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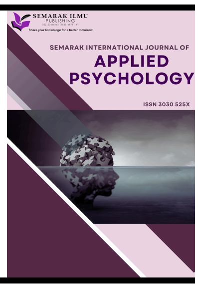

Tranquillity CuBOT: Nurturing Emotions Stability of Autism Children

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ABSTRACT

The increasing prevalence of autism spectrum disorder (ASD) highlights the urgent need for practical tools to manage the unique challenges faced by children with ASD, particularly in regulating emotional stability. Tantrums and emotional outbursts are common among children with ASD, often triggered by sensory overload, communication difficulties, and changes in routine. These episodes can be distressing for the child and their caregivers, necessitating innovative solutions to provide timely and effective calming interventions. The Tranquillity CuBOT project aims to develop an interactive robotic companion designed to help children with ASD manage emotional distress. The robot will feature calming music, a moving hand, and sensory-textured elements, all integrated into a design that walks on a predefined track. In designing and developing the Tranquillity CuBOT, iterative prototyping has been utilized as a methodology alongside many electronic components that make up the creation, such as ultrasonic sensors, NodeMCU ESP8266, I2C 1602 Serial LCD, and others, equipping it with the necessary functions. The study used a qualitative and quantitative approach, gathering data through observations and questionnaires. The data for the questionnaires was analyzed using SPSS 26.0 with descriptive statistics, measuring dimensions like usefulness, and attitude to use. Results indicated high satisfaction across all areas, with Cronbach's alpha ($\alpha = 0.833$) confirming the instrument's reliability. Findings suggest that Tranquillity CuBOT can significantly reduce the frequency and intensity of tantrums, promoting better emotional regulation and overall well-being. This research underscores the potential of innovative, technology-driven solutions in enhancing the quality of life for children with ASD and their caregivers, paving the way for future advancements in this field.

1. Introduction

The rising number of children diagnosed with autism spectrum disorder (ASD) presents challenges for families and society, particularly in social interactions, communication, and behavior

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[1]. People with ASD generally experience problems with emotional regulation, manifesting as tantrums and other negative behaviors [2]. In Malaysia, the government enacted the Persons with Disabilities Act 2008 [Act 685] to uphold the rights of persons with disabilities (PWDs) and ensure their access to public facilities, services, buildings, public transport, education, employment, information and communication technology (ICT), health, and habilitation and rehabilitation on an equal basis. By 2018, Malaysia had 21,287 registered individuals with autism, with a prevalence rate of approximately 1.6 per 1,000 people. The number of registered autism cases has been rising annually, with 305 cases in 2015, 473 cases in 2016, and 515 cases in 2017. In 2016, 210 new cases were registered, which surged to 1,392 cases by 2018, as shown in Figure 1. The age group with the most reported autism cases was 7 to 12 years old, and the total reported autism cases in 2018 reached 2,952 [3].

