

NO-CODE ARCHITECTURES AND LEARNING ENVIRONMENTS IN EARLY CHILDHOOD AND PRIMARY EDUCATION (II): MOBILE INTERFACE DESIGN AND DIGITAL ERGONOMICS

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Abstract

Continuing the functional taxonomy established in the first stage of this research series, this study investigates the ergonomic, user experience (UX/UI), and cognitive accessibility dimensions of no-code mobile applications (Google AppSheet®) in early childhood and primary education (ECPE). While the first article focused on structural and pedagogical classification, the second addresses the micro-level design challenges of human-computer interaction within hybrid learning environments. The research evaluates how interface ergonomics, visual hierarchy, touch-target sizing, and multimedia integration impact young learners (preschoolers and early graders) and educators. Applying the principles of Universal Design for Learning (UDL) and Cognitive Load Theory, the study proposes an evidence-based set of design guidelines for mobile interfaces that minimizes cognitive friction, ensures digital inclusion, and safeguards the engagement of young users. The findings provide developers, educational designers, and teachers with a practical guide for creating intuitive, child-friendly, and teacher-centric no-code digital environments.

Keywords: No-code architectures; Google AppSheet; UX/UI design; digital ergonomics; cognitive accessibility; Universal Design for Learning (UDL);

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1. Introduction

The recent evolution of no-code technologies, exemplified by cloud-based platforms such as Google AppSheet®, has opened new perspectives across multiple fields of activity, including the flexible digitalization of educational environments (Jitendra, 2025; Cioruța et. al, 2026a, 2026b). As demonstrated in the first stage of this research series, the introduction of a multidimensional functional taxonomy provides the structural framework necessary to transform mobile databases into psychopedagogical tools tailored for Early Childhood and Primary Education (ECPE).

The transition from structural and administrative validation to direct classroom interaction (as a promise of faster development cycles, reduced costs, and greater accessibility) - especially within category C interactive learning environments - brings to the forefront a critical new challenge: interface ergonomics, cognitive accessibility, and digital mediation (Gomathy, 2025).

While specialized literature has frequently focused on the technical feasibility of educational applications or the acquisition of rigid commercial software, the micro-ergonomic aspects of UX/UI design dedicated to preschool and early school-age children often remain superficially addressed. Developing interfaces on no-code platforms - by democratizing machine learning - entails utilizing pre-defined templates that require rigorous adaptation to prevent extraneous cognitive load (Giraldo & Laso, 2025). Children in preschool and primary education possess developing fine motor skills and visual processing abilities, rendering elements such as touch-target sizing, visual hierarchy, and multimedia feedback critical determinants for the pedagogical success or, conversely, failure of the application. Furthermore, within these hybrid environments, digital interaction does not replace but must be pedagogically mediated by the educator, requiring control panels to minimize the bureaucratic and cognitive effort of the teacher.

This study aims to bridge this gap by investigating the ergonomic dimensions, interface design models, and cognitive accessibility of no-code applications developed for ECPE. Grounded in the principles of Universal Design for Learning (UDL), Cognitive Load Theory, and the constructivist paradigms of mediated learning (Adamah & Gariba, 2026), this research analyzes how the constraints and opportunities of mobile interfaces associated with the Google AppSheet® platform can be optimized to create inclusive, secure, and intuitive digital environments (Halim, 2023; Goswami & Chauhan, 2025). By establishing an evidence-based best-practice framework for UX/UI design, the paper provides teachers - in their new role as educational architects - and designers with the tools necessary to configure digital experiences that support children's attention, motivation, and cognitive progress, while maximizing the pedagogical agency of educators through seamless interaction.

2. Literature review and UX/UI challenges in ECPE

2.1. Digital ergonomics and UX/UI dedicated to preschoolers and early graders

The integration of mobile technology in ECPE cannot be achieved by simply adopting or scaling down interfaces designed for adults or experienced users. Preschool and early school-age children are in a dynamic stage of neuro-motor and cognitive development, characterized by developing fine motor control, emerging hand-eye coordination, and a limited duration of sustained attention.

In the specialized literature dedicated to Human-Computer Interaction (HCI), the principles of Child-Computer Interaction (CCI) impose strict ergonomic and visual requirements:

- **Generous dimensions and error-tolerant touch targets** to compensate for fine motor imprecision;
- **The elimination of complex gestures** (such as multiple swipes, drag-and-drop sequences, or pinch-to-zoom), which generate cognitive roadblocks and frustration;
- **The use of an intuitive visual hierarchy** based on concrete iconography, contrasting color codes, and stimulating graphic elements, rather than dense tables or heavy text.

