Informatics in Education, 2024, Vol. 23, No. 2, 439–478

DOI: 10.15388/infedu.2024.12

A Systematic Mapping Study about Learner Experience Design in Computational Systems

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Received: June 2023

Abstract. Contemporary society is characterized by diversity and intricacy, necessitating more meaningful learning experiences. To meet these evolving needs, the incorporation of computational systems into education must acknowledge the distinctive characteristics of learners. Therefore, we conducted a Systematic Mapping Study (SMS) to investigate technologies that support the Learner eXperience (LX) design in computational systems. LX refers to learners' perceptions, reactions, and achievements while engaging with learning resources, encompassing digital games, simulations, and multimedia. The SMS results uncovered distinct LX design technologies, with a noticeable inclination towards learner-centric strategies. Interestingly, the results highlighted a scarcity of research targeting non-traditional learning environments (e.g., technical visits) and that facilitate interactions among learners beyond their own classmates (e.g., industry experts). In this way, the SMS contributes by revealing LX design technologies, LX design elements, relevant constructs/theories, computational systems, environments, contexts, and other related factors, thereby enhancing the understanding of optimal learning experiences within computational learning systems.

Keywords: Learning eXperience Design, Learner eXperience, LX design elements, Computational systems.

1. Introduction

Computational systems have gained global recognition and prominence in various educational domains, captivating the attention of teachers and researchers (Queiros *et al.*, 2019). However, it is important to note that just the utilization of these resources does not ensure substantial learning outcomes, as emphasized in the report by the Organization for Economic Cooperation and Development. (Peña-López *et al.*, 2015). Therefore, it is crucial to persistently explore ways to leverage them effectively (Silveira and Villalba-Condori, 2018). Such exploration entails considering the context and actual needs of learners and teachers in the use of computational systems.

Lesson planning for the utilization of computational systems can pose challenges for teachers. This complexity arises because the majority of the proposed tools and resources are not created by the teachers themselves but rather by learning designers or researchers (Queiros *et al.*, 2019). However, with proper support, it is indeed feasible to plan meaningful experiences both inside and outside the classroom, by integrating diverse educational resources. Consequently, one approach to facilitate the planning of such learning experiences is through the application of Learner eXperience (LX) design principles in the context of computational systems.

LX is defined as the perceptions and responses of learners that arise from their actual or anticipated use of a system. This includes their behaviors, attitudes, sensations, emotional responses, and more (Shi, 2014). LX design, in turn, is a process of providing support to learners as they engage in activities that may initially be beyond their current capabilities (Soloway *et al.*, 1996). As learners repeat these activities, they gradually develop proficiency, allowing for a reduction or complete withdrawal of support (Plotzky *et al.*, 2021). LX design can be employed to design learning activities, learning units, and even learning computational systems (Queiros *et al.*, 2019).

Huang *et al.* (2019) demonstrate that LX can be designed and enhanced by incorporating key elements. These elements include: (1) Usability: This pertains to the ease of use and learning of the computational system. It focuses on ensuring that the system is user-friendly and facilitates efficient interaction and navigation; (2) Adaptability: This refers to accommodating the diverse needs and preferences of learners through the computational system. It aims to provide personalized learning experiences that cater to individual learning styles and requirements; (3) Comfortability: This relates to the feeling of physical and emotional well-being experienced when using the computational system. It emphasizes creating a supportive and enjoyable learning environment that minimizes stress and fosters a positive emotional state; (4) Desirability: This encompasses the attractiveness and engagement of the computational system. It focuses on creating a pleasant perception of using the system, encouraging learners' motivation and sustained engagement; and (5) Value: This refers to the positive or negative responses resulting from changes and adaptations in the use of computational systems. It aims to maximize the benefits and value derived from the system while minimizing any negative impacts or challenges. By considering these elements during the design process, LX can be effectively enhanced, leading to improved learner experiences and outcomes.

The adoption of technologies that support LX design, including approaches, models, techniques, and guidelines, is crucial. These LX design technologies can assist in designing the elements of computational systems, as well as in defining the steps and activities for utilizing these resources. Moreover, the LX design provides the necessary support to incorporate a variety of learning resources while considering the diversity of learners and their actual needs. In this way, LX design becomes highly relevant as it enables the creation of improved learning experiences.

Therefore, the aim of our article is to present a Systematic Mapping Study (SMS) that investigates LX design technologies with computational systems. The main research question of this SMS is: "What technologies are utilized in the LX design that considers computational systems". Additionally, the study addresses several sub-questions, including the type of contribution (e.g., model, approach, or process), the type of resource (system and/or steps/activities), the educational environment (traditional or nontraditional settings), learner participation (individual or collaborative), and the elements of LX. Our SMS follows the guidelines proposed by Kitchenham *et al.* (2016), which include research questions, goals, the definition of data sources, search string, inclusion and exclusion criteria, data extraction strategy, and synthesis methodology.

In this SMS, 45 publications were selected and analyzed. The findings revealed the existence of 12 types of LX design technologies, with a predominant focus on approaches. There was a balanced distribution of technologies targeting both generic and specific educational contexts, indicating a need for more generic proposals that can be widely applied due to the diverse nature of learners. Moreover, most of the identified technologies utilized both steps/activities and computational systems to support LX design, resulting in a more dynamic and comprehensive process. The majority of the publications extracted qualitative data, which can be attributed to the fact that qualitative analysis help in understanding the reasons behind learners' responses. However, combining quantitative and qualitative analyses can be a beneficial approach for researchers, as it provides a broader range of data to be examined and allows for a more comprehensive understanding of the subject.

Overall, this article makes valuable contributions to professors, researchers, and learning designers by providing insights into the application of LX design in computational systems. For teachers, the SMS findings offer opportunities to foster activities in nontraditional learning environments, allowing learners to experience new contexts and observe practical applications of the concepts they are studying. Additionally, the SMS highlights the potential for teachers to facilitate new learning relationships through dialogue between learners and industry professionals, parents, or more experienced classmates, enabling valuable experiences through the exchange of knowledge and experiences. For researchers, the SMS serves as a foundation for the development of new LX design technologies. It provides avenues for conducting tests and evaluations of these technologies, allowing for adaptations and improvements based on specific research objectives. Researchers can also analyze the elements of LX both qualitatively and quantitatively to explore their impact on learning outcomes. For LX designers, the SMS offers a wide range of components that can be selected, utilized, and combined in the development of learning strategies. This includes types of computational systems, sequences of steps and activities, learning support mechanisms, and considerations of LX elements. Ultimately, learners are the primary beneficiaries, as LX design approaches centered around their needs and interests enable authentic and meaningful learning experiences.