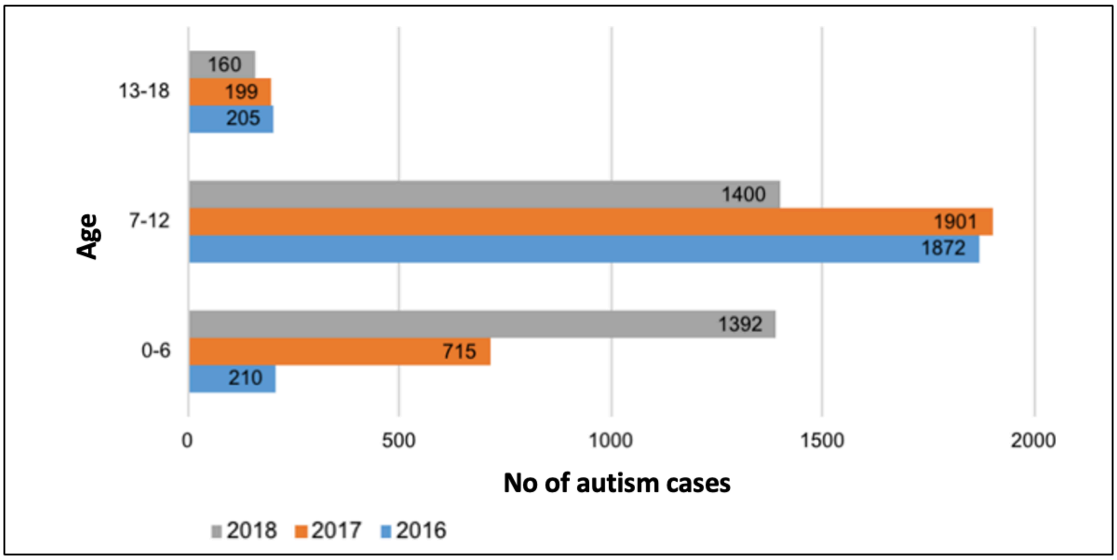

Fig. 1. Reported autism cases in Malaysia from 2016 to 2018

1.1 Problem Statement

Individuals with ASD often experience difficulties in emotional regulation, leading to issues such as tantrums [4]. Approaches such as deep breathing and engaging the senses have shown promising results in suppressing these difficulties. While various interventions exist to address the challenges faced by children with ASD, there remains a gap in effectively addressing the comprehensive sensory, emotional, and cognitive components of ASD [5]. Traditional interventions, despite their merits, may not fully meet the diverse needs of individuals with ASD, leading to persistent difficulties in social interaction, communication, and behavior. Therefore, there is a pressing need for innovative and holistic approaches that can provide comprehensive support to children with ASD, particularly in regulating emotions and promoting emotional stability.

1.2 Objectives and Scope

The Tranquillity CuBOT project is focused on creating an engaging and supportive robotic companion specifically designed to help children with ASD manage emotional challenges. This project aims to provide children with a dependable, personalized tool that helps them regulate emotions and improve their overall well-being. CuBOT will include carefully chosen features to encourage relaxation and comfort, such as soothing melodies, calming LED lights, and sensory-textured elements. By combining these sensory elements, CuBOT aims to deliver a complete sensory experience tailored to the unique needs and preferences of children with ASD.

The research gap in this work lies in the limited availability of personalized, portable, and interactive solutions specifically designed to support emotional regulation in children with ASD. Traditional calming interventions, such as sensory rooms, weighted blankets, and squeeze machines, are often effective but may lack adaptability, accessibility, and immediate responsiveness. Many current solutions are also static, requiring children to be in a fixed location or have caregiver assistance, which may not suit the dynamic and varying needs of children with ASD in different environments. Moreover, while some assistive technology exists [6], most devices are not tailored to address the sensory and emotional needs specific to children with ASD, particularly in real-time emotional distress scenarios. This gap underscores the need for an interactive, user-friendly tool to provide immediate calming interventions independently of caregiver input. It offers a more self-directed way for children to manage their emotions.

2. Literature Review

Tantrums are emotional outbursts often characterized by stubbornness, crying, screaming, defiance, anger, and sometimes violence [7]. They are common in young children, especially those between the ages of 1 and 4, as they are still learning to cope with new feelings and emotions and often lack the verbal skills to express themselves adequately [8]. Tantrums are common in typically developing children, and they can be more frequent, intense, and prolonged in children with ASD [9]. Emotional regulation is a critical aspect of development for children with ASD. These children often face significant challenges in managing emotional distress, which can significantly impact their daily lives and overall well-being.

Currently, caregivers and therapists use weighted blankets and squeeze machines as interventions to help manage and reduce tantrums [10]. Assistive technologies (AT) cover a broad spectrum of tools and strategies that seek to enhance the capacities of individuals with various disabilities to tackle mobility, visual, communication, cognitive, and sensorial issues, among others [11]. People with disabilities can use it to enhance participation in their lives and society. The assistive technologies platform within the Internet of Things (IoT) [12-14] enables the smooth data exchange between the involved parties in unique education settings, through which personalized learning environments for students with Special Educational Needs (SEN) are fostered [15].

2.1 Strengths and Weaknesses of the Existing Tools

This study compares several assistive tools to evaluate their efficacy in managing tantrums and supporting children with ASD. Among these tools are the 3i-learning system [15], known for its interactive learning modules; AutiSense [16], which employs sensory feedback to enhance user engagement; Smart Box [17], a cost-effective option that utilizes RFID technology for tracking behavior; and WearSense [18], a wearable device that simplifies data collection through smartwatch accelerometers. These systems have unique strengths and weaknesses that contribute to their effectiveness in various educational contexts. Table 1 presents a detailed analysis of these strengths and weaknesses, highlighting key features such as user-friendliness, adaptability to individual needs, and overall impact on emotional regulation. This comparative analysis is essential for guiding the development of the Tranquillity CuBOT, as it will leverage the insights gained from existing tools to create a more effective and tailored solution for managing emotional distress in children with ASD.

