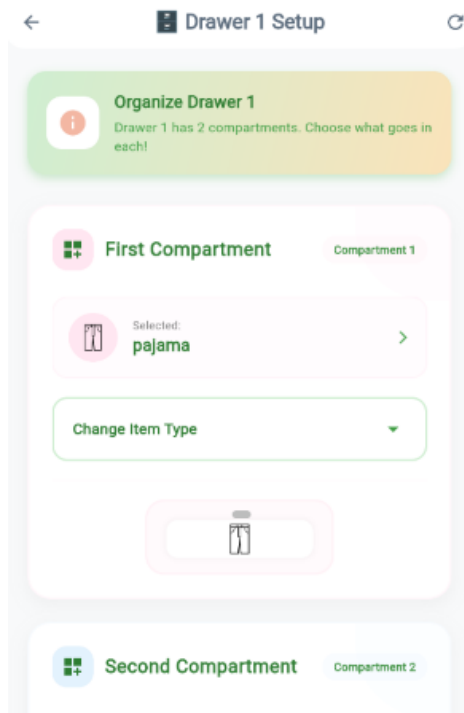


Figure 66: Setup - Drawer 1 (1).

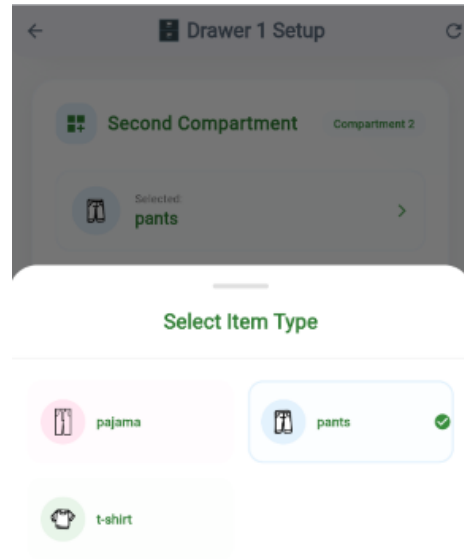


Figure 67: Setup - Drawer 1 (2).

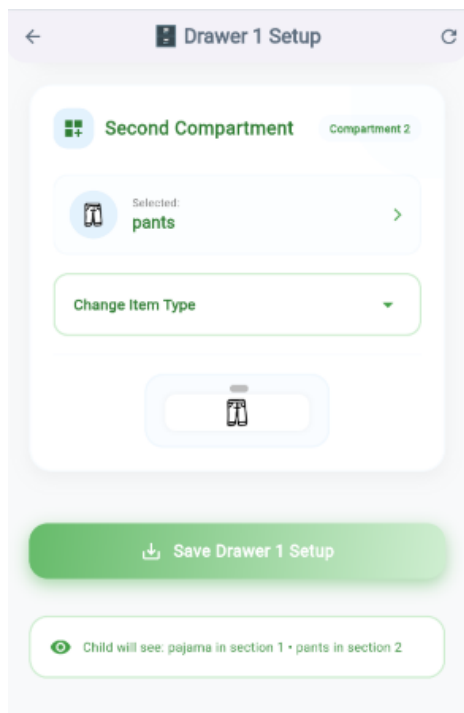


Figure 68: Setup - Drawer 1 (3).

3.2.2.2.1.6 Drawer 2

The second drawer setup screens allow parents to define categories for the drawer's three compartments, corresponding to the first, middle, and last thirds of the drawer.

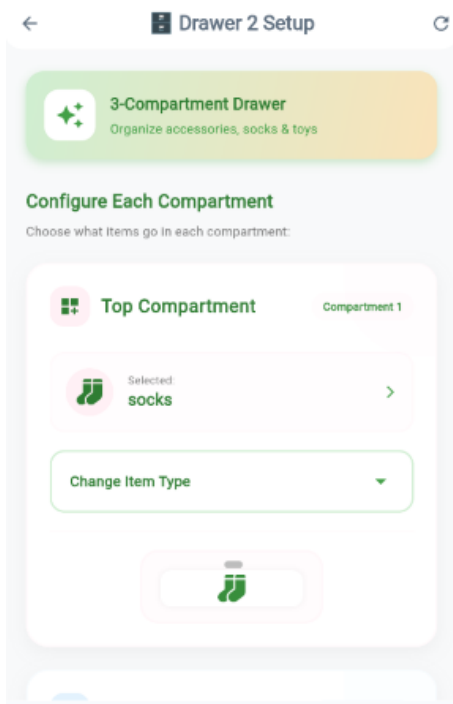


Figure 69: Setup - Drawer 2 (1).

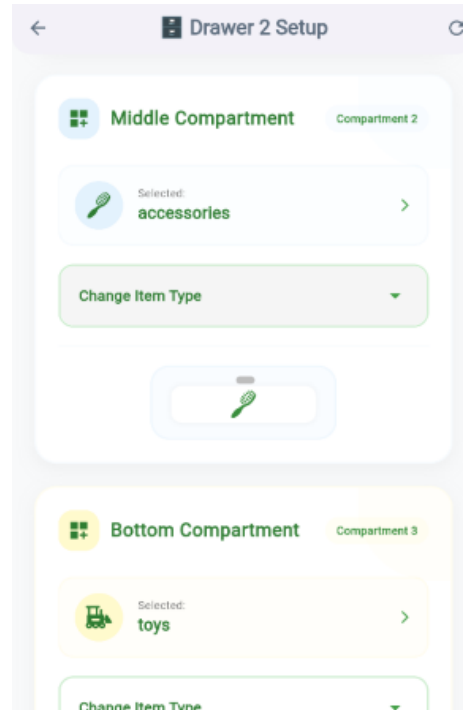


Figure 70: Setup - Drawer 2 (2).

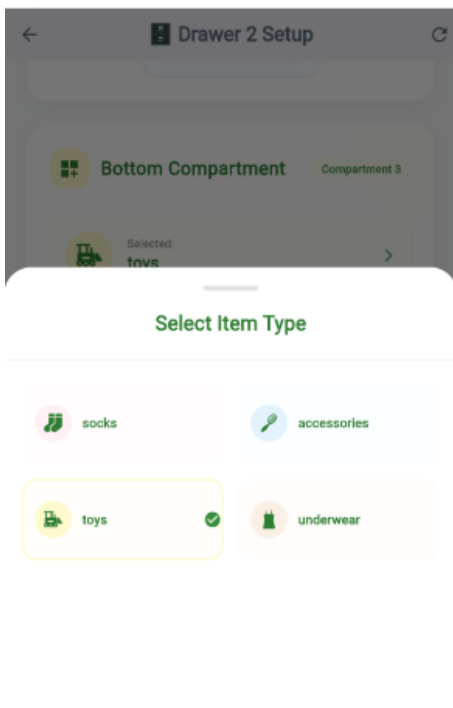


Figure 71: Setup - Drawer 2 (3).

3.2.2.2.1.7 Shoe Shelf

The shoe shelf setup screen allows parents to specify the type of shoes for each of the three sections.

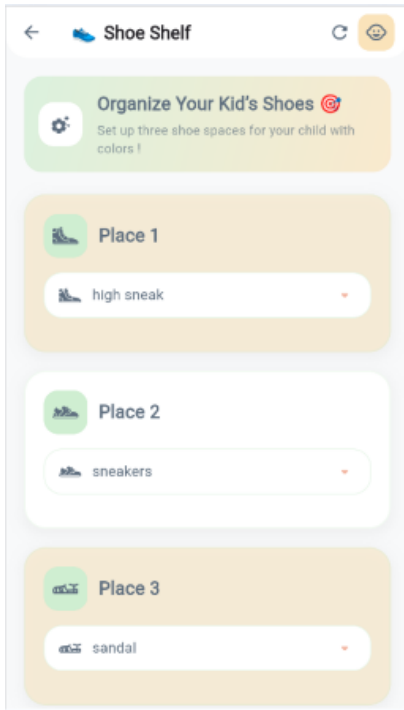


Figure 72: Setup - Shoe Shelf (1).