The article follows the following organizational structure: Section 2 discusses previous research and studies relevant to LX design and computational systems; Section 3 details the methodology and structure of the SMS; Section 4 presents the findings and outcomes of the SMS, including the identified LX design technologies; Section 5 analyzes and interprets the SMS results, highlighting key insights and implications; Section 6 acknowledges limitations or constraints encountered during the study; and Section 7 summarizes the main findings, draws conclusions, and suggests directions for future research.

2. Related Work

The computational systems in education pose various challenges for teachers, particularly when it involves a diverse group of learners participating in the same activity. Hence, when developing computational systems for educational purposes, it is essential to consider the contextual factors and the actual learning needs of the learners. In this regard, the utilization of LX design technologies and elements becomes crucial, as they enable the creation of novel learning experiences through these resources.

Queiros *et al.* (2019) conducted a Systematic Literature Review focusing on the benefits and limitations of adopting Learning Design in the planning phase of teaching practice. The review utilized the IEEE Xplore Digital Library as the search engine. From the initial search, 87 publications were returned, but only two were considered relevant for inclusion in the analysis. To supplement the automated search, the snowballing technique was also employed, leading to the inclusion of six additional publications for data extraction and analysis. The eight publications identified in this review were published between 2001 and 2018. The review highlighted two significant benefits associated with learning design: interoperability and reusability of generated artifacts, which ensure the use of effective and best practices across different learning environments. However, one limitation identified in the studies was the need for tools to have suitable interfaces and resources that align with the profiles of teachers, despite having good usability. Most of the eight publications tended to present specifications and examples of lesson plans, but there was a lack of evidence regarding the practical implementation and effectiveness of these resources by teachers and specialists. Therefore, there is a need for effective practical use to determine the actual use of these learning design resources. In conclusion, the results indicated that positive experiences enable teachers to reflect on the appropriate use of resources and media in the classroom, emphasizing the importance of practical application and ongoing evaluation of learning design approaches.

In Duque *et al.* (2019), a Systematic Literature Review was conducted to investigate the application of User-Centered Design and Participatory Design methods in the development of applications for elderly learning. The researchers utilized multiple search engines, including IEEE Xplore, ACM Digital Library, and Science Direct. Articles published between 2013 and 2018 were considered for inclusion. Out of the 166 articles initially identified, 51 articles directly contributed to answering the research questions posed in the study. The following research questions were defined: (1) Why is the application of User-Centered Design and Participatory Design important for older people? (2) How was User-Centered Design and Participatory Design conducted in the context of elderly learning applications? (3) What future work is suggested in this area? The results of the review revealed the potential of older adults not only as users of devices and applications but also as active co-creators who can actively participate and influence the design process, from idea generation to prototype testing. The study highlighted the importance of User-Centered Design and Participatory Design in involving older adults in the development process, often requiring workshops or group activities to facilitate their participation. However, the review acknowledged that gathering all elderly participants in one physical location might not always be feasible due to factors such as complex mobility issues or the preferences of older adults to stay at home. Consequently, the authors emphasized the need for studies that propose activities enabling the participation and interaction of elderly individuals, even when geographically separated. Overall, the findings of this review highlight the significance of User-Centered Design and Participatory Design in including older adults as active contributors in the development of applications for their learning needs, while also recognizing the challenges and suggesting future directions for research in this domain.

In Bragg *et al.* (2021), a Systematic Literature Review was conducted to explore Online Professional Development practices for teachers. Several search engines were employed, including Academic One File, Emerald Insight, ERIC ProQuest, Informit A + Education, MathSciNet, SAGE, Scopus, Web of Science, EBSCO Information Services, and Google Scholar. Of the 6028 articles returned, only 11 were selected for data extraction and analysis. The articles included in the review were published between 2010 and 2019. The review by Bragg *et al.* (2021) focused on identifying design elements related to practical programs and programs that foster engagement between peers or facilitators in Online Professional Development for teachers. The authors observed that programs incorporating practical and authentic activities in their learning materials tended to yield better outcomes. Interestingly, the review did not identify any publications discussing design elements such as student support or program length. The absence of these elements in the reviewed publications is considered a limitation of the review. The authors note that discussions on design elements are typically found in the fields of Learning Design, User Experience, or Learning Experience Design. However, these terms were not included in the search string used in this particular study. Overall, this review provides insights into Online Professional Development practices for teachers and highlights the importance of incorporating practical and authentic activities in Online Professional Development programs. The limitations of the study suggest opportunities for future research and emphasize the relevance of considering design elements from related fields to enrich the understanding of OPD design in the context of teacher professional development.

Plotzky *et al.* (2021) conducted a Systematic Literature Review that focused on educational simulations of Nursing in Virtual Reality and their potential application in LX design. The review involved several search engines, including Scopus, Cochrane Library, MEDLINE via PubMed, CINAHL, PsycINFO, PSYNDEX, PsycARTICLES, and ERIC (the last five via EBSCO host). Initially, a total of 13945 publications were identified, of which 8925 were duplicates. After screening, 22 papers were included for data analysis. The review considered papers published between 2014 and 2020. The review identified innovative approaches to the learning experience through the use of educational simulations in Virtual Reality. For instance, one of the identified simulations focused on allowing learners to experience what it is like to live with dementia, with the goal of teaching empathy. These simulations provide learners with gradual training, enabling the transformation of theoretical knowledge into practical skills. As learners become more proficient, certain features of the simulations can be removed.

Furthermore, the review highlighted the potential of Virtual Reality in improving existing simulation methods. Virtual Reality technology offers enhanced immersion and realism, providing learners with a more engaging and authentic learning experience in the field of Nursing. The findings of this review suggest that educational simulations in Virtual Reality can significantly contribute to the LX design in Nursing education. By incorporating immersive and interactive experiences, these simulations have the potential to enhance the acquisition of practical skills and promote a deeper understanding of complex nursing concepts and scenarios.

It is clear from the mentioned Systematic Literature Reviews that each study focused on specific aspects of LX design technologies in particular educational contexts, such as e-learning, elderly learning, online professional development, and nursing education. While these studies provided valuable insights into the application of LX design in those specific domains, there seems to be a lack of research that comprehensively explores different computational systems, elements, and technologies for supporting LX design in a broader sense. To address this gap, the SMS proposed aims to provide a more generic contribution by examining the state of the art on studies that address LX design technologies in various learning contexts. By conducting a systematic mapping of the existing literature, the SMS will gather relevant information on the different technologies used in LX design and their application in diverse educational settings. This comprehensive review will not only contribute to the understanding of LX design technologies but also support the creation of educational activities and the development of learner-centered software. By identifying and analyzing the existing research, the SMS can provide valuable insights and guidelines for teachers, researchers, and learning designers in designing effective and engaging learning experiences that cater to the diverse needs of learners in different contexts.

