

Beyond the App: MultiTalk, a Dedicated Augmentative and Alternative Communication Device for Autistic Children

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Abstract. *This paper presents MultiTalk, a conceptual low-cost (R\$390,43 / USD 65) Augmentative and Alternative Communication (AAC) device proposal for autistic children in Brazilian inclusive education. Using Orange Pi Zero 2W, it integrates pictogram slots, alphabetic keyboard, and numeric panel in a dedicated physical interface, overcoming high-cost vocalizers (R\$3.900+ / USD 650+) and distracting tablet apps. Framed by Universal Design for Learning and Design Science Research, the Figma-prototyped design includes hardware schematics and multimodal flows. Physical prototyping and empirical evaluation (e.g., pilots studies) are planned future work, aligned with Inclusion Law (13.146/2015) and AAC evidence (51% communicative gains). MultiTalk advances accessible embedded systems for equitable computing education.*

1. Introduction

Access to quality education requires more than school enrollment; it demands that communicative, cognitive, and sensory differences be meaningfully accommodated within learning environments. In Brazil, this obligation is grounded in Law No. 13.146/2015 (Statute of Persons with Disabilities) and Decree No. 7.611/2011, which require educational institutions to provide Specialized Educational Services (SES) and assistive technologies at no additional cost to students [Brazil 2015, Brasil 2011]. The 2022 Demographic Census reported 760,800 autistic students enrolled in Brazilian basic education, 1.7% of total enrollments, a figure that reflects both the growth of inclusion policies and the scale of the infrastructure challenge they demand [Instituto Brasileiro de Geografia e Estatística (IBGE) 2022].

Despite this legislative progress, enrollment numbers alone do not indicate meaningful inclusion. For autistic students classified at DSM-5 support levels 2 and 3 [APA 2022], participation in educational activities depends substantially on access to Augmentative and Alternative Communication (AAC) resources. Yet structural barriers, attitudinal, financial, and technological, continue to limit their reach in public

schools [Mantoan et al. 2023, Junior and Coutinho 2024], and the existing landscape of AAC solutions, as examined in Section 2, leaves a critical gap in the context of Brazilian Multifunctional Resource Rooms (MRRs).

This paper presents MultiTalk, a conceptual proposal for a low-cost, dedicated AAC device designed for autistic children in MRR settings. The device integrates three interaction modes: a pictographic card system for immediate expression, a full alphabetic keyboard for sentence construction, and a numeric panel for mathematical and daily communication contexts. The design is grounded in Universal Design for Learning principles [Meyer et al. 2014, Sebastián-Heredero 2020] and follows the methodological structure of Design Science Research [Hevner et al. 2008] combined with the assistive technology development framework proposed by [Manzini and Santos 2006]. Physical prototyping and empirical evaluation are defined as future work. The primary contribution of this paper is the specification of an evidence-based conceptual artifact aimed at reducing inequalities in AAC access within Brazilian inclusive education.

2. Theoretical Framework

Within inclusive education, Assistive Technology (AT) and Universal Design for Learning (UDL) are complementary frameworks guiding accessible learning resource design.

2.1. Assistive Technology, UDL, and AAC

AT, as defined by Brazilian legislation, encompasses products, methodologies, strategies, and services that enhance functionality and participation for people with disabilities [Brazil 2009]. Its core purpose is to neutralize barriers to knowledge and communication, not to correct disabilities [Galvão Filho 2009]. UDL, a complementary framework, advocates for curricula designed from the outset to be accessible to all learners, rather than adapted post-hoc. Grounded in cognitive neuroscience, UDL organizes instruction around three brain networks: affective (engagement), recognition (information processing), and strategic (response execution) [Meyer et al. 2014, Sebastián-Heredero 2020]. UDL guides inclusive environment design, while AT provides specific tools for complex needs.

AAC is a key AT area [Nunes et al. 2021], aiming to replace or supplement speech for individuals with complex communication needs, including autistic individuals at DSM-5 support levels 2 and 3 [APA 2022, Pereira et al. 2020]. Evidence supports AAC effectiveness: speech-generating devices improve expressive communication in autistic preschoolers [Therrien et al. 2025], and tablet-based AAC tools show gains in request responses and intraverbal communication [Muharib et al. 2024]. Nationally, a 51.47% increase in communicative acts was observed in children with ASD using AAC strategies [Pereira et al. 2020].

2.2. Existing AAC Resources and the Gap They Leave

AAC resources are categorized by technological level. Low-technology options (e.g., printed boards, pictogram cards) are inexpensive (R\$ 40-100 / USD 7-17) but lack auditory feedback and require a mediator. High-technology resources include software applications (on tablets/smartphones) and dedicated voice output devices (vocalizers). Table 1 summarizes these options and their costs.