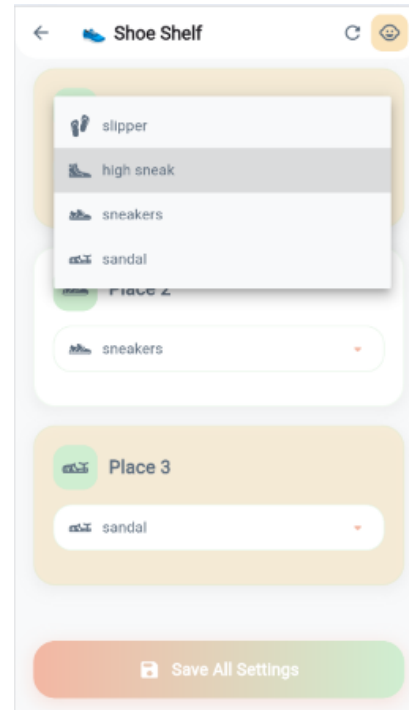


Figure 73: Setup - Shoe Shelf (2).

3.2.2.2.2 Management Screens

The closet management screen enables parents to add or remove clothing items within their designated sections. As the system is intended for use by children, an additional confirmation mechanism is implemented to verify that items returned to the rotary hanger are correctly placed, thereby maintaining system accuracy and reliability.

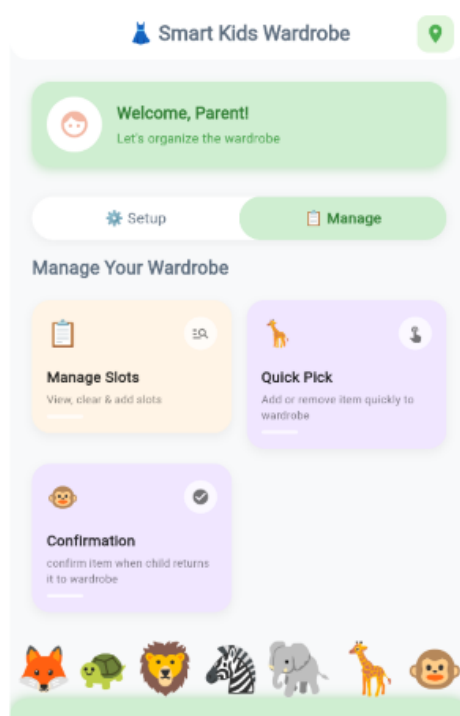


Figure 74: Management - Home screen

3.2.2.2.2.1 Confirmation

The confirmation screen displays clothing items returned to the rotary hanger by the child that have not yet been confirmed by the parent. The parent can verify whether each item is correctly placed; if not, the item can be removed and recorded as missing.

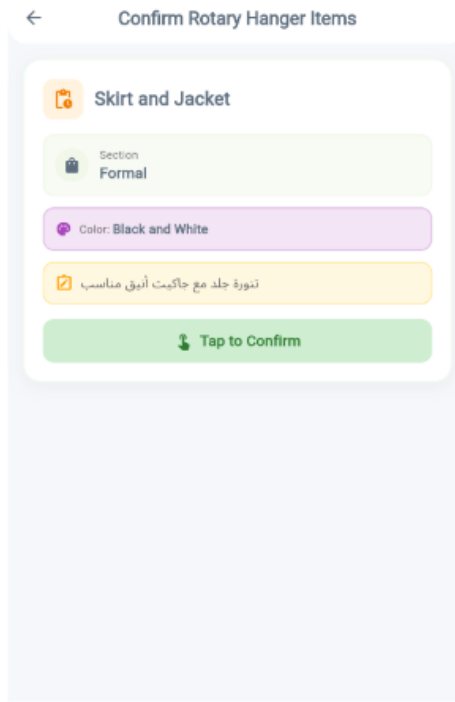


Figure 75: Management - Confirmation (1).

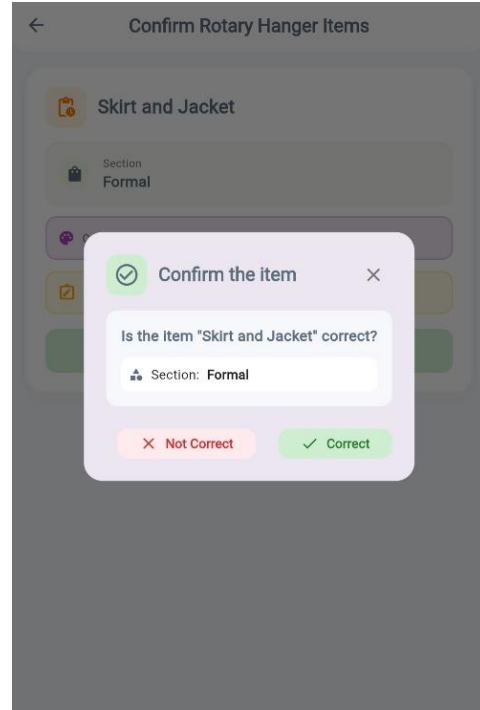


Figure 76: Management - Confirmation (2).

3.2.2.2.2 Rotary Hanger

The rotary hanger management screens enable parents to remove existing clothing items or add new items to any unoccupied slot, ensuring proper organization of the closet.

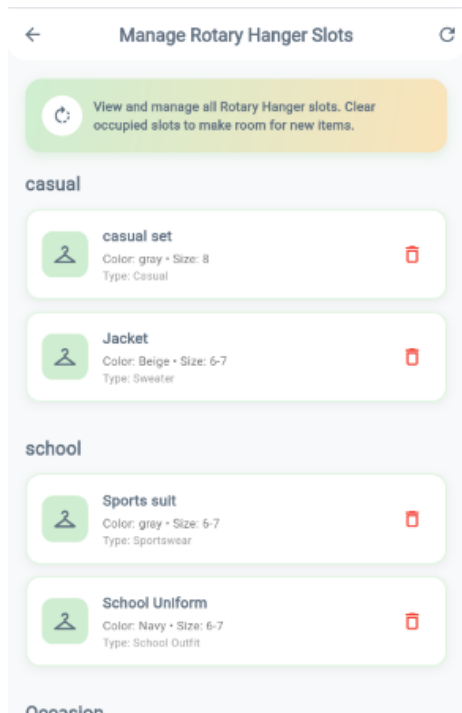


Figure 77: Management - Rotary Hanger (1).

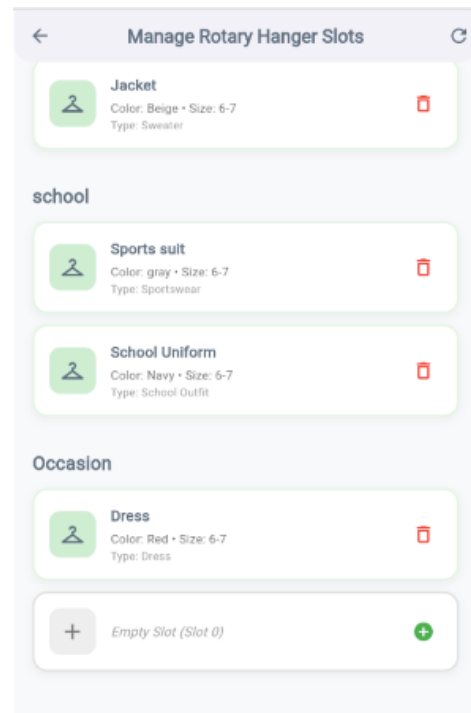


Figure 78: Management - Rotary Hanger (2).