3. Systematic Mapping Study

By following the guidelines proposed by Kitchenham *et al.* (2016) and Petersen *et al.* (2015), the SMS protocol was designed to ensure a systematic and comprehensive review of the relevant literature. The SMS aimed to identify and characterize LX design technologies in computational systems. By following established guidelines, the online collaborative tool Porifera was utilized that can assist in data collection, organization, and analysis (Campos *et al.*, 2022). By using the Porifera tool, the researchers were able to collect and organize data efficiently, facilitating the analysis and synthesis of the research findings. This SMS provides an overview of the research area, including the quantity and types of research available, as well as the results obtained.

3.1. *Goal*

The SMS goal was organized according to the Goal-Question-Metric (GQM) paradigm (Caldiera and Rombach, 1994), as seen in Table 1.

Table 1
SMS goal according to GQM paradigm

Analyze	scientific publications
For the purpose of	characterize
With respect to	Learner eXperience (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

The use of the term "technology" in the SMS as a synonym for "technique" is a valid approach. In educational contexts, the term "technology" can refer to a wide range of tools, artifacts, procedures, techniques, and methodologies that are used to support teaching and learning activities. This inclusive definition recognizes that technology encompasses more than just digital or electronic devices, but also encompasses any resource or method used to facilitate educational processes. By adopting a broad definition of technology, the SMS can explore a wide range of approaches, models, techniques, and guidelines that are relevant to LX design in computational systems. This allows for a comprehensive analysis of the various technologies used in the field and provides a more holistic understanding of their impact on learning experiences. The reference to Verasztо *et al.* (2009) and Santos *et al.* (2012) supports the notion that the term "technology" can be used as a generalization for different types of tools, techniques, and methodologies. This flexibility in the definition enables the SMS to capture the diversity of LX design technologies and their applications in different educational contexts.

3.2. *Research Questions*

The main question of this SMS is "What technologies are utilized in the LX design that considers computational systems?". Therefore, it is expected to understand the elements foreseen in the LX design, including the main characteristics and context of this experience. To answer the main question, sub-questions (SQs) and possible answers were created to facilitate the classification of technologies, as listed in Table 2.

3.3. *Search Strategy*

For this SMS, a predefined search strategy was employed, encompassing the search scope (search sources) and search terms (search string). This strategy was designed to maintain the integrity of the research, minimize bias, and maximize the number of sources examined. The search strategy is presented below.

Table 2
Research sub-questions

Sub-questions		Sample answers
SQ1.	The publication addresses what kind of LX design technology?	Model, Approach, Process, Framework, Method, Guidelines, among others
SQ2.	Which theory/construct supports the LX design?	Constructionism, Constructivism, Bloom's Taxonomy, among others
SQ3.	What type of resource was used to support the LX design?	Sequence of steps/activities, Computational System or Both
SQ3.1	What steps/activities are used to support the LX design?	This question is subjective and varies from publication to publication
SQ3.2	What computational systems were used in the LX design?	Robotics, Digital Games, Virtual Learning Environments (VLE), among others
SQ3.3	Was there support for the learner in using the computational system in the LX design?	Yes or no
Q4.	SWhat learning environment is the LX designed for?	Traditional (such as a classroom) or Nontraditional (such as technical visit, among others)
SQ5.	What is the learner's role in the LX design?	Learners, Teachers, among others
SQ5.1	What is the level of education at which the LX design takes place?	Elementary School, High School, Graduation, and Post-graduation
SQ5.2	How was the learner's participation in the LX design?	Individual, Collaborative or Both
SQ6.	What LX elements were considered in the LX design?	Adaptability, Value, Empowerment, Motivation, Skills, among others
SQ6.1	How does the construction of the LX design elements occur	This question is subjective and varies from publication to publication
SQ7.	Was there an empirical study to evaluate the LX design technology?	Yes or No
SQ7.1	What types of studies were considered in the LX design?	Case Study, Observation Study, Survey, among others
SQ7.2	What types of analyzes were performed in the LX design?	Quantitative, Qualitative or Both
SQ8.	In what context can LX design technology be used?	Generic (e.g., for any course) or Specific (e.g., for a specific course)

3.3.1. *Search Scope*

The defined search string was applied to the following digital libraries ACM Digital Library[1], IEEE Xplore[2], Science Direct[3] and Springer Link[4]. ACM Digital Library specializes in publications in the field of Computing, while IEEE Xplore covers Engineering,

[1] https://dl.acm.org/
[2] https://ieeexplore.ieee.org/Xplore/home.jsp
[3] https://www.sciencedirect.com/
[4] https://link.springer.com/

Computing, Information Technology, and other related areas. Science Direct comprises a wide collection of publications in Physical Sciences and Engineering, spanning various disciplines, and Springer Link provides an extensive collection of scientific, technological, and reference works. By utilizing these digital libraries, the aim was to find relevant publications in the field of Computing while also considering the possibility of uncovering interdisciplinary studies. Unfortunately, ERIC[5] was not included in the search, as access was unavailable during the data collection period for this SMS. Additionally, Scopus[6] did not permit the submission of the search string in advanced search mode during the same data collection period.

3.3.2. *Search Terms*

The terms used in the SMS were selected based on the researchers' prior knowledge and by searching for synonymous terms mentioned in the work of Huang *et al.* (2019). The PICOC criterion, which stands for Population, Intervention, Comparison, Outcome, and Context, was employed to define the terms (Kitchenham *et al.*, 2016). These terms were divided into two parts (see Table 3): (1) Population, which indicates the possible contexts where the research topic can be applied, and Intervention, which refers to the resources used in a specific context. In this SMS, the Population and Results terms were combined to obtain a more focused outcome related to LX design. The terms Comparison and Context were not used as the research did not involve a specific context and the aim was not to compare technologies but to characterize their results. The boolean operator "OR" was used to indicate synonyms or alternative terms, while the boolean operator "AND" was used to combine the two components.

3.3.3. *Selection of Publications*

The publication selection process for this SMS consisted of two stages, each involving two researchers. The aim of having two researchers was to minimize bias and ensure a collaborative evaluation process.

In the first filter, publications were assessed based on their metadata, including title, abstract, publication type, and other relevant information. Each researcher indepen-

Table 3
Search String

Population and Outcome	("Learner eXperience Design" OR "Learning eXperience Design" OR "Learner Centered Design")	AND
Intervention	("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")	

[5] `https://eric.ed.gov/`

[6] `https://www.scopus.com/home.uri`

dently reviewed the publications and assigned inclusion or exclusion criteria without knowledge of the other researcher's decisions. If both researchers agreed on the inclusion or exclusion of a publication, it proceeded to the next phase. In cases of disagreement, the researchers discussed the publication in a meeting to reach a consensus. This process not only helped in aligning their perspectives but also facilitated knowledge exchange and ensured consistent application of the criteria.

In the second filter, all publications accepted in the first filter underwent a detailed evaluation of their full texts. Each researcher individually read and evaluated the content of each publication. If both researchers agreed on the inclusion of a publication, it was included for data extraction. In cases of disagreement, the researchers discussed the publication and made a consensus decision.

