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**SCUOLA DI INGEGNERIA INDUSTRIALE
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EXECUTIVE SUMMARY OF THE THESIS

A Framework to Assist Therapists with the Applied Behavioural Analysis

LAUREA MAGISTRALE IN COMPUTER SCIENCE AND ENGINEERING - INGEGNERIA INFORMATICA

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1. Introduction

The Applied Behavioral Analysis (ABA) Service System is a collaborative effort between Politecnico di Milano and Spazio Autismo, an autism center in Mantova, Italy. The project aims to transition from paper-based to digital-led therapy for individuals with Autism Spectrum Disorder (ASD). With the increasing prevalence of ASD diagnoses, there is a growing need for effective interventions. Serious games on mobile devices have shown promise in facilitating behavioral learning.

The project focuses on developing a comprehensive digital system, including a mobile app and a web-based platform, to support ABA therapy. Rigorous ethical standards are maintained to ensure patient privacy and confidentiality.

The current ABA therapy methods and the paper-based approach used in Spazio Autismo are discussed, along with identified requirements for the project. The digital system, comprising a mobile app designed for tablets and a web-based platform, addresses the specific needs of the Mantova center. The mobile app targets behavioral skills aligned with ABA therapy principles. The web-based platform serves as a centralized hub for patient data management. The database

infrastructure supporting the entire system emphasizes secure storage and adaptability to new therapeutic objectives.

The system's efficacy is evaluated through data analysis, extracting insights to inform future interventions. In the conclusion, key points are summarized, strengths and weaknesses are highlighted, and potential future developments are suggested to improve in the initial implementation.

2. Project Background

To understand the project's development, it is crucial to delve into the characteristics of behavior and learning patterns for individuals with autism, particularly through the lens of ABA methodology and the assessment method Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP) [1], used in Spazio Autismo.

Autism is a neurodevelopmental disorder characterized by challenges in social interaction, communication difficulties, and repetitive behaviors. ABA, an evidence-based approach, utilizes principles of learning theory to bring about positive behavior changes in individuals with autism. The VB-MAPP is a criterion-referenced

assessment tool used to track progress in various categories [2].

Spazio Autismo employs a cohesive and integrated approach, involving professionals like psychologists, consultants, and educators to create meaningful life plans for individuals with autism and their families. At the center, ABA therapy was implemented with one-to-one sessions using a deck of cards representing objects that the patients need to recognize as part of their learning process. Therapists monitor and track correct responses using VB-MAPP categories. At the completion of each learning objective, the therapists create a report for the children's families.

To design and develop the ABA Service System, therapists provided specific requirements, including digitalizing therapy sessions to replicate the card-based experience in a gaming app, simplifying material preparation, and automatically collecting children responses. In data reporting, therapists wanted automatic tracking of correct responses and generation of standard reports for families. Privacy, security, and reliability concerns included access to only their patients' data, anonymity for children, and a seamless, issue-free implementation.

3. Project Overview

The project addresses these requirements by developing a comprehensive digital system, aligned with ABA principles. The mobile app targets specific VB-MAPP categories, facilitating therapy sessions, while the web-based platform serves as a centralized hub for patient data management. The system ensures privacy, security, and reliability, meeting the therapists' needs and enhancing the effectiveness of ABA therapy.

To elaborate on the framework, the data flow involves therapists logging into the mobile app at the beginning of each session, accessing patient data stored in the infrastructure. During the session, the app sends performance data to the database. Post-session, therapists access and manage data on the website, generating reports for supervisors and families. Learning objectives can be modified or added, and new patient profiles can be created through the website.

The outlined data flow diagram (Figure 1) illustrates the interaction between the mobile app, website, and infrastructure.

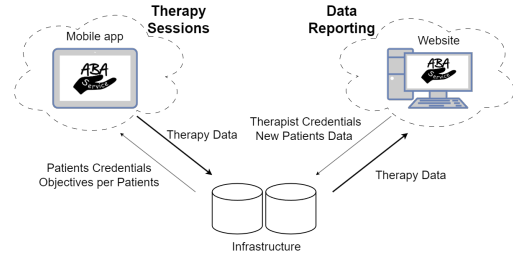


Figure 1: Data flow diagram

The system targets at automating learning materials preparation, data acquisition, and reporting. Therapeutic efficacy is assessed through reduced non-therapeutic time, increased patient focus, and decreased time to complete objectives. The system also aims to enhance privacy, security, and reliability.

