

AN ADAPTIVE MOBILE APPLICATION FOR CHILDREN WITH DISABILITIES: COMBINING AI-GENERATED STORYTELLING, GAMIFICATION, AND EXERCISE ENGAGEMENT

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ABSTRACT

This paper addresses the persistent challenges children with autism and other disabilities face in engaging with regular physical activity, a factor strongly linked to long-term health outcomes. Many existing interventions rely on rigid rehabilitation methods that fail to sustain motivation or adapt to individual needs. To overcome this gap, we propose a mobile application that combines exercise tasks, gamification, and AI-generated storytelling. Built with Flutter, Firebase, and the ChatGPT API, the system integrates three components: secure authentication and profile management, personalized storytelling to enhance engagement, and a reward-based progression system [12]. Major challenges include ensuring age-appropriate content, balancing extrinsic and intrinsic motivation, and maintaining secure data storage. Experiments tested the personalization accuracy of AI-generated stories, revealing significantly higher engagement compared to generic narratives. The results highlight the importance of detailed profiles and adaptive feedback. Ultimately, this project demonstrates a scalable, inclusive, and enjoyable approach to motivating healthier lifestyles in children with disabilities.

KEYWORDS

Assistive Technology, AI Storytelling, Gamification, Autism and Disabilities, Mobile Health Applications

1. INTRODUCTION

Children with physical disabilities, cognitive disabilities, and autism often face significant barriers to engaging in regular physical activity. For children on the autism spectrum, challenges can include sensory sensitivities, difficulty with transitions, and reduced interest in traditional sports or exercise programs. Many existing interventions focus heavily on medical rehabilitation or rigid fitness routines that lack engaging, personalized elements—leading to reduced attention and motivation. According to the Centers for Disease Control and Prevention, children with disabilities are 38% more likely to be obese and 45% less likely to participate in regular physical activity than their peers [1]. Research also shows that children with autism in particular demonstrate lower participation rates in structured physical activity compared to children without

disabilities [2][3]. This lack of activity increases risks of obesity, cardiovascular disease, poor motor coordination, and diminished social and mental health outcomes [5].

Beyond individual health, these patterns pose broader public health concerns. Physical inactivity in childhood strongly predicts adult health challenges, and long-term consequences include increased healthcare costs, caregiver strain, and reduced opportunities for inclusion in community activities [6]. The central issue lies in the absence of motivation-driven, tailored exercise programs that account for the sensory, cognitive, and social needs of autistic children. Without engaging and adaptable experiences, children disengage, caregivers struggle to maintain routines, and health disparities widen over time. Addressing this gap requires creative, technology-driven interventions that foster intrinsic motivation, adapt to diverse needs, and transform exercise into an enjoyable, meaningful part of daily life [4].

The three reviewed methodologies highlight different approaches to supporting individuals with autism through technology. PuzzleWalk demonstrated that gamified activity tracking can effectively reduce sedentary behavior, but it focused on adults and lacked personalization. SOFA emphasized structured digital storytelling for social skill development, showing promise with children, yet it did not address physical activity or motivation through rewards. Eggly advanced engagement through AR and EEG-based neurofeedback, creating immersive experiences, though it required specialized equipment and was limited in scalability. In comparison, our project integrates the strongest aspects of these methods, gamification from PuzzleWalk, storytelling from SOFA, and personalization from Eggly, while addressing their shortcomings. By using widely accessible mobile platforms, combining exercise with adaptive AI-generated stories, and implementing a scalable points-and-rewards system, our application provides a more holistic, practical, and inclusive solution that promotes both physical health and sustained engagement for children with autism and other disabilities.

The proposed solution is a mobile application designed to motivate children with autism and other disabilities to engage in physical exercise by combining gamified levels, personalized rewards, and AI-generated storytelling [7]. The system integrates three main elements: structured exercise tasks, a points-and-reward economy, and narrative feedback tailored to each child's profile.

When children complete a level, the application automatically generates a personalized story using the ChatGPT API. These stories incorporate elements from the child's interests, such as favorite animals, characters, or hobbies, creating a sense of ownership and motivation. Unlike traditional exercise programs, which often rely on rigid or repetitive routines, this application encourages sustained participation by framing physical activity as an interactive adventure [8]. Firebase serves as the backbone of the system, storing user profiles, completed stories, and purchased rewards, ensuring that progress is securely tracked across sessions and devices.

