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A Conceptual Framework for the Design and Evaluation of Learner Experience Across the Learning Lifecycle

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Abstract

Learner Experience (LX) aims to make learning more meaningful by accounting for motivational, social, and contextual factors. To support professors in the systematic design and evaluation of LX, we propose the Learner Experience Design and Evaluation Framework (LEDEF), a conceptual framework that integrates LEDG design guidelines with the LEEM evaluation model and focuses on the entire learning experience lifecycle. This paper presents a process for creating LEDEF oriented by Design Science Research (DSR), including a case study that investigates the applicability of LEDEF in an undergraduate course on Algorithms and Programming Techniques at a Brazilian university, involving one professor and a class of learners. The professor was responsible for designing and redesigning the learning activity using LEDEF and for assessing the LX throughout the process. Data were collected using checklists applied at different stages of the LX lifecycle and a semi-structured interview with the professor. The findings indicate that interactions mediated by computational resources positively influenced the learning experience, particularly in terms of efficiency and learner satisfaction. However, social interactions emerged as a critical challenge. Even in a context where learners were comfortable with technology, difficulties in communication and interpersonal skills adversely affected the LX. The main results include the development of three technologies to support educators, designers, and researchers. Overall, LEDEF enabled the professor to identify these issues and implement small, iterative interventions during the course, supporting continuous improvement of the learning experience.

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1 Introduction

The Learner eXperience (LX) concept refers to learners' perceptions and responses when participating in activities supported by computational resources, extending the concept of User Experience (UX) to education (Huang et al., 2019). The literature defines UX as the user's preferences, perceptions, emotions, and physical and psychological responses that occur before, during, and after use (Bevan et al., 2016). Thus, LX and UX are related concepts, both addressing the quality of the experience an individual has when interacting with computational resources.

LX resembles UX in that it involves cognitive processing and subsequent responses (Huang et al., 2015). This parallel is particularly evident when the experience focuses on learners' interactions with educational resources. On the other hand, Learning Design (LD) also shares similarities with LX, placing educational experiences at the center of the learning process (Miller, 2014). Just as UX is relevant to the success and acceptance of software, LD contributes to learning design by providing insights into learners' needs and experiences, fostering the creation of engaging and meaningful educational activities (Huang et al., 2019). Therefore, LX can be seen as the intersection of LD, UX, and educational technology (Schmidt & Huang, 2022).

LX encompasses elements that guide both the design and evaluation of educational experiences, enabling the inclusion and verification of experience-related characteristics, such as feelings and emotions in learning. Within the stages of the LX life cycle, particular emphasis has been placed on the design and evaluation phases, which are considered most critical due to their direct impact on the quality of the experience. For example, Arachchi et al. (2017) demonstrated that design can positively affect usability, accessibility, and learning, LX elements that shape educational experiences. Furthermore, Magyar and Haley (2020) showed that evaluation helps identify and correct LX design problems, preventing them from negatively affecting learners.

Based on the scientific literature, we found that LX technologies (both in design and evaluation) employ a variety of approaches to address LX, employing specific techniques, processes, and methods (Silva & Valentim, 2023). However, a key limitation is that these technologies often implicitly focus on a narrow set of LX elements, contrary to the recommendation by Huang et al. (2019) to adopt a comprehensive perspective. This pluralistic perspective considers the diversity of learners and their preferences, enabling a more comprehensive understanding of the educational experience involving computational resources.

Treating LX design and evaluation in isolation can lead to misalignment between design dimensions and actual learning outcomes (Martin et al., 2017), creating gaps between planned activities and learners' experiences. Also, separating design from evaluation hinders the identification of improvements. While LX evaluation is essential for identifying strengths and areas for improvement in the learner experience (El Mawas et al., 2020), without a direct connection to the design process, it becomes difficult to gather in-depth feedback on the effectiveness of computational resources and learners' needs during educational activities (Papavlasopoulou et al., 2019).

LX encompasses cognitive, affective, and motivational dimensions (Shi, 2014), which can be systematically designed and evaluated (Huang et al., 2019). In this regard, LX is particularly relevant for supporting educational experiences. However, significant challenges remain, including unintuitive interfaces, a lack of effective feedback, and information overload, which can hinder understanding and interaction (Magyar & Haley, 2020; Soares et al., 2023). Technological barriers, such as connectivity issues and limited accessibility, also negatively affect learner inclusion (Granić & Ćukušić, 2007).

In Brazil, although public policies such as the National Common Curricular Base (Base Nacional Comum Curricular - BNCC) promote the use of technology in basic education (Melo & Oliveira Junior, 2025), infrastructure and teacher training limitations still persist (Bulcão et al., 2021). This scenario highlights the importance of aligning the design and evaluation of LX to foster meaningful learner experiences. The design should meet learners' needs while supporting teachers (Arachchi et al., 2017), and the evaluation should help identify issues and guide continuous improvements (Magyar & Haley, 2020).

From this perspective, we proposed the Learner Experience Design and Evaluation conceptual Framework (LEDEF), using the Design Science Research (DSR) paradigm. According to Pawson and Tilley (1997), a conceptual framework serves as a guide for action, directing decision-making and the implementation of interventions in various contexts. It provides principles and guidelines for professional practice, promoting coherence and effectiveness in actions. LEDEF comprises two technologies: the Learner Experience Design Guidelines (LEDG) and the Learner Experience Evaluation Model (LEEM). The research question of this work was: "How can LX be designed and evaluated by considering appropriate elements and technologies to support educational experiences involving computational resources?". To evaluate LX using LEDEF, we conducted a case study.

This article, based on the study by Silva et al. (2025), introduces a new analytical lens by presenting the professor's experience as the designer of the LX. Through the planning, implementation, and continuous evaluation of an educational activity grounded in the LEDEF framework, the professor engages in an iterative cycle of reflection and redesign. This process contributes to the professor's professional development, as they deepen their pedagogical understanding through each informed refinement.

This research contributes to the field of Informatics in Education by analyzing an educational activity through the lens of Dewey's (1938) perspective on the nature of human experience, recognizing that LX involves not only cognitive processes but also an emotional and sensory journey that transforms both the individual and their context. A key contribution of this article is the application of our conceptual framework, LEDEF, which explicitly addresses LX elements and provides a structured process for designing, evaluating, and refining educational activities. LEDEF offers professors greater flexibility in selecting LX components while providing a well-defined workflow with steps, goals, and artifacts that can be adapted to diverse educational contexts.

This article is organized as follows. Section 2 presents the related work on the LX design and evaluation. Section 3 introduces the LEDEF framework. Section 4 describes the data collection and analysis methods, as well as the ethical considerations adopted in this research. Section 5 presents the results and discussion, including the case study conducted to evaluate LEDEF in a context involving a professor and their class. Section 6 presents the research limitations. Finally, Section 7 presents the conclusions and directions for future work.

2 Related Work

Despite the importance of discussing LX, the literature still lacks approaches that clearly define LX elements while providing systematic support for their design, evaluation, and continuous improvement. Thus, we analyzed studies that either (i) investigate LX in technology-enhanced educational contexts or (ii) provide support for the design and improvement of LX. Additionally, the selected studies use computational resources and offer insights that may inform the design or evaluation of LX.

2.1 Understanding and Evaluating Learner Experience

Ortiz et al. (2019) conducted activities with 12 learners in the Youth and Adult Education (EJA) program, aged between 21 and 70, to remove barriers to using WhatsApp. The methodology involved practical activities, such as cards depicting facial expressions, research, and qualitative observations, to capture participants' perceptions, emotions, and levels of engagement. The results indicate that contextualized, playful, and visually accessible activities foster positive feelings of satisfaction, autonomy, and belonging. This study highlights LX in a socially vulnerable context, as adult learners often face digital exclusion and limited prior access to technology.

Silva et al. (2020) conducted a study with 25 elementary school learners, divided into five groups of five, covering grades 4th to 9th, to analyze LX in Unplugged Computing activities in riverside schools in the Tapajós-Arapiuns region of Pará, Brazil. A qualitative approach was adopted, including a focus group. The results indicated that learners perceived the activities positively, fostering feelings of enjoyment, autonomy, collaboration, and motivation. This work also addresses digital vulnerability, as these schools have limited infrastructure and limited access to computational resources, highlighting how context-aware, low-cost interventions can support inclusive learning experiences.

Zhang et al. (2018) introduced a cross-stitch experiential learning model with rural children. The LX included four distinct stages: (1) Introduction; (2) Distribution of cross-stitch materials; (3) Practical demonstration of skills; and (4) Practice time for learners. Learners were also invited to self-assess at each stage of the activity, rating the Affinity, Challenge, and Frustration aspects on a scale of 1 to 5 stars. A study divided learners into two groups, each comprising one professor, one observer, and five learners. One group underwent the traditional cross-stitch method, while the other used a digital game. The results revealed differences between the two groups, with Group B demonstrating greater interest and engagement due to the use of the digital game, which also served as a tool to address difficulties and as a reference for learners.

More recently, Yates et al. (2026) investigated LX during emergency remote learning from the perspective of caregivers of elementary school students. Their findings revealed that learner experience is influenced not only by educational activities themselves but also by emotional, environmental, technological, and social factors. The study identified challenges related to emotional well-being, access to technology, learning gaps, and home learning environments, reinforcing the multidimensional nature of the learner experience.

Similarly, Monib et al. (2024) explored LX in relation to the use of ChatGPT as a learning assistant in higher education. The authors reported positive aspects of personalized learning, adaptive feedback, writing support, access to information, and research assistance. However, they also identified concerns regarding overreliance on AI-generated content, reduced critical thinking, information reliability, and loss of individuality in learning processes. These findings further highlight the complexity of learner experience in contemporary technology-enhanced learning environments.

Taken together, these studies demonstrate that LX encompasses cognitive, emotional, technological, social, and contextual elements. Furthermore, they illustrate different approaches for assessing LX, including qualitative observations, focus groups, self-assessment instruments, and analyses of learners' perceptions in diverse educational settings. Although these studies provide evidence on how learners experience educational activities and technologies, they primarily focus on understanding and evaluating LX during or after the activities. Consequently, they provide limited support for educators to intentionally design learner experiences or to systematically use evaluation results to guide the continuous improvement of educational activities.

2.2 Designing and Improving Learner Experience

In addition to understanding LX, several studies have proposed approaches to support the design and improvement of educational activities. Georgiou and Ioannou (2020) propose Learning Experience Design to help professors design activities that foster learner engagement, collaboration, and motivation. The authors suggest organizing learning stations where learners rotate through activities, including digital applications, hands-on tasks using traditional materials, and coding activities with robotics. The study also highlights the importance of co-creation between professors and learners, encouraging a participatory approach to LX design.

Capuano et al. (2009) present Adaptive Learning Experience Design, a system that supports professors in planning personalized learning experiences. The solution applies adaptive e-learning techniques to recommend content and activities based on each learner's profile, enabling professors to plan with the support of intelligent computational mechanisms. Recke et al. (2021) propose the Learning Activity Design Canvas, a visual tool to support professors' collaborative planning of learning activities. The tool structures the activity into four main components: Learning Outcome, Evidence of Learning for the activity, Required Resources, and Narrative Sequence (represented by Learning Bits that compose the activity). This approach can be applied in digital environments such as Miro, Mural, or Whimsical to encourage iterative and collaborative design.

