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INTEGRATING FUNCTIONAL ARCHITECTURE AND USABILITY IN EMIS DESIGN: A PROTOTYPE-BASED STUDY

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ABSTRACT

Aim/Purpose	To identify the macro-processes, processes, and institutional roles required for a comprehensive functional architecture that supports the design of an Educational Management Information System (EMIS) prototype, and to analyze educational stakeholders' initial perceptions of its usability.
Background	EMIS systems aim to integrate school processes and support institutional decision-making. However, some solutions are characterized by fragmented information flows and lack early usability validation. Furthermore, few studies integrate functionality and usability into a single EMIS design process. This study addresses this shortcoming by combining a functional architecture based on institutional processes with early usability validation through a prototype.
Methodology	The study adopted an applied usability evaluation design with a descriptive scope, supported by quantitative analysis and based on a non-experimental cross-sectional design, conducted in three phases: (a) a literature review of national, regional, and international guidelines on school management; (b) representation of institutional processes in a high-fidelity prototype designed in Figma; and (c) early usability evaluation, using Nielsen's heuristics, with nine teachers (n = 9), whose results should be interpreted as preliminary evidence.

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Contribution	The study offers an integrated approach to EMIS design by combining a functional architecture for school management with early usability evaluation in a high-fidelity prototype. This integration provides a framework that can be applied to other educational contexts to guide future user-centered EMIS developments.
Findings	The functional architecture was organized into a layered model that articulated eight macro-processes, 37 key processes, and seven educational roles, operationalized in a high-fidelity prototype consisting of 81 screens. Early usability evaluation, using Nielsen's 10 principles, showed significantly higher scores than the minimum acceptability threshold (Wilcoxon, $p < .05$), particularly in information organization, contextualized language, and simple visual structure. However, areas for improvement were identified in design consistency, feedback, and support resources. From this perspective, the functional architecture provides coherence to the prototype's design, while usability enables adjustments to make it understandable, navigable, and relevant to educational stakeholders.
Recommendations for Practitioners	The findings provide guidance to education stakeholders (ministries, institutional authorities) and educational technology companies (software engineers and UI/UX designers) on the processes required for comprehensive management within an EMIS. In addition, it is recommended to incorporate early usability validation through prototyping to adjust the user interface to the actual needs of education stakeholders prior to technical implementation.
Recommendations for Researchers	Researchers should continue to examine how to integrate additional school management processes into EMIS design to advance toward more comprehensive EMIS solutions. Additionally, interface improvements should be explored to achieve satisfactory usability, user experience, and EMIS acceptance, as users' perceptions and needs may vary with context and level of digital experience.
Impact on Society	This study could contribute to the development of a more comprehensive, user-centered, and sustainable approach to digital school management. Furthermore, this integration can enhance the availability for informed decision-making and lead to more efficient educational administration.
Future Research	Future studies should validate the proposed EMIS design using larger samples, a diverse range of educational stakeholders, and different institutional contexts. They should also move toward implementation and incorporate evidence-based decision-making capabilities supported by artificial intelligence.

Keywords	Education Management Information System, functional architecture, prototyping, usability, user-centered design, educational innovation

INTRODUCTION

In the digital era, the efficiency of school management increasingly depends on institutions' ability to process information from academic, administrative, governance, and student welfare domains, as highlighted by the United Nations Educational, Scientific, and Cultural Organization (UNESCO, 2025). In this context, Education Management Information Systems (EMIS) help optimize and integrate diverse processes such as enrollment, attendance, and grading control, academic planning, curriculum adaptations, institutional information, and others (Asio et al., 2022). Effective EMIS implementation strengthens decision-making at all levels of the education system, from early childhood to secondary education, contributing to more coherent, efficient school management focused on the needs of the educational community (World Bank, 2023).

From the perspective of information systems development, software prototypes can serve as design artifacts that enable the representation of organizational needs, the exploration of alternative solutions, and the anticipation of design decisions before full implementation (Bjarnason et al., 2023; Paust et al., 2025). In this vein, user-centered design aligns the prototype with the functional needs, tasks, and expectations of the users who will interact with the system, thereby improving the user experience (Mostefai et al., 2025). In turn, from the perspective of Human-Computer Interaction (HCI), early prototype evaluation is important because it enables the identification, in initial phases, of navigation, comprehension, feedback, and interaction issues that could affect users' ability to complete their tasks effectively (Bjarnason et al., 2023).

In addition, the early evaluation of prototypes can draw on well-established frameworks and tools from the literature, whose application has also been extended to educational information systems. For example, Nielsen's heuristics have been used to assess usability in the interaction flow of an educational chatbot prototype (Chen et al., 2025) or in a virtual laboratory prototype for scientific experiments (Putjorn et al., 2024). Similarly, the User Experience Questionnaire (UEQ) has enabled the evaluation of user experience in e-learning prototypes (Mostefai et al., 2025) and in Student Management Information Systems (SMIS) (Kuadey et al., 2024). Additionally, the Technology Acceptance Model (TAM) has been used to analyze user acceptance of an educational augmented reality prototype (Fernandez-Herrero et al., 2026).

These findings suggest that evaluating information system prototypes in the educational sector enables early examination of key aspects of interaction, usability, and user experience. However, in the case of an EMIS, the design must also ensure functional and comprehensive coverage of the school processes that the prototype integrates. This need is justified at the international level, as the Organization for Economic Co-operation and Development (OECD, 2023) highlights that a digital educational ecosystem comprises components such as student information, learning management, digital assessment, and academic guidance. In this context, it is reported that 65% (19 out of 29) of countries and education systems analyzed have a national or central student information system. Nevertheless, the same report notes that some systems have a limited scope or lack the integration characteristic of a consolidated information system. In contrast, a small number of countries still lack such systems.

In Latin America, although some countries have made significant progress, others still face challenges, as evidenced by the coexistence of multiple disconnected education systems with limited interoperability (KIX LAC, 2024). This issue is also evident in Ecuador, where educational institutions manage their processes using isolated solutions, manual procedures, or external systems that limit comprehensive information management (Coloma Andrade et al., 2025). Consequently, these findings highlight significant advances in school digitization, but also reveal disparities in the level of consolidation, coverage, and integration of educational data.

However, this overview also highlights a gap in the current literature regarding a comprehensive approach to EMIS design. Some studies focus on school management processes, institutional roles, or organizational structure (Coloma Andrade et al., 2025; Rodríguez-Mantilla et al., 2025), while others analyze the prototype alongside user experience or usability, as well as the implementation of EMIS (Hidayat et al., 2025; Muleya & Matela, 2025; Syamala et al., 2025; Vergara-Zurita et al., 2025). The integration of both approaches is relevant because the design of an EMIS must address both the identification of the institution's organizational needs and the interaction conditions required by educational stakeholders. This integration aligns with the observations of the OECD (2023), which highlight the need for more comprehensive and interoperable approaches to educational information systems that strengthen coordination among processes, stakeholders, and information. Additionally, the prototype allows for early evaluation of an EMIS design, verifying whether the integrated processes are understandable and acceptable to educational stakeholders (Bjarnason et al., 2023). These aspects constitute initial conditions that can promote the effective use and adoption of educational systems (Mostefai et al., 2025).

Within this framework, the objective of this study is to integrate both approaches into EMIS design: to define a functional architecture for a prototype based on the identification of macro-processes, processes, and institutional roles in school management, and to validate it early from a usability perspective, in order to identify opportunities for improvement prior to implementation. Therefore, the study aims to answer the following research questions:

RQ1: What macro-processes, processes, and institutional roles should be considered in the functional architecture of an EMIS prototype oriented toward school management**?**

RQ2: How do educational stakeholders perceive the EMIS prototype in terms of usability?