3.3.4. *Selection Criteria*

The researchers established specific criteria for the inclusion and exclusion of publications to ensure that the selected studies would provide relevant information for data extraction and the research questions. If a publication met any of the Exclusion Criteria (EC), it was excluded from the analysis. Conversely, if a publication met any of the Inclusion Criteria (IC), it was included for further consideration. In cases where a publication met multiple criteria, the researchers made a joint decision to determine the most representative criterion for inclusion or exclusion. By applying these criteria and making decisions in pairs, the researchers aimed to ensure consistency and objectivity in the selection process. The specific criteria used for inclusion and exclusion can be found in Table 4.

Table 4
Criteria for Publications Selection

Criterion	Category	Description
IC1	inclusion	Publications that propose LX design technologies considering computational systems;
IC2	inclusion	Publications that present resources and materials that support the LX design considering computational systems;
IC3	inclusion	Publications that present experimental studies of LX design technologies considering computational systems;
EC1	exclusion	Publications that did not meet the inclusion criteria were not selected;
EC2	exclusion	Publications that have a language other than English and Portuguese were not selected;
EC3	exclusion	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);
EC4	exclusion	No duplicate publications were selected;
EC5	exclusion	Publications that were not peer-reviewed, such as technical-scientific reports, proceedings, among others, were not selected;

3.3.5. *Data Extraction Strategy*

During the data extraction stage of the SMS, the researchers aimed to address the research sub-questions by extracting relevant information from the selected publications. This process involved using a standardized form, which was detailed in a technical report[7]), to systematically capture data from each publication. A separate document was created for each publication, and the extracted data were recorded in an electronic spreadsheet. The spreadsheet facilitated the organization and analysis of the data, allowing for counts, statistical calculations, and the creation of graphs to gain a deeper understanding of the results. To ensure the accuracy and reliability of the extracted data, one researcher performed the initial extraction, and a second researcher verified the extracted information. This verification process helped minimize errors and inconsistencies in the data extraction process.

4. Results

On October 6, 2021, the search string was submitted, and a total of 728 publications were retrieved from the digital libraries. These included 168 publications from ACM, 35 from IEEE Xplore, 233 from Science Direct, and 292 from Springer Link. In the first filter, both researchers independently evaluated the 728 publications. The evaluations resulted in a "simple" agreement of 85.16% and a Kappa index (Fleiss, 1971) of 0.4527. According to the interpretations of Altman (1990) and Landis and Koch (1977), the agreement level can be considered "moderate". The agreement was based on the criteria assigned by each researcher to determine inclusion or exclusion of the publications. As a result of the first filter, 129 publications were deemed relevant and moved on to the next step.

The second filter involved the evaluation of the 129 publications by the same two researchers. The "simple" agreement for this filter was 88.37% and the Kappa index was 0.7531. According to Altman (1990) and Landis and Koch (1977), this level of agreement can be considered "good" and "substantial", respectively. After the second filter, a total of 45 publications were accepted for the data extraction phase (refer to Fig. 1 for a visual representation of the filters).

4.1. *Publication Year*

The selected publications for data extraction spanned from 1996 to 2021. It is worth noting that the year with the highest number of studies was 2021, despite the search string being submitted in October of that year. This indicates a significant growth in the number of publications related to the research topic in recent years. The chart representing the publications by year (see Fig. 2) demonstrates a dynamic and active research field, with notable peaks in 2007, 2014, and 2021. These peaks suggest periods of increased research activity and interest in the LX design technologies related to computational systems.

[7] https://figshare.com/s/3eb8195b1715f596c883

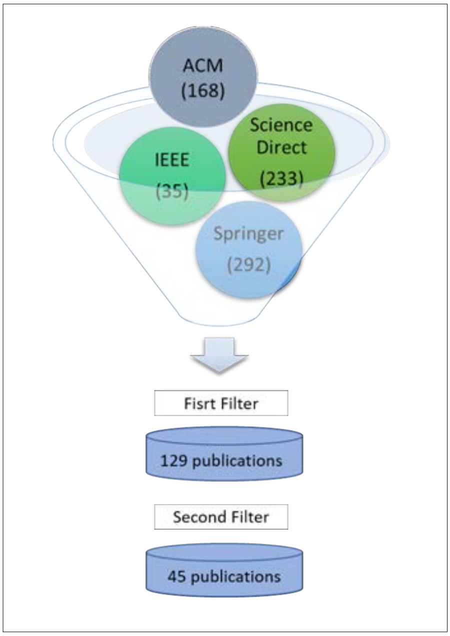

Fig. 1. Selection process of publications in the SMS.

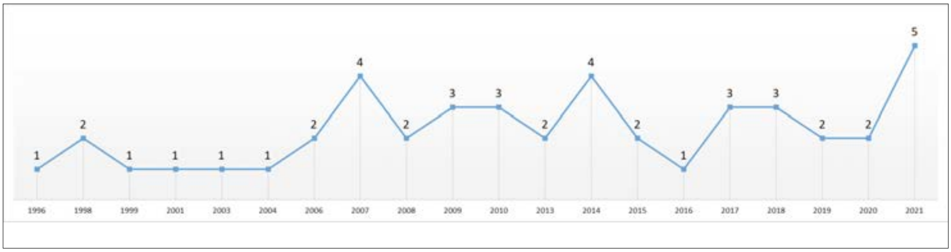

Fig. 2. Year of publication of selected publications.

The growth in the field of LX design technologies in the coming years is expected to increase, particularly due to the challenges posed by Remote Teaching during the Covid19 pandemic. Teachers had to quickly adapt to online learning environments and find effective ways to engage learners in remote education settings (Whittle *et al.*, 2020). The Remote Teaching experience also highlighted the difficulties faced by learners in terms of active participation and effective learning when using computational systems. Furthermore, the shift to online learning and the increased reliance on video conferencing platforms during Remote Teaching led to the emergence of isolated experiences known as "zoom fatigue" (Hammad *et al.*, 2021). Learners and educators experienced mental and physical exhaustion due to extended periods of screen time and limited social interaction. This has emphasized the need for better learning experiences that consider diverse learning needs within the same virtual classroom. These challenges and experiences have brought attention to the importance of designing and implementing effective LX design technologies in educational contexts. The ongoing pandemic has accelerated the adoption of online learning, making it crucial to address the limitations and optimize the learning experiences provided by computational systems.

4.2. *Places of Publication*

In the analysis of publication venues in this SMS, it was found that a majority of the selected studies on LX design were published in conference proceedings (Fig. 3), accounting for 71.11% (N = 32) of the total. The remaining 28.89% (N = 13) were published in journals (Fig. 4).