Santos et al. (2025) reported the use of project-oriented and socially conscious practices in an undergraduate Human–Computer Interaction course. Learners performed activities involving the evaluation, specification, modeling, prototyping, and assessment of interactive systems. The results highlighted the importance of collaborative work, iterative evaluation, active learning, and continuous refinement of educational artifacts. Furthermore, the study emphasized that evaluation activities helped identify usability and user experience issues and supported the proposal of improvement actions. These findings reinforce the importance of integrating design and evaluation activities throughout the learning process.

Although these approaches support the design of educational experiences, they primarily focus on planning educational activities or reporting on educational practices. Consequently, they provide limited support for the systematic evaluation of LX and for using evaluation outcomes to guide redesign decisions throughout the educational lifecycle.

Table 1 shows important gaps in the literature. First, studies such as Ortiz et al. (2019), Silva et al. (2020), Yates et al. (2025), and Monib et al. (2025) primarily focus on understanding and evaluating LX. Although they provide insights into learners' perceptions, emotions, engagement, and challenges, they offer limited support for designing educational activities or systematically improving them based on evaluation outcomes. Second, studies such as Georgiou and Ioannou (2020), Capuano et al. (2009), and Recke et al. (2021) provide mechanisms to support the design and planning of LX. However, these approaches provide limited support for evaluating LX throughout the educational process and for using evaluation results to guide redesign decisions.

Table 1: Comparison of studies about LX.

Study	Design	Eval.	Multi LX	Teacher	Comp. Res.	Redesign	Lifecycle
Capuano et al. (2009)	✓	✗	✗	✓	✓	✗	✗
Zhang et al. (2018)	✓	✓	○	✗	✓	✗	○
Ortiz et al. (2019)	○	✓	○	✗	✓	✗	✗
Silva et al. (2020)	○	✓	○	✗	○	✗	✗
Georgiou and Ioannou (2020)	✓	✗	○	✓	✓	✗	✗
Recke et al. (2021)	✓	✗	✗	✓	✓	✗	✗
Yates et al. (2025)	✗	✓	✓	✗	✓	✗	○
Monib et al. (2025)	✗	✓	✓	✗	✓	✗	○
Santos et al. (2025)	✓	✓	○	✓	✓	○	○
LEDEF	✓	✓	✓	✓	✓	✓	✓

Legend: ✓= Fully supported; ○= Partially supported; ✗= Not explicitly supported;
Design = support for LX design; Eval. = support for LX evaluation; Multi LX = consideration of multiple LX elements; Teacher = explicit support for educators; Comp. Res. = use of computational resources; Redesign = support for iterative improvement; Lifecycle = coverage of multiple stages of the LX lifecycle.

Third, the reviewed studies collectively demonstrate that LX is influenced by multiple elements, including emotional, social, technological, contextual, and pedagogical factors. Nevertheless, most existing approaches focus on specific aspects of LX rather than providing a comprehensive structure that supports the intentional design, monitoring, evaluation, and continuous improvement of multiple LX elements. Finally, although Santos et al. (2025) emphasize the importance of integrating design and evaluation activities in educational contexts, their work reports on an educational practice rather than providing a framework that can systematically support educators throughout the learner experience lifecycle. Therefore, none of the reviewed studies integrates learner experience design, evaluation, and redesign activities within a unified framework that supports the complete lifecycle of educational activities involving computational resources.

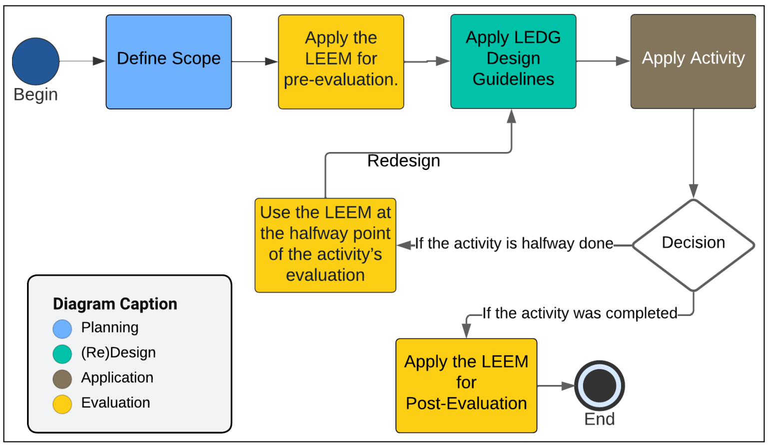
To address these gaps, the LEDEF integrates the Learner Experience Design Guidelines (LEDG) and the Learner Experience Evaluation Model (LEEM) into a unified framework. Unlike previous approaches, LEDEF supports the planning, design, application, evaluation, and redesign of educational activities involving computational resources. Furthermore, it enables educators to intentionally select and prioritize LX elements, evaluate them from multiple perspectives, and continuously refine educational activities based on evidence gathered throughout the learning process. By combining design and evaluation within a single structure, LEDEF provides comprehensive support for managing learner experience throughout its lifecycle.

3 LEDEF Conceptual Framework

LEDEF comprises two LX technologies: LEDG and LEEM (available in Appendices A and B). It provides a complete cycle of LX, allowing visualization of both what is proposed activity and what is actually experienced by learners, experiences that can directly impact the learning process. The LEDEF can help identify strengths and areas for improvement in LX, thereby enabling the redesign of activities using computational resources. As it addresses educational experiences, LEDEF can be used by all those interested in LX, including educators, instructional designers, and developers of educational resources and materials. The LEDEF meets the following requirements: (1) Applicable to Higher Education, because the use of resources requires a certain level of learner maturity. Furthermore, the framework was developed and validated through studies conducted in this context (dos Santos et al., 2022; Silva, Conte, & Valentim, 2024); (2) Possibility of Choosing LX Elements: A set of elements is provided that have been mapped and related so that the professor can select and work on the design and evaluation of LX, with a focus on elements of LX, such as Value, Usability, Adaptability, Desirability, and Comfortability; and (3) Possibility of Choosing Computational Resources: A set of 75 tools has been compiled and categorized for use in educational experiences, as recommended by the guidelines.

It is worth noting that the technologies comprising the LEDEF can be used independently. Thus, a professor interested in evaluating LX in their educational activities may choose to use only the LEEM. However, if the goal is also to create LX-based activities, the LEDG can guide the design. Figure 1 illustrates LEDEF, beginning with an educational activity in which the professor navigates and makes decisions, incorporating computational resources to provide an engaging LX. LEDEF comprises four stages (planning, design, application, and evaluation) and nine activities, as presented in Table 3.

Figure 1: LEDEF Conceptual Framework.



In LEDEF, the professor begins by defining the scope of the educational activity (1), including the course focus, class schedule, content, participating learners, and the learning environment. To better understand learners' difficulties and preferences, the professor administers the LEEM pre-evaluation questionnaire (2). Based on this data, the professor selects appropriate LEDG guidelines (3) (Silva, Conte, & Valentim, 2024) to plan the activity, choose computational resources (4), and prepare support materials (5). The activity is then implemented in the classroom

Table 2: Stages and activities of LEDEF.

Stage	Activities
Planning	Define activity scope
Design	Select LEDG guidelines; select computational resources; prepare support materials
Application	Apply educational activity
Evaluation	LEEM pre-evaluation; LEEM during-evaluation; LEEM post-evaluation
(Re)Design	Redesign activity when necessary

(6), with learners actively engaging in the proposed tasks. LEDEF reserves a specific moment for LX, during which learners can actively participate and have learning experiences. When learners reach 50% of the proposed activity, the professor conducts a mid-activity evaluation (7) using LEEM to monitor progress, identify any difficulties related to the activity, and document these experiences using the evaluation checklist. If necessary, the professor can redesign (8) their activities to seek a more satisfactory LX in the remaining 50% of the activity. LEDEF concludes with a post-evaluation (9) using LEEM, in which learners reflect on and share their educational experiences and participate in activities with computational resources.

LEDEF seeks to be flexible regarding this set of artifacts. Thus, the following conditions are presented: if the professor already has the activity ready, they can use only the LEEM post-evaluation to collect educational experiences; if the professor already has the activity defined but does not consider it satisfactory, they can administer the LEEM during-evaluation and the guidelines of LEDG to redesign it; if they wish to make a preliminary adaptation to their activity before presenting it to the learners, they can apply only the pre-evaluation and the guidelines of LEDG; finally, if the professor already has a ready LX evaluation process, they can use only the guidelines of LEDG to define the activity, the computational resource, and the support materials. In summary, LEDEF seeks to provide the professor with options to adapt the activity to learners' needs and educational contexts. Additionally, it enables the incorporation of new guidelines and technologies throughout the educational activity.

4 Method

This research was conducted within the framework of DSR, a methodological paradigm that guides rigorous scientific research focused on developing innovative technologies. DSR has two main goals: (1) to solve research problems, and (2) to generate new scientific knowledge for the area of study (Pimentel et al., 2019). Figure 2 outlines the overall research process, while Table 3 summarizes the main activities and outputs associated with each DSR phase.

Phase 1 generated the knowledge base for the research by identifying LX elements, existing technologies, and research gaps through Systematic Mapping Studies (SMSs) and a preliminary study. These findings were translated into design requirements that guided Phase 2. Based on these requirements, three complementary artifacts were developed: the LEDG guidelines to support LX design, the LEEM model to support LX evaluation, and the LEDEF framework to integrate both perspectives. Finally, Phase 3 assessed the proposed artifacts through feasibility studies and a case study, providing evidence regarding their usefulness, applicability, and potential to support LX in higher education contexts. The outputs of each phase served as inputs to the subsequent phase, ensuring the traceability of decisions throughout the DSR process.

Figure 2: Research Visual Abstract.

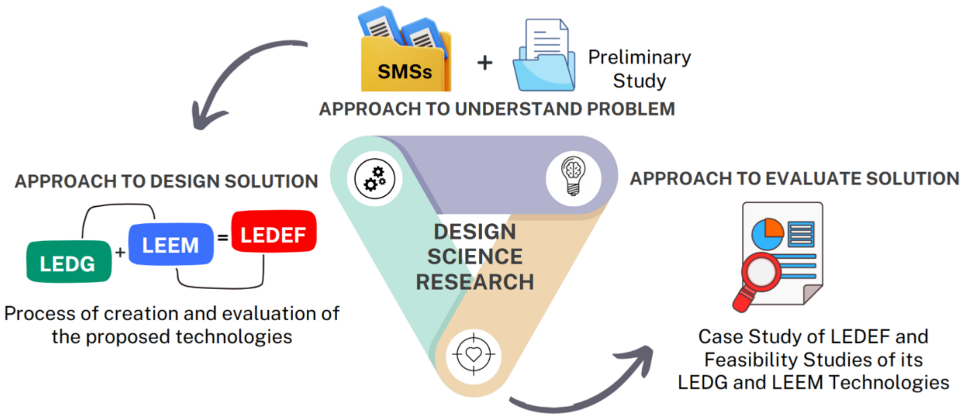


Table 3: Integration of the DSR phases.