Table 1
Strength and weakness of the existing systems

Product/System	Strength	Weakness
3i-learning system	• Integrates IoT technology with ABA therapy for a comprehensive view of student progress. • Helps create personalized education plans for students with special needs.	• Limited emotion recognition features. • High cost of Empatica E4 wristband may limit affordability.
AutiSense	• Personalized monitoring of body signals for emotional awareness. • User-centered design based on research insights.	• Limited functionality beyond monitoring emotions. • Usability challenges, especially regarding comfort and user experience.
Smart Box	• Offers sensory controls for ASD support. • Integration with IoT enhances quality of life.	• Limited customization for individual needs. • Effectiveness may vary based on child characteristics.
WearSense	• Use smartwatches for easy behavior monitoring in autism. • Accurate classification with machine learning aids caregivers.	• Not all individuals may wear smartwatches regularly. • Accuracy may vary due to individual behavior differences.

2.2 Features Comparison between the Existing Systems

A thorough review of the existing systems has been made. Table 2 presents comparisons based on various features, including data-gathering methods, educator involvement, cost-effectiveness, and the potential for automation and remote monitoring.

Table 2
Features comparison between the existing systems

Product/System	Data-gathering methods	Educator Involvement	Cost Effectiveness	Potential for Automation and Remote Monitoring
3i-learning system	Offers sensors that track task performance, physiology, and environment.	Medium	High	High
AutiSense	Offers sensor that records electrical activity in the skin, have pulse measurement and microchip to know status through smartphone apps.	Medium	Medium	High
Smart Box	Uses RFID tags attached to designated physical objects.	Medium	Low	High
WearSense	Uses Moto360 Smart Watch equipped with an accelerometer sensor.	Low	Medium	High

Based on Table 2, the 3i-learning and AutiSense approaches excel in extensive data collection across various parameters, offering a comprehensive understanding of learner engagement and challenges. Smart Box provides a cost-effective RFID tag-based option, while WearSense simplifies data collection using smartwatch accelerometers. Educator involvement varies, with 3i-learning, AutiSense, and SmartBox potentially requiring more expertise, whereas WearSense offers minimal ongoing involvement post-setup.

Despite these differences, all systems feature high automation and remote monitoring capabilities, which assist educators in efficiently managing learning processes. Functions like scheduling, notifications, and smartphone applications facilitate personalized learning experiences. The effectiveness of automation and monitoring depends on targeted outcomes and strategic support.

3. Materials and Method

The development and implementation of the Tranquillity CuBoT, featuring sensory elements such as hand movements and calming sounds, aims to transform environments to provide comfort for children with autism. This initiative aligns with the objectives of SDG 4, which focuses on creating inclusive and supportive learning environments [19]. By addressing the needs of children with ASD, the Tranquillity CuBoT contributes to the global goal of ensuring equitable and quality education for all.

The methods and materials used to develop Tranquillity CuBOT are crucial project components. The methods section details how the research was conducted, providing a comprehensive overview of the procedures and techniques used. Meanwhile, the materials section outlines the tools and components utilized during the project's development, specifying the resources and equipment essential for creating the Tranquillity CuBOT.

3.1 Materials

The Tranquillity CuBOT prototype is a physical project built primarily using various electronic components, including the Arduino Uno, Tiny Robot Microbit, HC-SR04 Ultrasonic Sensor, I2C 1602 Serial LCD, NodeMCU ESP322 Microcontroller, and SG90 Micro Servo. Several software tools were employed throughout the development process to facilitate the project's completion, with the Arduino Integrated Development Environment (IDE) as the primary software tool.

3.2 Method

This project utilized an iterative prototyping methodology, which involves developing and testing the product in incremental stages. This approach allows developers to gather feedback, implement necessary changes, and enhance the overall user experience. Figure 2 illustrates the five essential stages of the iterative prototyping process.

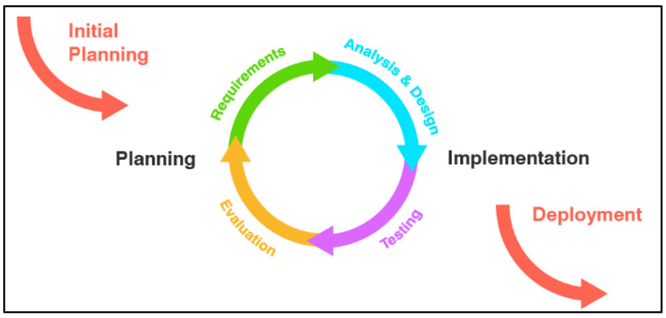

Fig. 2. Visual representation iterative prototyping methodology [20]

3.2.1 Planning

The planning stage outlines the project's objectives, specifications, and constraints. During this phase, the goal and scope of the project are defined, and a Gantt chart is created to illustrate the timeline and set realistic targets for each iteration. The Analysis and Design phase utilizes the data gathered during the planning stage to develop the project further.