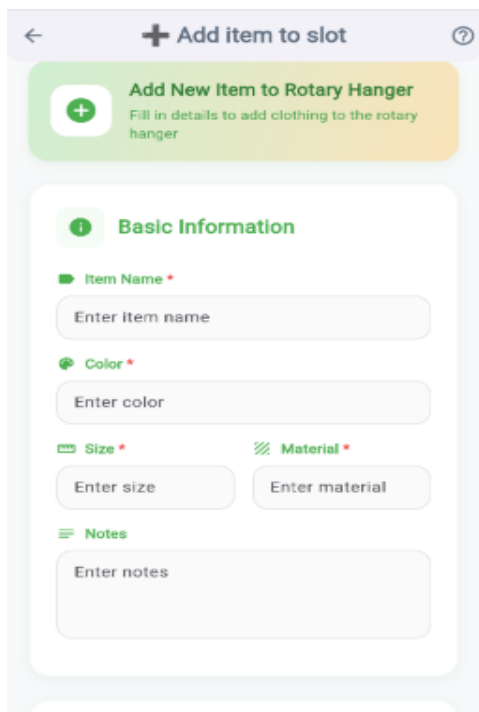


Figure 79: Management - Rotary Hanger Adding Cloth (1).

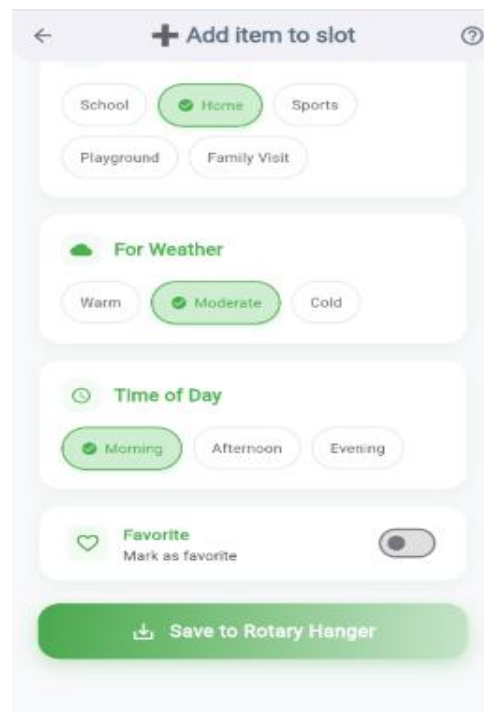


Figure 80: Management - Rotary Hanger Adding Cloth (2).

3.2.2.2.2.3 Drawers 1 and 2, Side Hanger, and Shoe Shelf

Management screens for the first and second drawers, the side hanger, and the shoe shelf allow parents to add or remove items as needed.

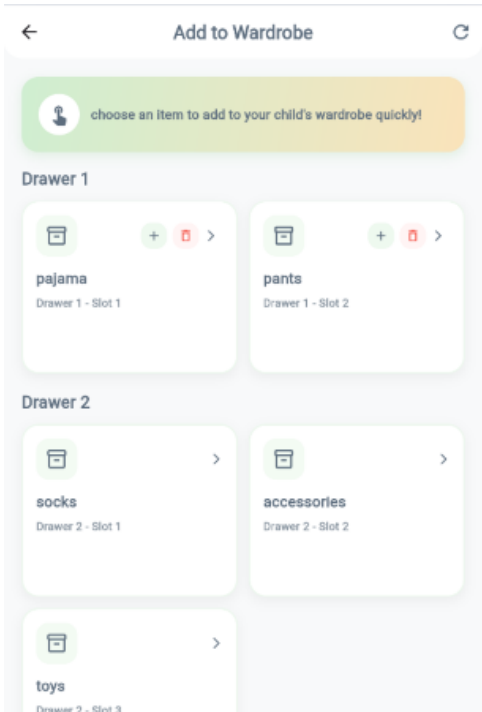


Figure 81: Management - Drawers 1 and 2.

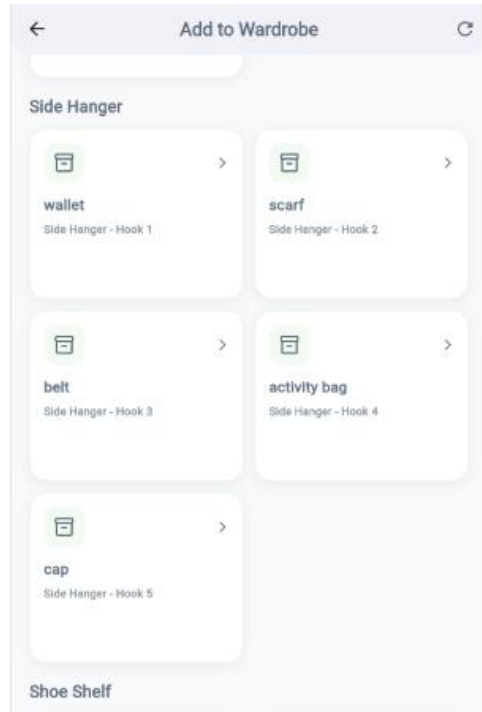


Figure 82: Management - Side Hanger.

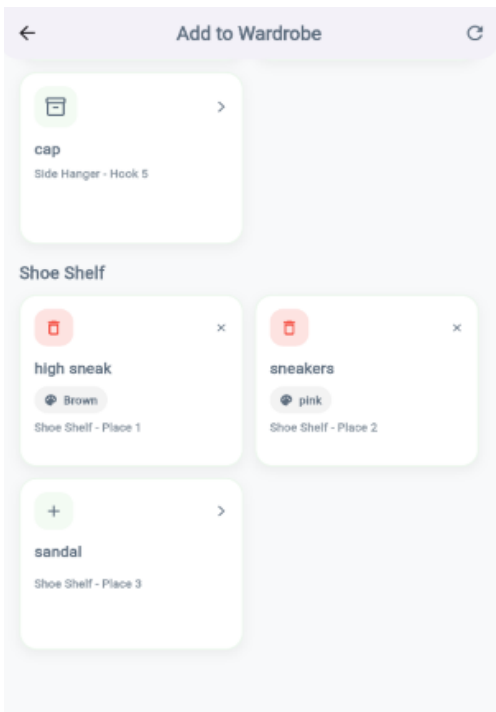


Figure 83: Management - Shoe Shelf

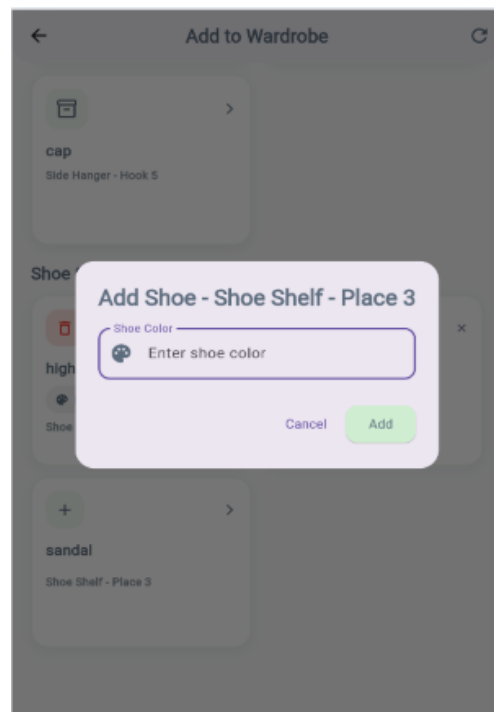


Figure 84: Management - Shoe Shelf Adding

3.3 System Operation and Workflow

3.3.1 Parent Setup

The parent configures the closet by assigning categories to each section and adding clothing items or other items to their respective locations.