Finally, although the study is conducted in Ecuador, the proposal offers a transferable framework to guide the future development of EMIS in other educational contexts. It aims to contribute to the design of solutions that prevent the replication of fragmented systems and promote more coherent, interoperable, and sustainable digital transformation processes, aligned with the needs of students, educators, and institutions.

RELATED WORKS

Current literature reflects a growing interest in the digitization of school management in educational contexts. For example, Student Information Systems (SIS) enable the collection and management of data related to enrollment, attendance, and academic performance, transforming institutional information into useful inputs for educational decision-making (OECD, 2023). Similarly, Orhani et al. (2023) report the adoption of an Electronic School Management System that integrates academic planning, institutional communication, and academic reporting, resulting in improved operational efficiency and school coordination. Along the same lines, EL Khaled et al. (2025) describe an EMIS for public schools in Saudi Arabia, highlighting the optimization of academic and administrative processes.

In addition, Kaindaneh et al. (2024) analyze an EMIS focused on disability and note that the effectiveness of these systems depends on the quality and level of detail of the available data. In this respect, the literature emphasizes the need for consolidated educational systems that integrate information from various dimensions of school management, including academic, administrative, governance, and student well-being (KIX LAC, 2024; OECD, 2023). This is particularly relevant given the use of isolated systems, which can limit control over and integration of institutional information (Coloma Andrade et al., 2025).

From a broader perspective in Information Systems (IS), the adoption of EMIS depends not only on functional coverage but also on ease of use and user acceptance. In educational settings, researchers have applied models such as the Technology Acceptance Model (TAM) (Hidayat et al., 2025), the Unified Theory of Acceptance and Use of Technology (UTAUT) (Kittinger & Law, 2024), or the DeLone and McLean Information Systems Success Model (Alduaij et al., 2024) to analyze the adoption and success of educational systems. In the field of usability, approaches such as Nielsen's heuristics (Okhovati et al., 2024), the User Experience Questionnaire (UEQ) (Mostefai et al., 2025), or the System Usability Scale (SUS) (Žerovnik, 2024) are employed.

In this vein, Žerovnik (2024) evaluates an educational system using SUS and TAM, highlighting the importance of usability and educational stakeholders' satisfaction. Furthermore, Hidayat et al. (2025) analyze the acceptance of EMIS 4.0 using TAM, highlighting the importance of perceived ease of use in the system's adoption. Finally, Okhovati et al. (2024) apply Nielsen's heuristics to the usability evaluation of learning management systems, noting that learning experience can be improved by incorporating usability principles into interface design.

At the same time, research in Human-Computer Interaction (HCI) emphasizes the importance of prototyping and usability evaluation during the initial stages of system development (Ntoa, 2025). An

important activity in Human-Centered Design (HCD) is developing prototypes prior to the final implementation of a system (Kretzer & Maedche, 2023) or representing key aspects of a solution aligned with users' actual needs (Paust et al., 2025). Additionally, Krajcovic et al. (2025) note that, in User Experience (UX) design, prototypes are a relevant tool for the early diagnosis of usability issues.

Based on this initial representation, Syamala et al. (2025) note that usability testing of prototypes helps identify factors influencing the user experience and adoption of educational systems, such as visual design, navigation, and content organization. Similarly, Vergara-Zurita et al. (2025) present an educational mobile prototype designed in Figma and evaluated through usability testing, highlighting that intuitive navigation, visual consistency, and simplicity of the interface promote user acceptance. Furthermore, Fakrudeen (2025) synthesizes research on usability and accessibility in university websites, emphasizing that these characteristics promote equitable access to information for various stakeholders involved.

In this context, the reviewed literature reveals studies on EMIS that primarily focus on functional coverage, data integration, and technology adoption. Additionally, studies have been identified that evaluate educational systems using acceptance and usability frameworks, as well as research on prototyping to detect usability issues early in educational systems. However, there remains a research gap regarding proposals that integrate, within a single EMIS design process, a functional architecture for school management and its early validation through a high-fidelity prototype evaluated using usability criteria supported by the literature.

To address this gap, this study proposes a functional architecture for school management based on macro-processes, processes, and institutional roles, and aligned with national and international regulations. Furthermore, it develops a high-fidelity prototype to provide a visual representation and conduct an early usability evaluation from the perspective of educational stakeholders. In this way, the study provides a framework that can be applied to other educational contexts to guide future user-centered EMIS development.

METHODOLOGY

STUDY DESIGN AND PROCEDURE

This research adopted an applied approach to usability design and evaluation with a descriptive scope, supported by quantitative analysis and based on a non-experimental cross-sectional design. The design component involves characterizing school processes, defining the functional architecture, and representing the prototype using UI (User Interface)/UX (User Experience) practices. The quantitative-descriptive component was used to analyze the responses obtained during the early usability validation of the EMIS prototype at a single point in time, without manipulating variables or comparing experimental groups. Within this framework, the procedure to characterize school management, develop its visual representation, and evaluate the early usability of an EMIS prototype consisted of three phases:

Phase A. Documentary Analysis and Functional Modeling. A normative and documentary corpus on school management was reviewed to identify institutional actors/roles, macro-processes, and processes required to operate an EMIS aligned with the application context.

Phase B. Prototype Design. The modeled processes were transformed into a high-fidelity user interface prototype that represented the interaction flows associated with each educational role.

Phase C. Early Usability Evaluation with Teachers. An online evaluation session was conducted, beginning with an explanation of the study's objective. Subsequently, the teachers interacted with the EMIS prototype, with support from the research team (providing technical assistance and operational clarifications). After this interaction, an evaluation instrument based on usability heuristics was administered.

PARTICIPANTS

The EMIS prototype was evaluated by nine teachers with degrees in Pedagogy of Experimental Sciences in Computer Science from various educational institutions. The selection was made through purposive sampling, as the evaluation required participants with direct knowledge of the educational context and the school management processes represented in the prototype. To this end, the following inclusion criteria were established: (i) teaching experience, (ii) familiarity with school management processes, and (iii) willingness to participate voluntarily in the study. This selection process provided informed assessments of how school management processes are represented in the interaction flows of the EMIS prototype.

The sample size (n = 9) was considered appropriate to conduct an early usability validation of the EMIS prototype. The objective was not to achieve statistical generalization, but rather to obtain preliminary evidence of the functional architecture and its representation through UI/UX design practices, to identify opportunities for usability improvement before a larger-scale implementation. This approach is consistent with iterative models, in which preliminary assessments allow for the optimization of user-centered solutions and the reduction of risks in later stages (Krajcovic et al., 2025; Syamala et al., 2025). Additionally, the data collection instrument was completed anonymously, ensuring the confidentiality of participants' responses. Table 1 presents the characteristics of the participants.

Table 1. Characterization of the participants

Gender	**Male**	55.6%		
	Female	44.4%		
Age (years)	**20 to 30**	**31 to 40**	**41 to 50**	**51 or older**
	77.8%	11.1%	11.1%	0%
Education level	**Undergraduate**	**Master's**	**PhD**	
	44.4%	55.6%	0%	
Years of teaching experience	**0-10**	**11-20**	**21 or more**	
	88.9%	11.1%	0%	

Note. Data obtained from the instrument applied to teachers

MATERIALS AND INSTRUMENTS

Documentary corpus

The documentary sources included national regulations, regional evidence, and international literature in order to contextualize the functional architecture of the EMIS from various levels of analysis.