Phase	**Main Activities**	**Output**
Problem Understanding	Two SMSs and a preliminary study	LX elements, research gaps, and requirements
Solution Design	Development of LEDG, LEEM, and LEDEF; feasibility studies	Refined design and evaluation artifacts
Solution Evaluation	LEDEF case study in a real educational setting	Evidence of usefulness, applicability, and improvement opportunities

4.1 Data Collection Methods

In this work, various instruments were prepared and used to collect data. First, the Informed Consent Form (ICF) was employed to ensure participants' understanding and voluntary participation in the study. Next, a participant characterization questionnaire was administered to gather relevant demographic and contextual information for data analysis. Specific instruments were developed, including a presentation of the technology being evaluated and a suggested activity for its use. Technology Acceptance Model (TAM3) questionnaires were also used to assess participants' perceptions of Ease of Use, Perceived Usefulness, and Future Use Intention.

In some cases, semi-structured interview scripts were developed to provide a deeper understanding of participants' experiences and opinions. A request form for the use of image and/or voice for research purposes was prepared, ensuring participants' authorization for audiovisual recording during the interview process. These instruments were carefully selected and developed to meet the specific objectives of the research and to ensure the quality and ethical standards of data collection. The study was approved by the Research Ethics Committee of UFPR under the Certificate of Presentation for Ethical Consideration (CAAE): 77365824.4.0000.0102 (LEDG feasibility study), 64733822.0.0000.0102 (LEEM feasibility study), 67603723.9.0000.0102 (LEEM case study), 77365824.4.3001.9247 (LEDEF case study).

4.2 Data Analysis Methods

The collected data were analyzed quantitatively and qualitatively. For the quantitative data, descriptive statistics were used. For questionnaires that used TAM3 indicators, participants' responses on the agreement scale (strongly agree, partially agree, neither agree nor disagree, partially disagree, and strongly disagree) were collected. The original sentences for each indicator were adapted to reflect the specific research context and were peer-reviewed in collaboration with the research advisor. The goal was to focus on aspects directly relevant to the evaluation of the proposal. The use of TAM3 was based on its validation in various previous experiments (Venkatesh & Bala, 2008). For quantitative analysis, Microsoft Excel[1] was used. Qualitative data were analyzed using thematic analysis (Braun & Clarke, 2006) in Atlas.ti[2], which enabled the identification of emerging patterns and themes. The analysis process included steps such as familiarizing with the data, generating initial codes, identifying potential categories, and refining these categories. Coding was performed by the primary researcher and subsequently reviewed by the research advisor. Discrepancies in code interpretation or category assignment were discussed until consensus was achieved. This iterative peer-review process enhanced the rigor, credibility, and dependability of the qualitative analysis.

5 Results and Discussion

Approach to Understand Problem. In the first phase of the research, the aim was to understand the problem and define its scope. Two SMSs were conducted: one focused on the LX design and the other on its evaluation, with the latter followed by a preliminary study. The SMSs were conducted according to the guidelines proposed by Petersen et al. (2015) and Kitchenham et al. (2016), using the collaborative online tool Porifera to plan and conduct the SMSs (Campos et al., 2022). According to Petersen et al. (2015), an SMS provides an overview of a research area by identifying the number, types, and available results of studies in that area.

To identify technologies that support the design of LX mediated by computational resources, an SMS was conducted (Silva, Conte, & Valentim, 2024). The main question of this SMS was: "What technologies are utilized in the LX design that considers computational systems?". The goal of the SMS was defined according to the Goal-Question-Metric (GQM) paradigm, proposed by Basili and Rombach (1988), being: **Analyze** Scientific Publications; **With the purpose of** Characterize; **In relation to** LX design technologies; **From the point of view of** researchers in Informatics in Education, Human-Computer Interaction (HCI) and Software Engineering; **In the context of** scientific publications in ACM Digital Library, IEEE Xplore, Science Direct and Springer Link.

To help answer the main question, 16 research sub-questions (SQs) were defined. The sub-questions are: SQ1. "The publication addresses what kind of LX design technology?"; SQ2. "Which theory/construct supports the LX design?"; SQ3. "What type of resource was used to support the LX design?"; SQ3.1 "What steps/activities are used to support the LX design?"; SQ3.2 "What computational systems were used in the LX design?"; SQ3.3 "Was there support for the

[1] https://www.microsoft.com/pt-br/microsoft-365/excel
[2] https://atlasti.com/pt

learner in using the computational system in the LX design?"; SQ4. "What learning environment is the LX designed for?"; SQ5. "What is the learner's role in the LX design?"; SQ5.1 "What is the level of education at which the LX design takes place?"; SQ5.2 "How was the learner's participation in the LX design?"; SQ6. "What LX elements were considered in the LX design?"; SQ6.1 "How does the construction of the LX design elements occur?"; SQ7. "Was there an empirical study to evaluate the LX design technology?"; SQ7.1 "What types of studies were considered in the LX design?"; SQ7.2 "What types of analyses were performed in the LX design?"; and SQ8. "In what context can LX design technology be used?".

The string search used was: ("Learner eXperience Design" OR "Learning eXperience Design" OR "Learner Centered Design") AND ("approach" OR "process" OR "technique" OR "framework" OR "model" OR "method" OR "methodology" OR "tool" OR "guideline" OR "scenario" OR "technology" OR "rule" OR "pattern" OR "principle"). When running the string in search engines, 728 studies were returned. In the first filter, 129 studies were selected based on the titles and abstracts. In the second filter, 45 studies were selected after reading the full articles.

Each article selected for this SMS was independently reviewed and evaluated by two researchers (the author of this research and the advisor). The researchers decided whether or not the publication should be included based on a set of criteria divided into (1) Inclusion Criteria (IC) and Exclusion Criteria (EC). Criteria for inclusion of articles: **IC1.** Publications that propose LX design technologies considering computational systems; **IC2.** Publications that present resources and materials supporting LX design in computational systems; **IC3.** Publications that present experimental studies of LX design technologies considering computational systems; Criteria for exclusion of articles: **EC1.** Publications that did not meet the inclusion criteria were not selected; **CE2.** Publications that have a language other than English and Portuguese were not selected; **CE3.** Publications that do not have available content for reading and data analysis were not selected (especially in cases where studies are paid or not available by search engines); **CE4.** No duplicate publications were selected **CE5.** Publications that were not peer-reviewed, such as technical-scientific reports and proceedings, were not selected.

To conduct the SMS, articles were selected in two stages (first and second filters). In the first filter, both researchers read the title and abstract. A justification was provided for each article excluded in this stage. In the second filter, the articles that passed the first filter were read in full. For article selection, both stages underwent the same processes: 1) The researchers analyzed the inclusion and exclusion criteria and recorded the results obtained; 2) The researchers reached consensus when there was no unanimity on the inclusion or exclusion of a publication; 3) In the consensus stage, in case of disagreement on the inclusion of a publication, the study was included for the next stage.

The results revealed a wide variety of approaches and tools, with the Approach category being the most recurrent among the identified technologies. A trend was also observed in the use of computational resources integrated into sequences of steps or activities, promoting learner engagement. The Value element was highlighted as central to LX design, given its strong relationship with learning effectiveness. The analysis showed that strategically combining multiple elements can enrich the LX.

The second SMS aimed to identify strategies and technologies for LX evaluation (dos Santos et al., 2022). The main question of this SMS was: "Which initiatives evaluate LX and use computational resources in the learning process?". The goal of the SMS was **Analyze** Scientific Publications; **With the purpose of** Characterize; **In relation to** Learner eXperience (LX) evaluation technologies; **From the point of view of** researchers in Informatics in Education and HCI; **In the context of** scientific publications in ACM Digital Library, IEEE Xplore and ERIC.

To help answer the main question, 11 research sub-questions (SQs) were defined. The sub-questions are: SQ1. "What type of contribution is being proposed to evaluate LX?"; SQ2. "What scenarios are being evaluated at LX?"; SQ3. "What resources are being used in initiatives that assess LX?"; SQ3.1 "What applications are being used in the evaluation of LX?"; SQ4. "What emerging technologies are being used in initiatives that evaluate LX?"; SQ5. "What active methodologies are adopted in initiatives that evaluate LX?"; SQ6. "Which elements of LX are being evaluated in the learning process?"; SQ7. "How was/were the element(s) evaluated?"; SQ8. "What types of experiments were conducted with LX initiatives?"; SQ9. "What types of experimental analyses were conducted with the LX initiatives?"; and SQ10 "What is the target audience for initiatives that evaluate LX?".

The string search used was: (Learner eXperience") AND ("Element*" OR "Usability" OR "Adaptability" OR "Comfortability" OR "Desirability" OR "Value") AND ("tool" OR "framework" OR "technique" OR "method" OR "model" OR "process" OR "metric" OR "inspection" OR "heuristic" OR "methodology" OR "questionnaire" OR "checklist") AND (Evaluation" OR "Assessment"). When running the string in search engines, 584 studies were returned. In the first filter, 61 studies were selected based on the titles and abstracts. In the second filter, 18 studies were selected after reading the full articles.

Criteria for inclusion of articles: **IC1.** Publications that present information and discussions about the evaluation of LX using computational resources; **IC2.** Publications that present experimental studies conducted with the LX assessment initiatives using computational resources; **IC3.** Publications that propose instruments and resources used in LX assessments using computational resources; **IC4.** Publications that report on the use of educational technologies in LX assessments using computational resources; **IC5.** Publications that propose instruments and resources used in LX assessments using computational resources. Criteria for exclusion of articles: **EC1.** Publications that did not meet the inclusion criteria were not selected; **CE2.** Publications that have a language other than English and Portuguese were not selected; **CE3.** Publications that are not available for consultation or download in open format, i.e., those that have costs to obtain the information, will not be selected.); **CE4.** Duplicate publications will not be selected, meaning those that have already been selected in another digital library **CE5.** Publications that have not been peer-reviewed (grey literature), such as scientific and technical reports, books, and other materials, will not be selected.

32 distinct evaluation approaches were identified, with "Items/Sentences" being the most frequently used. The analysis enabled mapping 54 distinct elements that serve as targets of evaluation in the reviewed publications. However, these elements are generally used in isolation, with Value, Usability, and Adaptability being the most prominent. This fragmentation highlights a gap in the literature: the absence of integrated evaluative approaches that simultaneously consider multiple LX elements within a single methodological structure. In response to this gap, the LEEM evaluation model was proposed to unify these elements and to incorporate multiple evaluation forms into a cohesive structure.

The complete protocol, including selection criteria, other strategies, and data extraction, is available in the technical reports in Appendices C and D. Based on the results obtained from the SMSs, several directions for future research emerge. One is the deepening of collaborative LX, considering interactions among different stakeholders (such as peers, professors, parents, and industry professionals) to expand social interaction dynamics. Another possibility is to investigate why the LX design has predominantly focused on basic education, whereas evaluation studies have primarily targeted higher education. Finally, the need to explore LX in more dynamic and immersive educational contexts, such as extended reality and ubiquitous, pervasive, or virtual platform learning environments, is highlighted.