4. Mobile App

The ABA Service System's mobile app serves as a pivotal component, engaging patients during therapy sessions. The development phase involves the strategic selection of tools and frameworks to ensure a seamless digital adaptation of ABA therapy. Unity Engine is chosen for its versatility, ease of use, and active community support. The Localization Package enables accessibility in multiple languages, and Figma facilitates UI/UX design.

An authentication system is implemented in PHP and hosted on a private Docker image for enhanced reliability and scalability. This approach offers several advantages, combining stringent security measures with a user-friendly authentication process. The goal is to achieve a balance between robust security and a seamless, intuitive user experience, enabling therapists to access the app's features without unnecessary obstacles.

Game development aligns with the VB-MAPP framework used by the center. Through a series of meetings and deliberations with the therapists, three of the 15 VB-MAPP categories emerge as the most promising starting points for ABA Service App implementation:

- TACT: the ability to label or describe objects, actions, or events in the environment.
- LISTENER: receptive language abilities where an individual responds appropriately to verbal stimuli or instructions from others.

- Visual-Perceptual Matching to Sample (VPMTS): matching or identifying objects, pictures, or symbols based on visual cues. Each category’s mini-games are designed within Unity, leveraging parameterization for scalability and images selected from therapists are integrated to maintain continuity with the paper-based therapy sessions.

The games are organized into classes following the principles of Object-Oriented Programming (OOP). Each implemented category has a base class from which specific implementations of individual games derive. An expandable infrastructure is designed, allowing for the intuitive isolation of each game.

Interaction design principles for children with ASD guide the user interface development, addressing unique needs. Unity’s drag-and-drop system facilitates VPMTS mini-games. The authentication process, game structures, and UI design are thoroughly examined to design user interfaces and experiences that are accessible, engaging, and supportive of the developmental and educational goals of children with ASD.

Prototyping and iterative testing refine the UI, ensuring a child-friendly, distraction-free, and effective digital therapy experience. The app’s visual representation, created using Figma, evolves through iterations, emphasizing simplicity and reduced on-screen elements [3].

5. Website

The ABA Service Website acts as a central hub for therapists to manage patient profiles and learning objectives. Furthermore, individuals without therapist profiles can utilize the website as a resource to access relevant information about ABA methodology and gain insights into the ABA Service System.

The website comprises four sections:

- ABA: a short description of the method and its purpose.
- Technology: an overview of the ABA Service System development and implementation to let the users know the project background.
- Therapists: a Q&A page where the therapists have collected a list of frequently asked questions and their exhaustive answers.
- Spazio Autismo: a log in form to the thera-

pists personal area and a presentation of the Mantova center, participating in the creation of ABA Service System.

Development tools, including the Nuxt framework, Prisma ORM, and jsPDF for PDF generation, are chosen for their capabilities in ensuring a smooth and efficient development process. Netlify hosts the website, making it accessible to therapists and others interested in ABA.

Technical analysis highlights the website’s component-based structure, developed from scratch using Vue.js. The focus on component scalability ensures optimal user experiences across various devices. The website’s technical foundation rests on adaptability, usability, and efficiency.

The user interface design is thoroughly planned through frameworks created in Figma. The components are drawn with scalability and adaptability in mind, ensuring a consistent experience across different screen sizes. The development process adheres to Nielsen’s Heuristics for User Interface Design, prioritizing usability and user experience [4].

6. Infrastructure

The ABA Service Infrastructure is the back-end component of the project, encompassing databases, server infrastructure, and networking to ensure the overall functionality and performance of the system.

The MySQL database serves as the repository for patient data, chosen for its open-source nature, cost-effectiveness, and robust performance. Security features, adherence to ACID principles, and a user-friendly interface make it an ideal choice. The use of phpMyAdmin facilitates efficient MySQL administration, allowing for various tasks related to database management.