3.2.2 Analysis and design

During the Analysis and Design phase, extensive research and concepts for the Tranquillity CuBOT were made, which involved evaluating various electronic components and identifying those most suitable for the project, particularly those relevant to the needs of individuals with ASD. In ensuring seamless integration of hardware and software components, the work also reviewed source codes, focusing on developing a design that incorporates the intended functionality and meets the goals established in the preliminary phase. To further ensure that the CuBOT design meets the sensory needs of individuals with ASD and aligns with the project objectives, consultations with psychology, occupational therapy, and special education experts were made. Their feedback and recommendations helped refine the design to serve better CuBOT users' interactive engagement, emotional stability, and sensory regulation needs.

The Tranquillity CuBOT comprises several key components: an Arduino Uno as the central control unit, an HC-SR04 Ultrasonic Sensor integrated with a Tiny Robot Microbit, an I2C 1602 Serial LCD connected to the Arduino Uno for user interaction, and an SG90 Micro Servo linked with the NodeMCU ESP32. Most components are connected using wires, except those providing power to the Tranquillity CuBOT. The Arduino is connected to the LCD and NodeMCU ESP8266, with interconnections between their pins. The power source for Tranquillity CuBOT includes a mini power bank for the Arduino and a battery with a total voltage of 3.7 volts housed in the Tiny Robot Microbit battery case. Figure 3 shows the circuit diagram of Tranquillity CuBOT, detailing the connections of the electrical components.

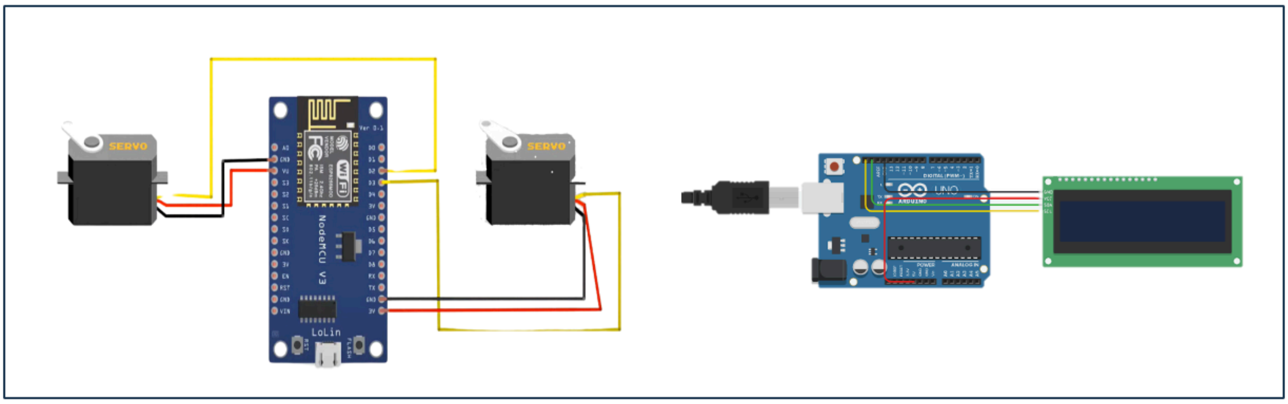

Fig. 3. Circuit diagram of Tranquillity CuBOT

3.2.3 Implementation

During the implementation phase of the Tranquillity CuBOT, the design specifications from the Analysis and Design stage are translated into a physical prototype. Components are gathered and assembled to construct the initial version of CuBOT. Source codes are written using MakeCode and the Arduino IDE to program CuBOT's specific functionalities. To simplify the overall operation of

Tranquillity CuBOT, a block diagram has been created to represent the procedural flow. The personalized track will be detected by the HC-SR04 ultrasonic sensor, which identifies the line on the track. This data is then passed to Microbit for analysis based on the programmed code. The analyzed data is subsequently sent to the robot, which moves along the track. The block diagram of Tranquillity CuBOT is shown in Figure 4.