However, no-code platforms (such as Google AppSheet®) are natively built on standardized display patterns and workflows oriented toward business productivity and relational databases. This commercial lineage/native limitation generates a major challenge within contemporary educational architecture: translating a pedagogical data structure into an accessible and child-friendly/inclusive interface (Parveen et. al, 2026) requires rigorous micro-ergonomic calibration of visuals, step-by-step navigation flows, and direct interaction elements.

2.2. Cognitive load and accessibility in hybrid environments

Another essential pillar in the analysis of educational mobile interfaces is Cognitive Load Theory. In the process of digitally mediated learning, children are exposed to - and are particularly vulnerable to - extraneous cognitive load: a form of overload that does not derive from the intrinsic complexity of the educational content, but is instead generated by confusing interface design, redundant visual elements, or non-intuitive/cumbersome navigation within the application.

Within the context of category C of the taxonomy established in the first stage of the research (interactive learning environments), no-code applications must not consume the child's attentional resources through technical complexity; rather, they must function as a dynamic cognitive scaffold, reducing digital friction and preventing distraction (Rahman & Moh, 2025). From this perspective, cognitive accessibility becomes inextricably linked to adhering to the principles of UDL. The micro-ergonomic design of interfaces must provide multiple and flexible pathways for content representation and expression (visual, auditory, kinesthetic), thereby responding to diverse

developmental and learning rhythms, as well as to special educational needs, while guaranteeing an inclusive experience within hybrid educational environments.

Although a vast corpus of research exists regarding the general effects of screen exposure on children, the current specialized literature presents a significant and persistent gap: the scarcity of investigations dedicated to the micro-ergonomic optimization of no-code applications configured directly by educators. Most empirical studies analyze either rigid, closed commercial educational software or complex applications developed by dedicated teams of professional programmers, which unfortunately fail to reflect actual classroom realities and constraints.

Against this backdrop, there is an acute lack of methodological frameworks and structural guidelines indicating how the teacher - in their new posture as a no-code architect - can overcome the native constraints of cloud-based platforms to reduce cognitive friction and ensure an inclusive, safe, and ergonomic experience for preschoolers and early graders. The present study aims to precisely address this critical gap, substantiating the theoretical and practical transition from the mere technical functionality of databases to the excellence of UX and digital ergonomics in ECPE.

3. Methodology and heuristic evaluation models for mobile interfaces

3.1. Methodological approach and analytical framework design

To investigate and optimize how no-code platforms (exemplified by the Google AppSheet® ecosystem) can support ergonomic interaction and cognitive accessibility, this study adopts a mixed methodological approach grounded in structural analysis, heuristic design, and psychopedagogical alignment. The research is not limited to isolated empirical prototype testing; rather, it constructs a systematic analytical framework that maps native platform design constraints onto the developmental requirements of preschool and early school-age children (ECPE), as well as onto educators' workflows. The methodological design stems from the fundamental premise of the dual role that a mobile educational application must fulfill within a hybrid environment:

- On the one hand, ***a simplified, highly intuitive, and secure interface for direct utilization by the child*** (frontend);
- On the other hand, ***a complex yet ergonomic and rapid control panel intended for administrative and formative management by the teacher*** (backend).

To evaluate this duality, the methodology employs a multidimensional model structured around three interconnected axes:

- ***Physical and tactile interface ergonomics*** (touch-target ergonomics);
- ***Optimization of cognitive load and visual hierarchy*** (cognitive load mitigation);
- ***Universal accessibility and compliance with UDL principles.***

3.2. Major UX/UI evaluation criteria for no-code platforms

The proposed analytical framework evaluates interfaces generated via no-code platforms based on three fundamental criteria, specifically operationalized for the educational environment:

A. ***Touch-target ergonomics and control*** analyze the adaptation of native visual templates to preschoolers' fine motor development:

- ***Minimum touch-target dimensions*** - evaluates adherence to ergonomic standards (the recommendation of a minimum of 48x48 dp for active surfaces) to prevent operational errors caused by developing hand-eye coordination.
- ***Physical spacing (whitespace)*** - analyzes the distance between buttons to eliminate accidental touches during touchscreen navigation.
- ***Elimination of complex gestures*** - restricts actions requiring advanced precision (multiple swipes, drag-and-drop gestures, or pinch-to-zoom), substituting them with large, single-action buttons (one-touch action).