- National regulatory framework (Ecuador): the Constitution of the Republic of Ecuador (Constitución de la República del Ecuador, 2008) as stated in article 344, LOEI (Ley Orgánica de Educación Intercultural, 2011) and its RGLOEI (Reglamento General a la Ley Orgánica de Educación Intercultural, 2023), as well as ministerial agreements (Ministerio de Educación del Ecuador, 2023a, 2023b, 2025). The Ecuadorian regulatory framework was incorporated because it defines the organizational structure of the National Education System, the roles of educational stakeholders, and the institutional processes that underpin school management.
- Complementary national evidence: Coloma Andrade et al. (2025) identify 10 guidelines at the organizational and student assessment levels for school control in Basic General Education (EGB), the compulsory education level in Ecuador that spans from 1st to 10th grade.
- Regional frameworks on EMIS: KIX LAC (2024) analyzes the current state of EMIS and highlights its importance in technological integration and the administration of education

systems in Latin America and the Caribbean, incorporating perspectives from multilateral organizations.

- International guidelines on EMIS: UNESCO (2025) presents guidelines for diagnosing and strengthening EMIS, showing their contribution to planning and decision-making. Additionally, the World Bank (2023) emphasizes that interoperability among school management processes must be articulated within a coherent, integrated EMIS to support decision-making in the education system.

The document analysis followed a structured three-phase procedure (Figure 1). During the document selection phase, a corpus of documents related to school management at the national, regional, and international levels was identified. Subsequently, during the content analysis phase, a comprehensive review of the selected documents was conducted, and relevant information regarding the components of school management was identified. In the data synthesis phase, the extracted information was organized into an analysis matrix comprising five criteria: institutional role, responsibility, macroprocess, process, and document source. Finally, a process of refining and validating the matrix was developed to review the information, consolidate similar elements, and eliminate duplicate records. This procedure yielded a validated information matrix that served as the basis for defining the proposed functional architecture of the EMIS.

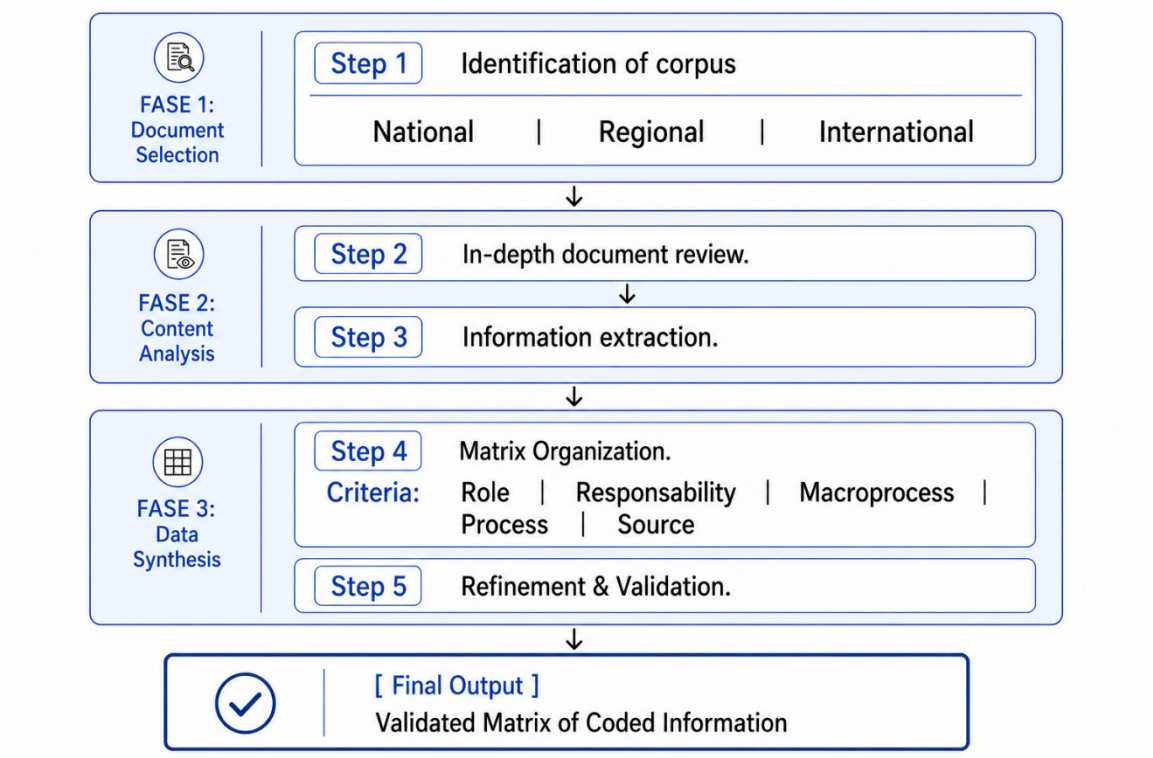

Figure 1. Procedure for coding information during the document analysis phase

High-fidelity prototype

A high-fidelity (clickable) prototype was designed to visually represent school management processes and their interaction with the various educational stakeholders identified during the documentary analysis phase. Figma was selected as the tool for its ability to efficiently and collaboratively generate medium- and high-fidelity prototypes, as well as its widespread adoption in interface design (Krajcovic et al., 2025; Vergara-Zurita et al., 2025).

Heuristic-based usability evaluation instrument

Usability was assessed using a structured instrument derived from usability heuristics, based on Nielsen's principles (Alshamari & Althobaiti, 2024) and their adaptation to educational application contexts (Othman et al., 2025; Yin et al., 2024). The instrument was contextualized for the EMIS prototype (Table 2) and operationalized into 10 principles (P1–P10), consisting of items rated on a 3-point ordinal Likert scale (1 = disagree, 2 = agree, 3 = strongly agree).

Table 2. Usability evaluation instrument

Usability principle	Alternative responses			Observations
	1	2	3	
I. Visibility of system status (P1)				
1. The prototype clearly indicates in which module the user is located.				
2. Buttons and links in the prototype are well-labeled and easy to identify.				
II. Relationship between design and the real world (P2)				
1. The language used is understandable for the end users of the system.				
2. Icons, graphics, and labels are consistent and easy to interpret.				
III. User Control and Freedom (P3)				
1. Navigation buttons are available to easily return to the previous screen.				
2. Buttons are available to return to the main menu from any module.				
IV. Consistency and Standards (P4)				
1. There is consistency in colors, button styles, and visual layout.				
2. Section and page titles match the displayed content.				
V. Error prevention (P5)				
1. The prototype includes instructions or visual aids that prevent operational problems.				
2. There are no confusing elements that could lead to misinterpretations.				
VI. Recognition Rather Than Recall (P6)				
1. Links and icons on the screens are intuitive and do not require memorizing navigation paths.				
2. The user can quickly identify their location within the system.				
VII. Universal Usability (P7)				
1. The interface is easy to use for both basic and advanced users.				
VIII. Aesthetic and Minimalist Design (P8)				
1. The interface presents essential information without visual overload.				
2. The content is well distributed and organized into sections.				

Usability principle	Alternative responses			Observations
	1	2	3	
IX. Error Diagnosis and Recovery (P9)				
1. Alerts are displayed clearly, indicating the problem and possible solution.				
X. Help and Documentation (P10)				
1. There are informative links to expand the information, such as user manuals or other resources.				

Note. Adapted from Alshamari and Althobaiti (2024), Othman et al. (2025), and Yin et al. (2024)

A 3-point Likert scale was chosen because it makes it easier for participants to respond to each principle. Although this scale offers less sensitivity than 5-point or 7-point scales, it is appropriate for the context of the study, as the purpose was to obtain preliminary evidence of perceived usability during an early validation of the prototype. Furthermore, previous studies indicate that reliability and validity do not necessarily depend on the number of response categories, and that reducing broader scales to 2-point or 3-point formats does not affect the reliability or validity of the resulting scores (Sobrino-Duque et al., 2024).

In addition, validation and reliability procedures were conducted prior to the instrument's final application. First, a pilot study was conducted using a test–retest procedure with participants whose characteristics were similar to those of the target sample to verify the temporal stability of the responses. To this end, Pearson's correlation coefficient was calculated, obtaining a value of $r = 0.94$, indicating a strong correlation between the two administrations. Subsequently, internal consistency was assessed using Cronbach's alpha, yielding $\alpha = 0.90$, indicating excellent internal consistency.