This method is particularly effective because it combines motivation (through rewards), personalization (via AI stories), and accessibility (through a mobile platform). Compared to existing physical therapy interventions, which may feel clinical or generic, the app fosters autonomy, creativity, and positive reinforcement. Gamification research has shown that points and achievement systems increase adherence and engagement in children's programs, while narrative-based learning enhances retention and emotional connection [9][10][11]. By merging these approaches, the system overcomes the limitations of current methods and creates a sustainable, inclusive, and engaging solution for children who otherwise might struggle to maintain regular exercise routines.

The experiment focused on testing the accuracy of the AI-driven storytelling system in personalizing narratives for children. Ten children between the ages of five and nine were recruited, each with a short profile containing interests, reading levels, and potential triggers. After completing an exercise level, every child received two stories: one generated by the AI using their profile, and a control version that was generic and not personalized. The stories were presented in randomized order, and two blinded adult raters independently scored alignment with each child's profile. Results revealed that personalized stories consistently outperformed controls, with mean scores of 85.6 versus 45.5. However, incomplete or outdated profiles limited the effectiveness of personalization, and variability in control scores was greater than expected. These findings suggest that profile completeness and data quality are crucial to maximizing the AI's effectiveness, highlighting the importance of maintaining updated and detailed user information.

2. CHALLENGES

In order to build the project, a few challenges have been identified as follows.

2.1. AI-Driven Adaptive Storytelling

One major component of this program is the AI-driven storytelling engine, which tailors narratives based on a child's progress and preferences. Potential challenges include ensuring that the generated stories remain age-appropriate, culturally sensitive, and adaptable to various communication and sensory needs—especially for children with autism. Another concern is preventing overly complex or overwhelming storylines that could cause frustration or disengagement.

To address these issues, safeguards could be implemented to filter content and limit complexity based on user profiles. Adjustable sensory settings could be offered to control visual and audio intensity, ensuring comfort for children with sensory sensitivities. Additionally, feedback loops from caregivers could be integrated to continuously refine the appropriateness and engagement level of the content.

2.2. Adaptive Reward and Points System

Another significant component of the program is the reward and points system. This system must balance engagement with accessibility, ensuring that rewards are motivating without becoming overly competitive or distracting. A potential problem is that children may focus only on external rewards rather than on the intrinsic benefits of exercise. Additionally, rewards that are not aligned with a child's preferences may lose motivational impact over time. To resolve this, customizable reward options could be introduced, allowing caregivers to select or update items. Adaptive scaling of points and periodic introduction of new rewards could help sustain long-term interest and balance.

2.3. Secure Data Storage and Privacy Framework

The data storage and security framework also presents challenges. Since the application stores sensitive information about children's profiles, interests, and progress, privacy and reliability must be guaranteed. Potential risks include unauthorized access, data loss, or synchronization failures between devices. These issues could undermine caregiver trust and reduce adoption of the system. To address this, strong encryption protocols and Firebase Authentication could be applied to safeguard data [13]. Regular backups and offline caching would help maintain

continuity if connectivity is lost. Transparent caregiver controls and audit logs could further ensure accountability and promote confidence in the application's safety and integrity.

3. SOLUTION

The program links together three major components: exercise and level management, AI-generated storytelling, and reward storage within Firebase. The flow begins when a child logs into the app. Their profile information, including interests, sensitivities, and previous progress, is retrieved from Firebase. From there, the child can select and complete an exercise-based level, such as a short tennis-inspired activity designed to promote coordination and movement.

Upon completion, the system automatically triggers the ChatGPT API to generate a personalized story [14]. This story integrates key elements from the child's profile, reframing their achievement as part of a fun and imaginative adventure. For example, a child who loves dinosaurs may read about a "dinosaur tennis match" celebrating their success. The story is stored in Firebase for later review and sharing with caregivers.

After reading the story, the child receives points, which can be used in the reward shop. Rewards are securely managed through Firebase, and caregivers can monitor and adjust available items. This process reinforces the value of physical activity while encouraging ongoing participation.

The system is built using Flutter for cross-platform mobile development, Firebase for authentication and data management, and the ChatGPT API for narrative generation. Together, these technologies ensure the program is accessible, engaging, and scalable.