B. ***Visual hierarchy and cognitive friction reduction*** targets the screen's informational architecture to protect the child's attentional resources:

- ***Screen information density*** - strictly limits the number of simultaneously active elements to prevent extraneous cognitive load.
- ***Intuitive iconography*** - utilizes concrete visual symbols consistently associated with specific actions, replacing dense text labels.
- ***Instant multimodal feedback*** - integrates immediate visual, chromatic, or auditory responses that clearly confirm the success of the student's interaction.

C. ***Universal accessibility and multimedia integration*** analyzes interface flexibility in supporting learning diversity:

- ***Multiple means of representation*** - the capability to convert or accompany textual elements with audio or visual support, essential for pre-literate children.
- ***Adaptability for special needs*** - support for high visual contrast and interface scaling options for students with special educational needs.
- ***Structural separation of roles*** - visual and functional isolation between student-dedicated screens and teacher administration panels, guaranteeing data integrity.

To ensure the practical validity of the methodological framework, the established criteria are integrated into an iterative cycle of real didactic scenario simulations. This method enables the identification of optimal configuration solutions within the Google AppSheet® platform, transforming the structural limitations of a commercial productivity-oriented tool into an inclusive, secure digital environment perfectly tailored to educational micro-ergonomics.

4. UX/UI design taxonomy and ergonomic solutions applied in Google AppSheet®

Building directly upon the established methodological criteria and confronting them with the native constraints of the Google AppSheet® platform, this section details an operational design taxonomy oriented toward micro-interaction. The solutions are structured into three essential categories of ergonomic configuration and cognitive accessibility for ECPE.

4.1. Category A. Visual architecture for teachers

Although educators possess developed digital competencies, the dynamic and often tense classroom working environment requires administrative interfaces to minimize visual fatigue and operational time. UX/UI challenge - native dense data tables in Google AppSheet® are designed for the business environment and become difficult to navigate rapidly on mobile devices during teaching activities.

Design solutions applied in Google AppSheet®:

- **Modular view grouping (card and dashboard views)** - replacing long textual lists with large visual cards, color-coded according to priority level or activity status (e.g., *attendance status* or *progress alerts*);
- **Simplified scrolling forms (column grouping)** - organizing long data-entry fields into restricted, expandable sections, minimizing the visual load of the mobile screen;
- **Single-action button automation (action buttons)** - configuring large "one-touch" buttons for frequent administrative tasks (e.g., *marking collective attendance* or *automatically generating a daily report*), eliminating multi-step menu navigation.

4.2. Category B. Interfaces for formative assessment and observation logs

This category targets applications frequently utilized by the educator directly in the presence of students, where speed, discretion, and recording accuracy are vital. UX/UI challenge - the necessity to record behavioral observations or learning evidence in real-time without the interface distracting the educator's attention away from the group.

Design solutions applied in Google AppSheet®:

- **Icon-based visual grading systems** - utilizing intuitive graphic buttons (expressive symbols, color-coded progress indicators) instead of abstract numerical scales or cumbersome dropdown menus that are difficult to operate on the fly.
- **Integrated multimedia fields** - optimizing evidence-attachment buttons (e.g., *photographs of practical work* or *short voice notes by the teacher*) via a single touch, directly within the student's individual file.

- **Adaptive contextual menus** - hiding elements irrelevant to the current evaluation moment, dynamically displaying on the screen only the options strictly necessary for the evaluated group or student.

4.3. Category C. Guided interactive environments for preschoolers and early graders

This is the most sensitive category of the taxonomy, where the application is utilized directly by children on tablets under the guidance or mediation of the educator. UX/UI challenge - adapting a relational database platform to respect the motor and cognitive limits of pre-literate children or those at the beginning of the primary cycle.

Design solutions applied in Google AppSheet®:

- **Maximizing touch targets** - configuring interactive elements to generous dimensions (minimum 48x48 dp), appropriately spaced to eliminate operational errors caused by incomplete fine motor control.
- **Minimizing text and utilizing rich iconography** - replacing textual labels with explicit visual elements, large image buttons, and contrasting color codes to guide navigation.
- **Step-by-step guided interfaces** - structuring digital content so that only a single interactive task is visible on the screen at any given time, preventing cognitive overload and channeling the child's attention.