Table 1. AAC Resources and Estimated Market Prices

Resource	Type	Target Audience	Price
Low-Technology			
Communication board	Printed material	ASD, CP, mutism	R\$ 40–100*
High-Technology — Applications			
LetMeTalk	Mobile app	ASD, CP	Free
Proloquo2Go	Mobile app	ASD, CP	USD 249.99**
TD Snap (Tobii Dynavox)	Mobile app	ASD, CP, motor	Subscription***
High-Technology — Vocalizers			
GoTalk 9+	Vocalizer	Multi-message	R\$ 3.961,50
QuickTalker FeatherTouch	Vocalizer	Multi-message	R\$ 3.990,00

*Estimated cost for printing, lamination, binder, and velcro (Feb. 2026). **Available in English, Spanish, French, and Dutch; no Portuguese version. ***Monthly subscription; price varies by plan. Hardware prices from [Loja Civiam 2024].

Figure 1 shows examples. Dedicated vocalizers (R\$ 3,961-3,990 / USD 660-665) are financially inaccessible for most Brazilian public schools [Loja Civiam 2024]. Application-based solutions, while more affordable, use general-purpose devices that introduce distracting digital stimuli for autistic students [Junior and Coutinho 2024, Gevarter et al. 2016]. Free apps offer limited interaction (pictogram selection only). Crucially, no existing solution combines pictographic, alphabetic, and numerical communication in a single, dedicated physical interface, which is essential for the multimodal communicative and pedagogical demands of autistic students in MRR settings. This gap directly motivates the MultiTalk proposal.



Figure 1. A) GoTalk 9+ voice output device; B) Quick Talker voice output device; C) Talker Buddy voice output device; D) LetTalk software; E) Proloquo2Go software; F) TD Snap software.

3. Related Works

Research on AAC systems for autistic individuals demonstrates effectiveness, yet few solutions address the specific constraints of Brazilian public MRRs, particularly regarding cost, hardware dependency, and curricular integration.

In Brazil, [Passerino et al. 2010] proposed SCALA (Alternative Communication System for Literacy of People with Autism), a pedagogically grounded system integrating pictographic boards for literacy. Its limitation, however, is its dependency on computers or tablets, which are often unavailable in public schools with limited infrastructure.

Internationally, interventions combining aided modeling with voice output technologies improve sociocommunicative behaviors [Schlosser and Koul 2015]. Brazilian case studies also report advances in communication through alternative systems [Montenegro et al. 2021]. While these findings reinforce AAC's clinical relevance, most studies occur in controlled settings, limiting direct applicability to everyday MRR contexts [Therrien et al. 2025].

A comparative analysis reveals a consistent gap: software-based systems rely on general-purpose devices without dedicated physical interfaces; dedicated vocalizers are hardware-independent but limited to pictographic communication and are financially inaccessible. Crucially, no existing system integrates pictographic, alphabetic, and numerical modalities within a single artifact designed for structured educational use. MultiTalk is positioned to address this specific multimodal combination, offering a complementary tool adapted to the communicative and pedagogical demands of autistic students in MRR settings.

4. Methodology

This study presents the conceptual specification of MultiTalk, a dedicated AAC device for autistic children in MRR settings, as a design-oriented theoretical essay. It proposes and theoretically substantiates an assistive technology artifact grounded in educational principles and empirical evidence. The methodological approach follows Design Science Research (DSR) [Hevner et al. 2008], covering problem analysis, solution objectives, and conceptual design. Physical prototyping and empirical evaluation are future work, pending Research Ethics Committee approval.

The AT development model by [Manzini and Santos 2006] guides the design logic, comprising five stages: needs assessment, idea generation, resource construction, evaluation, and implementation. Needs assessment and idea generation were addressed via the literature review and comparative analysis (Sections 2 and 3). This section details MultiTalk's conceptual design (resource construction), covering interaction modes, component architecture, and functional specifications. Evaluation and implementation are future stages.

4.1. Device Architecture

The proposed MultiTalk device uses an Orange Pi Zero 2W as the central processing unit, responsible for managing audio playback, input processing, and display control. The choice of this single-board computer is justified by its low cost relative to comparable alternatives, its open-source hardware architecture, and its sufficient processing capacity for the proposed functionalities — factors that make it particularly suitable for replication in public schools with limited budgets.

The system architecture is organized into four functional groups, as illustrated in the block diagram (Figure 2). The power supply group comprises a rechargeable battery

and a standard charging port, enabling autonomous operation without a permanent electrical outlet. The input group includes the pictogram card slots, the alphabetic and numeric keypads, and an audio recorder module that allows teachers to store customized audio for each card or key directly on the device. The output group comprises a speaker for audio verbalization and an LED display for visual feedback during alphabetic and numeric interactions. The control group includes a power switch and a send button that triggers verbalization of complete sentences formed in alphabetic mode.