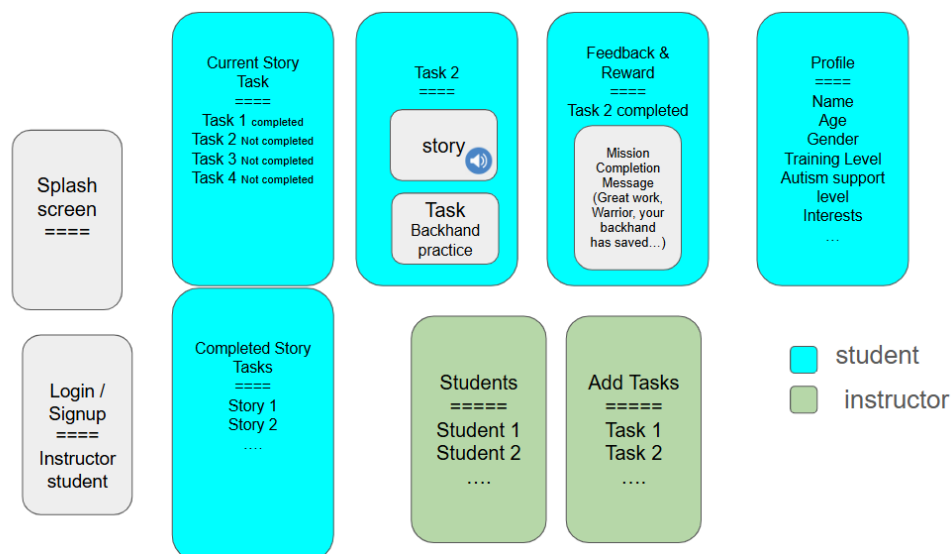


Figure 1. System Flowchart

The authentication component ensures secure access to the app. Implemented with Firebase Authentication, it manages user sign-ups, logins, and password resets. This component guarantees that each child's profile and progress remain private while enabling caregivers and administrators to access data responsibly. Authentication provides the foundation for a secure, personalized experience.

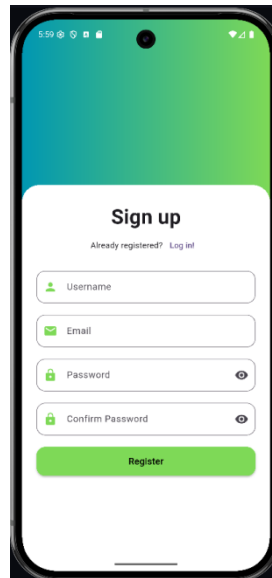


Figure 2. Screenshot of sign up page

```

Future<void> registerNewUser() async {
  setState(() {
    _isLoading = true;
    _error = null;
  });

  if (!_formKey.currentState!.validate()) {
    setState(() => _isLoading = false);
    return;
  }

  try {
    final credential = await FirebaseAuth.instance.createUserWithEmailAndPassword(
      email: emailController.text.trim(),
      password: passwordController.text,
    );

    final uid = credential.user!.uid; // get the new user's id

    await FirebaseFirestore.instance.collection('users').doc(uid).set({
      'username': usernameController.text.trim(),
      'email': emailController.text.trim(),
      'isAdmin': false,
      'createdAt': FieldValue.serverTimestamp(),
      'level': 'level1',
      'currentExercise': 'exercised',
      'money': 0,
      'rewards': []
    });

    if (mounted) {
      Navigator.pushReplacement(context, MaterialPageRoute(builder: (context) => BottomNavigationBar()));
    }
  } on FirebaseAuthException catch (e) {
    setState(() {
      if (e.code == 'weak-password') {

```

Figure 3. Screenshot of code 1

The code sample for this component demonstrates the use of Firebase Authentication to manage user login and registration. When a child or caregiver attempts to sign in, the method calls Firebase's authentication service, passing the entered email and password as parameters. If the credentials are valid, Firebase generates a secure authentication token and returns the user's unique identifier (UID) [15]. This UID is then used to retrieve the corresponding profile data from the Firebase database. In the event of invalid credentials, the code triggers an error handler that displays an appropriate message to the user. The variables being created include the input fields for email and password, the UID returned from Firebase, and a status flag indicating whether authentication was successful. This code runs at the start of every session, ensuring that all user progress and preferences remain private while also linking authenticated users to their individualized exercise, storytelling, and reward experiences.

The storytelling component uses the ChatGPT API to generate personalized narratives after each completed exercise [16]. Its purpose is to motivate children by embedding their achievements within fun, interest-based stories. This system relies on natural language processing (NLP) and personalization, dynamically adapting narratives to reflect user profiles, preferences, and progress [17].

