KittyGatto: A Low-Cost Learning Companion for Multilingual Children

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Abstract*—This paper presents KittyGatto, a low-cost handheld learning companion designed to support multilingual language development in children aged 2 to 8. Inspired by the founder's personal experience raising bilingual children, the device combines an e-ink display, physical buttons, dual-speaker audio, and optional on-device AI speech recognition to deliver engaging, parent-guided vocabulary and pronunciation practice across multiple language pairs. KittyGatto is part of Lingo Starters, an early-stage startup backed by the Royal Academy of Engineering's Regional Talent Engine programme. The device prioritises responsible screen-free interaction, parental control, and affordability, targeting a bill of materials under £80. This paper describes the motivation, design, intended hardware and software architecture, and next steps toward a functional prototype.

I. Introduction / Background

Research consistently shows that children between the ages of 2 and 8 are in a critical window for language acquisition, during which their brain plasticity allows them to absorb and internalise multiple languages far more effectively than at any later stage [1]. Yet despite this well-documented opportunity, raising multilingual children remains a significant challenge for families. Studies suggest that 8 out of 10 multilingual families struggle to maintain active bilingualism in their children, often due to limited exposure, inconsistent practice, and a lack of accessible, age-appropriate resources [2].

The inspiration for KittyGatto comes from a deeply personal place. When my first daughter turned two, she had not yet begun speaking. As an Italian father raising her bilingually in English in the United Kingdom, I feared that speaking Italian to her was causing confusion. After researching multilingual speech development, I learned that slight delays in early speech are common in bilingual children and that continued exposure to both languages was essential. This motivated me to explore how technology could support, rather than replace, the parent-child language learning journey.

KittyGatto is conceived as a low-cost, screen-limited, AI-capable handheld device shaped like a friendly cat. It is designed to make multilingual vocabulary and pronunciation practice engaging and accessible for young children, while keeping parents actively involved. The device is part of a broader venture called Lingo Starters, which is currently building an online community of experts and parents to support multilingual families, with the hardware device planned as a Phase 3 product [3]. Lingo Starters has been accepted into the Royal Academy of Engineering's Regional Talent Engine programme (Cohort 6), which provided mentorship, business development support, and credibility as the project moves into the next steps.

II. Related Work

Several consumer products address children's language learning, but none specifically targets the multilingual family use case with a dedicated hardware device. Duolingo ABC and Duolingo Kids offer app-based vocabulary games but require a smartphone or tablet, introducing screen-time concerns for very young children [4]. LeapFrog devices such as the LeapReader provide guided phonics and reading activities with physical books and a stylus, but they focus on monolingual English literacy and lack multilingual content [5]. Toniebox and Yoto offer audio-based storytelling through physical tokens, but their content libraries are primarily in single languages and do not include interactive pronunciation practice [6].

On the research side, studies have explored AI-driven conversational agents for child language learning [7], though these typically run on tablets or smart speakers and are designed for monolingual contexts. The BBC micro:bit has demonstrated the value of low-cost, purpose-built educational hardware [8], and its design philosophy of simplicity, physical interaction, and accessibility strongly influences KittyGatto's approach.

KittyGatto differentiates itself by combining a child-friendly physical form factor, an e-ink display free of blue light, dual-language audio pronunciation, parental controls via a companion smartphone app, and optional on-device AI speech recognition for sustained conversational practice. No existing product integrates all of these features in a single, affordable, purpose-built device for multilingual children aged 2 to 8.

III. Imagined Prototype

A. Design Philosophy

KittyGatto's design is driven by three core principles: responsible technology for children, active parental involvement, and affordability. The device deliberately avoids a traditional smartphone or tablet form factor. Instead, it uses an e-ink display to eliminate blue light exposure, physical buttons to encourage tactile interaction, and a cat-shaped enclosure with customisable silicone covers to make the device feel like a toy rather than a screen. Parental controls, accessible via a companion BLE-connected

smartphone app, allow parents to set daily time limits, select target languages, and track their child's progress.

B. Hardware Architecture

The intended hardware architecture is illustrated in Figure 1 (KittyGatto rendering) and Figure 2 (component diagram). The core components are as follows.

- Microprocessor: An ESP32-S3 module, selected for its dual-core processing capability, integrated Wi-Fi and Bluetooth Low Energy (BLE), and broad ecosystem support. The ESP32-S3 also includes a vector instruction set suitable for lightweight on-device machine learning inference.
- Display: A 2.9-inch e-ink screen (e.g. GDEY029T94, 296×128 pixels) connected via SPI. E-ink consumes power only during screen updates and produces zero blue light, making it ideal for young children.
- Audio: Dual I2S digital amplifiers (e.g. MAX98357A) driving two small full-range speakers, enabling clear pronunciation playback in both target languages simultaneously or sequentially.
- Microphone: A MEMS microphone (e.g. INMP441) for the Pro version, enabling on-device speech recognition so the child can practise pronunciation and receive feedback.
- Input: Five tactile push buttons arranged ergonomically for small hands: a directional pad (left, right), two language selection buttons (labelled "1" and "2" for each language), and a central "paw" button for confirmation and playback.
- Storage: A curated on-device language database stored on the ESP32-S3's flash memory or an external SD card, containing vocabulary, pronunciation audio clips, and simple illustrations for the e-ink display.
- Connectivity: BLE 5.0 for pairing with the parent's smartphone app for configuration, progress syncing, and parental controls. Wi-Fi for optional firmware updates and content downloads.
- Power: A 1200 mAh LiPo battery with a TP4056-based charging circuit and USB-C connector, targeting over two weeks of battery life given the low power consumption of e-ink and the intermittent usage pattern.
- Enclosure: A cat-shaped injection-moulded (or initially 3D-printed) ABS shell with interchangeable silicone covers for personalisation. The form factor is approximately 12 cm × 7 cm × 2.5 cm.