Additionally, a preliminary study was conducted with 36 learners from an experimental HCI course, aiming to explore, in a real classroom context, the constitutive elements of LX (D. Silva et al., 2022). This practical experience led to the formulation of 16 initial guidelines, organized around the LX elements: Value, Usability, Desirability, Adaptability, and Comfortability (D. Silva et al., 2023). These guidelines provided pedagogical support for promoting interaction in learner-centered experiences with computational resources, and contributed to decisions and lessons learned throughout the study. Such preliminary guidelines, combined with those identified in the SMS on LX design, underpinned the LEDG's final proposal (Silva, Conte, & Valentim, 2024). These guidelines were conceived to align with the LEEM evaluation model (derived from the SMS on evaluation), jointly forming the LEDEF framework, which integrates the design and evaluation aspects of LX in the use of computational resources.

Approach to Design Solution: The first version of the guidelines LEDEF contained 35 guidelines. After a peer-review process conducted by research supervisors and specialists in Informatics in Education, Human-Computer Interaction, and Software Engineering, two guidelines were excluded, and 11 were integrated into the others, resulting in 22 guidelines in the current version (Table 4). The removed guidelines "Propose activities with computational resources" and "Allow learners to interact with new computational resources" were considered redundant, as the use of computational resources is already transversally encouraged in the other guidelines.

In grouping the guidelines, the aim was to consolidate those with similar objectives. For instance, guidelines on diagnostic assessment and feedback were unified in G6, which covers learner feedback before, during, and after the activity. G20 resulted from the fusion of guidelines addressing the practical application of content and the presentation of challenges. G12 brought together guidance on thematic organization, emerging topics, and division into smaller parts. Similarly, guidelines on the presence of tutors and on continuous support now constitute G22.

In addition to restructuring, it was necessary to make the guidelines more practical and accessible to professors. In the initial version, the guidelines presented more abstract orientations, with only the guideline name and a general description. To facilitate their understanding and application, each guideline now includes detailed information, such as goals, prerequisites, application examples, tips, expected results, and suggestions for computational resources (Figure 3). This aimed to offer a more direct entry point for professors, promoting the adoption of the guidelines in specific activities rather than in complete modules or entire courses.

Even with this level of detail, the material's accessibility remained limited because the revised version was only available as a text document (Appendix E). To broaden access and facilitate use by professors, a website was developed based on Google Sites templates. Figure 4 presents

Table 4: List of LEDG Design Guidelines.

Qty.	List of Guidelines (G)
G1.	Foster learners' responsibility
G2.	Anticipate materials for learners' preparation
G3.	Allow learners to choose an appropriate space and time
G4.	Allow personalized access to materials
G5.	Allow learners to express themselves and ask questions
G6.	Request continuous feedback from learners
G7.	Explain content with visual and multimedia support
G8.	Provide guidance and tips to support learners
G9.	Allow learners to make choices
G10.	Connect content to prior knowledge
G11.	Present content clearly and concisely
G12.	Organize content by themes or topics
G13.	Allow learners to break down problems into smaller steps
G14.	Offer visible and challenging support
G15.	Use appropriate icons and menus
G16.	Use consistent layout positioning
G17.	Use appropriate fonts and colors
G18.	Use familiar and recognizable symbols
G19.	Avoid visual distractions
G20.	Apply content to learners' daily lives
G21.	Promote the exchange of experiences and knowledge
G22.	Facilitate the inclusion of a tutor in the experience

the organization of the guidelines by LX elements, which serve as filters on the website to facilitate educators' identification and use of the guidelines. By following the provided guidelines, educators are expected to create and/or redesign educational activities aligned with LX.

The process suggested on the website organizes the adoption of the guidelines into five steps: 1) Select: identify which LX elements are relevant to the learning objectives of the activity; 2) Include: choose guidelines that can be integrated into the activity, considering interaction, collaboration, and skill development; 3) Apply: consult examples and tips to employ the guidelines with computational resources; 4) Adjust: adapt the activity during its execution based on learners' reactions and engagement, promoting redesign when necessary; 5) Evaluate: reflect on the impact of the applied guidelines through collecting feedback and analyzing the obtained results. This workflow aims to support the professor through all stages of the LX cycle, aligning with the LEDEF framework's proposal to foster an iterative process between design and evaluation.

Complementary to the LEDG, the LEEM contributes to the LEDEF by providing specific instruments for evaluating the LX at different stages of the educational process. LEEM encompasses three stages: pre-evaluation, during-evaluation, and post-evaluation (dos Santos et al., 2023b), as illustrated in Figure 5. In the pre-evaluation stage, pairs of opposite adjectives are used to characterize learners' initial profiles, including their feelings and expectations regarding the use of computational resources. This stage supports the identification of LX elements related to skills, value, participation, authenticity, usability, and desirability. Skills refer to learners' perceived abilities to perform the proposed educational activities. Value concerns the relevance and usefulness that learners attribute to the activity for achieving their learning goals. Participation reflects learners' willingness to engage in the educational process. Authentic refers to opportunities for learners to express their own expectations, prior experiences, perspectives, and goals, ensuring that the educational experience is grounded in their personal context. Usability concerns the ease with which learners can interact with the computational resources, while desirability reflects the attractiveness and positive expectations associated with the learning experience.

Figure 3: Example of Detailed Guideline (Actual Version).

LEDG Home

G17. Use appropriate fonts and colors, taking legibility into account.

General Description: This guideline helps create a clear visual design that highlights important information and facilitates the identification of key elements. Such identification can improve content comprehension, navigation, and visual comfort, making the presentation more pleasant and cohesive. This guideline can be applied both when selecting a digital resource and when designing new interactive material.

Goals

- Promote an effective reading experience that does not visually overwhelm students.
- Make content accessible for reading and understanding using readable fonts and high-contrast colors.

Prerequisite

- The teacher needs to choose fonts and colors that are easier to see and read, and adjust font and color settings to improve legibility.
- The teacher needs to observe students while they use digital resources. This can help identify areas where students are having difficulty seeing or using the materials.
- The teacher needs to adapt the digital resources as needed. This may include increasing font size, changing font and background colors, or providing other types of support.

How to apply the guideline:

1. Choose digital resources that allow customization, such as font and color adjustments.
2. Provide students with instructions on how to adjust font and color settings in the digital resources. This may include information on how to increase font size, change font and background colors, and adjust contrast.
3. Offer support to students who are having difficulty seeing or using the digital resources.

Example of Applying the Guideline:

- **Example 1:** The teacher can create slide presentations for their classes using large, readable fonts such as Arial or Verdana, and choose text and background colors with high contrast, such as black text on a white or yellow background. The teacher can avoid color combinations that may hinder readability, such as red text on a green background.
- **Example 2:** The teacher can distribute printed materials, such as exercises or readings, using a clear and legible font in an appropriate size (e.g., size 12 or 14), and choose a color palette that highlights titles and important sections without compromising readability. The teacher can avoid using colors that may be hard to distinguish on paper, such as very light shades of gray.
- **Example 3:** The teacher can configure the virtual learning environment by selecting themes or layouts that use legible fonts and color combinations that are easy to read, such as light backgrounds with dark text. They can also adjust the settings so that important links and buttons use colors that clearly stand out.

Tips

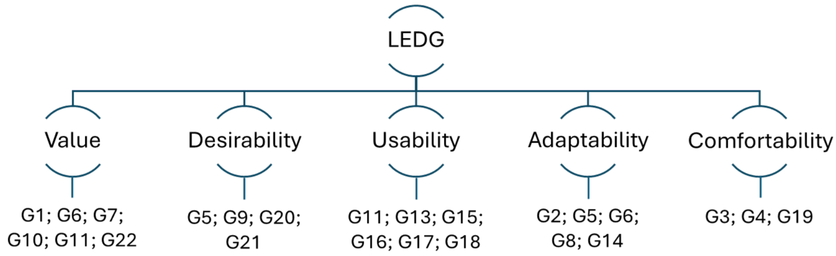
- Use sans-serif fonts such as Arial, Verdana, or Calibri, which are easier to read on digital screens. Avoid decorative or script fonts, as they can be difficult to understand.
- Use a consistent color palette across all your teaching materials. This helps students become familiar with the layout and the location of important information.
- Check how digital materials, such as presentations and documents, appear on different devices (computers, tablets, smartphones).
- Ask students if they have vision difficulties or reading preferences and adjust your font and color choices to meet their needs.
- Avoid excessive use of different colors and fonts on a single page or slide. A clean and simple design helps keep the focus on the content and improves readability.

Ways of Evaluation:

- **Increased Effectiveness:** Are students able to use the digital resources independently? Can they complete tasks and projects effectively using the digital resource?
- **Increased Satisfaction:** Are students satisfied with the use of the digital resources? Do they find the resources easy to use?
- **Increased Acceptance of the Resource:** Do students think the resource is easy to use? Do they believe it is useful? Would they like to use it for other activities?

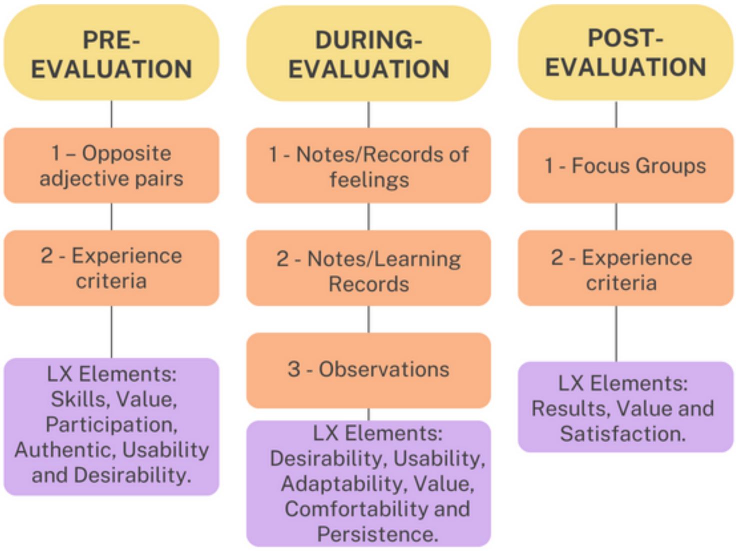
In the LEEM during-evaluation, records and observations are carried out by both professors and learners. Data are collected from multiple perspectives, including learners' self-reflections and professors' feedback, thereby enriching understanding of LX by enabling comparisons across perspectives. This stage focuses on the evaluation of desirability, usability, adaptability, value, comfortability, and persistence. Adaptability refers to the extent to which educational activities

Figure 4: Organization of the Guidelines by LX Elements on the LEDG Website.



and computational resources accommodate learners' needs and characteristics. Comfortability concerns learners' sense of ease and well-being while interacting with the educational environment. Persistence reflects learners' willingness to continue engaging with learning activities despite challenges or difficulties encountered during the process.

Figure 5: LEEM Evaluation Model.