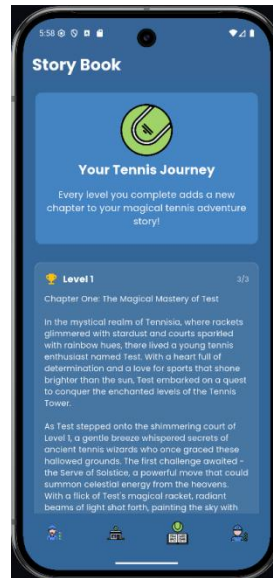


Figure 4. Screenshot of story page

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Figure 5. Screenshot of code 2

This method, generateStory, is called immediately after a child completes an exercise level. The function prepares a request to the OpenAI ChatGPT API, sending structured parameters such as the child's name, preferred interest, and the activity performed [18]. The system message establishes context, instructing the AI to behave as a supportive, child-friendly storytelling assistant. The user message injects personalized details, ensuring that the resulting story is

tailored to the child's preferences and recent achievement. The `http.post` request communicates with the API endpoint, while the headers authenticate the request using the app's API key [19]. The body of the request is encoded in JSON format, containing the conversation history that guides the story generation. When the response is returned, it is parsed into a usable string, which is then displayed to the child within the app's interface. This mechanism guarantees that each story is unique, personalized, and motivated.

The exercise and level management component enables administrators to create and customize new levels and exercises in the app. Built with Flutter and Firebase Firestore, it ensures that new activities can be added dynamically, stored securely, and immediately reflected in the system for children to access during training sessions.

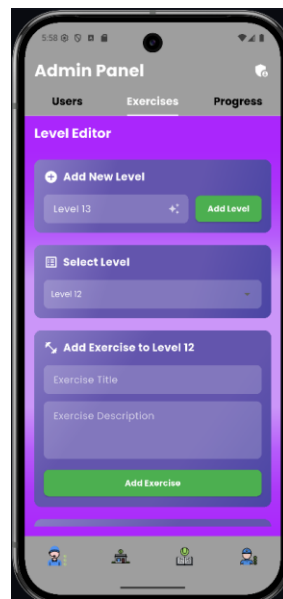


Figure 6. Screenshot of admin panel

```
void addLevel() async {
  try {
    String nextLevelId = await getNextLevelNumber();
    await FirebaseFirestore.instance.collection('levels').doc(nextLevelId).set({
      'createdAt': FieldValue.serverTimestamp(),
    });

    // Update the text field to show the created level
    setState(() {
      levelController.text = nextLevelId;
    });

    ScaffoldMessenger.of(context).showSnackBar(
      SnackBar(
        content: Text('Level $nextLevelId added successfully!'),
        backgroundColor: Colors.green,
      ), SnackBar
    );
  } catch (e) {
    print('Error adding level: $e');
    ScaffoldMessenger.of(context).showSnackBar(
      SnackBar(
        content: Text('Failed to add level: $e'),
        backgroundColor: Colors.red,
      ), SnackBar
    );
  }
}
```

Figure 7. Screenshot of code 3

The `addLevel()` method manages the creation of new exercise levels in the application's admin panel. When an administrator presses the "Add Level" button, the function first calls `getNextLevelNumber()` to determine the next available level identifier. It then sends this identifier to Firebase Firestore, creating a new document under the "levels" collection with a server-generated timestamp to ensure accuracy and consistency.

After successfully writing to the database, the `setState()` method updates the local UI, automatically displaying the newly created level in the text field. To provide feedback, a `SnackBar` is triggered, notifying the administrator that the level was successfully added in green. If an error occurs, such as a connectivity issue or invalid write, the catch block handles the exception, logs the error for debugging, and displays a red `SnackBar` message indicating the failure.

This transaction ensures that level creation is both user-friendly and robust, balancing real-time UI responsiveness with secure backend storage. By connecting administrative input directly to Firestore, the system guarantees that newly created levels are available instantly to children, caregivers, and other parts of the application.

4. EXPERIMENT

A blind spot to the program is how accurately the AI personalizes stories to each child's interests, sensitivities, and reading level. This matters because poor personalization reduces engagement, triggers sensitivity, and weakens therapeutic value significantly.

The experiment involves a group of ten children between the ages of five and nine, each with a short personal profile that includes interests, reading level, and known triggers. After completing a level in the application, each child receives two stories: one generated by the AI using their profile information to personalize the content, and another templated control story that references the same goal but is not tailored to the child. The order of presentation is randomized to reduce bias. Two adult raters, blinded to the condition, independently score the stories on a scale from 0 to 100, based on how well each aligns with the child's profile; any disagreements are resolved by averaging the scores. Completion time and potential adverse triggers are also recorded. This within-subject, randomized design minimizes variability, while blinding limits bias, and the use of two raters strengthens reliability without introducing excessive complexity or cost.