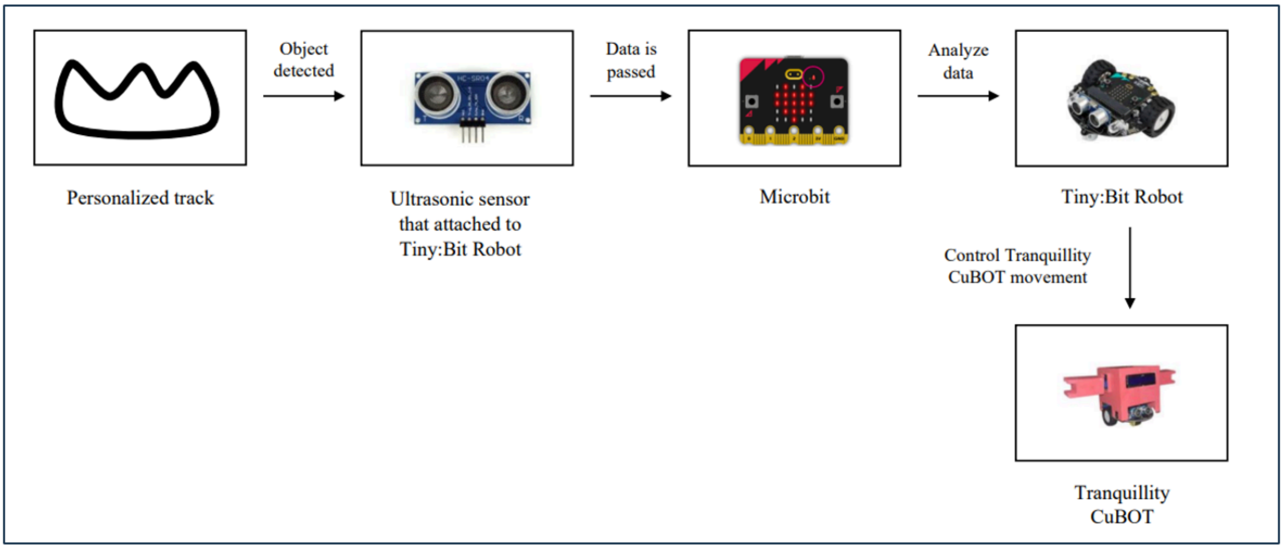

Fig. 4. The block diagram of Tranquillity CuBOT

The ideal component positioning configuration in Tranquillity CuBOT is shown in Figure 5 below. After all the components and functionalities worked as expected, the design of Tranquillity CuBOT was given more attention, where the components inside the body were closed with a personalized lid so it would not show what was inside the body of the robot. The CuBOT's hands are being replaced with a lighter material to reduce the overall weight, making the CuBOT more lightweight and efficient. Moreover, the robot's body was equipped with all the sensory elements related to people with ASD.

(a) (b)

Fig. 5. Implementation of CuBOT (a) Optimal position for components (b) Final design of CuBOT

3.2.4 Testing

Ensuring the quality of the Tranquillity CuBOT through thorough testing is crucial. The CuBOT is tested during this phase, and the outcomes are documented. These tests validate the functionality objectives established in the previous stages. This stage aims to ensure that the Tranquillity CuBOT operates as intended, free from errors and malfunctions. If any issues are identified, they are noted for improvement in subsequent iterations. Figure 6 shows the final testing conducted on CuBOT to ensure all features were operating as intended.

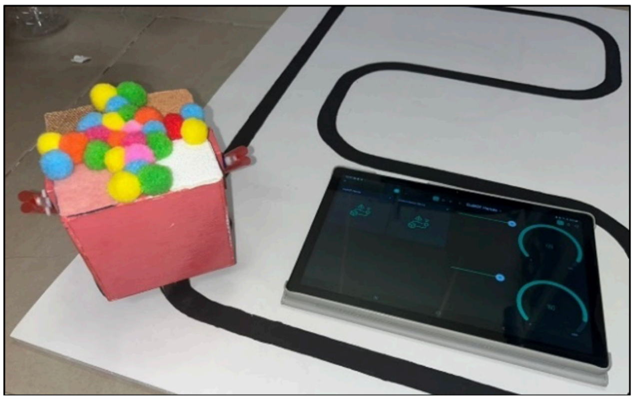

Fig. 6. Final iteration testing

3.2.5 Evaluation

The evaluation of the Tranquillity CuBOT has been conducted at Sekolah Kebangsaan Pendidikan Khas (SKPK) Batu Pahat. This phase is critical to ensure the device meets its intended objectives and functions correctly in the real world—a collaboration with experts in autism and special education to obtain detailed feedback and recommendations for improvement. Potential areas for enhancement were identified during the assessment procedure using unbiased data collected from the testing sessions. This comprehensive evaluation helps pinpoint specific issues and understand how well the CuBOT meets the needs of children with ASD. Figure 7 illustrates some activities conducted with the students.

(a) (b) (c)

Fig. 7. Evaluation process (a) A group of four students; (b) A boy with minor tantrums; (c) A boy who are sensitive to noise

The following subsections provide a detailed overview of the sampling methods, research instruments, and procedures employed during this phase.

3.2.5.1 Sampling

This study employed two distinct sampling methods to gather comprehensive data: qualitative (observation) and quantitative (survey).