3.3.2 Child Interaction

From the Nextion touchscreen, the child can select one of the following options:

3.3.2.1 Choosing Outfit:

Choosing the Outfit option provides access to all five sections of the closet: **Rotary Hanger, Side Hanger, Drawer 1, Drawer 2, and Shoe Shelf.**

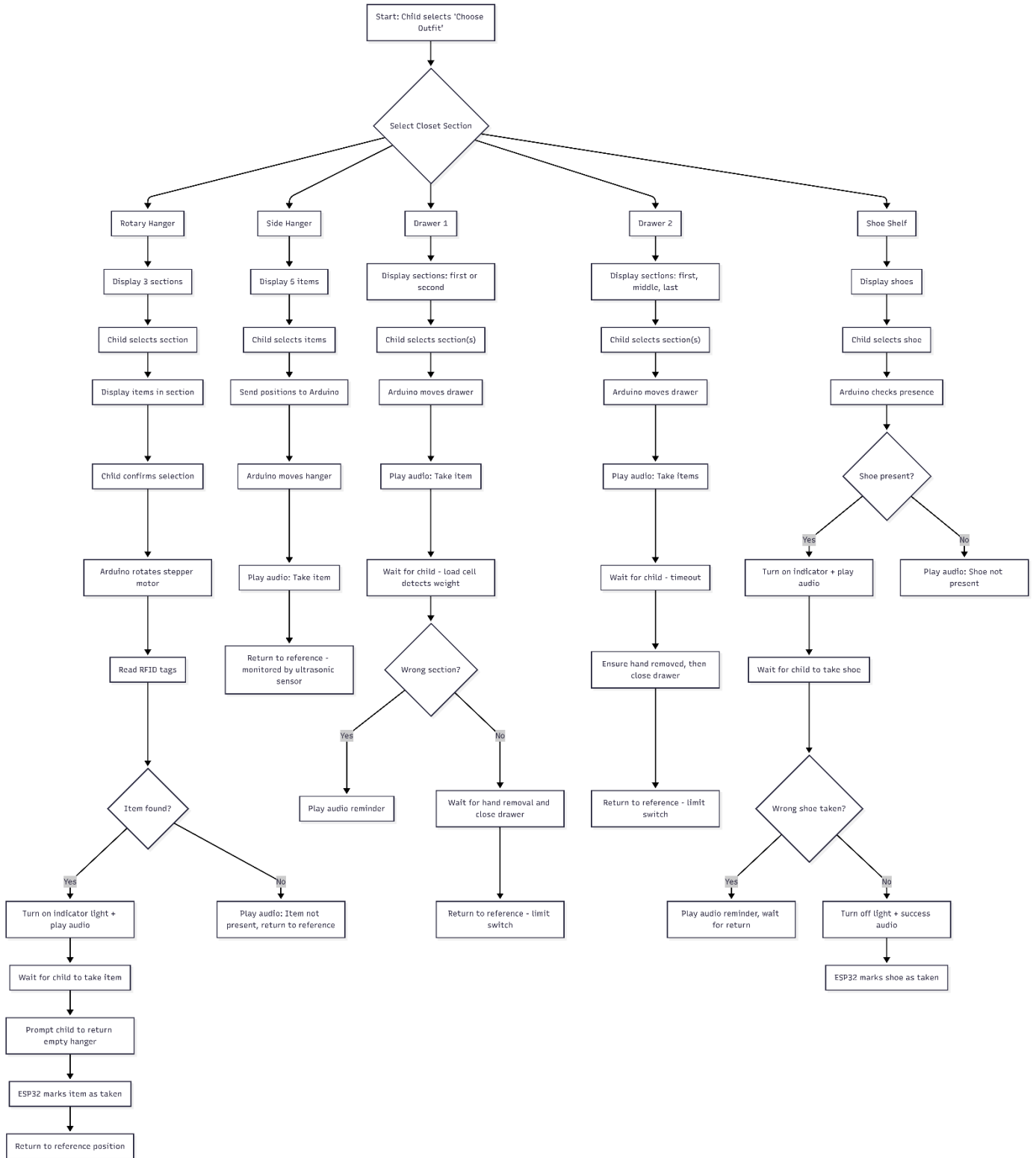


Figure 85: Child Interaction - Choosing Outfit option Flowchart

3.3.2.1.1 Rotary Hanger

- 1) The child selects which of the three sections of the rotary hanger they want to retrieve an item from.
- 2) The clothing items available in the chosen section are displayed on the Nextion screen, showing only items currently in the closet.
- 3) Once the child confirms their selection, the chosen item and section information are sent to the Arduino.
- 4) The Arduino controls the stepper motor to rotate the hanger to the appropriate section.
- 5) Upon reaching the section, the system reads the RFID tags of the items and compares them to the chosen item.
- 6) If the selected item is found, the corresponding indicator light is turned on and an audio message instructs the child to take the item.
- 7) The system continuously monitors the limit switch state within a set timeout; if no change is detected, the hanger returns to the reference point.
- 8) After the child takes the item, an audio message prompts them to return the empty hanger, and the system waits until the hanger is returned.
- 9) The information is sent to the ESP32 to mark the item as taken.
- 10) Finally, the rotary hanger returns to its reference position.

3.3.2.1.2 Side Hanger

- 1) The child can select one or more items from the five available on the side hanger.
- 2) Once the selection is confirmed, the positions of the selected items are sent to the Arduino.
- 3) The Arduino controls the stepper motor to move the hanger to the correct items.
- 4) An audio message is played to inform the child to take the items.
- 5) After the items are taken, the system returns the side hanger to its reference position, monitored using the ultrasonic sensor.

3.3.2.1.3 Drawer 1

- 1) The child selects which section of the drawer to take items from, either the first or second section, or both.
- 2) Once the selection is confirmed, the section information is sent to the Arduino, which controls the stepper motor to move the drawer to the appropriate section.
- 3) When the drawer opens, an audio message prompts the child to take the item.
- 4) The system waits within a timeout period for the child to retrieve the item, detecting the weight change using the load cell sensor.
- 5) If the child attempts to take an item from the wrong section, an audio message reminds them to take it from the correct section.
- 6) After the item is taken, the system waits for the child's hand to be removed before closing the drawer.
- 7) The drawer then returns to its reference position, monitored using a limit switch.

3.3.2.1.4 *Drawer 2*

- 1) The child selects which section(s) of the drawer to take items from, first, middle, last, or multiple sections.
- 2) Once the selection is confirmed, the section information is sent to the Arduino, which controls the stepper motor to move the drawer to the appropriate sections.
- 3) When the drawer opens, an audio message prompts the child to take the items.
- 4) The system waits within a timeout period for the child to retrieve the items.
- 5) The system ensures the child's hand is removed before proceeding with opening or closing the drawer.
- 6) After all selected sections are processed, the drawer returns to its reference position, monitored using a limit switch.

3.3.2.1.5 *Shoe Shelf*

- 1) The child selects one of the shoes displayed on the screen.
- 2) Once the selection is confirmed, the section information is sent to the Arduino.
- 3) The system checks if the selected shoe is available in the closet. If it is, the corresponding indicator light turns on; if not, an audio message informs the child that the shoe is not present.
- 4) The system waits for the child to take the shoe.
- 5) If the child attempts to take a shoe from the wrong location, an audio message reminds them to take the shoe from the illuminated section. If the wrong shoe is not returned, it is recorded as taken.
- 6) Once the child successfully takes the shoe, the indicator light turns off, and a success audio message is played.
- 7) The system records the shoe as taken once it has been successfully removed from the closet.

3.3.2.2 Missing Items:

The **Missing Items option** allows the child to return clothing to all relevant sections of the closet: Rotary Hanger, Side Hanger, Shoe Shelf, and the drawers.