Among the conferences, the Conference on Human Factors in Computing Systems (CHI) emerged as the event with the highest number of selected publications. CHI is recognized as the largest conference in the field of Human-Computer Interaction (HCI) worldwide. Additionally, four other events related to Computing Education and HCI were referenced in the selected publications: Conference on Interaction Design and Children (IDC), Conference on Innovation and Technology in Computer Science Education (SIGCSE), Conference on Innovation and Technology in Computer Science Education (ITiCSE), and Conference on Human-Computer Interaction (INTERACT).

Other events appeared with at least one selected publication each, demonstrating their relevance in the field. These events include the International Conference on Advanced Learning Technologies (ICALT), Symposium on Video Games (SIGGRAPH), International Conference on Computing, Design and Making in Education

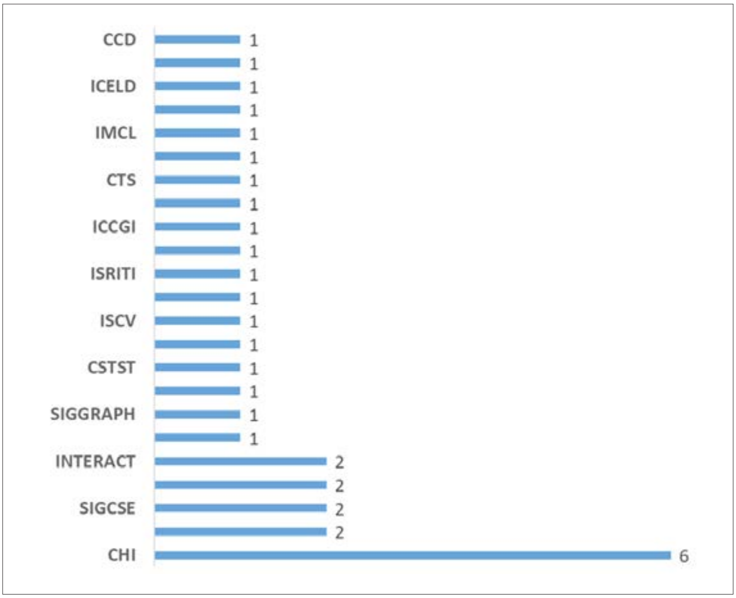

Fig. 3. Distribution of Publications by Scientific Events.

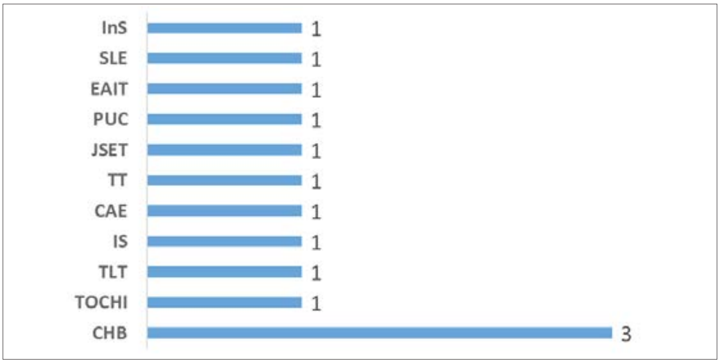

Fig. 4. Distribution of Publications by Journals.

(MakEd), International Conference on Soft computing as Transdisciplinary Science and Technology (CSTST), International Workshop on Multimedia Technologies for Distance Learning (MTDL), Conference Intelligent Systems and Computer Vision (ICSV), Conference on Creating, Connecting and Collaborating Through Computing (C5), International Seminar on Research of Information Technology and Intelligent Systems (ISRITI), International Congress on Advanced Applied Informatics (AAI), International Multi-conference on Computing in the Global Information Technology (ICCGI), International Conference on Information and Education Technology (ICIET), International Conference on Collaboration Technologies and Systems (CTS), International Conference on Computer Supported Cooperative Work in Design (CSCWD), International Conference on Interactive Mobile Communication Technologies and Learning (IMCL), International Conference on New Horizons (INTE), International Conference on Learner Diversity (ICELD), International Conference on Universal Access in Human-Computer Interaction (UAHCI), and International Conference on Cross-Cultural Design (CCD). These findings reflect the diverse range of conferences and events where research on LX design technologies has been disseminated, indicating the interdisciplinary nature of the field and the interest in sharing knowledge and experiences in various academic settings.

Fig. 4 shows an overview of the selected publications in journals. Among the journals, Computers in Human Behavior (CHB) had the highest number of selected publications, with a total of three. The remaining journals each had one selected publication, as follows: Transactions on Computer-Human Interaction (TOCHI), Transactions on Learning Technologies (TLT), Information Sciences (IS), Computers and Education (CAE), TechTrends (TT), Journal of Science Education and Technology (JSET), Personal and Ubiquitous Computing (PUC), Education, and Information Technologies (EAIT), Smart Learning Environments (SLE) and Instructional Science (InS).

These journals cover a wide range of topics related to LX design technologies, including Human-Computer Interaction, Learning Technologies, Information Sciences, Education, and more. The inclusion of publications in these journals demonstrates the relevance and interest in disseminating research on LX design in scholarly outlets.

4.3. *Research Sub-question Results*

Table 5 presents the quantitative results identified in this SMS. The sub-questions SQ1, SQ2, SQ3.2, and SQ6 were not presented in this table, as they have many response options. Thus, it was decided to represent them as figures within the subsections dedicated to them for discussion. Finally, SQ3.1 and SQ6.1 were also not included in this table because they have subjective responses, as explained in Table 2.

Table 5
Summary of Answers by Sub-question

Sub-questions		Possible Answers	Quantitative	
SQ3.	What type of resource was used to support the LX design?	Sequence of steps	3	6.67%
		Computer System	9	20.00%
		Both	33	73.33%
SQ3.3	Was there support for the learner in the use of the computer system in the LX design?	Yes	28	62.22%
		Not	17	37.78%
SQ4.	What learning environment is LX designed for?	Traditional	28	62.22%
		Non-Traditional	3	6.66%
		Both	7	15.56%
		Not identified	7	15.56%
SQ5.	What is the learner's role in the LX design?	Learners	33	73.33%
		Teachers	2	4.45%
		Learners and teachers	6	13.33%
		Learners and parents	1	2.22%
		Learners and professionals	1	2.22%
		Not identified	2	4.45%
SQ5.1	What is the level of education at which the LX design occur?	Elementary Education	16	35.56%
		High School	10	22.22%
		Graduation	10	22.22%
		Post-graduation	3	6.67%
		Vocational Education	1	2.22%
		Not identified	10	22.22%
SQ5.2	How was the learner's participation in the LX design?	Collaborative	26	57.78%
		Individual	5	11.11%
		Both	8	17.78%
		Not identified	6	13.33%
SQ7.	Was there an empirical study to evaluate the technology that designs the LX?	Yes	38	84.44%
		Not	7	15.56%
SQ7.1	What types of studies were considered in the LX design?	Case Study	25	55.57%
		Experimental Study	5	11.11%
		Observation Study	2	4.44%
		Pilot Study	2	4.44%
		Study	2	4.44%
		Phenomenography Study	1	2.22%
		Survey	1	2.22%
SQ7.2	What types of analyzes were performed on the LX design?	Qualitative	15	33.33%
		Quantitative	11	24.45%
		Both	9	20.00%
		Not identified	10	22.22%
SQ8.	In what context can LX design technology be used?	Generic	24	53.33%
		Specific	21	46.67%