(i) Qualitative method

For the observation sampling, a purposive sampling approach was utilized to select participants who could provide relevant insights into the behavioral responses of children with ASD in real-time settings. This method allowed for direct observation of participants' interactions with the intervention tool, providing qualitative data on behaviour, emotional state, and engagement level. Observational sampling was conducted in naturalistic settings to capture authentic behavioral responses. The sampling for this study involved three targeted cases of students with autism spectrum disorder (ASD), each selected to explore specific aspects of sensory regulation, emotional distress, and interaction in response to the Tranquillity CuBOT intervention. Table 3 shows the observation sampling of the respondents. The sample included a group of four students in a classroom setting to observe general engagement and group dynamics, a boy experiencing minor tantrums to assess emotional regulation capabilities and a boy is particularly sensitive to noise when evaluating sensory sensitivity responses. These cases were purposefully chosen to represent a range of sensory and emotional needs, allowing for a detailed examination of Tranquillity CuBOT's impact on diverse challenges associated with ASD.

Table 3
Demographic of respondents for observation sampling

Type of respondents	Frequency (f)
A group of four students	4
A boy with minor tantrums	1
A boy who are sensitive to noise and with major tantrums	1

(ii) Quantitative method

A stratified random sampling approach was adopted for the survey sampling to ensure diversity and representativeness among respondents. Surveys were distributed to caregivers and educators of children with ASD to gather quantitative data on perceptions of the tool's usability and impact on emotional regulation. The survey sampling included individuals with varying experiences managing ASD, providing a broad perspective on the intervention's applicability and effectiveness across different demographics. Table 4 represents the demographic of the respondents.

Table 4
Demographic of respondents for survey sampling

Demographic	Variables	Frequency	Percentage (%)
Relationship with ASD children	Teacher	6	50.0
	Parents	3	25.0
	Caregivers	3	25.0
Age of the child with ASD	Below 5	1	8.3
Gender of the child with ASD	6 - 11	9	75.0
	Over 12	2	16.7
	Male	10	83.3
	Female	2	16.7

In the first category, participants' relationships with the ASD children varied widely. Six respondents (50%) were teachers, three respondents (25%) were parents, and three respondents (25%) were caregivers. The second category revealed that 75% of the ASD children were between 6 and 11 years old, 16.7% were over 12 years old, and 8.3% were under 5 years old. The third category addressed the gender of the ASD children, showing that 83.3% were male, while 16.7% were female.

3.2.5.2 Instrument

(i) Qualitative method

A structured observational checklist was developed to capture each child's critical behavioral responses, emotional states, and engagement levels. Each category was assessed before and after interactions with Tranquillity CuBOT, allowing for a clear comparison of the children's responses to the intervention.

- Behavioral Observations: This section tracked any observable actions such as resistance, distraction, or attentiveness.
- Emotional State Assessment: Observers rated signs of anxiety, restlessness, or calmness to determine each child's emotional response to CuBOT. This was particularly important for assessing how CuBOT impacted the student's self-regulating ability.
- Engagement Level: Engagement was measured by observing the degree of participation, focus, and interaction each child displayed before and after using CuBOT. Observers noted instances of reluctance or active participation to quantify CuBOT's effect on engagement.

ii) Quantitaive method

A questionnaire was created to evaluate how well Tranquillity CuBOT supports children with ASD. It focuses on two main areas: perceived usefulness and attitudes toward using the device, covering eight key aspects. Table 5 provides a breakdown of these components, showing how they are grouped into these two dimensions.

Table 5
Dimensions and components of the survey instrument

Component	Item	Statement
Perceived Usefullness (PU)	PU1	Tranquillity CuBOT meets the needs and requirements of children with ASD.
	PU2	Tranquillity CuBOT can help children with ASD manage their emotions and behavior.
	PU3	Tranquillity CuBOT provides a comprehensive sensory experience and helps children with ASD feel calmer and more comfortable.
	PU4	Tranquillity CuBOT adds value to children with ASD in managing emotions and behavior in daily contexts
Attitude towards its Use (AU)	AU1	Tranquillity CuBOT helps improve the focus and engagement of children with ASD in daily activities.
	AU2	The use of Tranquillity CuBOT helps reduce challenging behaviors at home, school, or similar environments.
	AU3	There is an improvement in social interaction among children with ASD after using Tranquillity CuBOT in daily activities.
	AU4	I would recommend the Tranquillity CuBOT in supporting children with ASD compared to other commonly used methods or tools.

Responses from the questionnaire were analyzed using a Likert scale [21], as detailed in Table 6, to provide a quantitative measure of how well the research objectives were met.

