A Mobile and AI-Based Framework for Supporting Autonomy and Learning in Individuals with Down Syndrome

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This paper presents a supportive framework of three mobile apps — StepWise, CareWise, and RobotWise — aimed at helping individuals with Down syndrome gain autonomy, improve learning, and foster social inclusion. StepWise delivers AI-powered lessons in academics and daily life, validated in real-time with vision and speech tools. CareWise lets parents and educators track progress, identify strengths, and offer job opportunities. RobotWise features an AI-integrated JetRacer robot for hands-on exploration via tablet. Developed with the "Arc-en-Ciel" association and psychologist input, early feedback confirms its benefits for users' daily and professional lives.Assistive technology

- AI-powered education
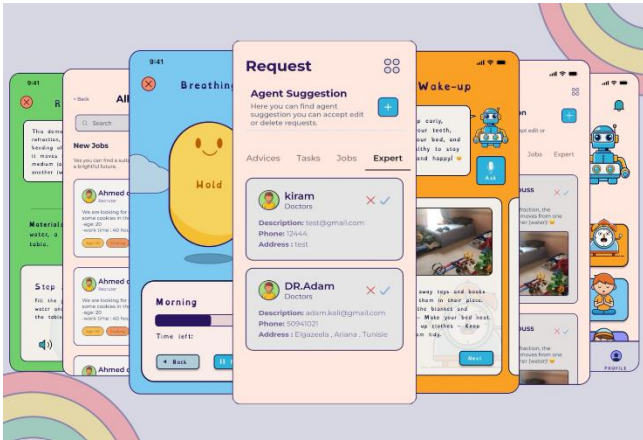- mobile applications
- special needs
- robotics

Fig. 1. Few Interfaces Of The Applications

I.   INTRODUCTION

Down syndrome, also known as trisomy 21, affects approximately 1 in every 700 live births worldwide, making it one of the most prevalent genetic conditios. it is characterized by intellectual disabilities, delayed language development, and difficulties in motor coordination, which can significantly impact daily living and social integration.

Over the past decades, significant progress has been made in early intervention programs, special education, and assistive technologies [2]. However, many existing digital solutions remain poorly adapted to the unique cognitive and sensory needs of individuals with Down syndrome. Most available tools do not offer sufficient personalization, real-time feedback, or multisensory engagement, which are crucial for effective learning and skill acquisition [7] .

Moreover, within family environments, there is often a tendency toward overprotection, where parents may unintentionally hinder the development of independence due to concerns about their child's capabilities [9] [8] . For instance, a mother might continue dressing her child despite his ability to perform this task independently. This behavioral pattern, while rooted in care and concern, can delay the acquisition of essential life skills and reduce opportunities for self-expression and autonomy.

To address these limitations, we introduce a novel digital framework that combines mobile applications, artificial intelligence, and robotics to support the development of autonomy, education, and social skills among individuals with Down syndrome. Our solution consists of three components: **StepWise, CareWise, and RobotWise**. These applications were co-designed with experts and validated through

continuous collaboration with "Arc-en-Ciel," a Tunisian association supporting individuals with Down syndrome.

II.   METHODOLOGY

The proposed framework combines three digital tools — **StepWise**, **CareWise**, and **RobotWise** — designed to support individuals with Down syndrome in developing autonomy, education, and social integration.

StepWise

This mobile application is designed as a personalized educational assistant. It offers structured activities across several domains:

- **Academic learning**(mathematics, physics, etc.)
- **Language development** with a spelling module based on Deep Learning that corrects pronunciation and encourages improvement through immediate feedback.
- **Daily routines** tailored to the specific needs of individuals with Down syndrome: waking up, hygiene, dressing, breathing exercises, etc.
- **Social awareness**: an interactive quiz generated by Gemini addresses important topics such as sexual harassment and manipulation in a playful and educational format.

Each completed task is validated in real time using image and voice analysis via Gemini [3] , ensuring smooth and secure interaction. The earning of badges encourages perseverance and motivates the learner to continue progressing.

CareWise

Targeted at parents and professionals, this mobile application allows for tracking each child's progress, discovering their talents, and receiving recommendations for suitable job opportunities through intelligent automation (via n8n). It also includes a newsfeed where families can share their experiences.

RobotWise

This tablet application, connected to a **JetRacer** robot, offers a new way to learn through exploration. The child controls the robot via the app and interacts with their environment using voice and visual commands, stimulating motor coordination and curiosity.

Throughout the development process, we worked closely with the **Arc-en-Ciel** Association and psychologist **Dr. Mohamed Jemaa** to ensure that every feature meets the real needs of users.

Fig. 2. Home Screens of Applications

III.   TOOLS AND TECHNOLOGIES USED

Driven by rapid technological advances, artificial intelligence (AI) has become **a key driver** in transforming educational, social, and healthcare systems [1] [10]. Today, AI enables the development of intelligent solutions that not only respond to user needs but also learn from and adapt to individual capabilities [4] . In an increasingly digital world, AI opens new opportunities for inclusive design—especially for people with disabilities—by offering personalized, interactive, and evolving tools.