4.3.1. *Type of Technology (SQ1)*

Fig. 5 illustrates the results for SQ1 regarding the types of technologies identified in the publications on LX design. According to the data presented, 20.00% (N = 9) of the publications fall under the category of **approach**. This means that these publications focus on proposing a particular approach or methodology for designing and developing LX. For instance, the study by Dinimaharawati *et al.* (2018) is an example of an approach-based publication. They presented an instructional design approach for implementing Learning Experience Design in an educational game. The approach they proposed consists of five stages of development, including sensory, interaction, structure, requirement, and strategy. These stages guide the design process and cover aspects such as course description, learning objectives, media usage, curriculum design, and assessment strategies. This information indicates that various publications in the field of LX design offer different approaches or methodologies to guide the design process and create meaningful learning experiences.

The second technology type identified in the publications on LX design is the **model**, which refers to the structure or format used to organize the design of the learning experience. According to the data, 15.56% (N = 7) of the publications included in the analysis fall into this category. For example, the study by Barnes *et al.* (2007) presented a project model called Game2Learn. The objective of this model was to provide learners with a structured framework for creating games as part of their learning experience. The Game2Learn model consisted of a 10-week process, where learn-

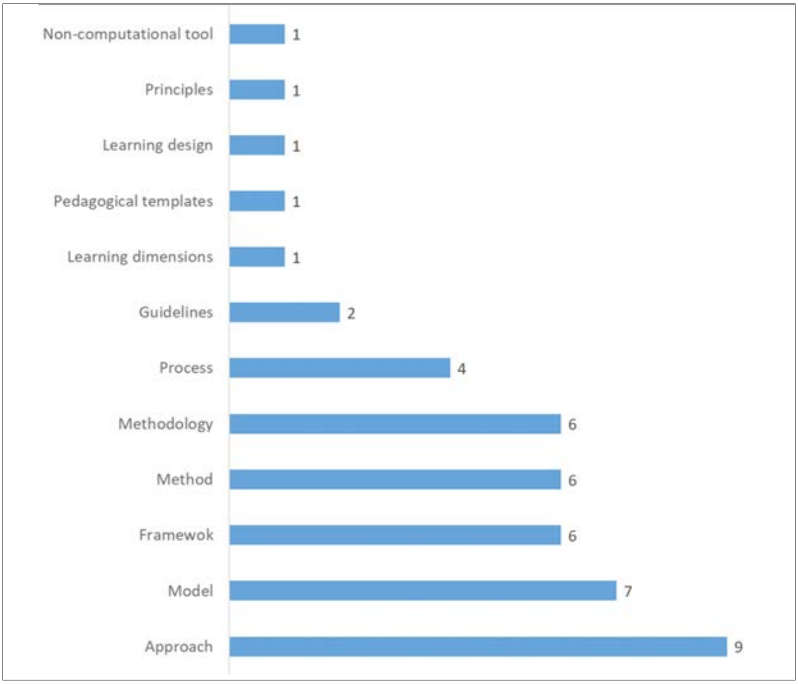

Fig. 5. Type of Technology (SQ1).

ers were guided through various stages. In the first and second weeks, learners were introduced to the fundamental concepts and mechanisms of building small games. In the third week, learners selected specific concepts from the Computing curriculum that they wanted to focus on, such as conditional, iterative, and recursive structures. From the fifth to the seventh week, learners worked on implementing game prototypes based on their selected concepts and ideas. In the eighth and ninth weeks, the learners conducted user testing to gather feedback and improve their games. Finally, in the tenth week, learners wrote a report summarizing their results, literature review, and overall experience in the project. This example demonstrates how a model can provide a structured framework and timeline for learners to follow during the design and development of their learning experiences. It helps to ensure a systematic approach and provides guidance throughout the process.

The third technology type identified in the publications on LX design is the framework. Frameworks represent sets of ideas or rules that serve as a basis for making design decisions in the context of learning experiences. According to the data, 13.33% (N = 6) of the publications included in the analysis employed frameworks. Here are brief descriptions of the six frameworks identified: (1) Learner-Centered Design: This framework focuses on designing scaffolding to provide support to learners as they engage in activities that are typically beyond their current abilities. The aim is to create a learner-centered environment that supports and enhances the learning experience (Soloway *et al.*, 1996); (2) Conceptual Framework for Learning Experience Design in Computational Systems: This framework aims to design learning experiences in computational systems using Learning Content Object Providers (LCOPs) as a central concept (Nakakoji *et al.*, 2003); (3) Mobile Learning Framework: This framework is designed to analyze, design, and evaluate practical and collaborative experiences in the context of mobile learning (m-learning) (Herrera and Sanz, 2014); (4) Game-based m-Learning Design Framework: This framework leverages the positive qualities of mobile devices and aims to engage learners in rich learning experiences through game-based mobile learning (Parsons *et al.*, 2006); (5) Lifelong Learning Mobile Learning Framework: This framework focuses on designing lifelong learning experiences using mobile technologies (Nordin *et al.*, 2010); and (6) Theoretical Framework for E-Learning Experience Design: This framework aims to design the ideal flow of e-learning experiences based on theoretical principles and best practices (Katuk *et al.*, 2013). These frameworks provide conceptual structures that inform the design and development of learning experiences. They offer a systematic approach to designing LX and serve as valuable resources for educators and instructional designers.

In addition to the technology types mentioned earlier, the SMS identified six different **methods** used in the LX design. These methods represent specific procedures or approaches employed to design the LX according to a predetermined plan. The analysis revealed that these methods were present in 13.33% (N = 6) of the selected publications. The first method focuses on empowering children as designers and aims to produce games with a strong narrative element (Duh *et al.*, 2010); The second method involves a group of designers in the creation of a Massive Open Online Course using personas, which are fictional representations of ideal users (Quintana *et al.*, 2017); The third is aimed at implementing a Virtual Learning Environment and adopts agile principles and practices for the design and development process (Battou *et al.*, 2017); The fourth method aims to encourage collaborative learning experiences through the design of a Virtual Learning Environment that supports group interactions and knowledge sharing (Anaya and Boticario, 2009); The fifth method utilizes a system that incorporates activities, stories, and personal knowledge to manage and enhance the learning experience (Mutlu, 2015), and the sixth method utilizes a system that incorporates activities, stories, and personal knowledge to manage and enhance the learning experience (Girvan and Savage, 2019). These methods provide structured approaches for designing LX. By employing these methods, designers can enhance the learning experiences they create and ensure that they align with their intended goals and objectives.