With regard to content validity, the instrument was reviewed by three experts with methodological expertise and subject-matter knowledge in information systems and usability. To assess item validity, Lawshe's model was applied, yielding a content validity ratio (CVR) of 1.00 for all evaluated principles, confirming that the items were considered essential by all experts. In addition, the experts evaluated the categories of theoretical basis, adequacy, clarity, coherence, quality, and relevance using a scale of 1 to 5, with the maximum score achieved for all criteria.

Data Analysis

The analysis was performed using IBM SPSS Statistics. Due to the ordinal nature of the Likert scale (3 points) and the sample size ($n = 9$), descriptive statistics were reported for each principle (frequency, minimum, maximum, and mean) to summarize the response trend for each of the ten principles (P1–P10).

In addition, given the small sample size and the non-normal distribution of the data, it was deemed appropriate to use a nonparametric test, such as the one-sample Wilcoxon signed-rank test, to determine whether the central tendency of the scores for each principle exceeded the minimum acceptable threshold. The reference value was established at 2, corresponding to the "Agree" category on the three-point Likert scale, which is considered the minimum acceptable level of compliance with each usability principle. A significance level of $\alpha = 0.05$ was used in all cases.

Results

Based on the documentary analysis (Phase A), seven educational roles were identified, along with their operational scope within the EMIS (Table 3), considering functions related to curriculum development, teaching activities, student learning, and specialized support.

Table 3. Educational roles in school management processes

Role	Responsibilities
Administrator	Management of educational stakeholders and institutions
Academic Authority	Configuration of study plans, academic years, academic programs, academic periods, distribution of teaching hours, and documentation by the educational institution
Secretary	Enrollment management and institutional documentation
Teacher	Setting up virtual classrooms, publishing activities, grading, and attendance recording
Tutor Teacher	Monitoring academic progress and student performance reports
Student	Access to resources, submission of assignments, and consultation on academic progress
DECE (Student Counseling Department) is a school support unit focused on psychosocial guidance, inclusion, and student well-being	Monitoring students with curricular adaptations

Note. Adapted from Coloma Andrade et al. (2025)

Based on the responsibilities associated with these roles, a layered conceptual architecture was defined (Figure 2), consisting of a cross-cutting core that centralizes the basic configurations of school management (actors and educational institutions) and supports three interrelated layers: (i) strategic and governance layer, focused on institutional organization, planning and documentation; (ii) academic operational layer, which integrates processes related to teaching and student evaluation; and (iii) community and welfare layer, focused on mechanisms for interaction and comprehensive support for the educational community. This hierarchical structure facilitates the delimitation and articulation of processes in complex organizational environments (Möller et al., 2025).

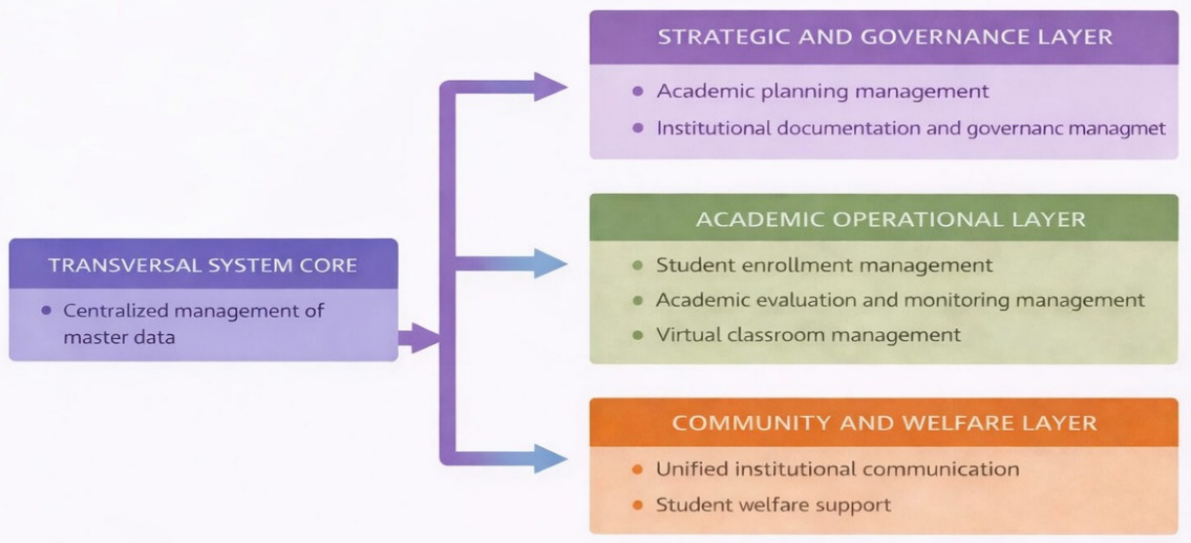

Figure 2. Conceptual layered architecture of the EMIS functional model

The conceptual architecture enabled the identification of 8 macro-processes, which were organized into 37 key processes of digital school management and articulated with the corresponding educational roles, as detailed in Table 4.

Table 4. School management macro-processes and associated roles

Macro-process	Process	Role
Centralized management of master data	Institutional access for educational stakeholders	All roles
	Management of educational institutions	Administrator
	Management of administrative access profiles	Administrator
	Management of educational stakeholders (academic authority, secretary, teacher, tutor teacher, and DECE) by the educational institution	Authority
	Management of students and their legal representatives at each educational institution	Authority, Secretary
Academic planning management by educational institution	Curriculum management	Authority
	Grade level management	Authority
	Subject management	Authority
	Academic year management	Authority
	Academic period management	Authority
	Course offering management	Authority
	Parallel groups and tutor teacher assignment management	Authority
	Assignment of subjects to be taught by the teacher	Authority, Teacher
	Assignment of class hours to teachers	Authority, Teacher
	The Configuration of the Annual Curriculum Plan (ACP) is a pedagogical document that describes what will be taught during the school year.	Teacher
Student enrollment management by educational institution	Enrollment requirement management	Authority
	Enrollment calendar management	Authority
	Enrollment and documentation	Student
	Enrollment legalization, release, and cancellation	Authority, Secretary
Management of academic evaluation and monitoring by educational institution	Gradebook configuration	Teacher
	Grade record	Teacher
	Attendance record	Teacher
	Partial and final grade calculation	Teacher
	Student progress reports	Secretary, Teacher, Tutor teacher
Management of virtual classrooms by educational institution	Learning resource configuration	Teacher
	Learning activity configuration	Teacher
	Learning activity submission	Student
	Learning activity monitoring	Teacher, Student
	Learning activity grading	Teacher
Unified communication by educational institution	Institutional notification issuance	All roles
	Institutional notification reception	All roles

Macro-process	Process	Role
Document management and governance by educational institution	Management of the Institutional Educational Project (IEP) report, a strategic planning document that defines the institution's identity, guides school management, and promotes the pedagogical proposal and harmonious coexistence.	Authority, Secretary
	Management of the Code of Conduct (CC) report, a document that establishes the rules, responsibilities, and coexistence guidelines for the educational community.	Authority, Secretary
	Management of the Risk Plan (RP) report, a document that identifies potential risks and establishes prevention and response actions to protect the educational community.	Authority, Secretary
Student welfare support by educational institution	Curriculum adaptation management	Authority
	Configuration of the curricular adaptation to be applied	Teacher
	Monitoring of curricular adaptations	DECE

Note. Adapted from Coloma Andrade et al. (2025)

In this context, the functional architecture of digital school management is organized into a layered model comprising a cross-cutting core of configurations and three interrelated layers: strategic-governance, academic-operational, and community-well-being. In turn, these layers coordinate administrative, academic, governance, and student well-being processes through eight macro-processes, which are organized into 37 key processes and linked to seven educational roles (RQ1). In this way, the proposal comprehensively organizes and centralizes the essential components of school management. Consequently, to simulate interactions between educational stakeholders and the identified school management processes, a high-fidelity prototype comprising 81 user interface screens was developed (Phase B). A representative subset of the EMIS prototype at the macro-process level is described below.