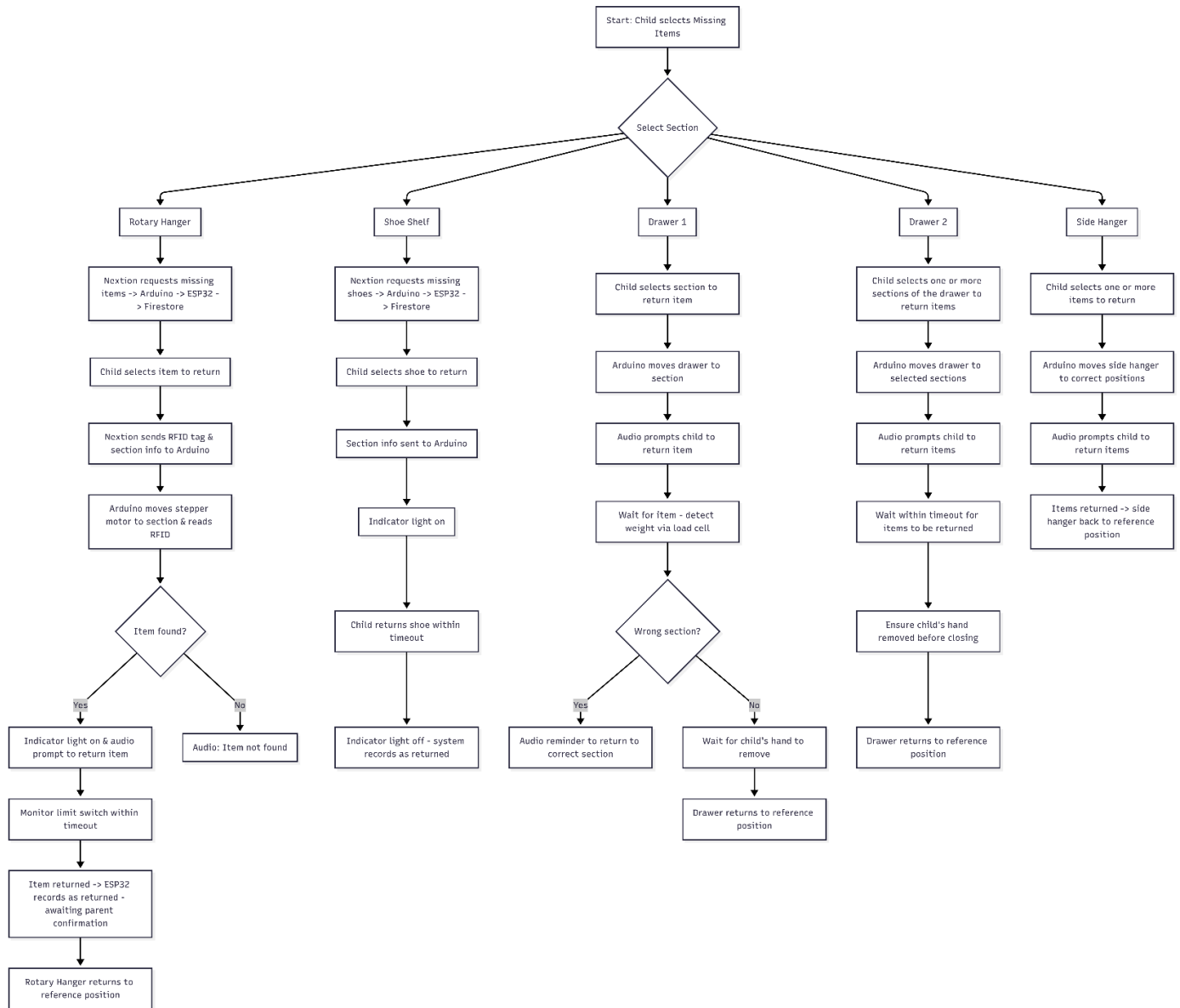


Figure 86: Child Interaction - Missing Items option Flowchart

3.3.2.2.1 Rotary Hanger

- 1) The Nextion screen sends a command to the Arduino to request missing items. The Arduino forwards this to the ESP32, which retrieves the missing items data from the Firestore database.
- 2) The child selects the item they want to return.
- 3) Once confirmed, the Nextion sends the RFID tag and section information of the item to the Arduino.
- 4) The Arduino controls the stepper motor to rotate the rotary hanger to the appropriate section and begins reading RFID tags.
- 5) If the item is found, the corresponding indicator light turns on, and an audio message instructs the child to return the clothing.
- 6) The system monitors the limit switch within a timeout period to detect whether the item has been returned.
- 7) Once successfully returned, the Arduino sends the information to the ESP32 to record the item as returned but marked as unconfirmed, awaiting parent verification.
- 8) Finally, the rotary hanger returns to its reference position, monitored using the hall effect sensor.

3.3.2.2.2 Shoe Shelf

- 1) The Nextion screen sends a command to the Arduino to request missing items. The Arduino forwards this to the ESP32, which retrieves the missing shoes data from the Firestore database.
- 2) The child selects the shoe they want to return from the items displayed on the screen.
- 3) Once the selection is confirmed, the section information is sent to the Arduino.
- 4) The corresponding indicator light turns on to guide the child.
- 5) The system waits for the child to return the shoe within a timeout period.
- 6) After the shoe is successfully returned, the indicator light turns off.
- 7) The system records the shoe as returned once it has been placed back in the closet.

3.3.2.2.3 Drawer1

- 1) The child selects which section of the drawer to return items to: either the first section, the second section, or both.
- 2) Once the selection is confirmed, the section information is sent to the Arduino, which controls the stepper motor to move the drawer to the appropriate section.
- 3) When the drawer opens, an audio message prompts the child to return the item.
- 4) The system waits for the child to return the item within a timeout period, detecting the weight change using the load cell sensor.
- 5) If the child attempts to return an item to the wrong section, an audio message reminds them to place it in the correct section.
- 6) After the item is returned, the system waits for the child's hand to be removed before closing the drawer.
- 7) The drawer then returns to its reference position, monitored by a limit switch.

3.3.2.2.4 *Drawer2*

- 1) The child selects which section(s) of the drawer to return items to: first, middle, last, or multiple sections.
- 2) Once the selection is confirmed, the section information is sent to the Arduino, which controls the stepper motor to move the drawer to the appropriate sections.
- 3) When the drawer opens, an audio message prompts the child to return the items.
- 4) The system waits within a timeout period for the child to place the items back.
- 5) The system ensures the child's hand is removed before proceeding to close the drawer.
- 6) After all selected sections are processed, the drawer returns to its reference position, monitored using a limit switch.

3.3.2.2.5 *Side Hanger*

- 1) The child selects one or more items to return from the five available hooks on the side hanger.
- 2) Once the selection is confirmed, the positions of the items are sent to the Arduino.
- 3) The Arduino controls the stepper motor to move the side hanger to the correct positions.
- 4) An audio message prompts the child to return the items.
- 5) After the items are successfully returned, the system moves the side hanger back to its reference position, monitored using the ultrasonic sensor.

3.3.2.3 Get Outfit Ideas:

The **Get Outfit Ideas** section allows the child to receive outfit suggestions based on the occasion and current weather.