The SMS also identified six different **methodologies** used in the LX design. These methodologies represent established sets of rules and steps that guide the process of LX design. The analysis revealed that these methodologies were present in 13.33% (N = 6) of the selected publications. The first methodology focuses on developing a learner-centered system by analyzing the learning context and the specific needs of the learners (Wallace *et al.*, 1998); The second methodology aims to develop a simplified learning-by-doing tool that is specifically designed for children (Kuhn *et al.*, 2009); The third methodology to incorporate ideas and knowledge shared by learners and teachers into the learning process, specifically in the fields of Computer Science and Engineering (Charlton and Avramides, 2016); The fourth methodology focuses on designing learner-centered and cloud-based learning experiences that can be accessed through mobile devices (Ktoridou, 2014); The fifth methodology aims to model an adaptive system using iterative design processes, where users actively participate and provide interaction data to inform the system's adaptation (Cocea and Magoulas, 2015); and the sixth methodology is centered around designing interdisciplinary learning experiences within the context of Technology Enhanced Learning (Winters and Mor, 2008). These methodologies taking into account specific factors such as learner needs, knowledge sharing, mobile accessibility, adaptivity, and interdisciplinary integration. By following these methodologies, designers can ensure a systematic and effective design process that enhances the quality and impact of the learning experiences they create.

Four **processes** were found that were employed in the LX design. These processes represent continuous actions and involve various activities throughout the LX design. The analysis revealed that these processes were present in 8.89% (N = 4) of the selected publications. The first process aims to help learners engage in scientific investigation activities as part of the learning experience design (Quintana *et al.*, 1999); The second process focuses on producing tutorials that are usable and provide effective support for learners. Usability considerations are taken into account during the design and development of these tutorials to enhance the LX (Brown and Lu, 2001); The third process utilizes the principles and practices of design thinking to guide the design of an educational program, specifically a factory lab program. Design thinking involves empathy, problem-solving, and iterative prototyping to create innovative and user-centered solutions (Nail and El-Deghaidy, 2021); and the fourth process aims to explicitly support learners in the different stages of the creative process through the use of software. The software provides tools, resources, and guidance to assist learners in generating and developing creative ideas as part of their learning experience (Robertson and Nicholson, 2007). These processes highlight the importance of structured and iterative approaches in the LX design. By incorporating these processes, designers can facilitate scientific inquiry, improve usability, apply design thinking principles, and support learners in their creative endeavors. This enhances the overall quality and effectiveness of the LX designed using these processes.

The SMS identified several other types of contributions to the learning experience design. In this instance, Guideline**s** provide a set of rules or instructions on how to design the LX. Guidelines were found in 4.44% (N = 2) of the publications. The first set of guidelines focused on designing educational tools for desktop computers and mobile devices (Luchini *et al.*, 2004). The second set of guidelines aimed to create inclusive designs of e-learning modules accessible to people with intellectual disabilities (Arachchi *et al.*, 2017). A study with Learnin**g** dimension**s** (2.22%, N = 1) was also found. This study aimed to support Computer Science teachers by providing learning dimensions as a resource for creating new learning experiences or as a toolkit for reviewing and improving programming learning experiences. Another type of contribution identified was the **Pedagogical** template**s** (2.22%, N = 1), which aimed to support teachers in the selection of e-learning resources to be used in the classroom (Capuano *et al.*, 2009); A technology called Learnin**g** Desig**n** (2.22%, N = 1) was also identified, which aimed to support tutoring tasks, based on the project, goals, experiences and learning environments (Norita *et al.*, 2020). Also, Desig**n** principle**s** were found (2.22%, N = 1), which aim to reduce the cognitive complexity of learning to perform a task, allowing the learner less confusion (Fardoun *et al.*, 2010). Finally, a Non-computationa**l** too**l** was identified, called Learnin*g* Activit*y* Desig*n* Canvas, (2.22%, N = 1), which aimed to support learning activities in collaborative virtual environments (Recke *et al.*, 2021).

4.3.2. *Theory/Construct (SQ2)*

Fig. 6 presents the results for SQ2, which aimed to investigate the theories or constructs that guide the different learning formats addressed within the LX design. The results revealed that 17.78% (N = 8) of the publications on LX design are related to Constructivism. Constructivism is a learning theory that emphasizes the active construction of knowledge by the learner through interaction with the environment (Soloway *et al.*, 1996). One example of the application of Constructivism in LX design is demonstrated by Tsivitanidou *et al.* (2021), who explored the use of Virtual Reality as a tool to enhance constructivist learning experiences. The study showed that learners can build their knowledge through reflections on objects simulated in the virtual environment and by connecting abstract concepts previously learned. By incorporating Constructivism into LX design, designers can create immersive and interactive learning experiences that encourage learners to actively engage with the content and construct their understanding of the subject.

According to the results of the study, approximately 11.11% (N = 5) of the publications of the publications reported the use of the Technology-Integrated Learning theory in LX design. Technology-Integrated Learning refers to the incorporation of technology

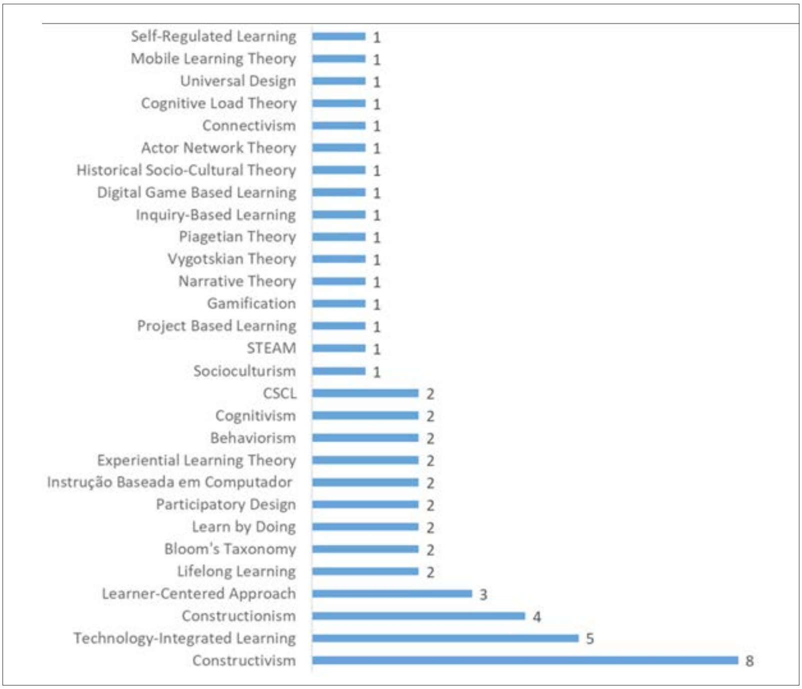

Fig. 6. LX Design Theory/Construct (SQ2).