Institutional access for educational stakeholders: Figure 3 shows the features enabled based on the roles assigned to each user, making it easier to navigate between the various school management processes within the selected institutional context.

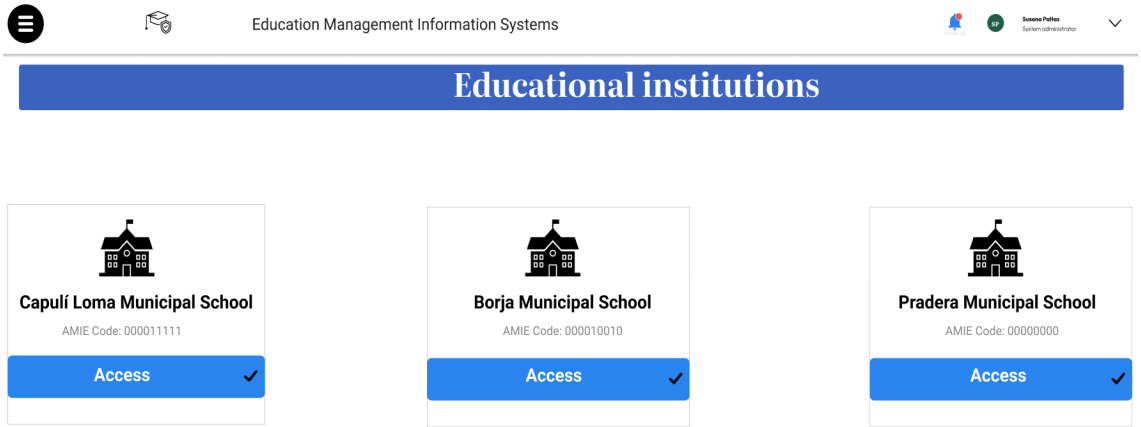

Figure 3. Educational institutions screen (macro-process 1)

Institutional academic planning: The academic authority defines the curriculum structure for a specific institution in clear language familiar to the school community (Figure 4), facilitating the definition and editing of its components.

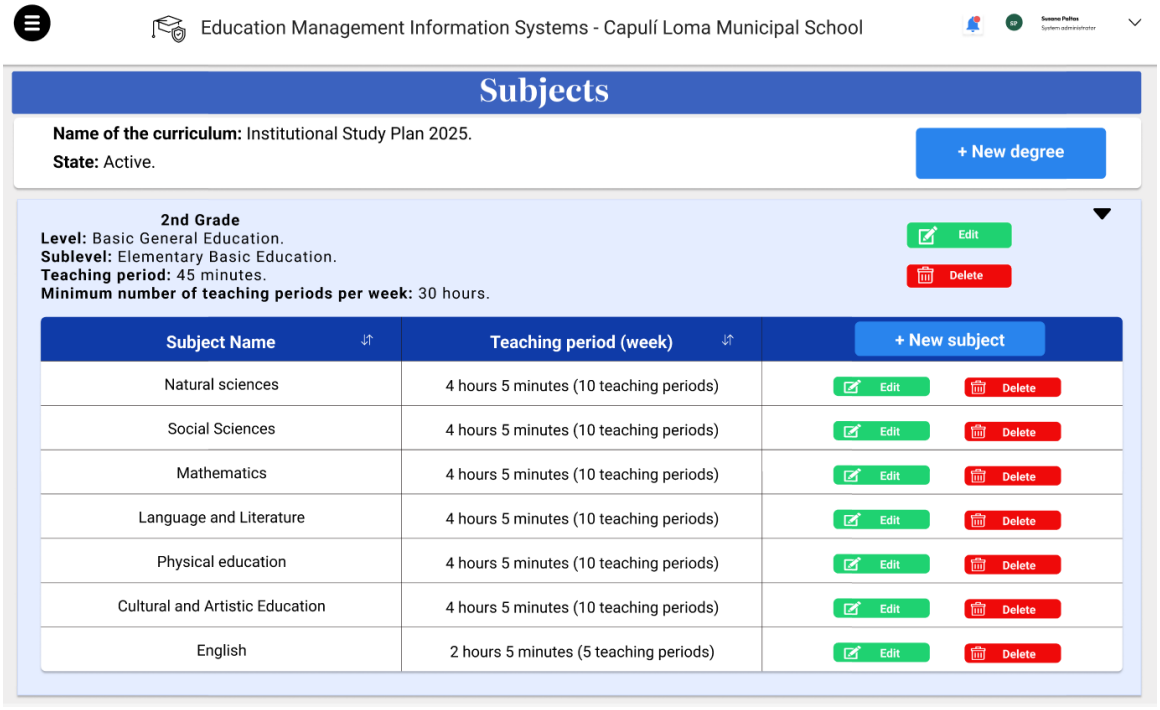

Figure 4. Grade level and subjects management screen (macro-process 2)

Student Enrollment and Requirements: The student enrollment and requirements process is presented with a clean design, free of visual overload (Figure 5), to facilitate a clear, orderly sequence of required actions.

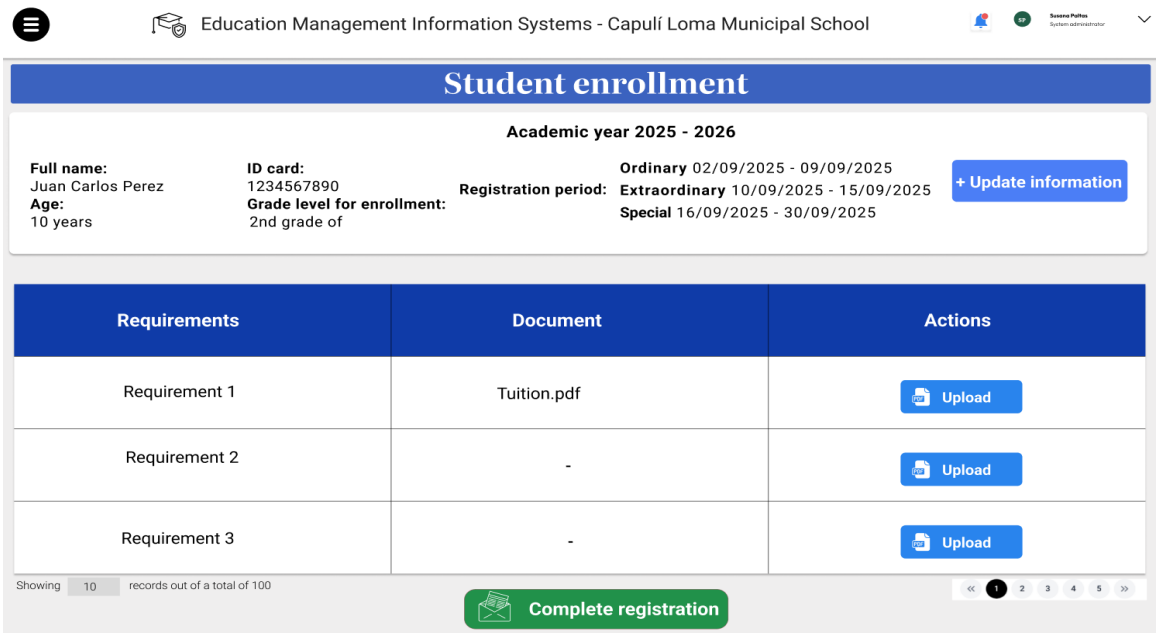

Figure 5. Registration application screen (macro-process 3)

Monitoring attendance and evaluation: Figure 6 enables teachers to track student attendance through a weekly structure, guiding the necessary actions to ensure the process runs efficiently.