In the post-evaluation stage, the focus group technique is adopted to promote active listening to learners' perceptions of their experience. This stage investigates LX elements associated with results, value, and satisfaction. Results refer to learners' perceptions of the outcomes of the educational experience, including the knowledge and skills acquired. Satisfaction concerns the degree to which learners perceive that their expectations and learning needs were met. This allows the identification of learning outcomes and encourages self-reflection and empowers learners as protagonists. The integration of LEEM with LEDG strengthens LEDEF by establishing a systematic, learner-centered approach to evaluating educational experiences and interactions. This integration supports the identification of strengths and areas for improvement.

Approach to Evaluate the Solution. The feasibility study of the LEDG was conducted with 24 higher education professors in Computer Science and Education, all experienced in using computational resources in their activities, leading to significant improvements in the guidelines, particularly regarding their interface, organization, and content. These enhancements facilitated professors' applications and amplified their impact on the educational experience. The implemented changes, such as abbreviated titles, the use of IDs for quick navigation, and the adoption of dropdown menus, improved readability and made the content more objective and adaptable to selective viewing. Organizing the guidelines by elements, coupled with the indication of specific tools for each computational resource category, provided more targeted navigation and a selection better suited to professors' needs. Based on these contributions, the LEDG evolved into its current version.

The feasibility study of the LEEM involved 19 professors from different educational levels (dos Santos et al., 2023a). The analysis identified areas for improvement, including clarifying checklist items and better aligning them with the objectives of each LX element. Although the instrument's length was identified as a negative point, it's understood that its use according to the guidelines, before, during, and after the activity, can minimize the fatigue associated with completion (dos Santos et al., 2025). Generally, professors found it practical, interesting, and suitable for evaluating the learning experience. However, its application in real-world contexts was still necessary (dos Santos, Silva, et al., 2024).

For the LEEM, a case study was conducted with 23 learners and one professor from a Software Engineering course (dos Santos, Silva, et al., 2024). The application of LEEM enabled the evaluation of LX before, during, and after the educational activity. The data revealed that integrating computational resources contributed to a more comfortable and engaging experience. Variations in interest were also observed throughout the activity, along with distinct preferences for individual versus collaborative work. Applying the checklist at different times facilitated the collection of multiple perspectives, highlighting both positive aspects and areas for improvement, such as greater clarity in instructions and scale appropriateness. The feedback helped make the LEEM objective and accessible, highlighting its effectiveness in supporting professors.

The LEDEF case study was conducted with 19 learners and one professor from an Algorithms and Programming Techniques course (D. Silva et al., 2025). Table 5 presents the activities performed by both the professor and the learners. The proposal was guided by specific directives from the LEDEF framework, namely: G3 (allow learners to choose their own learning space and time), G5 (encourage expression and questioning), G9 (offer freedom of choice), G20 (relate content to learners' daily lives), and G21 (promote the exchange of experiences and knowledge). While some of these guidelines can be applied without technology, they were designed to support the integration of computational resources into educational contexts. The goal of the activity was to deepen both the theoretical understanding of recursion and its practical application, as well as the implementation of recursive functions. To this end, learners worked collaboratively in groups of three to four members. Each group was responsible for producing two main deliverables: (1) a detailed report, shared via a link on Notion; and (2) a summary presentation, created using one of the tools suggested by LEDEF: PowerPoint, Prezi, Google Slides, or Genially.

The structure of the deliverables was predefined and included three main sections: a) Introduction to the Topic, with a definition of recursion, an explanation of recursive functions, and a discussion of their importance and applications in computing; b) Explained Examples of Recursive Functions, requiring the presentation of the code and a detailed explanation of how the recursive process works. Groups were required to select at least three from the following examples: factorial calculation, Fibonacci sequence, recursive sum, binary search, exponentiation, and Tower of Hanoi; c) Recursion Analysis, addressing its advantages and disadvantages. The eval-

Table 5: Overview of Activities Performed in the Case Study.

Actors	Requirements
Professor	Consults, defines, and applies guidelines
	Monitors activity using LEEM checklists
	Performs redesigns
	Intervenes in groups
	Participates in the interview
Learners	Answers LEEM pre-evaluation
	Answers LEEM during-evaluation
	Answers LEEM post-evaluation

uation considered criteria such as conceptual clarity and accuracy, the correctness and depth of examples, the quality of the report and visual presentation, and group cohesion and collaboration. The activity lasted for three weeks. In the first week, learners began and developed the practical programming component; in the second, they finalized and submitted the report via Notion; and in the third week, they delivered their presentations, each lasting up to 30 minutes per group.

Throughout the activity, the professor provided all necessary instructions and support. When approximately 50% of the task had been completed, learners were invited to fill out the During Evaluation Checklist (Learners). This During Evaluation Checklist had two main objectives: (1) to identify potential difficulties in time to make adjustments before completion, and (2) to avoid the need for daily evaluations in longer activities, respecting the professor's workload. Simultaneously, the professor recorded their own impressions using the During Evaluation Checklist (Professor). At the end of the educational activity, the professor conducted a focus group with the invited learners, who, if they felt comfortable, were asked to respond to a set of questions about their learning experiences. Finally, the professor participated in a semi-structured interview that covered the complete LEDEF framework cycle, including the design and evaluation of the learning experience, as well as learners' post-activity feedback on their participation and the professor's interventions based on LEDEF's suggested guidelines. These activities were carried out between September 17 and October 1, 2024.

The qualitative analysis of the case study presents the professor's comments, obtained through a semi-structured interview, on the complete cycle of the LEDEF framework, which encompasses the planning and evaluation of the learning environment, and the learners' impressions, obtained in the post-evaluation, regarding their participation in the activities and interventions carried out by the professor based on the guidelines suggested by LEDEF.

The professor is male, aged 20 to 30, and holds a PhD in Computer Science. Since the beginning of his teaching career, he has consistently integrated a range of resources to support his classes, including Mentimeter, WhatsApp, Moodle, Trello, Lucidchart, and Google tools. When asked whether he evaluates LX in any of his courses, the instructor confirms that he does, though not systematically or with specific LX elements. Instead, he evaluates the overall course experience using Google Forms. The results of his experience with LEDEF will be discussed below.

5.1 Professor Perceptions

Iterative Cycle and Professor Autonomy. The professor perceived LEDEF as a useful mechanism for observing and assessing classroom dynamics. Beyond supporting the assessment pro-

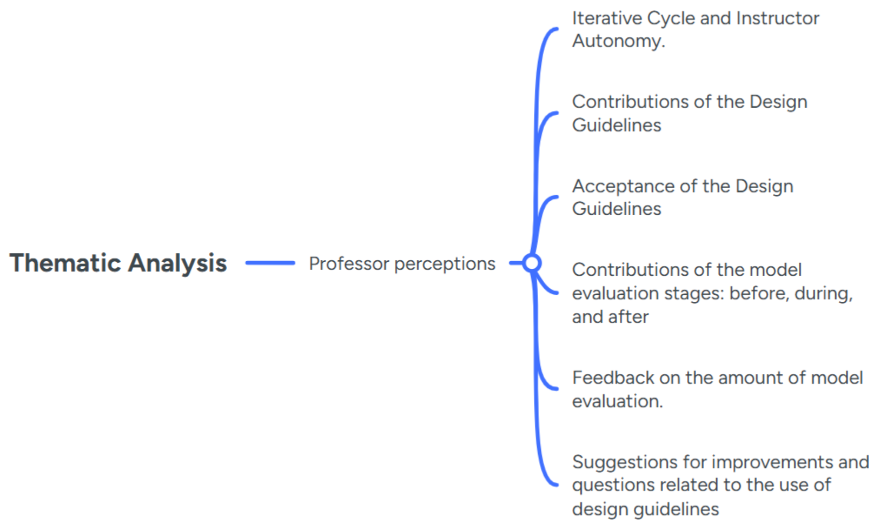


Figure 6: Overview of Thematic Analysis.

cess, the framework also provided ideas for designing educational activities, selecting resources, and adapting evaluation strategies according to contextual needs. The professor reported choosing guidelines and resources that best matched the activity's objectives and adapting the post-evaluation stage by using forms to encourage more open participation from shy learners. Evidence supporting these findings is presented in Table 6 (Q1 to Q6).

The findings suggest that LEDEF functions as a flexible rather than prescriptive framework. Instead of requiring professors to follow a fixed set of procedures, it provides guidance adaptable to different teaching styles, classroom contexts, and learner profiles. This flexibility was reflected in the professor's autonomy to select specific guidelines, choose computational resources, and modify the data collection strategy according to the needs of the activity. Such adaptability is particularly relevant in educational settings, where learner characteristics and classroom dynamics often require adjustments that cannot be anticipated during planning.

Another important finding concerns the role of the iterative evaluation cycle. Although the professor was already familiar with observational assessment practices, using evaluation during the activity encouraged more active intervention and continuous monitoring of learners' progress. Rather than serving only as a mechanism for collecting feedback, the evaluation process became an opportunity to identify difficulties, provide immediate support, and redesign aspects of the educational experience while the activity was still taking place.

Furthermore, adapting the focus group to a questionnaire-based approach demonstrates that the framework can accommodate the social and emotional characteristics of different learner groups. By allowing the professor to tailor the evaluation strategy to the classroom context, LEDEF helped create conditions that encouraged more authentic and comfortable participation. This finding reinforces the learner-centered nature of the framework, as assessment decisions were guided by learners' needs rather than by rigid methodological requirements. Overall, these results provide evidence that the iterative cycle proposed by LEDEF effectively supports reflective teaching practices. The combination of structured guidance and pedagogical autonomy enabled the

Table 6: Evidence supporting professor perceptions of LEDEF.