Fig. 1. Figure 1 – KittyGatto 3D rendering showing the cat-shaped enclosure, e-ink display window, physical buttons, and customisable cover.

C. Software Architecture

The firmware will be developed using the ESP-IDF framework (or Arduino-ESP32 for rapid prototyping). The software stack includes four main layers: (a) a hardware abstraction layer managing the e-ink display, audio DACs, buttons, BLE, and microphone; (b) a content engine that retrieves vocabulary entries from the on-device database, renders illustrations and text on the e-ink display, and plays audio pronunciation clips; (c) a session manager that tracks interaction time, enforces parental time limits, and logs learning progress; and (d) for the Pro version, a speech recognition module running a lightweight model such as a quantised TensorFlow Lite model fine-tuned for children's multilingual speech.

The companion smartphone app, developed using a cross-platform framework such as Flutter, will communicate with KittyGatto over BLE. It will allow parents to configure language pairs, set daily usage limits, view vocabulary progress dashboards, and download new content packs.

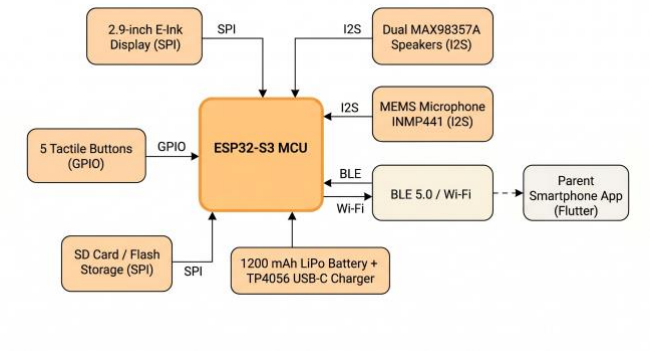

Fig. 2. Figure 2 – KittyGatto hardware block diagram showing the ESP32-S3 microprocessor, e-ink display, dual speakers, MEMS microphone, BLE/Wi-Fi connectivity, buttons, battery, and companion app.

D. Bill of Materials and Target Cost

A preliminary bill of materials estimate, based on single-unit pricing from common suppliers, places the total component cost at approximately £40–60. The most significant cost drivers are the ESP32-S3 module (approximately £5–8), the e-ink display (approximately £10–15), the speakers and amplifiers (approximately £4–6), and the battery and charging circuit (approximately £3–5). The enclosure cost will depend on whether 3D printing (for initial small batches) or

injection moulding (for production volumes of 500 or more units) is used.

IV. Responsible innovation

KittyGatto is designed with responsible innovation at its core. The device addresses a genuine societal need: supporting the millions of multilingual families worldwide who struggle to maintain their children's heritage languages. By providing an affordable, accessible tool, KittyGatto can help preserve cultural identity and linguistic diversity.

From a child safety perspective, the design makes deliberate choices to limit technology exposure. The e-ink display eliminates blue light. There is no internet browser, no social media, and no advertising. Parental controls enforce time limits. The device is designed to complement, not replace, parent-child interaction: the recommended usage model involves the parent sitting with the child, engaging in the vocabulary activities together, and reinforcing learning through conversation.

Environmental sustainability is considered in the choice of durable, repairable materials and modular component design. The e-ink display and low-power ESP32-S3 contribute to long battery life, reducing charging frequency and energy consumption. Future iterations will explore the use of recycled plastics for the enclosure and replaceable battery modules to extend the device's useful life.

Data privacy is critical given the target age group. KittyGatto will comply with GDPR and the UK Children's Code (Age Appropriate Design Code). Speech data processed by the on-device AI model will remain on-device and will not be transmitted to external servers. The companion app will collect only the minimum data necessary for functionality, with clear parental consent mechanisms.

V. Author bio / experiences

I'm an Italian entrepreneur and technologist based in Kendal, Cumbria (UK). I'm the founder of Lingo Starters, a startup based in Liverpool building technology and community to support multilingual families. Lingo Starters is my third business venture, drawing on over a decade of experience in software engineering, and hardware-software integration across enterprise and startup environments.

My motivation for KittyGatto is deeply personal. As a bilingual Italian-English father raising three children in the UK, I experienced firsthand the challenges of maintaining my daughter's Italian language development alongside English. My daughter's initial speech delay, which I initially attributed to bilingual confusion, became the catalyst for researching multilingual child development and ultimately founding Lingo Starters.

My technical background spans full-stack software development, automation, and embedded systems integration. I have hands-on experience with ESP32 firmware development, BLE communication, and AI model deployment. However, my hardware prototyping skills, particularly in PCB design, component sourcing, surface mount assembly, and design for manufacture, are areas where he seeks to develop greater confidence. Attending the pro² Summer School would directly address this gap, enabling me to advance KittyGatto from a conceptual design toward a functional, manufacturable prototype.

Lingo Starters has been selected for the Royal Academy of Engineering's Regional Talent Engine programme (Cohort 6, started October 2025), which provides structured mentorship and business support. The project's current Phase 1 (an online expert and parent community at https://www.lingostarters.com) is live and collecting expressions of interest, with the hardware device planned as the Phase 3 deliverable.

VI. Acknowledgements

I would like to thank the Royal Academy of Engineering for their support through the Regional Talent Engine programme, which has been instrumental in refining the Lingo Starters business proposition and advancing the KittyGatto concept. Thanks also to the multilingual parents and speech therapy professionals who have provided invaluable feedback during the early stages of this project.

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