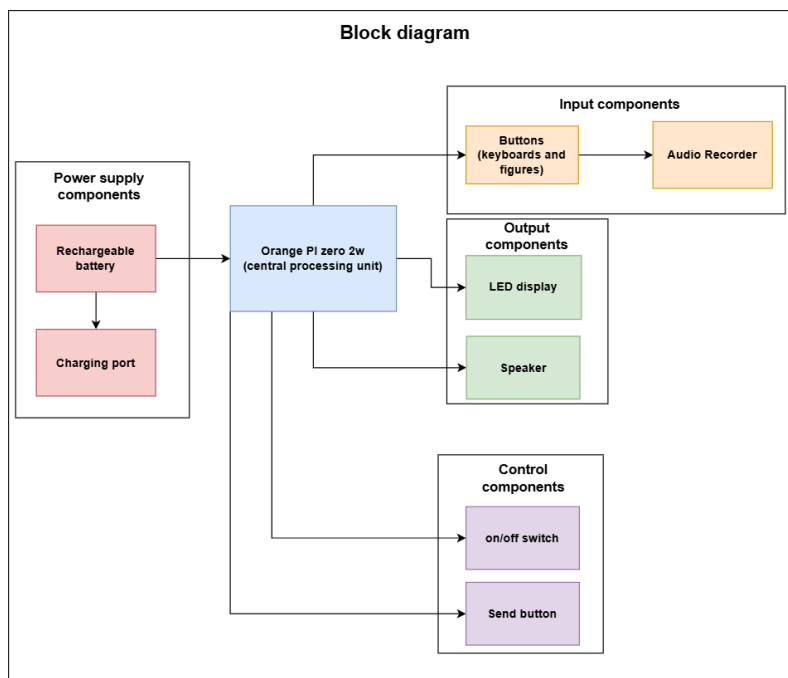


Figure 2. Block diagram of the MultiTalk device and its components.

Based on this architecture, MultiTalk operates in three distinct interaction modes, each corresponding to a specific communicative or pedagogical context within the MRR. In Pictogram Mode, the child presses a card inserted into one of the six slots; the pressure sensor detects the input and triggers immediate audio verbalization without LED output, preserving the immediacy of the interaction. In Alphabetic Mode, individual key presses are detected, verbalized, and simultaneously displayed on the LED screen; pressing the send key triggers verbalization of the complete sentence. In Numeric Mode, number key selections are verbalized and accumulated on the LED display, enabling the formation of multi-digit numbers for use in pedagogical activities or everyday communication contexts.

The architecture was designed around three guiding principles: low cost, simplicity of use, and flexibility for adaptation to different communicative and pedagogical contexts. For its visual materialization, a high-fidelity prototype was developed in Figma¹ (Figure 3), simulating the physical interface and ensuring the ergonomic arrangement of card slots, alphabetic keyboard, and numeric keypad.

¹Figma, Inc. *Figma: The Collaborative Interface Design Tool*. Available at: <https://figma.com>. Accessed: March 2, 2026.



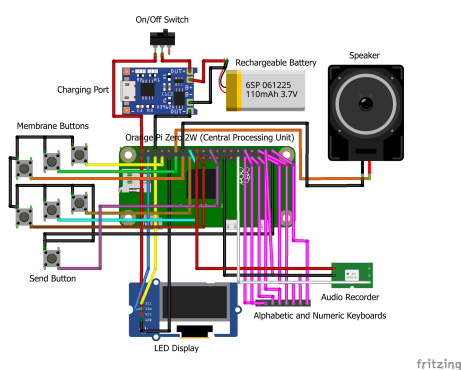


Figure 4. MultiTalk electronic wiring diagram. The Raspberry Pi Zero represents the Orange Pi Zero 2W due to Fritzing library constraints.

children [Walter 2000]. Pictograms can be sourced from ARASAAC², which offers a broad repository of free universal symbols, or produced from photographs provided by families, enabling personalization according to each child's individual communicative profile.

4.3. Pedagogical Applications

MultiTalk is designed to integrate into MRR activities across three communicative and pedagogical dimensions. In immediate communication contexts, pictogram cards enable the child to express basic needs, preferences, and responses — greetings, requests, affirmations, and negations — reducing communicative frustration and supporting autonomy. In literacy and cognitive development activities, the device can support grapheme-phoneme association through alphabetic mode, color and animal categorization through thematic card sets, and number recognition through numeric mode. In narrative and routine activities, sequential card sets representing the child's daily schedule or story elements promote identification, temporal organization, and communicative participation.