ID	Quotations
Q1	“I found it interesting. As a researcher, I’ve been conducting evaluations for some time. For example, I assign an activity, observe how they’re behaving, conduct an observational evaluation, look at them, and think, "Wow, that group over there, they have more doubts, or they’re very separated, or they’re not doing anything.”
Q2	“When we got together to talk about assessment and what actually helped the learners, I found that interesting because I usually make the learners feel very comfortable.”
Q3	“The guidelines helped me not only to plan the assessment, but also to generate ideas for the activity.”
Q4	“I was able to choose [the tools] according to what I thought made sense for my activity at that moment. However, I also passed on to them, when I finished explaining the activity, I wrote some tools I found in LEDG on the board to show them.”
Q5	“As I read the guidelines, I went through them, thinking: "This one I can use, I’ll do it this way." - "Oh, this one won’t work, I won’t use it, next one." I eliminated the guidelines based on what I thought I could use and what I couldn’t.”
Q6	“Especially when it’s more isolated, that’s why I opted to create the form, because if it were in a traditional focus group, I don’t know if they would say everything they’re thinking.”
Q7	“So it was a good resource that I could rely on to find new ideas for doing an activity.”
Q8	“I think this was only possible because of the approach I used, which was to encourage participation, seek resources, and everything else. Another thing was the group work, which wasn’t something I worked on in the course.”
Q9	“It helped me so much to plan the assessment, to get out of what I was used to, out of the routine, so to speak.”
Q10	“I think they were mainly excited to do a different activity using a computational resource they had never used before, which was Notion.”
Q11	“I think so. I think that’s enough for now. They’re all separated in the same way. I also liked the resources page; it’s very helpful. It communicates very well with the guidelines.”
Q12	“Yes, I found it easy to use the guidelines.”
Q13	“I think they’re well organized for what we need, so we can explore them effectively. So, I have no complaint.”
Q14	“I enjoyed using it, I think it’s supportive and I felt quite comfortable.”
Q15	“I would use the guidelines again. If they were available here for me, I would definitely take a look to get ideas for new activities and resources. So yes, I would use them.”
Q16	“Yes, I had already noticed in the pre-evaluation that a large part of the class preferred to do things at home and alone, but that’s not how it works, right?.”
Q17	“When I realized I needed to help, to ask if they had any questions, I went to their desks and everything. And some of them asked me things they wouldn’t have asked if I hadn’t gone there, you know? So I think this helps both those learners who feel more comfortable and those who are very shy”
Q18	“I went to each group and asked them how they were doing with the activity, what part they were on, and how they had divided it. And they had to explain that to me during the evaluation, before answering the questionnaire, right? How they had divided it and everything else helped them ask questions right then and there and helped me understand how the group was progressing. That’s why it caught my attention, because I think it wouldn’t have happened if I hadn’t needed to do that evaluation during the activity”
Q19	“Now, in a focus group, I don’t think anyone would talk or betray a classmate. So, in my case, with this subject, with this group, I think the questionnaire was better for giving them that privacy.”
Q20	“This evaluation also helped us develop the very elements of the learner’s experience”
Q21	“I’m thinking that, for example, we lost two participants, right? So, if you don’t answer one of the questionnaires, you’re no longer part of the evaluation, because if you missed an evaluation during the week, you can’t do it the following week, because after that it’s the end of the evaluation, right?”
Q22	“Nobody complained to me, but I think that for a short evaluation period, I think it’s a problem.”
Q23	“Nobody really likes answering questionnaires, that’s the truth. We in research do it because it’s an easy way to collect data.”
Q24	“It wasn’t a problem in my case because I encouraged them to participate and not give up, but I believe you need to think about this carefully, or perhaps even space out the time between evaluations more.”
Q25	“I think one suggestion would be to divide the guidelines into effective guidelines for designing educational activities and guidelines for professor behavior in the classroom.”
Q26	“Regarding the behavioral aspects, I was a little hesitant, like, how am I going to actually do that in an activity, you know? So I ended up setting it aside because it didn’t make sense to me at that moment, since it’s my own behavior, meaning, in a way [indirectly], I ended up using it.”
Q27	“I was wondering if the same guideline could affect different elements. Because sometimes I’d think, "I’m applying guideline 1, but could it also affect another element?" It wasn’t clear to me, you know?.”
Q28	“In the resources section, I suggest explaining how the resources can be used in the guideline, and then on the resources page, there should be an explanation about the resources, or even in the guideline itself, for example, in guideline X, you can use these resources to do this. So, Notion, how can you use it for this guideline? Or Miro, how can you use it for this guideline? Or WhatsApp, I’m going to create groups? I suggest making the link between the resource and the guidelines clear, you understand?”
Q29	“I was thinking about how I can use the other [tools] that I’ve never heard of, or even know what they are. If I were to examine each one, test it, and explore it, it would take too much time to plan activities. So, if you want to work with forums, you could put a description down there so we can see, because sometimes I could have used some of them here, but since I would have to explore to learn about them and everything, I ended up not using them, you know?”

professor to monitor, adapt, and improve the educational experience throughout the activity.

Contributions of the Design Guidelines. The professor reported that the design guidelines contributed to their teaching practice by supporting the development of educational activities that differed from those usually adopted in the course. The guidelines encouraged exploration of new computational resources, promoted collaborative work among learners, and inspired the adoption of teaching strategies not previously part of the professor's pedagogical repertoire. Evidence supporting these findings is presented in Table 6 (Q7 to 10).

The findings suggest that LEDG served not only as a collection of recommendations but also as a source of pedagogical inspiration. Rather than merely guiding the implementation of predefined activities, the guidelines encouraged the professor to rethink existing teaching practices and experiment with alternative approaches. By presenting concrete suggestions and examples, the guidelines appear to lower the effort required to explore new possibilities in the classroom.

Another important contribution concerns the diversification of educational experiences. The professor reported introducing collaborative activities and computational resources that had not previously been used in the course. Such changes are significant because learner engagement is often associated with novelty, interactivity, and variety in educational experiences. The use of unfamiliar resources and collaborative dynamics may have created opportunities for learners to participate more actively in the learning process, thereby enriching their overall experience.

The findings also indicate that the guidelines can support pedagogical creativity. Instead of prescribing specific activities, they encouraged the professor to adapt and combine recommendations to suit the course objectives. This characteristic is important because educational design requires balancing structured guidance with opportunities for contextual adaptation and innovation. In this sense, the guidelines functioned as catalysts for generating new ideas rather than as rigid instructions to be followed. Overall, these results provide evidence that LEDG contributes to the design of learner-centered educational experiences by expanding professors' pedagogical repertoire and encouraging the adoption of new teaching strategies, collaborative practices, and computational resources.

Acceptance of the Design Guidelines. The professor expressed a positive perception of LEDG, highlighting the adequacy of the guidelines for their intended purpose, the usefulness of the associated resource page, and the overall ease of use of the proposed materials. The professor also emphasized the organization of the guidelines, reporting that their structure facilitated exploration and application in educational activities. In addition, they reported feeling comfortable using the guidelines and expressed interest in reusing them in future teaching practices to generate new ideas and explore different computational resources. Evidence supporting these findings is presented in Table 6 (Q11 to 15).

The findings suggest that the design and organization of LEDG contributed to its acceptance. The professor found the guidelines easy to understand and navigate, suggesting that the artifact's structure reduced potential barriers to adoption. This aspect is particularly important because educational frameworks and teaching support materials are less likely to be incorporated into practice when they are perceived as overly complex, time-consuming, or difficult to understand. Another relevant finding concerns the complementary role of the resource page. Rather than functioning as an isolated repository, the resource page was perceived as an extension of the guidelines, providing support for their implementation. This integration helps to reduce the gap between understanding a recommendation and applying it in practice, which is often a challenge when using pedagogical frameworks. The results therefore suggest that combining conceptual guidance with concrete implementation support may facilitate professors' adoption of the guidelines.

The professor's intention to continue using the guidelines is also an important indicator of acceptance. Beyond expressing satisfaction with the artifact, the willingness to reuse it suggests that the professor valued its application and recognized its potential to support future educational activities. This perception is relevant because continued use is often associated with an intervention's practical usefulness and perceived benefits.

Contributions of the model evaluation stages: before, during, and after. The professor reported that each evaluation stage contributed distinct information about learners' experiences. The pre-evaluation revealed characteristics of the class, such as learners' preference for working individually and outside the classroom. During the activity, direct interactions with learners enabled the professor to identify difficulties, answer questions, and monitor group progress more closely. In the post-evaluation, the professor adapted the focus group procedure by incorporating questionnaires to provide greater privacy for learners who might feel uncomfortable expressing criticism in front of their peers. The professor also perceived that the evaluation process contributed to the development of LX elements throughout the activity. Evidence supporting these findings is presented in Table 6 (Q16 to 20).

The findings suggest that the three evaluation stages captured complementary aspects of LX that would likely have gone unnoticed if only a single assessment moment had been used. The pre-evaluation provided information about learners' preferences, expectations, and social characteristics, enabling the professor to better understand the context in which the educational activity would take place. This early understanding is necessary because LX begins before the activity itself and is influenced by prior perceptions, motivations, and concerns.

The evaluation conducted during the activity emerged as one of the most interesting stages from the professor's perspective. It created opportunities for interaction, support, and pedagogical intervention. The professor identified difficulties that might otherwise have remained hidden, especially among more reserved learners. This finding suggests that LEEM supports formative assessment practices by transforming evaluation into an ongoing process that informs instructional decisions and promotes continuous improvement of the educational experience.

The post-evaluation stage provided an opportunity to reflect on the experience after the activity's completion. The professor's decision to adapt the focus group by using questionnaires illustrates the importance of creating conditions that encourage honest feedback. By accommodating learners' social and emotional characteristics, the assessment process became more inclusive and increased the likelihood of obtaining authentic perceptions of the educational experience.

The combination of pre-evaluation, during-evaluation, and post-evaluation stages enabled the professor to understand learners' needs, intervene when necessary, and reflect on the activity's outcomes from multiple perspectives. Therefore, the model could provide a more comprehensive understanding of LX than approaches that rely exclusively on end-of-course assessments, while also supporting real-time actions to improve educational experiences.

Feedback on the amount of LEEM model evaluation. The professor raised concerns regarding the frequency of assessments and the potential loss of participant data when learners miss one of the evaluation stages. Although no complaints were reported by learners during the study, the professor acknowledged that questionnaires are not usually perceived as enjoyable and suggested that the spacing between assessments should be carefully considered, particularly in longer interventions. The professor also noted that learner engagement mitigated these issues in the study's context. Evidence supporting these findings is presented in Table 6 (Q21 to 24).

The findings highlight an important trade-off associated with the application of LEEM. On the one hand, collecting data at multiple stages enables a more comprehensive understanding of LX throughout the educational process. On the other hand, increasing the number of assessments may introduce practical challenges related to participation, response fatigue, and data completeness. This trade-off is common in longitudinal evaluations, where richer data collection often requires greater commitment from participants.

The professor's observations suggest that the effectiveness of LEEM depends on how it is integrated into the educational context. While the evaluation schedule adopted in this study did not elicit significant resistance among learners, the results indicate that longer activities may require adjustments to reduce participant burden and minimize the risk of data loss. Spacing assessments more evenly throughout the intervention may help maintain learner engagement while preserving the continuity of the evaluation process.

Importantly, these findings do not challenge the relevance of conducting evaluations before, during, and after educational activities. Instead, they reveal practical considerations that should guide the model's implementation across different contexts. The professor's feedback suggests that LEEM is feasible in educational settings, but that the frequency and timing of assessments should be adapted according to the duration and characteristics of the intervention. Overall, the results help refine the operational use of LEEM by identifying factors that may influence participation and data quality.

Suggestions for improvement and questions regarding the use of design guidelines. The professor suggested separating the guidelines into two categories: one specifically for educational activities and another for those guiding professors' behavior in the classroom. He noted that the guidelines on professor behavior raised questions about how to implement them in practice. Furthermore, he questioned whether the same guideline could influence more than one element of the LX. The professor emphasized the importance of clear explanations of resource use to facilitate appropriate selection for each guideline. Finally, the professor shared that a lack of familiarity with some resources prevented him from using them, as exploring them would take too much time. Evidence supporting these findings is presented in Table 6 (Q25 to 29).

The findings provide important information to refine LEDG. The professor's suggestions focused primarily on improving the organization and operationalization of the guidelines. This observation suggests that the conceptual foundations of LEDG were perceived as relevant, while opportunities remain to improve the guidelines' presentation and application in practice.