Table 6
Likert scale

Rating	Scale
Completely disagree	1
Disagree	2
Neutral	3
Agree	4
Completely agree	5

We evaluated the instrument's reliability using Cronbach's alpha, a coefficient that checks how consistently the questionnaire items work together. This internal consistency shows how well items within each part of the questionnaire align to measure the same underlying concept. According to George & Mallery [22], a Cronbach's alpha of 0.7 or above is acceptable. Following this standard, Table 7 shows the Cronbach's alpha values for each dimension.

Table 7
Range of reliability and its coefficient of Cronbach's alpha

Cronbach Alpha Value	Category
More than 0.90	Excellent
0.80 – 0.89	Good
0.70 – 0.79	Acceptable
0.60 – 0.69	Questionable
0.50 – 0.59	Poor
Less than 0.50	Unacceptable

The test results showed that the instrument's reliability score, or Cronbach's alpha, is 0.833. This means that the instrument is valid and reliable based on standard guidelines.

3.2.5.3 Research procedure

(i) Qualitative method

The observational phase of this research involved systematically monitoring and recording the behavior, emotional state, and engagement levels of children with autism spectrum disorder (ASD) as they interacted with Tranquillity CuBOT. This observation aimed to understand how CuBOT influences the sensory regulation and emotional responses of children with ASD.

A. Participant Selection: Three distinct cases were selected to capture a range of behaviors and responses:
    - A group of four students in a classroom setting.
    - A boy prone to minor tantrums.
    - A boy is sensitive to noise and significant tantrums.
B. Setting and Environment: Observations were conducted in a controlled environment where participants could interact with CuBOT freely. The setting was designed to resemble typical learning spaces to encourage natural responses.
C. Observation Guidelines: During each session, researchers observed and noted specific behaviors in three areas:
    - Behavior: This included signs of resistance, interaction patterns, and the overall responsiveness of each participant toward CuBOT.

- Emotional State: Researchers monitored indicators of anxiety, calmness, or frustration as participants engaged with CuBOT.
- Engagement Level: This included the duration and focus of interaction with CuBOT and willingness to follow prompts and participate actively.

D. Observation Tools: Researchers used an observation checklist based on these categories (behavior, emotional state, engagement level), allowing for consistent data collection across all cases. Observations were documented using both written notes and, where permitted, video recordings to capture nuances in behavior.

E. Data Recording and Analysis: Observational data were compiled and analyzed. Each participant's responses were documented before and after interacting with CuBOT. This before-and-after comparison provided insights into CuBOT's immediate impact on participants' emotional and behavioral responses.

F. Ethical Considerations: The observation was conducted with sensitivity to each child's needs and limits. Parents and caregivers were informed, and consent was obtained prior to observation.

(ii) Quantitative method

The study was conducted in three stages:

- Participants were provided with a brief explanation of the CuBOT and its functionalities,
- Participants were given 10 minutes to explore the CuBOT and interact with it.
- Participants were asked to complete a set of questionnaires via Google Form to provide feedback, with their identities remaining anonymous.

The collected data will be analyzed using SPSS software (version 26.0). To understand different aspects like perceived usefulness and attitudes toward using Tranquillity CuBOT, we applied quantitative analysis techniques, focusing on descriptive statistics. Mean scores were calculated to interpret the responses on the questionnaire's Likert scale items. Table 8 provides a detailed breakdown of the mean ranges, which help categorize the results into acceptance levels: low, medium, and high.

Table 8
Mean range level interpretation

Mean Score Range	Interpretation
1.00 – 2.32	Low
2.33 – 3.65	Moderate
3.66 and above	High

4. Results and Discussion

This section presents the study's findings, followed by an analysis and discussion of their implications. The results are organized according to the primary research objectives, covering aspects such as perceived usefulness and user attitudes toward Tranquillity CuBOT. Table 9 presents the results based on the observations conducted during the study.

Table 9
Observation results

Case	Aspect	Observation: Before	Observation: After
A group of four students	Behaviour	• Some students distracted and not paying attention to the teachers.	• Students were focused on CuBOT, interacting with it and showing interest.
	Emotional State	• Some students appeared anxious and restless.	• Students become calm, interested, and happy while interacting with CuBOT.
	Engagement Level	• Students demonstrated low participation in classroom activities with the teachers.	• All students participated in the activities, which means there was high engagement.
A boy with minor tantrums	Behaviour	• He refused to enter the room, signs of resistance.	• He showed calm interaction with CuBOT and followed the prompts.
	Emotional State	• He is hesitant to participate.	• He seemed to be relaxed, emotionally stable, and happy.
	Engagement Level	• There was no initial engagement due to the refusal to enter the testing room.	• High engagement with CuBOT. He can retain focus for 15 minutes with CuBOT.
A boy who are sensitive to noise and with major tantrums	Behaviour	• He refused to enter the room, signs of resistance.	• He engaged with CuBOT and reduced his sensitivity to noise.
	Emotional State	• He is hesitant to participate.	• He is at ease and willing to participate.
	Engagement Level	• There was no initial engagement due to the refusal to enter the testing room.	• CuBOT increased his engagement despite initial reluctance.