The ease of replacing cards and recording new audio tracks makes MultiTalk adaptable to each child's developmental stage without requiring advanced technical knowledge from the teacher. Figure 5 illustrates representative card sets across six pedagogical activity types: color recognition, animal categorization, narrative and musicalization, musical instrument identification, literacy, and daily routine. Pictograms can be sourced from ARASAAC, which offers a broad repository of free universal symbols, or produced from photographs provided by families, enabling personalization according to each child's individual communicative profile.

5. Expected Results

The development and future application of MultiTalk are expected to produce contributions in three interconnected dimensions: communicative repertoire, pedagogical engagement, and sustained adherence to activities.

In terms of communication, the device is expected to expand the functional communicative repertoire of nonverbal or minimally verbal autistic students, enabling the expression of immediate needs, desires, and feelings through pictogram selection and voice

²Aragonese Centre of Augmentative and Alternative Communication. Available at: <https://arasaac.org>. Accessed: Feb. 1, 2026.

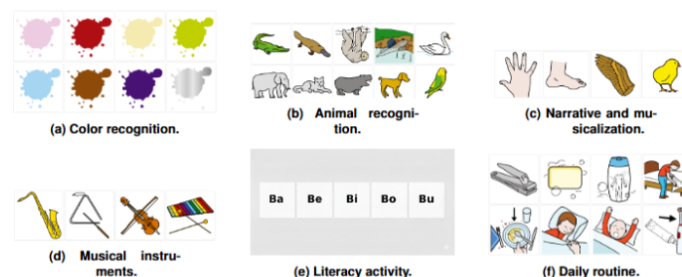


Figure 5. Representative card sets for different pedagogical applications.

synthesis. This expectation is grounded in evidence from prior studies that documented significant increases in communicative acts among autistic children following the introduction of AAC resources in structured educational environments [Pereira et al. 2020].

Regarding pedagogical engagement, the integration of literacy, numeracy, and visual recognition activities within a single dedicated interface is expected to promote greater student participation in SES sessions. The tangible and purposefully designed nature of the hardware, contrasting with general-purpose tablets that compete with other digital content for the child's attention, is expected to provide a predictable and structured interaction context — particularly relevant for autistic students who benefit from consistent routines [Pozzobon et al. 2025].

Concerning adherence, it is worth acknowledging that AT abandonment is a documented risk in educational contexts [Junior and Coutinho 2024]. MultiTalk's design addresses this through low operational complexity, teacher-controlled audio customization, and the absence of competing digital affordances that typically discourage sustained use. The physical and sensory characteristics of the device, tactile feedback, card-based interaction, and audio output, are expected to favor continuous engagement across activity types.

Finally, from an equity standpoint, the estimated production cost of R\$ 390,43 (approximately USD 65) positions MultiTalk as a replicable alternative for public schools in socioeconomically vulnerable regions, where imported voice output devices and subscription-based software remain largely inaccessible. By offering an affordable and locally producible solution, the proposal aims to contribute to reducing the documented gap in AAC access within Brazilian inclusive education [Junior and Coutinho 2024].

6. Conclusion

This article presented MultiTalk, a conceptual proposal for a dedicated, low-cost Augmentative and Alternative Communication device designed for autistic children in Multifunctional Resource Rooms. Grounded in DSR and the AT development model proposed by [Manzini and Santos 2006], the work specified the functional architecture, interaction modes, hardware components, and pedagogical applications of the device, establishing a theoretically substantiated design basis for future prototyping and empirical evaluation.

The present contribution is explicitly conceptual in scope. The next stages of the research, defined as future work, comprise physical prototyping, submission to a Research Ethics Committee, and empirical evaluation with autistic students in MRR settings, involving both speech-language pathologists and specialized teachers as co-evaluators.

Quantitative and qualitative instruments will be employed to assess communicative gains, pedagogical engagement, and device adherence over time.

By proposing an evidence-based, replicable, and low-cost artifact, this work seeks to contribute to reducing structural inequalities in access to assistive technology within Brazilian inclusive education and to open a research agenda around dedicated AAC hardware as a complement to software-based and printed solutions in public school contexts.

Use of Artificial Intelligence

Artificial intelligence tools were used in an auxiliary capacity during the preparation of this article. Large language models were employed to support academic writing tasks, including grammar revision, syntactic reformulation, and stylistic improvement of passages originally drafted by the authors. All conceptual content, theoretical arguments, design decisions, and bibliographic references were produced and verified exclusively by the authors. The use of these tools did not influence the research design, the selection of cited works, or the conclusions presented.

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