The server infrastructure is vital to manage the flow of data, task execution, and user interaction. Docker containerization is employed for MySQL, phpMyAdmin, and NGINX reverse proxy, providing consistency, scalability, and efficiency. The use of a reverse proxy enhances security, load balancing, and web acceleration. Networking involves an on-premise server hosting Docker containers and leverages Cloudflare for DNS management. The integration of a registered domain and custom sub-domain ensures public access and secure interaction with the

database. The strategic design choices enhance data integrity and access control [5].

For hosting the ABA Service Website, Netlify, a cloud-based platform, is chosen. Netlify simplifies deployment processes, integrates with version control systems, and offers features like continuous deployment, serverless functions, and global Content Delivery Network support.

7. Project Outcomes

The system has been tested at the Mantova center for a period of 4 months, with 18 children (7 female and 11 male) diagnosed with classic autism and high support needs, ranging from 4 to 7 years old.

The ABA Service System success is proved by the following achievements:

- Automation of Learning Materials Preparation. Before the ABA Service System, therapists manually prepared session materials. Thanks to the digitalization, therapists can log in, select the category, and continue from the previous session's level, streamlining the preparation process.
- Automation of Data Acquisition. Data collection during therapy sessions was previously done manually. Each therapist had a personal way of collecting these data on paper to maintain a historical record for the patient, leading to potential human errors. The system now automates data collection, eliminating the need for manual recording during therapy and improving accuracy.
- Efficacy of the Therapy. To evaluate the efficacy of the therapy during individual patient sessions, the analysis focused on three sub-goals: time spent on non-therapeutic activities, patient focus during therapy, and the speed of objectives completion. Firstly, thanks to the automation of learning materials preparation and data acquisition, time spent on activities that do not directly contribute to the patient progress in therapy is reduced. Secondly, using the timestamps within the app's database, data shows that patients' focus increases by 10 to 68%. Better results are observed for LISTENER and VPMTS categories, where children are more actively involved with the app. At last, speed of objectives completion accelerates, with an average of 6.61 objectives

completed in 4 months, in contrast with the 5.11 prior to the digitalization.

- Automation of Data Reporting. The system automates the generation of objective completion reports, saving therapists time and reducing errors. Moreover, it also adds the feature of recording the words that the patient struggled with. Reports can be easily downloaded from the ABA Service Website.
- Privacy, Security and Reliability. The ABA Service System enhances the security and privacy of therapy data. Therapists can access patient data securely from any location, ensuring convenience without compromising privacy. The system has demonstrated reliability during the four-month testing period.

The introduction of the ABA Service System allows for valuable data analysis beyond the initial objectives. Data on the percentage of completed objectives per category, the number of objectives completed per user, and error rates per category provide insights that can guide therapy design and resource allocation.

8. Conclusion and Future Developments

The ABA Service System represents a successful case study of digitalization of ABA therapy sessions. Thanks to the development of a mobile app, website and infrastructure, the therapists have been able to transition from their paper-base to a digital-led therapy.

The testing phase at the Mantova center demonstrates the system efficacy in meeting the needs of the therapists. The implementation of a login-based system and continuous data backup strengthen privacy and security measures, garnering positive feedback. The automated data collection, learning materials preparation, and report creation functions significantly improve efficiency.

The impact of the ABA Service System in the efficacy of the therapy is evident through the data analysis. The reduction in non-therapeutic activity time, increased patient focus, and accelerated completion of objectives underline the system's positive influence. While the potential for predicting patients' objective completion rates over time may be tempting, therapists cau-

tion against the inherent challenges and unpredictability associated with ASD. Individualized factors, personal nuances, and daily variations make accurate predictions elusive, emphasizing the complexity of the therapeutic process.

Recognizing the transformative power of data, therapists foresee the possibility to tailor the therapy to each individual patient, something that is not currently possible. This aligns with the observed success of digitalization in TACT, LISTENER, and VPMTS categories. However, it is acknowledged that not all aspects of therapy can be digitized uniformly, and the impact may vary across categories.

Looking ahead, the system holds promise as a tool supporting home-based ABA activities, leveraging the ubiquity of mobile devices. The recommendation to make the ABA Service App compatible with Android aims to broaden accessibility, facilitating continuous engagement beyond therapy sessions with family members.

Moreover, the potential for refining the objects completion report represents a valuable future enhancement. While the report's current structure is maintained for continuity, the incorporation of new data can offer more user-friendly insights for patients' families.

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