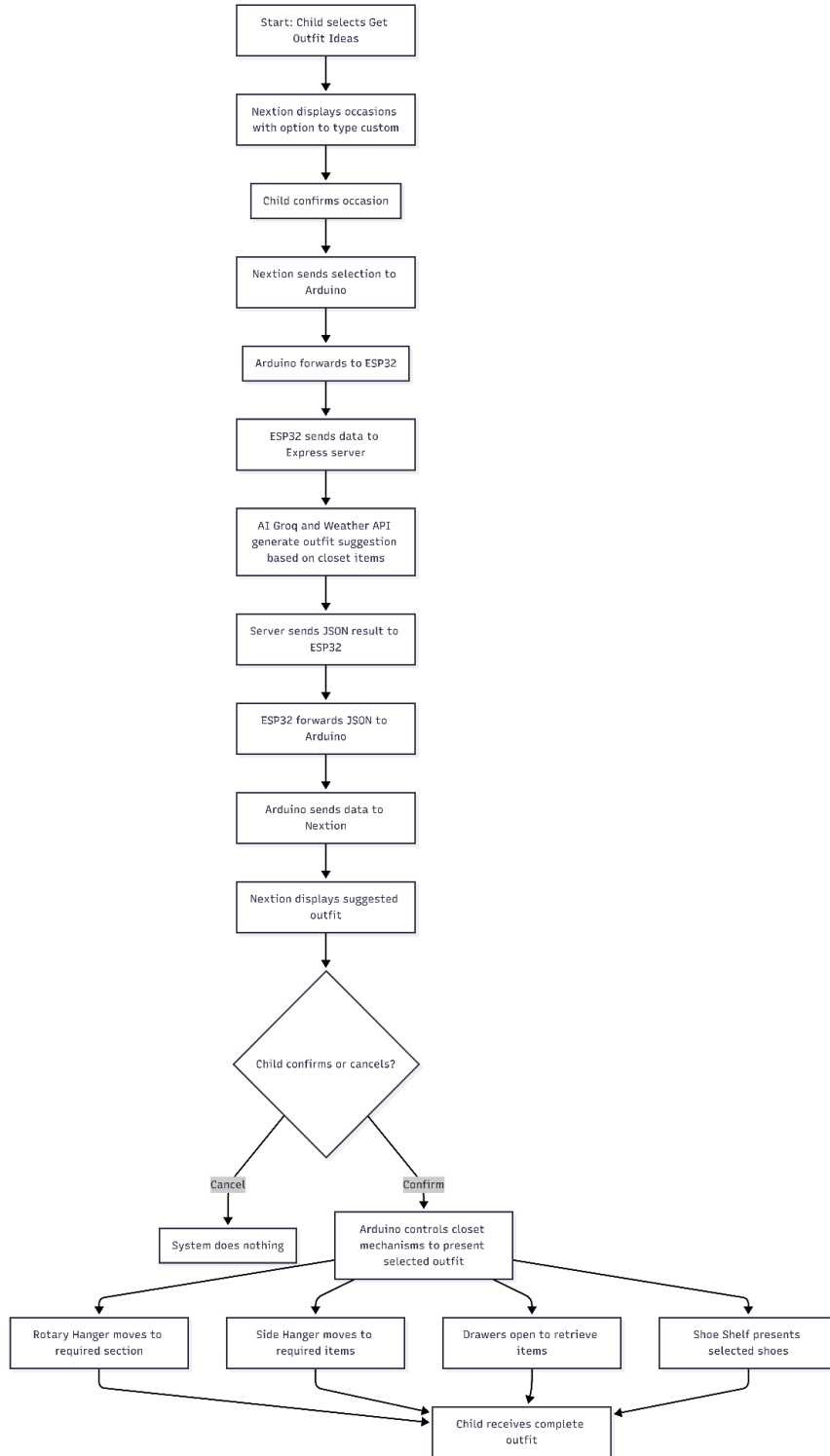


Figure 87: Child Interaction - Get Outfit Ideas Flowchart

- 1) The Nextion screen displays predefined occasions and provides an option for the child to type a custom occasion if it is not listed.
- 2) Once the child confirms the occasion, the Nextion sends the selection to the Arduino, which forwards it to the ESP32, and then to the Express server.
- 3) The Express server uses a prompt AI (Groq) along with a weather API to generate outfit suggestions based on the items currently available in the closet.
- 4) The suggested outfit is returned as a JSON response to the ESP32, then passed to the Arduino, and finally displayed on the Nextion screen.
- 5) The Nextion displays the suggested outfit, and the child can either confirm or cancel it.
- 6) If the child cancels, the system does not take any action.
- 7) If the child confirms, the Arduino controls the closet mechanisms (rotary hanger, side hanger, drawers, and shoe shelf) to present the items specified in the JSON suggestion.

3.3.3 Parent interaction

Through the mobile application, parents can manage the closet by adding or removing clothing items and confirming returned items placed back into the closet.

3.3.3.1 Adding

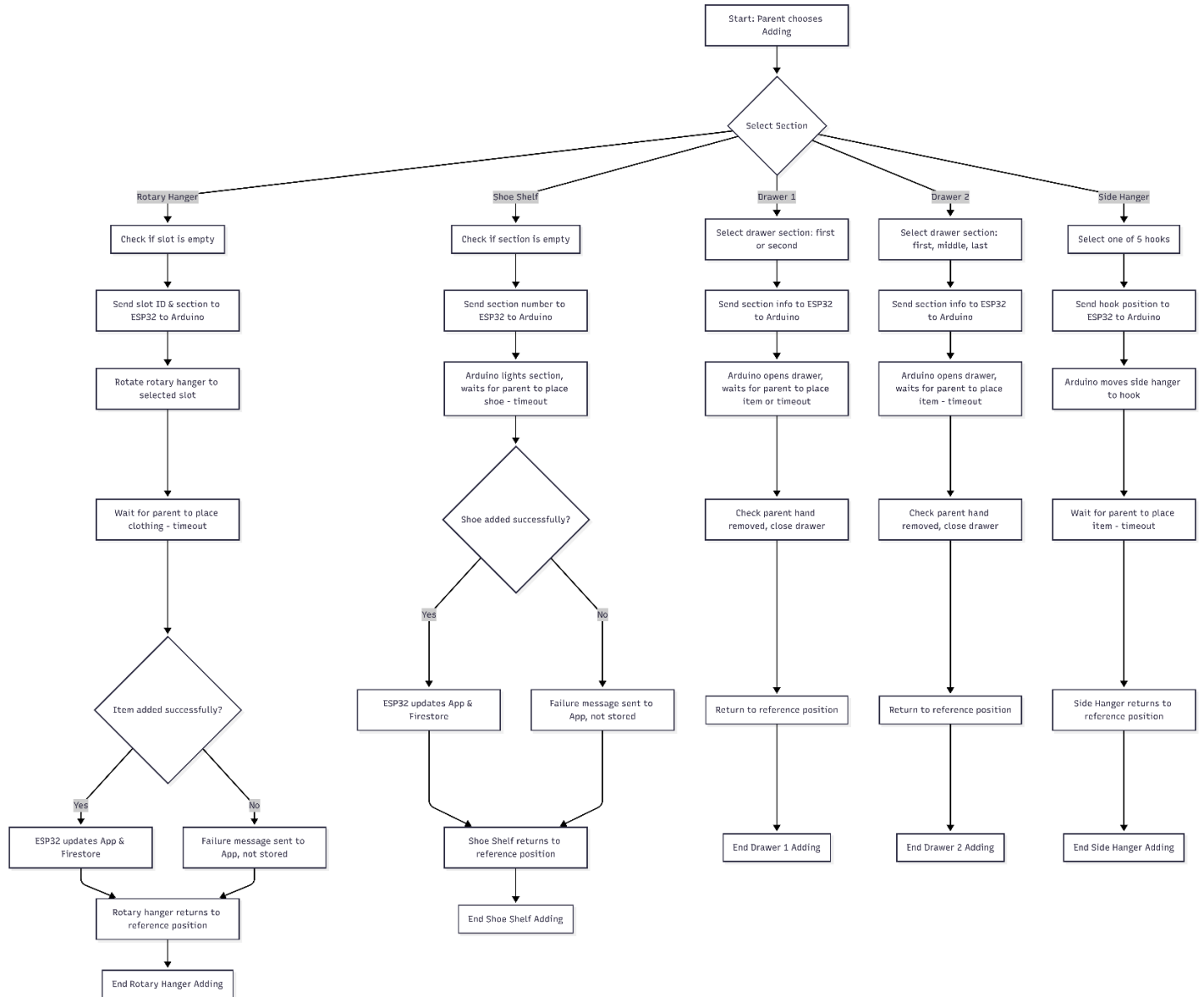


Figure 88: Parent Interaction - Adding Flowchart

3.3.3.1.1 Rotary Hanger:

- 1) If a slot on the rotary hanger is not occupied, the parent can add a new clothing item to that slot.
- 2) The mobile application sends the slot ID and section number to the ESP32, which forwards the information to the Arduino.
- 3) The Arduino controls the rotary hanger and rotates it to the selected empty slot.
- 4) The system waits for the parent to place the clothing item within a defined timeout period.
- 5) If the item is successfully added, the Arduino notifies the ESP32, which updates the application and stores the new item in the Firestore database. If the operation fails, a failure message is sent to the application, and the item is not stored.
- 6) Finally, the rotary hanger returns to its reference position.

3.3.3.1.2 Shoe Shelf

- 1) If a shoe section is not occupied, the parent can add a new shoe by entering its color in the mobile application.
- 2) The mobile application sends the selected section number to the ESP32, which forwards the information to the Arduino.
- 3) The Arduino activates the indicator light for the selected section and waits for the parent to place the shoe within a specified time period.
- 4) If the shoe is successfully added, the Arduino notifies the ESP32, which updates the mobile application and stores the shoe information in the Firestore database. If the operation fails, a failure message is sent to the application, and the shoe is not stored.