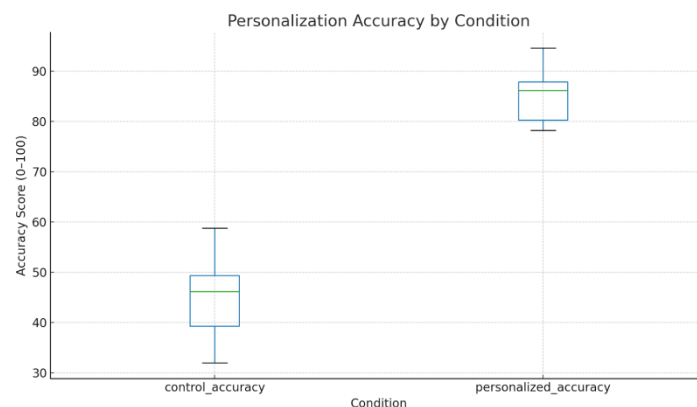


Figure 8. Figure of experiment

Personalized stories scored higher than controls. Mean/median were 85.6/86.2 versus 45.5/46.2. The lowest scores were 78.2 (personalized) and 32.0 (control); the highest were 94.6 and 58.8. Two findings stood out: some personalized stories underperformed expectations for children with sparse or outdated profiles, and variability in control scores was wider than anticipated. I attribute the first to incomplete profiles limiting the model's ability to tailor characters, settings, or sensory content; the second likely reflects rater sensitivity to generic content. The dominant driver appears to be profile completeness and specificity, followed by prompt quality and safety filters that prevent potentially engaging but risky details. Improving data hygiene (periodic profile refresh), adding guardrail checks for reading level, and prompt templates that force explicit profile attribute grounding should further tighten performance. Inter-rater agreement was acceptable, yet half-point disagreements suggest clearer rubric with anchors could reduce noise and make improvements detectable with fewer participants.

5. RELATED WORK

A recent feasibility study evaluated PuzzleWalk, a mobile app designed for adults with autism that uses behavior-change techniques (BCTs) and gamification to reduce sedentary behavior and promote moderate-to-vigorous physical activity (MVPA). The app incorporates activity tracking, goal setting, and rewards to encourage movement [21]. Results showed it effectively decreased sedentary time and increased activity levels, comparable to mainstream apps like Google Fit. However, the study focused on adults, not children, and lacked personalized narrative or storytelling components. Unlike PuzzleWalk, our project targets children, integrating AI-generated, interest-based stories and adaptive gamification tailored to developmental and sensory needs, adding personalization and motivation absent in prior work.

A recent study introduces SOFA (Stories Online For Autism), a digital app delivering Social Stories to autistic children through a participatory, user-friendly interface. The app enables authors to write structured narratives and rate story effectiveness, while children access personalized stories with text-to-speech features[22]. SOFA demonstrated effectiveness particularly among younger, verbal autistic children, improving story comprehension and enjoyment, with large-scale data collection enhancing external validity. However, it focuses narrowly on social scenarios without linking to physical activity or gamified engagement. Our project expands upon SOFA by embedding AI-generated, interest-based storytelling within a gamified exercise framework—promoting movement, personalization, and sustaining motivation beyond narrative alone.

A novel research project developed Eggly, a mobile augmented reality (AR) game incorporating EEG-based neurofeedback (NFT) to support social attention in autistic children

JMIR Research Protocols[23]. Through AR overlays and real-time brainwave feedback, the system creates immersive, personalized engagement; field studies with five children showed improvements in attentional focus and game enjoyment. Yet Eggly requires specialized hardware and targets limited sessions, making scalability and integration with daily activities challenging. By contrast, our app uses widely available mobile devices, integrates AI-driven storytelling tied to exercise, and offers caregiver-monitored, adaptive gamification—making it more accessible, daily-use ready, and behaviorally reinforcing compared to NFT-based systems.

6. CONCLUSIONS

Although the application demonstrates promise in motivating children with autism and other disabilities to exercise, several limitations remain. First, the AI storytelling system depends

heavily on the completeness of user profiles; sparse or outdated information reduces personalization quality, diminishing engagement. Second, while gamified rewards increase motivation, they risk shifting focus toward extrinsic reinforcement rather than building intrinsic enjoyment of exercise. Third, the current system requires stable internet access to generate stories and synchronize data, which may limit usability in low-connectivity settings. Accessibility across different devices and operating systems also requires further optimization.

Future improvements could include integrating offline caching and lightweight local story models to reduce internet dependency, expanding customization options for rewards to sustain motivation, and refining caregiver dashboards for more actionable insights [20]. Additionally, longitudinal testing with larger, more diverse populations is needed to validate effectiveness and adapt the program to broader developmental and cultural contexts.

This project demonstrates the potential of combining exercise, gamification, and AI-driven storytelling to support children with autism in achieving healthier lifestyles. By integrating personalization, security, and adaptive motivation strategies, the application offers a scalable, engaging, and inclusive approach that bridges therapeutic goals with enjoyable, child-centered experiences.

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