Another important finding concerns the practical use of computational resources. The professor's comments suggest that resource availability alone may not be sufficient to support guideline adoption. Lack of familiarity with certain technologies and the time required to explore them may discourage their use, particularly among professors with limited technological experience. This challenge was also identified during the LEDG feasibility study, indicating that implementation support remains an important aspect of the framework. Providing concise descriptions, examples of use, and explicit connections between resources and guidelines may help reduce the effort required for adoption while maintaining the LEDEF's practicality.

5.2 Ethical Considerations

This research adhered to the ethical principles established for research involving human participants. Initially, all participants were informed of the study's goals, procedures, and potential risks through the ICF to ensure understanding and voluntary participation. In advance, the potential discomfort the professor might experience when using the LEDG during the development of their practical work was acknowledged. To mitigate this risk, the guidelines were recommended for use in a flexible, adaptable manner, respecting the professor's specific educational goals. The professor was informed that answering all questions on the checklist was not mandatory and that they could withdraw from participation or skip any questions if they felt uncomfortable, tired, or unwilling to share certain information. In this way, respect for the participant's privacy, autonomy, and well-being was prioritized throughout the study.

The likelihood of discomfort was considered low, especially regarding the use of LEDEF, because the professor had the freedom to use it at different stages of the practical work (beginning, middle, and end) and autonomously chose both the timing and duration of the activity. This flexibility aimed to provide a more comfortable experience, aligned with the professor's routine and pedagogical planning. Various instruments were prepared to collect data ethically and responsibly. In addition to the ICF and the participant characterization questionnaire, specific materials were used to present LEDEF and guide its use in the classroom. Semi-structured interview scripts were developed to gain deeper insight into the professor's perceptions and experiences. For the interviews, a separate consent form was used to request authorization to use images and/or voice, ensuring that audiovisual recording was conducted only with explicit consent.

6 Limitations

Despite the progress and results achieved in this research, some limitations deserve highlighting. The SMS on LX design was conducted using publications through October 2021, and the search for the SMS on LX evaluation was conducted in June of the same year. The analysis of such a large volume of publications required considerable time, so that new contributions on technologies for evaluating and designing LX may have been published subsequently and were not considered in the SMSs.

Another limiting factor lies in the definition of LX elements. When the authors of the analyzed publications did not clearly describe the elements, they had to be inferred. To reduce interpretive bias, the advisor reviewed the inferences; however, interpretation is susceptible to bias, influenced by prior knowledge and experience in the field. This same challenge applies to the relationship between the elements of the LEDG and those that guide the LEEM's evaluation stages. To mitigate the influence of these biases, the proposal was submitted to expert and professor evaluations to assess its suitability to the reality of learners before its implementation in a real-world scenario. This validation and evolution process sought to ensure the robustness of the developed methodologies and artifacts.

Another challenge is the complexity of interpreting learners' perceptions from self-reports, underscoring the importance of the professor considering both learners' preferences and educational objectives when planning resource use. The aesthetics or simplicity of a resource may be attractive to the learner, but it is not always the best pedagogical option. Furthermore, learners' perceptions tend to evolve over time and through interactions, requiring the professor to integrate feedback and continuous adjustments into the LX evaluation process. The accuracy of learners' self-reports represents another limitation. For example, shy learners may self-report as participative. Thus, it is recommended to complement these self-reports with direct observations or assessments during the activity, as suggested by LEDEF, to improve the reliability of the data.

Given the challenge of conducting detailed observations in large classes with a single professor, the assessment model proposes a simplified in-class checklist that is more intuitive than detailed observations. It also allows for group assessments as an alternative for scenarios where an intermediate or more comprehensive analysis is not feasible. The need for flexibility in the LEEM model is another limitation, given the different assessments. In this sense, the model provides the professor with options for selecting methods and steps that best meet the class's needs and educational objectives. Structured in pre-evaluation, during-evaluation, and post-evaluation phases, the professor can choose which steps to follow. Finally, an additional limitation is the lack of studies applied to more complex and larger classes, which prevents a detailed analysis of the model's scalability. Additionally, computational resources, including Artificial Intelligence (AI), can be used to support large classes. AI can automate administrative tasks, such as initial data collection and analysis, and provide real-time feedback, allowing professors to dedicate more time to pedagogical monitoring and learner interactions. This technological integration can alleviate the professor's workload, making the assessment process more efficient.

Expert comments also highlighted LEEM's role in group formation, even though its focus is not on deepening collaborative learning. LEEM suggests that learner preferences, such as the option to work individually or collaboratively, be collected during the pre-evaluation. Although it is an initial reference for group formation, factors such as prior knowledge and personality traits are also relevant. Thus, the use of LEEM in group formation can be explored in future research to develop specific and effective collaboration guidelines. Regarding the LEDG guidelines, it was observed that, despite their potential to improve teaching, their application requires more than access to technological tools. Institutional support that alleviates professors' workload, including time for planning and technological training, is essential. Ongoing professional development initiatives are also important for professors to acquire the skills and time necessary to implement the guidelines, minimizing the repetition of traditional practices.

Another identified limitation was the need for a more in-depth analysis of the results, considering different educational contexts. Furthermore, the lack of dialogue with other education professionals, such as pedagogues, psychologists, and administrators, is a significant limitation, since decisions regarding the application of the guidelines do not depend exclusively on the professor but also on management, which allows for greater flexibility. It is also necessary to coordinate with basic education, which follows the BNCC guidelines, to implement the use of computational resources at this level. Finally, it was identified that each subject's context directly influences the choice and application of the guidelines. Therefore, it is emphasized that the LEDG need not be used in its entirety. Dividing the guidelines into categories allows professors to select those most appropriate to the specific needs of their subject, facilitating a gradual implementation adapted to the realities of each activity.

7 Conclusion and Future Work

This research presents a framework for the design and evaluation of LX to support educational professors and LX designers. This work addressed the research question: "How to design and evaluate LX, considering the appropriate elements and technologies to support educational experiences?". To achieve this purpose, a LEDEF was developed as part of this research. The LEDEF focuses on these two stages of the LX lifecycle and links them to other stages, such as planning, application, and redesign, to facilitate the gradual inclusion of elements and technologies. These choices are the professor's responsibility and can be informed by a pre-evaluation or prior experience with learners. LEDEF provides a structure, but its process is flexible, granting the professor the autonomy and adaptability needed to accommodate the specifics of the activity and class.

It was observed that the use of LEDEF expanded the professor's awareness of the importance of intentionally planning every aspect of the activity, thereby favoring well-founded decision-making and the continuous improvement of educational practice. The professor also came to perceive more clearly the impact of the design guidelines on learners' motivation, engagement, and autonomy.

Among the main learnings, the importance of balancing the freedom granted to learners (such as the choice of tools and the timing for carrying out activities) with the provision of continuous support stands out. The professor realized that providing clear guidance, frequent feedback, and accessible channels for expression, including for more reserved learners, contributed to a more satisfactory and inclusive experience. Moreover, the systematic evaluation of the activity proposed by LEDEF enabled relevant adjustments throughout the process, making the teaching action more responsive to learners' real needs.

Another relevant result was the LEDEF framework's flexibility, which enabled the incorporation of new guidelines throughout the activity, promoting an adaptable pedagogical practice sensitive to classroom observations. The comparison with approaches that apply LX design in a punctual way, without a continuous evaluation cycle, reinforced LEDEF's contribution as an integrated model for LX design and evaluation.

The novelty of this research lies in presenting a framework guided by LX elements that facilitates adapting educational activities to account for ongoing changes in learner profiles and the educational landscape. LEDEF's ability to incorporate new guidelines and technologies as experiences unfold provides a dynamic approach that enriches the framework, keeping it up to date and relevant throughout the educational process. Although LEDEF's guidelines are geared towards the use of computational resources, those that do not involve usability aspects can be applied without these resources, leaving it to the professor's discretion to adapt them to the target audience's needs. This work invites higher education professors to reflect on their practices. While there is a more evident effort and deeper discussion of the use of computational resources in basic education, higher education lacks investment and debate on these issues.

Despite the contributions, some limitations should be considered. The systematic review included studies only up to mid-2021. Identifying LX elements in publications with unclear descriptions requires author inference, which is subject to bias, even when reviewed by experts. Understanding learners' perceptions solely from self-reports may compromise data reliability; LEDEF recommends triangulation with direct observations to mitigate this limitation. Moreover, the feasibility and evaluation studies involved relatively small samples of professors and learners, whose profiles (e.g., experience with computational resources, educational context, and prior exposure to LX design) may not fully represent the broader population. Therefore, the results cannot be generalized. Additionally, LEDEF's scalability may be constrained in large or highly heterogeneous classes, and the framework's adoption could require investment in professor training and preparation, particularly in diverse or resource-limited educational settings.

Future work may focus on adapting the LEDEF to better support inclusive education by accounting for diverse learner profiles, such as neurodivergent learners and those with disabilities. Investigating the automation of LEDEF using AI tools could reduce professors' workload by providing real-time feedback and optimizing the planning and evaluation processes. Expanding training initiatives for educators, especially through hybrid or online formats, can broaden adoption and foster practical engagement with the framework. Additionally, new experimental studies are needed to validate LEDEF on larger and more heterogeneous classes to assess its scalability.

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References

Arachchi, T. K., Sitbon, L., & Zhang, J. (2017). Enhancing access to elearning for people with intellectual disability: Integrating usability with learning. *Human-Computer Interaction-INTERACT 2017: 16th IFIP TC 13 International Conference, Mumbai, India, September 25-29, 2017, Proceedings, Part II 16*, 13–32. https://doi.org/10.1007/978-3-319-67684-5_2 [GS Search].

Bevan, N., Carter, J., Earthy, J., Geis, T., & Harker, S. (2016). New iso standards for usability, usability reports and usability measures. *Human-Computer Interaction. Theory, Design, Development and Practice: 18th International Conference, HCI International 2016, Toronto, ON, Canada, July 17-22, 2016. Proceedings, Part I 18*, 268–278. https://doi.org/10.1007/978-3-319-39510-4_25 [GS Search].

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa [GS Search].

Bulcão, J. d. S. B., Madeira, C. A. G., Guimarães, C. A. S., & de Sousa, C. A. (2021). Capacitando professores no programa norte-rio-grandense de pensamento computacional. *Revista Brasileira de Informática na Educação*, *29*, 1178–1201. https://doi.org/10.5753/rbie.2021.2120 [GS Search].

Caldiera, V. R. B. G., & Rombach, H. D. (1994). The goal question metric approach. *Encyclopedia of software engineering*, 528–532. [GS Search].

Campos, T. P. D., Damasceno, E. F., & Valentim, N. M. C. (2022). Porifera: A collaborative tool to support systematic literature review and systematic mapping study. *Proceedings of the XXXVI Brazilian Symposium on Software Engineering*, 452–457. https://doi.org/10.1145/3555228.355527 [GS Search].

Capuano, N., Pierri, A., Colace, F., Gaeta, M., & Mangione, G. R. (2009). A mash-up authoring tool for e-learning based on pedagogical templates. *Proceedings of the first ACM international workshop on Multimedia technologies for distance learning*, 87–94. https://doi.org/10.1145/1631111.1631126 [GS Search].