5. Pedagogical implications and UX/UI best practice guidelines in no-code environments

The transformation of no-code platforms (such as the Google AppSheet® ecosystem) from simple administrative and data-storage tools into ergonomic, secure, and inclusive educational environments generates major implications for pedagogical practice in ECPE. This section synthesizes the impact of UX/UI design decisions on the educator's role, instructional efficiency, and compliance with digital ethics principles.

5.1. Redefining the teacher's role - from user to ergonomic designer

Implementing user-centered design in custom applications radically alters the educator's position within the edtech landscape. The teacher is no longer viewed as a passive consumer of rigid commercial software, but becomes an architect of the digital experience (micro-level UX designer). Understanding the principles of tactile ergonomics, visual hierarchy, and database structuring enables educators to customize their applications according to the neuro-motor and cognitive specificities of their student groups. This functional autonomy enhances teachers' confidence in technology, stimulates classroom innovation, and considerably reduces resistance to digitalization, transforming design into a creative pedagogical endeavor.

5.2. *Maximizing inclusion and accessibility through UDL*

From a constructivist perspective, ergonomically optimized no-code applications become powerful tools for the effective implementation of the principles of UDL. Providing multiple means of representation, expression, and engagement - such as pairing intuitive visual elements with audio feedback and generously spaced buttons - directly supports children with diverse learning rhythms or special educational needs. By lowering physical and cognitive interaction barriers, mobile technology ceases to be a source of exclusion or frustration, becoming a genuine cognitive scaffold throughout discovery-based learning.

5.3. *Essential best practice guidelines for no-code educational architects*

To ensure a secure bridge between theoretical rigor and practical classroom application, the research synthesizes an evidence-based set of guidelines recommended for both educators and educational developers:

- ***The one-touch rule*** - eliminate nested menus and multi-step navigation in sections dedicated/intended for children; every essential interaction must be accessible through a single, clear touch.
- ***Strict interface separation (backend vs. frontend)*** - visually and structurally isolate the teacher's complex administrative panels from the minimalist interactive screens used by students, thereby protecting data integrity and visual clarity.
- ***Minimizing cognitive load through iconography*** - replace long, dense texts with explicit/intuitive graphic symbols, contrasting color codes, and multimedia elements that support the pre-literacy or early reading stage.
- ***Privacy by design*** - configure access rights and cloud security so that minors' sensitive data is strictly protected and anonymized, complying with GDPR standards even within simplified classroom applications.

6. Conclusions and Future Directions

The present study has completed the conceptual framework established in the first stage of this research series, transitioning from a structural and pedagogical taxonomy to an in-depth analysis of mobile interface design models, micro-ergonomics, and cognitive accessibility in no-code applications (the Google AppSheet® ecosystem) designed for ECPE. By investigating how mobile interfaces can be optimized to respect the neuro-motor and cognitive limits of preschool and early school-age children, the research has demonstrated that cloud-based platforms can successfully overcome native commercial constraints (oriented toward the business environment) to become flexible and inclusive educational environments.

The main theoretical and practical contributions of this study are reflected in:

- The development of ***an analytical framework for UX/UI design and digital ergonomics***, which directly correlates touch-target ergonomics and visual hierarchy with the principles of UDL and Cognitive Load Theory.
- The ***redefinition of the educator's role***, transformed from a simple passive consumer of commercial software into a novel architect of the digital experience (micro-level UX Designer), capable of configuring adapted and secure learning environments.
- The establishment of ***evidence-based practical guidelines***, designed to support teachers and educational developers in creating intuitive interfaces that are structurally separated between administrative panels (backend) and interactive student-dedicated screens (frontend).

Although this study provides a solid structural and functional guide for designing no-code interfaces in education, it simultaneously opens new directions for empirical exploration essential to the development of our field of interest:

- ***Field experimental validation*** - the implementation and testing of application prototypes configured according to these criteria in real kindergarten and primary school classrooms, measuring the direct impact on children's sustained attention, retention, and cognitive progress.
- ***Integration of advanced automations and AI*** - investigating how native automation functions and AI-based generative tools within no-code platforms can facilitate the real-time generation of personalized formative assessment reports for each child.
- ***Longitudinal study of ergonomic efficiency and professional resilience*** - long-term evaluation of how reducing digital friction and increasing design autonomy influence stress levels, job satisfaction, and burnout among educators.

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