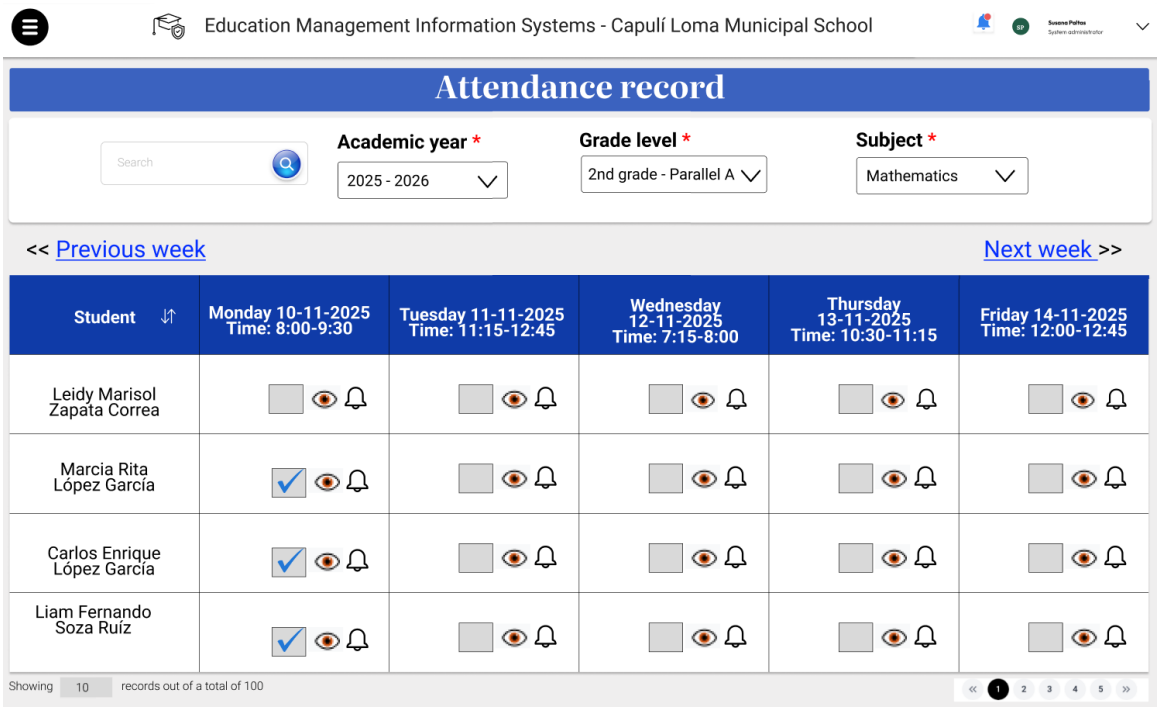

Figure 6. Student attendance recording screen (macro-process 4)

Additionally, Figure 7 enables the management of student grades, facilitating quick access to information and simplifying its use for users with varying levels of system experience. Furthermore, Figures 6 and 7 incorporate a notification module associated with macro-process 6, which enables reporting of incidents that may occur in the educational environment.

Figure 7. Screen for recording students' activity scores (macro-process 5)

Document management: An academic year includes the configuration of periods, requirements, and the enrollment calendar, as well as the documentation of school governance (Figure 8), centralizing the main elements that regulate the school year within the digital environment.

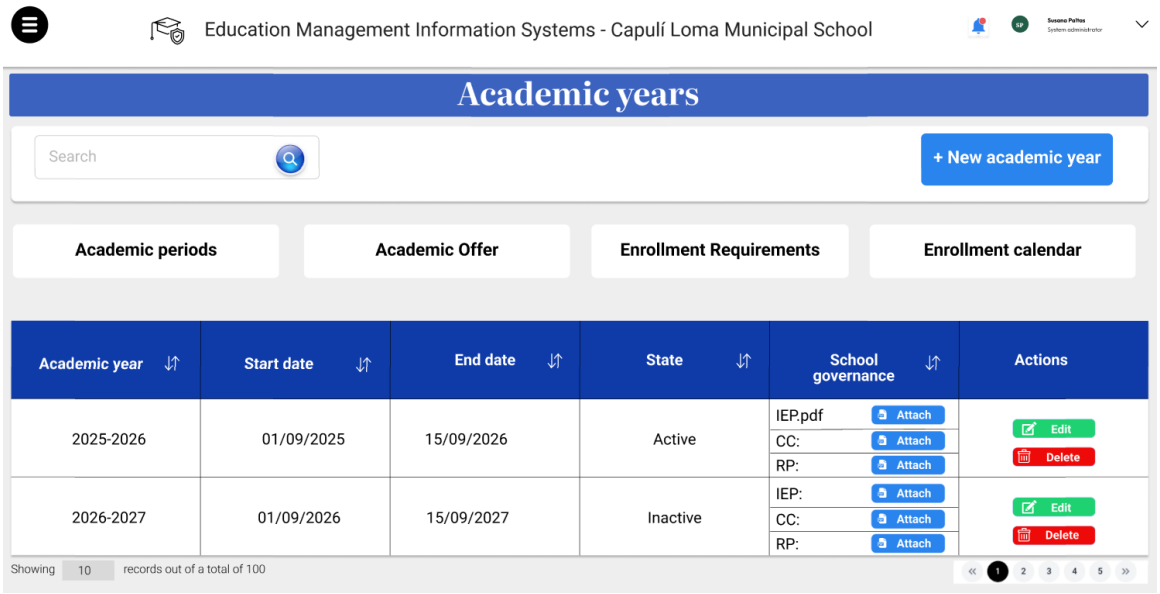

Figure 8. Document management screen by academic year (macro-process 7)

Management of curricular adaptations: The curriculum adaptations shown in Figure 9 enable individualized monitoring of each case through information that is integrated and structured within the digital environment.

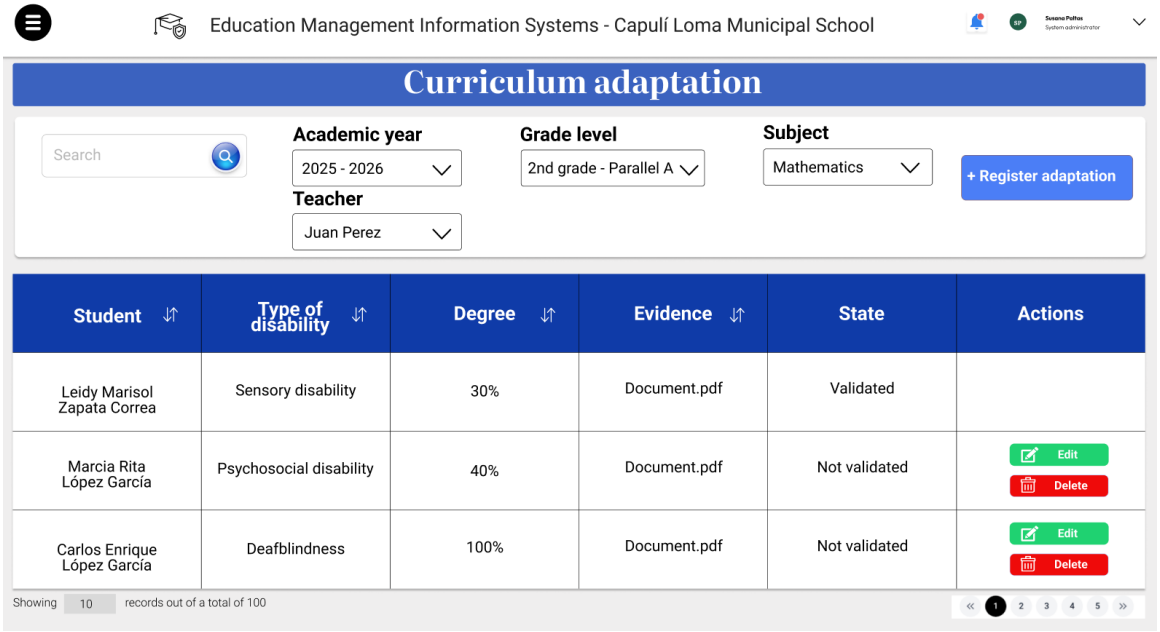

Figure 9. Curricular adaptations management screen (macro-process 8)

The results of the early usability evaluation (see Table 2) of the EMIS prototype developed by the teachers (Phase C) are presented in Figure 10. The results show full compliance with three principles:

(P1) visibility of system status, clearly showing the school management process in which the user is located, and providing adequate labelling of available actions; (P2) the relationship between design and the real world, with clear and familiar language aligned to the educational context; and (P8) an aesthetic and minimalist design that organizes institutional information efficiently, and provides a clean and balanced interface.