Dewey, J. (1986). Experience and education. *The educational forum*, *50*(3), 241–252. https://doi.org/10.1080/00131728609335764 [GS Search].

dos Santos, G., Silva, D., Peres, L. M., & Valentim, N. M. C. (2024). Case study of a model that evaluates the learner experience with dicts. *Extended Abstracts of the CHI Conference on Human Factors in Computing Systems*, 1–9. https://doi.org/10.1145/3613905.363713 [GS Search].

dos Santos, G., Silva, D., & Valentim, N. (2025). Learner experience evaluation: A feasibility study and a benchmark. *Journal of the Brazilian Computer Society*, *31*(1), 132–153. https://doi.org/10.5753/jbcs.2025.4306 [GS Search].

dos Santos, G., Silva, D. E., & Valentim, N. M. (2023a). Feasibility study of a model that evaluates the learner experience: A quantitative and qualitative analysis. *XXII Simpósio Brasileiro sobre Fatores Humanos em Sistemas Computacionais*, 1–11. https://doi.org/10.1145/3638067.36381 [GS Search].

dos Santos, G., Silva, D. E., & Valentim, N. M. (2023b). Proposal and preliminary evaluation of a learner experience evaluation model in information systems. *Proceedings of the XIX Brazilian Symposium on Information Systems*, 308–316. https://doi.org/10.1145/3592813.3592919 [GS Search].

dos Santos, G., Silva, D. E. d. S., Peres, L. M., & Valentim, N. M. (2024). Acceptance analysis of a learner experience evaluation model. *Simpósio Brasileiro de Informática na Educação (SBIE)*, 1057–1070. https://doi.org/10.5753/sbie.2024.241385 [GS Search].

dos Santos, G., Silva, D. E. d. S., & Valentim, N. M. (2022). Um mapeamento sistemático da literatura sobre iniciativas que avaliam a experiência do aprendiz. *Anais do XXXIII Simpósio Brasileiro de Informática na Educação*, 621–633. https://doi.org/10.5753/sbie.2022.224673 [GS Search].

El Mawas, N., Tal, I., Moldovan, A.-N., Bogusevschi, D., Andrews, J., Muntean, G.-M., & Muntean, C. H. (2020). Investigating the impact of an adventure-based 3d solar system game on primary school learning process. *Knowledge Management & E-Learning: An International Journal*, *12*(2), 165–190. https://doi.org/10.34105/j.kmel.2020.12.009 [GS Search].

Georgiou, Y., & Ioannou, A. (2021). Developing, enacting and evaluating a learning experience design for technology-enhanced embodied learning in math classrooms. *TechTrends*, *65*(1), 38–50. https://doi.org/10.1007/s11528-020-00543-y [GS Search].

Granić, A., & Ćukušić, M. (2007). Universal design within the context of e-learning. *Universal Access in Human-Computer Interaction. Applications and Services: 4th International Conference on Universal Access in Human-Computer Interaction, UAHCI 2007 Held as Part of HCI International 2007 Beijing, China, July 22-27, 2007 Proceedings, Part III 4*, 617–626. https://doi.org/10.1007/978-3-540-73283-9_68 [GS Search].

Huang, R., Hu, Y., & Yang, J. (2015). Improving learner experience in the technology rich classrooms. *Ubiquitous learning environments and technologies*, 243–258. https://doi.org/10.1007/978-3-662-44659-1_13 [GS Search].

Huang, R., Spector, J. M., & Yang, J. (2019). *Educational technology a primer for the 21st century*. Springer. https://doi.org/10.1007/978-981-13-6643-7 [GS Search].

Kitchenham, B. A., Budgen, D., & Brereton, P. (2016). Evidence-based software engineering and systematic reviews. [GS Search].

Magyar, N., & Haley, S. R. (2020). Balancing learner experience and user experience in a peer feedback web application for moocs. *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*, 1–8. https://doi.org/10.1145/3334480.337523 [GS Search].

Martin, C., Hughes, J., & Richards, J. (2017). Learning dimensions: Lessons from field studies. *Proceedings of the 2017 ACM Conference on Innovation and Technology in Computer Science Education*, 299–304. https://doi.org/10.1145/3059009.305904 [GS Search].

Melo, A. A. S., & Oliveira Junior, R. (2025). Base nacional comum curricular de computação (bncc computação) na conferência nacional de educação (conae 2024). *Revista Brasileira de Informática na Educação*, *33*, 672–691. https://doi.org/10.5753/rbie.2025.4642 [GS Search].

Miller, B. (2014). Six dimensions of learner experience design. *Retrieved March*, *18*, 2026. [GS Search].

Monib, W. K., Qazi, A., & Mahmud, M. M. (2024). Exploring learners' experiences and perceptions of chatgpt as a learning tool in higher education. *Education and Information Technologies*, *30*(1), 917–939. https://doi.org/10.1007/s10639-024-13065-4 [GS Search].

Ortiz, J., Junior, D. S., Oliveira, C. M., & Pereira, R. (2019). Pensamento computacional e cultura digital: Discussões sobre uma prática para o letramento digital. *Brazilian Symposium on Computers in Education (Simpósio Brasileiro de Informática na Educação-SBIE)*, *30*(1), 1241. https://doi.org/10.5753/cbie.sbie.2019.1241 [GS Search].

Papavlasopoulou, S., Giannakos, M. N., & Jaccheri, L. (2019). Exploring children's learning experience in constructionism-based coding activities through design-based research. *Computers in Human Behavior*, *99*, 415–427. https://doi.org/10.1016/j.chb.2019.01.008 [GS Search].

Pawson, R., & Tilley, N. (2001). Realistic evaluation bloodlines. *American Journal of Evaluation*, *22*(3), 317–324. https://doi.org/10.1177/109821400102200305 [GS Search].

Petersen, K., Vakkalanka, S., & Kuzniarz, L. (2015). Guidelines for conducting systematic mapping studies in software engineering: An update. *Information and software technology*, *64*, 1–18. [GS Search].

Pimentel, M., Filippo, D., & Santoro, F. M. (2019). Design science research: Fazendo pesquisas científicas rigorosas atreladas ao desenvolvimento de artefatos computacionais projetados para a educação. *Metodologia de Pesquisa em Informática na Educação: Concepção da Pesquisa. Porto Alegre: SBC*. [GS Search].

Recke, M. P., Perna, S., & Pereira, T. G. (2021). Designing narratively driven learning activities for blended learning experiences. *2021 9th International Conference on Information and Education Technology (ICIET)*, 171–177. https://doi.org/10.1109/ICIET51873.2021.9419659 [GS Search].

Santos, G., & Valentim, N. (2025). Percepções e experiências sobre o ensino e aprendizado de uma disciplina de ihc com foco em práticas colaborativas. *Anais do Simpósio Brasileiro sobre Fatores Humanos em Sistemas Computacionais (IHC)*, 173–195. https://doi.org/10.5753/ihc.2025.10847. [GS Search].

Schmidt, M., & Huang, R. (2022). Defining learning experience design: Voices from the field of learning design & technology. *TechTrends*, *66*(2), 141–158. https://doi.org/10.1007/s11528-021-00656-y [GS Search].

Shi, L. (2014). Defining and evaluating learner experience for social adaptive e-learning. *Imperial College Computing Student Workshop*. https://doi.org/10.4230/OASIcs.ICCSW.2014.74 [GS Search].

Silva, Conte, T., & Valentim, N. (2024). A systematic mapping study about learner experience design in computational systems. *Informatics in Education*, *23*(2), 439–478. https://doi.org/10.15388/infedu.2024.12 [GS Search].

Silva, Conte, & Valentim, N. M. C. (2024). Learner experience design guidelines: Proposal and a preliminary evaluation with experts. *Simpósio Brasileiro de Informática na Educação (SBIE)*, 2922–2930. https://doi.org/10.5753/sbie.2024.244888 [GS Search].

Silva, D., Conte, T. U., Guerino, G. C., & Valentim, N. M. C. (2025). From design to evaluation: A case study on learner experience. *20th IFIP TC13 International Conference on Human-Computer Interaction (Interact) - accepted for publication*. https://doi.org/10.1007/978-3-032-05002-1_22 [GS Search].

Silva, D., Guerino, G., & Valentim, N. (2022). Ensino remoto emergencial da disciplina ihc experimental: Uma análise baseada na experiência do aprendiz. *Anais do XXX Workshop sobre Educação em Computação*, 215–226. https://doi.org/10.5753/wei.2022.222577 [GS Search].

Silva, D., Guerino, G. C., & Valentim, N. M. (2023). Analyzing the learners' experience of an experimental hci course in a remote context. *Journal on Interactive Systems*, *14*(1), 341–353. https://doi.org/10.5753/jis.2023.3243 [GS Search].

Silva, D. E., Sobrinho, M. C., & Valentim, N. M. (2020). Educação 4.0: Um estudo de caso com atividades de computação desplugada na amazônia brasileira. *Anais do Computer on the Beach*, *11*, 141–147. https://doi.org/10.14210/cotb.v11n1.p141-147 [GS Search].

Silva & Valentim, N. M. C. (2023). Projeto e avaliação da experiência do aprendiz em sistemas computacionais. *Simpósio Brasileiro de Educação em Computação (EDUCOMP)*, 36–37. https://doi.org/10.5753/educomp_estendido.2023.229055 [GS Search].

Soares, L. E., Clementino Júnior, J. M., Brito, L. A. V., Gonzaga, R. G., Antico, H. A., Azevedo, R. J. d., & Macedo, A. A. (2023). Usabilidade dos ambientes virtuais de aprendizagem canvas e blackboard: Caso de estudo em uma universidade brasileira. *Revista Brasileira de Informática na Educação*, *31*, 149–173. https://doi.org/10.5753/rbie.2023.2921 [GS Search].

Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision sciences*, *39*(2), 273–315. https://doi.org/10.1111/j.1540-5915.2008.00192.x [GS Search].

Yates, J., Davidson, C. A., Orchard, T., Burke, S. M., & Mantler, T. (2026). "i watched my child become half of the person they were": Emergency remote learning experiences among primary caregivers of elementary school children during the covid-19 pandemic. *Journal of Education*, *206*(1), 60–71. https://doi.org/10.1177/00220574251349795 [GS Search].

Zhang, D., Yang, Y., Ji, T., Xie, H., & He, Y. (2018). Designing craft learning experience for rural children: A case study on huayao cross-stitch in southwest china. *Cross-Cultural Design. Applications in Cultural Heritage, Creativity and Social Development: 10th International Conference, CCD 2018, Held as Part of HCI International 2018, Las Vegas, NV, USA, July 15-20, 2018, Proceedings, Part II 10*, 117–132. https://doi.org/10.1007/978-3-319-92252-2_9 [GS Search].

Appendix 1

- Appendix A (LEDG) https://sites.google.com/view/lexdg/home
- Appendix B: (LEEM) https://figshare.com/s/c413a259aa038535edcd
- Appendix C: (SMS on Design LX) https://figshare.com/s/3eb8195b1715f596c883
- Appendix D: (SMS on Evaluation LX) https://figshare.com/s/57a28e783af82620ce13
- Appendix E: (Versioning of the LEDG) https://dx.doi.org/10.6084/m9.figshare.23699250