Based on Table 9, the group of four students, consisting of one female and three males, initially displayed low engagement and signs of anxiety before interacting with CuBOT. After using CuBOT, their behavior and emotional states improved significantly. The students showed increased focus, participation, and visible happiness, indicating a positive shift in their engagement and emotional well-being. Xiaobo (a pseudonym), who initially exhibited minor tantrums and refused to enter the room, became calm, emotionally stable, and happy after seeing CuBOT. He maintained focus on CuBOT for about 15 minutes, displaying more concentration than he typically did in the classroom. Asyraf (a pseudonym) was initially hesitant due to his sensitivity to noise and fear of new things, and he also refused to enter the testing room. After interacting with CuBOT, he demonstrated reduced noise sensitivity and increased comfort levels. He engaged actively and could focus for several minutes, showing a notable improvement in his ability to cope with sensory stimuli. In conclusion, Tranquillity CuBOT demonstrates promise as a tool for children with ASD, enhancing emotional management and social interaction skills through innovative technology. The positive outcomes suggest CuBOT's potential to support children with ASD in both educational and daily life settings. Further research is necessary to explore CuBOT's long-term impact and scalability.

In addition to the observations, findings were gathered through a questionnaire-based survey. The results for this section are presented in Table 10.

Table 10
Mean values, standard deviation and level of the instrument

Dimension	Item	Mean	Std. Deviation	Level
Perceive Usefulness (PU)	PU1	4.25	0.621	High
	PU2	4.33	0.651	High
	PU3	4.58	0.668	High
	PU4	4.33	0.778	High
Attitude towards its Use (AU)	AU1	4.5	0.522	High
	AU2	4.25	0.621	High
	AU3	4.25	0.754	High
	AU4	3.92	0.793	High

The table summarizes responses across two key dimensions: Perceived Usefulness (PU) and Attitude towards Use (AU) of Tranquillity CuBOT. Four items represent each dimension, and the average scores reflect a generally high acceptance level, as indicated by the mean values and the "High" level classification. The Perceived Usefulness dimension includes items PU1 through PU4, with mean values ranging from 4.25 to 4.58, all categorized as "High."

PU3 has the highest mean score (4.58) with a standard deviation of 0.668, suggesting that users find this specific usefulness aspect particularly beneficial. The lower standard deviation indicates a relatively consistent perception among respondents, showing general agreement. The other items (PU1, PU2, PU4) also have high means but slightly higher standard deviations, especially PU4 (0.778), indicating a slightly more comprehensive range of responses. This variation could suggest that while usefulness is generally perceived as high, certain aspects of Tranquillity CuBOT may resonate differently with individual users. The Attitude towards Use dimension also shows high mean scores, with AU1 having the highest mean (4.5) and the lowest standard deviation (0.522). This low standard deviation suggests strong consensus on the positive attitude towards using Tranquillity CuBOT.

AU4 has the lowest mean (3.92) and the highest standard deviation (0.793) within this dimension. Although still categorized as "High," this lower mean and higher variability could indicate that some users may have reservations or mixed feelings about specific aspects of their attitude toward using the tool. Identifying the reason for this slight discrepancy could provide insights into areas for improvement. The high mean scores suggest that Tranquillity CuBOT is on the right track in meeting user needs, particularly for ASD-related emotional and sensory support. However, conducting follow-up studies or gathering qualitative feedback would be beneficial to understand better the response variability, especially for items with higher standard deviations. Insights from such feedback could guide further development and customization efforts to improve user experience consistency.

5. Conclusion

This study demonstrated that Tranquillity CuBOT effectively supports sensory regulation, emotional distress management, and engagement in children with ASD, as evidenced by high perceived usefulness and positive attitudes toward its use. By providing a portable and interactive tool for emotional regulation, this study offers a valuable alternative to traditional, static interventions, making it adaptable to various settings and user needs. However, the findings are limited by the small sample size and focus on controlled environments, which may not fully capture the diversity of ASD experiences. Future research should aim to assess the tool's effectiveness across a broader range of environments and consider long-term impacts. Overall, Tranquillity CuBOT represents a significant step forward in assistive technology, potentially enhancing autonomy and emotional well-being for children with ASD.

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