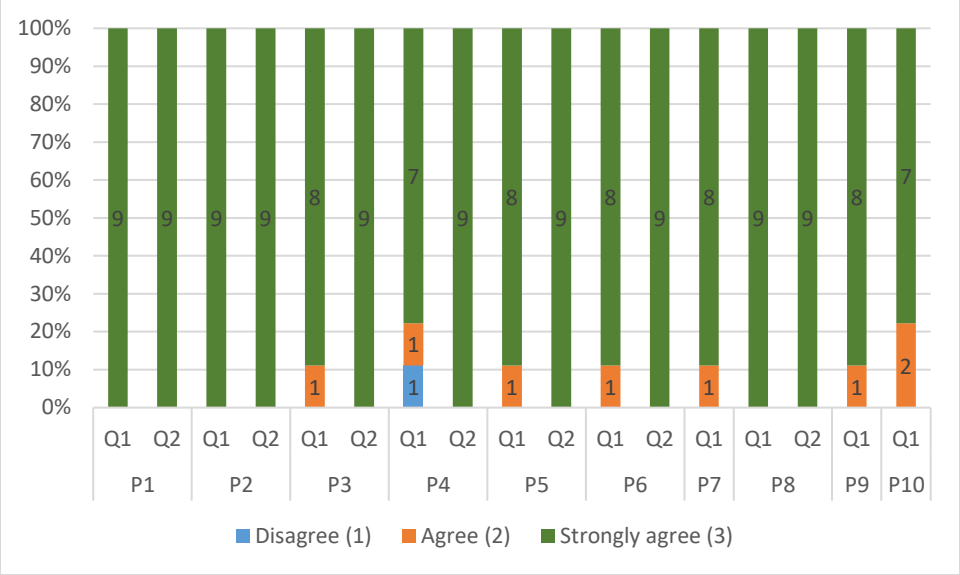

Figure 10. Results of the usability principles evaluation

However, the results also reveal areas for improvement. In particular, principle (P3) (user control and freedom) suggests the need to improve the uniformity of navigation across school management processes. Regarding principle (P4) (consistency and standards), it is recommended to standardize the visual style of certain components, especially in terms of color and size. Likewise, principle (P6) (recognition rather than recall) suggests improving icon visibility to facilitate better understanding of the available actions. In relation to principles (P5) (problem prevention) and (P9) (problem recovery), it is recommended to refine the wording and visibility of certain messages to provide better guidance to users. Finally, regarding principles (P7) (universal usability) and (P10) (help and documentation), there is a need to strengthen the visibility, completeness, and integration of support resources (videos, manuals) for users with varying levels of experience.

Overall, the results suggest that the EMIS prototype provides a functional, understandable, and coherent representation of school management processes. Positive ratings for principles related to information organization, alignment with the educational context, and a clean and balanced design indicate that the functional architecture was successfully translated into the interface design, enabling educational stakeholders to identify and interact with institutional tasks in a relatively intuitive manner. Likewise, the principles with lower scores primarily reflect opportunities for improvement associated with visual consistency, feedback, and user support resources, rather than limitations in the prototype's overall functional structure.

Additionally, Table 5 presents the results of the one-sample Wilcoxon signed-rank test applied. All 10 principles showed scores significantly higher than the minimum acceptability threshold (2 = agree), supporting a favorable overall perception of usability in the early evaluation of the EMIS prototype (RQ2). These results provide preliminary evidence regarding the acceptability of the EMIS prototype from the perspective of the participating teachers. Furthermore, they support moving forward to subsequent stages of refinement and development, provided that the improvements identified in the lowest-scoring principles are addressed first. However, due to the small sample size and the early-

stage nature of the study, these findings should be interpreted with caution and should not be considered generalizable.

Table 5. One-sample Wilcoxon signed-rank test (*p < .05)

Principles	Minimum value (1)	Maximum value (3)	Mean	p-value
P1	3	3	3.000	0.003*
P2	3	3	3.000	0.003*
P3	2.5	3	2.944	0.004*
P4	2	3	2.833	0.007*
P5	2.5	3	2.944	0.004*
P6	2.5	3	2.944	0.004*
P7	2	3	2.889	0.005*
P8	3	3	3.000	0.003*
P9	2	3	2.889	0.005*
P10	2	3	2.778	0.008*

DISCUSSION

FUNCTIONAL ARCHITECTURE OF THE EMIS PROTOTYPE

The eight macro-processes, organized into 37 processes and aligned with seven institutional roles, form a modular functional architecture for school management (RQ1). This organization centralizes core configurations and groups processes into layers (strategic/governance, academic/operational, and community/well-being). Furthermore, the proposal is based on the documentary corpus and is aligned with national (Coloma Andrade et al., 2025) and international regulations on EMIS (KIX LAC, 2024; UNESCO, 2025; World Bank, 2023), which is a relevant aspect for promoting sustainable educational digitalization processes.

Compared with previous studies on functional EMIS architecture, approaches reported in the literature tend to focus on specific dimensions of school management rather than on a holistic integration of these dimensions. For example, Kaindaneh et al. (2024) emphasize systems for the educational inclusion of students with disabilities, while OECD (2023) describes systems aimed at student information. In the national context, Massuh (2025) also highlights the limited adoption of Virtual Learning Environments (VLEs) in educational institutions. In this regard, the proposal seeks to address the fragmentation of institutional processes (KIX LAC, 2024) by integrating academic, administrative, governance, and student well-being processes into a unified model. This approach responds to the growing demand for centralized school management models (EL Khaled et al., 2025; UNESCO, 2025; World Bank, 2023) that are accessible to a wide range of stakeholders in the education system (EL Khaled et al., 2025; Mohseni et al., 2024).

From an Information Systems (IS) perspective, prototyping enables the translation of organizational requirements into comprehensible design artifacts (Paust et al., 2025). It is an established practice in user interface design (Bjarnason et al., 2023). In this regard, the proposed architecture relied on prototyping to transform roles, macro-processes, and processes into interaction flows through user interfaces, thereby providing greater clarity on how school management can be organized and executed within a digital environment.

INTERFACE DESIGN ELEMENTS THAT INFLUENCE USER EXPERIENCE

The HCI community has emphasized the role of information technology evaluation, highlighting its benefits for both final product improvement and resource optimization. In this context, usability is

recognized as a central evaluation criterion, defined as a quality attribute associated with the ease of use of a user interface (Ntoa, 2025). From this perspective, the EMIS prototype, comprising 81 screens, was evaluated by teachers in an early usability test.