3.3.3.1.3 Drawer1

- 1) The parent selects which section of Drawer 1 to add a new item to, either the first section or the second section.
- 2) The mobile application sends the selected section information to the ESP32, which forwards it to the Arduino.
- 3) The Arduino opens the drawer to the selected section and waits for the parent to place the item, detecting the weight change using the load cell sensor or stopping after a timeout if no item is added.
- 4) Before closing the drawer, the system checks that the parent's hand is removed, then closes the drawer and returns it to its reference position.

3.3.3.1.4 Drawer2

- 1) The parent selects which section of Drawer 2 to add a new item to: first, middle, or last section.
- 2) The mobile application sends the selected section information to the ESP32, which forwards it to the Arduino.
- 3) The Arduino opens the drawer to the selected section and waits for the parent to place the item within a predefined time period.
- 4) Before closing the drawer, the system checks that the parent's hand is removed, then closes the drawer and returns it to its reference position.

3.3.3.1.5 Side Hanger

- 1) The parent selects one of the five side hanger hooks to add a new item to.
- 2) The mobile application sends the selected hook position to the ESP32, which forwards the information to the Arduino.
- 3) The Arduino moves the side hanger to the selected position.
- 4) The system waits for a predefined time period to allow the parent to place the item on the hanger.
- 5) After the time period expires, the side hanger returns to its reference position.

3.3.3.2 Removing

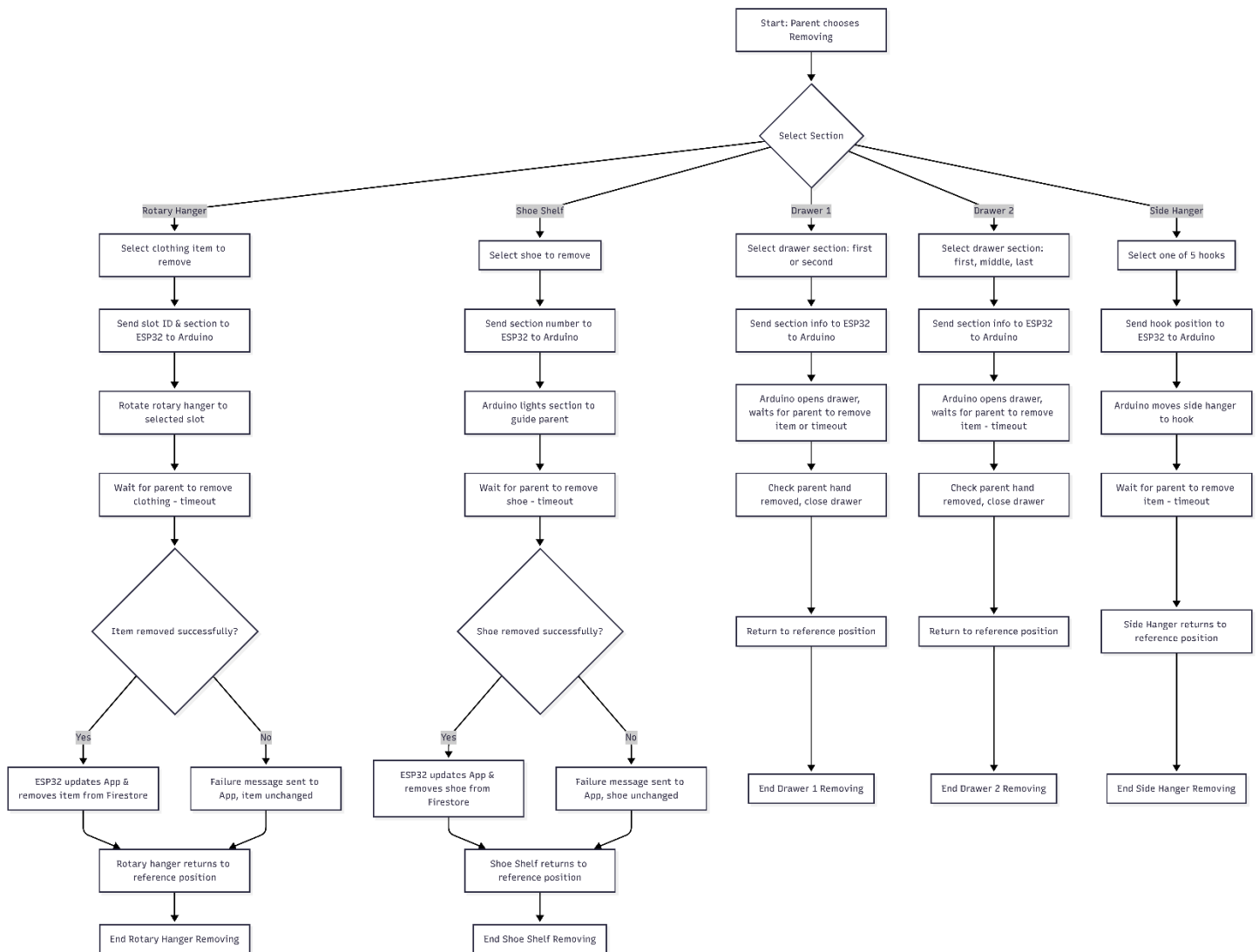


Figure 89: Parent Interaction - Removing Flowchart

3.3.3.2.1 Rotary Hanger

- 1) The parent selects the clothing item to be removed from the rotary hanger using the mobile application.
- 2) The mobile application sends the slot ID and section number to the ESP32, which forwards the information to the Arduino.
- 3) The Arduino controls the rotary hanger and rotates it to the selected slot.
- 4) The system prompts the parent to remove the clothing item and waits within a defined timeout period.
- 5) Once the item is successfully removed, the Arduino notifies the ESP32, which updates the mobile application and removes the item from the Firestore database. If the removal is not completed within the timeout period, a failure message is sent, and no changes are stored.
- 6) Finally, the rotary hanger returns to its reference position.

3.3.3.2.2 Shoe Shelf

- 1) The parent selects the shoe to be removed from the mobile application.
- 2) The mobile application sends the selected section number to the ESP32, which forwards the information to the Arduino.
- 3) The Arduino activates the indicator light for the selected shoe section to guide the parent.
- 4) The system waits for the parent to remove the shoe within a specified time period.
- 5) If the shoe is successfully removed, the Arduino notifies the ESP32, which updates the mobile application and removes the shoe information from the Firestore database. If the operation fails, a failure message is sent to the application, and the shoe data remains unchanged.

3.3.3.2.3 Drawer 1

- 1) The parent selects which section of Drawer 1 to remove an item from, either the first section or the second section.
- 2) The mobile application sends the selected section information to the ESP32, which forwards it to the Arduino.
- 3) The Arduino opens the drawer to the selected section and waits for the parent to remove the item, detecting the weight change using the load cell sensor or stopping after a timeout if no removal is detected.
- 4) Before closing the drawer, the system checks that the parent's hand is removed, then closes the drawer and returns it to its reference position.

3.3.3.2.4 *Drawer 2*

- 1) The parent selects which section of Drawer 2 to remove an item from: the first, middle, or last section.
- 2) The mobile application sends the selected section information to the ESP32, which forwards it to the Arduino.
- 3) The Arduino opens the drawer to the selected section and waits for the parent to remove the item within a predefined time period.
- 4) Before closing the drawer, the system ensures the parent's hand is removed, then closes the drawer and returns it to its reference position.

3.3.3.2.5 *Side Hanger*

- 1) The parent selects one of the five side hanger hooks to remove an item from.
- 2) The mobile application sends the selected hook position to the ESP32, which forwards the information to the Arduino.
- 3) The Arduino moves the side hanger to the selected position.
- 4) The system waits for a predefined time period to allow the parent to remove the item.
- 5) After the time period expires, the side hanger returns to its reference position.