This is precisely where our work fits in: using AI not just as a technology, but as a means to **support, empower, and foster** independence for individuals with Down syndrome in their daily routines, learning processes, and professional integration. Through our applications we introduce a user-centered ecosystem where technology becomes a reliable, patient, and committed partner. Built with :

- FlutterFlow
- NestJS,
- Gemini AI
- TensorFlow
- WebRTC
- n8n automation
- WebSocket
- LiveKit
- Text-to-Speech: Speechify [6]

 Our platform delivers real-time feedback, adaptive learning paths, and intelligent task validation reel time with ai AI agent tailored to the unique needs of each user.

IV. JETRACER

The robot used in this project is based on the JetRacer platform from **NVIDIA** [5] , a miniature autonomous vehicle designed for learning artificial intelligence and computer vision. Equipped with a high-resolution 8MP camera, it enables real-time visual recognition of the environment, facilitating autonomous navigation. The JetRacer is built on a lightweight alloy chassis, features precise motors, and includes an **NVIDIA Jetson Nano** module that runs the AI models required for video processing and decision-making.

This robot is controlled via the mobile application **RobotWise** specifically developed to allow children with Down syndrome to easily interact with the robot using a tablet. The application's intuitive interface enables users to control the robot through voice or manual commands, promoting sensory and motor exploration. Through this interaction, children develop skills such as hand-eye coordination, spatial understanding, and autonomy in performing guided tasks.

Thanks to its wireless connectivity and machine learning capabilities, the JetRacer serves as a physical extension of the proposed digital educational system, enhancing user engagement through a playful and interactive approach [5]

Fig. 3. Robot JetRacer

V. RESULTS

Preliminary evaluations of the system involved usability testing with five individuals diagnosed with Down syndrome, aged between 7 and 14 years. Participants engaged with StepWise for daily routine validation, performed basic math and language tasks, and explored their environment using RobotWise. Results indicated high levels of engagement and comprehension, particularly in tasks involving visual and auditory feedback.

CareWise demonstrated effective data aggregation capabilities, successfully identifying relevant job opportunities and expert contacts based on user profiles. Parents and caregivers reported increased confidence in tracking their child's progress and understanding their strengths.

Technical evaluations showed that the AI validation system achieved an accuracy rate of approximately 89% in recognizing correct task execution using Gemini-powered image and speech analysis. The JetRacer robot responded reliably to voice commands and provided consistent navigation support during interactive sessions.

Fig. 4. Zeineb a 7 years old girl enjoying our application

VI. DISCUSSION

This study demonstrates the feasibility and relevance of a multi-modal digital platform tailored for individuals with Down syndrome. Compared to existing assistive technologies, our solution offers several unique advantages: real-time AI feedback, integration of robotics for active engagement, and a collaborative caregiver-professional interface. [2] [7]

However, limitations remain, including the current small sample size and the reliance on internet connectivity for some AI functions. Future work will focus on expanding the user base, improving offline functionality, and incorporating additional sensory feedback mechanisms.

One notable strength of the project lies in its interdisciplinary nature, combining expertise from psychology, education, and robotics. The involvement of "Arc-en-Ciel" ensured that the system addressed real-life challenges faced by individuals with Down syndrome and their families.

VII. CONCLUSION

Looking ahead, we envision a future where technology does not merely assist, but actively celebrates the unique strengths and humanity of individuals with Down syndrome. Our work is driven by the belief that every person deserves the freedom to grow, learn, and contribute to society in their own way — with dignity, support, and understanding.

StepWise, CareWise, and RobotWise were developed with deep care, patience, and collaboration — reflecting our commitment to building solutions that empower rather than simply accommodate. These applications go beyond digital tools; they represent meaningful steps toward a world where individuals with Down syndrome can explore, express themselves, and achieve independence on their own terms.

By designing with empathy and purpose, we challenge the boundaries of what is possible in inclusive education and assistive technology. Our goal is not only to support users in mastering daily routines and professional skills, but also to shift perspectives — from seeing limitations to recognizing abilities. We are honored to be part of a movement that uses innovation to affirm the rights, talents, and aspirations of one of the most kind-hearted and resilient communities among us.

VIII. PERSPECTIVES

Our Apps StepWise , CareWise , and RobotWise , shows great promise in supporting individuals with Down syndrome in gaining autonomy, improving learning, and fostering social inclusion. Future work will focus on refining AI-based feedback mechanisms, enhancing voice and image recognition, and expanding the system to support other groups such as children with autism. A pilot study in 2025 will validate system improvements with a larger user group. We also plan to integrate multisensory features and improve offline functionality for broader accessibility. Expanding into special education institutions and healthcare centers will allow professional validation and wider adoption. International deployment will begin after localization into Arabic and French, with plans for additional language support. Long-term goals include developing AR-based modules and emotion-aware AI to further enhance user engagement and educational outcomes

VIII. REFERENCES

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