Overall, the results indicate a favorable perception of the EMIS prototype's usability (RQ2). The findings suggest that the organization of information (P1) and contextualized language (P2), together with a simple and balanced visual structure (P8), fostered an understandable interaction experience for users while carrying out the represented school-related processes. These characteristics align with studies indicating the importance of proper content integration (Syamala et al., 2025) and the simplicity of interface elements (Vergara-Zurita et al., 2025) in promoting ease of use in educational prototypes. Furthermore, given that poor interface design can increase cognitive load during learning (Ahmad Faudzi et al., 2023), the favorable usability results suggest that the EMIS prototype could help educational stakeholders focus their efforts on carrying out school management processes rather than on understanding the technological environment.

However, the evaluation also revealed, albeit infrequently, opportunities for improvement in the consistency of the design across the prototype's screens. These relate to uniformity in navigation (P3) and visual components (P4), as well as the clarity of the iconography (P6). These findings align with studies that associate usability issues with inconsistent designs, inappropriate colors, and typography and icons that are difficult to understand (Syamala et al., 2025). Consequently, visual consistency should be viewed not only as an aesthetic consideration but also as a mechanism that supports recognition, navigation, and task execution within the digital environment.

The evaluation also identified the need to strengthen feedback and user support mechanisms. In particular, there is a need to improve error prevention (P5) and recovery (P9) through clear messages that enable users to recognize, understand, and resolve problems while interacting with the system, in accordance with Rangraz Jeddi et al. (2020). Similarly, it is recommended to expand support mechanisms (P10) to assist users with varying levels of digital experience (P7) in carrying out institutional processes. This aligns with Žerovnik (2024), who notes that the adoption of educational technologies can vary depending on the user's profile, making it appropriate to integrate guides, manuals, or other resources tailored to different usage needs.

Overall, these results underscore the importance of involving educational stakeholders in the early evaluation of EMIS design, as their participation made it possible to identify necessary adjustments before moving on to later phases of implementation. This approach aligns with HCI frameworks, particularly the User Experience (UX) perspective, which integrates usability and considers users' perceptions, responses, and needs during interactions with products, systems, or services, thereby promoting continuous design improvement (Ntoa, 2025). Furthermore, it aligns with User-Centered Design (UCD) approaches in digital educational systems, which hold that design must respond to end-user-identified functionalities (Mostefai et al., 2025).

Finally, the integration of functional architecture and prototype usability in EMIS design highlights a complementary relationship between these two components. The definition of educational roles, macro-processes, and processes provided an organized structure that guided the design of school management interaction flows in the prototype. In turn, early usability evaluation enabled assessment of user perceptions of the design and identification of areas for improvement to optimize interaction before moving on to later implementation phases. From this perspective, the architecture provides functional coherence to the prototype design, while usability enables it to be adjusted to be understandable, navigable, and relevant to educational stakeholders. Consequently, this integration can promote the effective adoption of educational software and contribute to the long-term sustainability of EMIS implementations (Izhar et al., 2025; Mostefai et al., 2025).

Practical Implications for the Design and Implementation of EMIS

The findings of this study offer practical guidance for the design, refinement, and phased implementation of Educational Management Information Systems (EMIS). The proposed functional architecture, organized into layers and supported by a modular structure, facilitates scalability by allowing for the incorporation of new institutional processes or educational services without altering the system's overall organization. Furthermore, its alignment with international guidelines enhances its transferability to school management digitalization initiatives in educational contexts with diverse organizational cultures.

The implementation of school management processes in a high-fidelity prototype allowed educational stakeholders to evaluate both the functional organization and the interaction design of institutional processes before a larger-scale rollout. In this regard, early usability validation enabled identification of adjustments to design consistency, feedback, and support resources, thereby reducing potential risks to the user experience and subsequent adoption of the system.

Based on this integration of functional architecture and usability evaluation, the proposal provides an initial foundation for future EMIS implementation processes. However, these scenarios may pose challenges in integrating with existing institutional systems. Therefore, it will be necessary to consider interoperability conditions that enable the secure, consistent, and timely exchange of data across different systems. This includes the use of standardized communication protocols, common criteria for data structures, mechanisms for migrating educational information, and available technological infrastructure. Furthermore, the effective adoption of EMIS may depend on institutional conditions, including organizational support, digital governance policies, and training for educational stakeholders with varying levels of digital experience.

Consequently, the proposal serves not only as a design tool but also as a transferable, adaptable framework to guide the development, refinement, and gradual adoption of EMIS across various educational settings.

Limitations and Future Work

Although the usability validation provided initial evidence of educational stakeholders' perceptions of the EMIS prototype, the results should be interpreted with caution, given the small sample size and participant characteristics. Future research should incorporate a larger number of participants, including all stakeholders in the educational community, to obtain more representative results.

Additionally, the progressive incorporation of new educational macro-processes into the functional architecture is recommended to expand the scope of the proposal toward an EMIS with multi-level coverage (KIX LAC, 2024): central level (strategic planning and allocation of resources), intermediate level (monitoring and evaluation of educational policies), and school level (early identification of students at risk of withdrawal).

Finally, the proposed architecture can also serve as a reference model for future EMIS implementations by integrating academic, administrative, governance, and student welfare data and facilitating the transformation of this data into strategic information for institutional decision-making. In this context, future lines of research could incorporate Artificial Intelligence (AI) techniques to create predictive models oriented not only to management support (Machkour & Abriane, 2025) but also to formative decision-making (Abdelfattah et al., 2026), as well as to democratize autonomous learning experiences and provide support tailored to each student's needs (OECD, 2023).

CONCLUSIONS

This study's primary contribution is the integration of a functional architecture for school management with an early usability evaluation within a single EMIS design process. This approach provides a methodological framework for linking the organization of institutional processes to the user experience of educational stakeholders before proceeding to technical implementation phases.

The functional architecture was defined in layers, consisting of a cross-cutting core of configurations and three interrelated layers: strategic-governance, academic-operational, and community-well-being. This architecture was organized into eight macro-processes, 37 key processes, and seven educational roles. Its modular structure facilitates scalability and adaptation to diverse institutional contexts. Furthermore, the operationalization of the architecture in a high-fidelity prototype allowed for the visual representation of school management processes and their early validation with users.

The usability evaluation yielded favorable results, with scores significantly above the minimum acceptability threshold for all 10 principles assessed with teachers. In particular, strengths were evident in information organization, contextualized language, and simple visual structure. However, opportunities for improvement were also identified in design consistency, feedback, and support resources, confirming the need to incorporate iterative evaluation cycles from the early stages of EMIS development. To obtain more representative results, future research should expand the validation to include a larger number of participants and involve all stakeholders in the educational community.

These findings contribute to the EMIS literature by framing functionality and usability as complementary dimensions of educational system design. Furthermore, the proposal offers a transferable framework to guide the progressive development of more comprehensive and user-centered EMIS.

Finally, future EMIS implementations should account for interoperability requirements that enable the efficient, secure, and consistent exchange of information among existing systems. In addition, it is recommended that the functional architecture be expanded to include new macro-processes and that artificial intelligence capabilities be integrated to strengthen evidence-based decision-making.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICAL APPROVAL

Participation was voluntary and anonymous; therefore, no personally identifiable information was collected or stored. Participants provided informed consent prior to data collection. The study was conducted in accordance with the relevant national regulations on personal data protection.

DATA AVAILABILITY STATEMENT

The anonymized datasets generated or analyzed during this study are available upon reasonable request after the peer-review process.

USE OF GENERATIVE ARTIFICIAL INTELLIGENCE

The authors declare the use of Generative Artificial Intelligence (GAI) in the writing process. In accordance with the GAIDeT taxonomy, the following tasks were delegated to GAI tools under full human supervision:

- Literature search
- Text synthesis
- Text correction and editing

The GAI tools used were ChatGPT and Gemini AI. These tools are not listed as authors and do not assume responsibility for the final manuscript; responsibility for it rests entirely with the authors.

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