3.3.3.3 Confirming

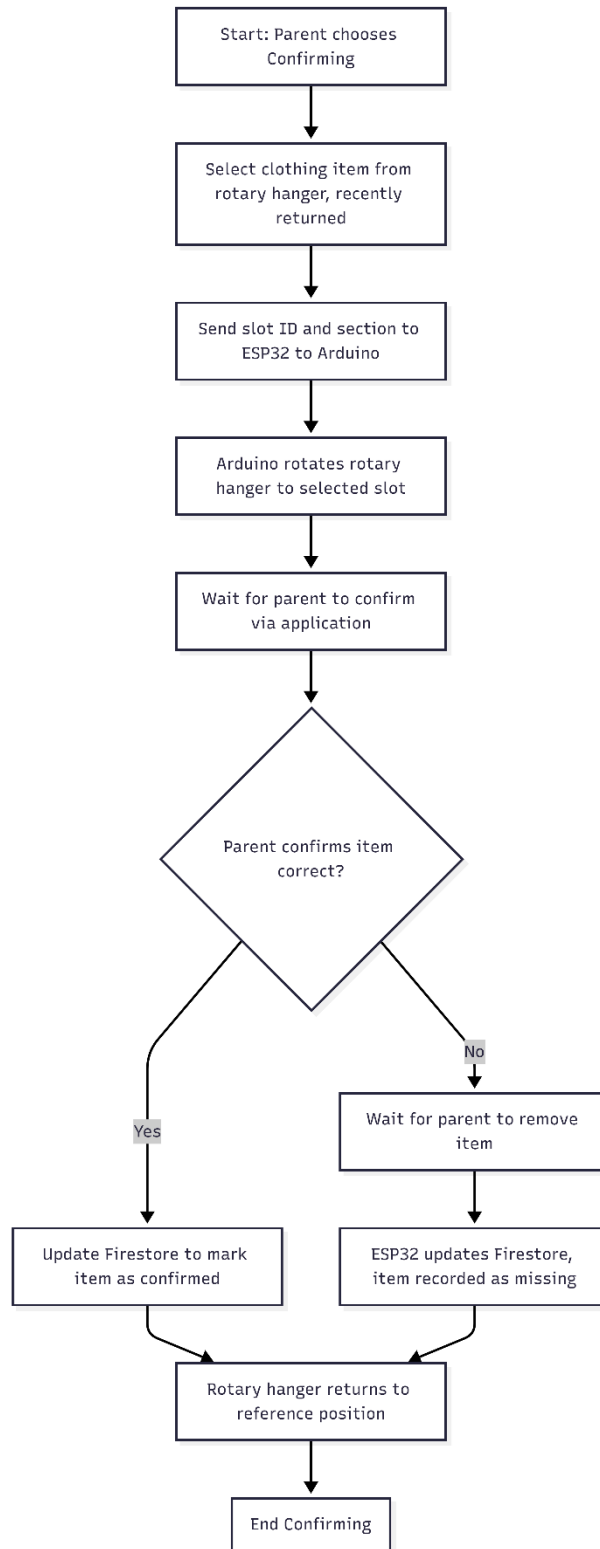


Figure 90: Parent Interaction - Confirming Flowchart

- 1) The parent selects a clothing item from the rotary hanger that was recently returned by the child but not yet confirmed.
- 2) The mobile application sends the slot ID and section number to the ESP32, which forwards the information to the Arduino.
- 3) The Arduino rotates the rotary hanger to the corresponding slot.
- 4) The system waits for the parent to confirm the item as correct or incorrect via the application. The response is sent to the ESP32 and then to the Arduino.
- 5) If the parent confirms the item is correct, the system updates Firestore to mark the item as confirmed and returns the rotary hanger to its reference position.
- 6) If the item is incorrect, the system waits for the parent to remove it. Once removed, the ESP32 updates Firestore to record the item as missing, allowing the child to return it correctly later.
- 7) The rotary hanger then returns to its reference position.

3.4 Constraints:

- 1) **Limited component availability:** Some hardware components were difficult to source from local stores.
- 2) **Rotary hanger mechanics:** The hanger must rotate and return precisely to its starting position; otherwise, the wire inside the rod may twist or get damaged.
- 3) **Complex usage scenarios:** The closet has many different use cases and edge cases, especially when used by children, which makes system handling challenging.
- 4) **Touchscreen limitations:** The Nextion touchscreen has limited dynamic flexibility for interface design.
- 5) **Mechanical detection weaknesses:** Using limit switches to detect the presence of clothes on hangers can be unreliable due to mechanical limitations.
- 6) **RFID limitations:** The RFID tags and readers have a limited range; the distance between the hanger and reader must not exceed 3 cm, which is difficult to guarantee when children interact with the system.

Chapter 4: Results and Discussion:

The KiddieCloset system was tested to evaluate its functionality, usability, and overall performance. The rotary hanger successfully rotates to present the desired clothing section and reliably returns to its starting position, while the pull-out hangers and movable shelves operate smoothly to allow easy access to items. The RFID tags effectively identify clothing pieces, and the indicator lights guide children in selecting the correct items. Interaction through the Nextion touchscreen proved to be intuitive for children, and the built-in speaker provided clear and timely audio instructions, enhancing the overall user experience.

Parents were able to manage closet sections and clothing data through the mobile application, which communicates with the system in real time via the Firestore database. This synchronization allowed updates to be reflected immediately on the hardware interface, ensuring accurate and efficient management of the closet.

During testing, the system demonstrated a high level of reliability, though some limitations were observed. The RFID tags required precise placement, as the reading distance could not exceed 3 cm, and the Nextion touchscreen had limited dynamic flexibility for more complex interactions. Additionally, mechanical components, such as the limit switches and wire mechanism in the rotary hanger, occasionally require adjustment to maintain accuracy. Despite these minor issues, children were able to independently select outfits, return items to their proper place, and interact with the closet without assistance, indicating that the system effectively promotes independence while reducing the need for parental guidance.

Overall, the results show that KiddieCloset is a practical and engaging solution for organizing clothing and supporting children in their daily routines. The system successfully combines mechanical hardware, embedded electronics, and software to create an interactive experience. At the same time, the observed limitations highlight areas for future improvement, such as enhancing RFID reliability, expanding touchscreen flexibility, and strengthening mechanical components to better withstand frequent use by children.

Chapter 5: Conclusions and Future Work

5.1 Conclusion:

KiddieCloset presents an innovative solution for closet management, serving as a helpful companion for children in their daily routines. The system effectively combines hardware and software to create a practical and well-engineered product. It provides clear benefits for children by supporting organization, guiding outfit selection, and encouraging independence. At the same time, it allows parents to manage and organize the closet efficiently, ensuring that children can use the system effectively. Overall, KiddieCloset demonstrates how technology can enhance everyday tasks, making them more engaging and convenient for both children and parents.

5.2 Future Work:

Several enhancements can be considered for future versions of KiddieCloset:

- 1) Integrate a camera to identify outfit styles and provide smart suggestions.
- 2) Adapt the closet to the child's age, allowing it to remain useful as they grow.
- 3) Increase flexibility so the closet can be used by multiple users or family members.
- 4) Add a feature that allows parents to choose outfits for the child for specific occasions.

Chapter 6: References

Goh, K. N., Chen, Y. Y., & Lin, E. S. (2011). Developing a smart wardrobe system. *2011 IEEE Consumer Communications and Networking Conference (CCNC)*, 303–307.
<https://doi.org/10.1109/CCNC.2011.5766478>

Mun, S.-H., Lee, • Ju-Hyon, Lee, • Ji-Min, Park, • Gun-Hee, Han, • Young-Oh, Author,
• Corresponding, Han, Y.-O., & 론서. (n.d.). 아두이노 메가 기반의 스마트 옷장 문세훈 Smart Closet based on Arduino MEGA. *Journal of the KIECS*, 17(5), 1975–8170.
<https://doi.org/10.13067/JKIECS.2022.17.5.949>

Na Nakorn, D., & Rakmanee, O. (n.d.). *Smart Closet Statistical-based apparel recommendation system. Smart Wardrobe Market Size, Outlook, SWOT & Forecast 2033*. (2025). Verified Market Reports.
https://www.verifiedmarketreports.com/product/smart-wardrobe-market/?utm_source