into the learning process to enhance and support learning experiences. One example of the application of Technology-Integrated Learning theory in LX design is presented by Nakakoji *et al.* (2003). The study highlighted the use of Artificial Intelligence techniques to create computational systems that infer the most suitable way of teaching based on the learner's characteristics and preferences. This adaptive approach allows the system to automatically adapt the teaching methods to meet the learner's needs. Similarly, Katuk *et al.* (2013) emphasized the importance of learner-content, learner-teacher, and learner-learner interactions in Technology-Integrated Learning. These modes of interaction play a vital role in developing effective learning experiences that leverage technology. The integration of technology enables various forms of interaction, fostering collaborative learning and personalized instruction. Furthermore, Georgiou and Ioannou (2021) discussed the challenges associated with integrating technology into learning experiences. They emphasized the need for LX design that ensures the effective deployment of technology in alignment with teachers' needs and expectations, as well as considering the content and time constraints of school curricula. Designing LX that effectively integrates technology requires careful consideration of pedagogical goals, instructional strategies, and the overall learning context. By incorporating the Technology-Integrated Learning theory into LX design, educators and designers can leverage technology to create interactive and personalized learning experiences. This approach enables adaptive learning environments, promotes collaboration, and enhances the effectiveness of teaching and learning processes.

In addition to these, other theories/constructs related to the LX design were identified, such as: Constructionis**m** (4 publications, being Charlton and Avramides (2016), Papavlasopoulou *et al.* (2019), Girvan and Savage (2019) and Lister (2021)): in which the learner is seen as an active builder of knowledge, instead of a passive receiver of information; Learner-Centere**d** Approac**h** (3 publications, being Battou *et al.* (2017), Ktoridou (2014) and Moser (2013)): in which the learner is proactive, independent and responsible for what he learns and how he learns; lifelon**g** learnin**g** (2 publications, being Fardoun *et al.* (2010) and Mutlu (2015)): in which the learner acquires and reinforces knowledge and skills necessary to prosper throughout life through activities that do not are limited to scheduled times and places, as required by traditional education; Bloom'**s** Taxonom**y** (2 publications, being Capuano *et al.* (2009), and Blasquez and Leblanc (2018)): which consists of the learner's process of thinking and learning through educational objectives; Learnin**g** b**y** doin**g** (2 publications, being Kuhn *et al.* (2009) and Lammer *et al.* (2015): where the learner is actively engaged in designing and creating things; Participator**y** Desig**n** (2 publications, being Duh *et al.* (2010), and Cocea and Magoulas (2015)): in which the learner is positioned as a "co-designer" and is continuously present and involved in the design process at all stages; Computer-Base**d** Instructio**n** (2 publications, being Brown and Lu (2001), and Chen and Liu (2008)): it is a useful means to support learning, expanding the time, pace and place of education through the computer and the internet; Experientia**l** Learnin**g** Theor**y** (2 publications, being Zhang *et al.* (2018) and Arachchi *et al.* (2017)): in which learning occurs through experience and reflection on doing; Behavioris**m** (2 publications, being Nordin *et al.* (2010) and Arachchi *et al.* (2017)): in which positive reinforcements can be incorporated into e-learning projects to encourage the learner to get involved in the learning process; Cognitivis**m** (2 publications, being Nordin *et al.* (2010) and Arachchi *et al.* (2017)): this is an internal process in which the learner uses his memory, thinking, reflection, abstraction and metacognition skills to build the knowledge; Computer-Supporte**d** Collaborativ**e** Learnin**g** – CSC**L** (2 publications, being Herrera and Sanz (2014), and Anaya and Boticario (2009)): in which technology is inserted in collaborative learning tasks.

The theories/constructs with fewer occurrences were: **Socioculturism** (1 publication, being Soloway *et al.* (1996)): which seeks to include social and cultural aspects, taking into account the diversity of a community of learners; **Science, Technology, Engineering, Arts and Mathematics – STEAM** (1 publication, being Nail and El-Deghaidy (2021)): which consists of design-based practice proposed for education in Science, Technology, Engineering and Mathematics, in manufacturing laboratories, to promote the learning of skills and practices; **Project-Based Learning** (1 publication, being Blasquez and Leblanc (2018)): in which the learner participates and gradually becomes autonomous in the development of his project); **Gamification** (1 publication, being Dinimaharawati *et al.* (2018)): which seeks to engage, motivate behaviors and facilitate the learner's learning; **Narrative theory** (1 publication, being Recke *et al.* (2021)): whichseeks to overcome the problems of curricular principles to better promote the involvement of individual and collective learners in learning units; **Vygotsky Theory** (1 publication, being Herrera and Sanz (2014)): in which the learner can be supported by a more experienced colleague or with more knowledge and in a group can also share understanding and involve individuals at different levels of participation; **Piaget Theory** (1 publication, being Herrera and Sanz (2014)): in which collaboration is important for the conceptual growth of the learner because of the cognitive conflict that can be generated through group discussions and arguments; **Inquiry-Based Learning** (1 publication, being Tsivitanidou *et al.* (2021)): in which the learner learns about scientific phenomena in an exploratory way similar to authentic scientific practices; **Digital Game-Based Learning** (1 publication, being Parsons *et al.* (2006)): which takes advantage of the positive qualities of mobile devices to involve learners in a rich learning experience, facilitating self-motivation and self-regulation; **Historical Sociocultural Theory** (1 publication, being Lister (2021)): which seeks to raise sociocultural concerns for learners in terms of relevance, interest, cultural significance, value or affective factors related to the place; **Actor-network theory** (1 publication, being Lister (2021)): in which the learner establishes a social network, not only interacting with other colleagues, but with other resources and materials as well, such as computers, multimedia, games, among others; **Connectivism** (1 publication, being Lister (2021)): in which learning and knowledge are supported by the diversity of opinions, through the connection of specialized nodes or different sources of information; **Cognitive Load Theory** (1 publication, being Corbalan *et al.* (2006)): in which learning is encouraged if the cognitive system is not overloaded and if the available cognitive resources are actually allocated to learning processes; **Universal Design** (1 publication, being Granić and Ćukušić (2007)): which seeks to design products, services, environments and interfaces that can be used by as many people as possible; **Mobile Learning Theory** (1 publication, being Nordin *et al.* (2010)): in which learning uses mobile devices and wireless connectivity as a teaching tool; **Self-regulated learning** (1 publication, being Norita *et al.* (2020)): which allows the learner to regulate thoughts, feelings and actions to achieve learning objectives.

4.3.3. *Resource Type (SQ3)*

The resource type in LX design refers to the instruments and tools used to support learning and facilitate the development of skills and understanding of content. The study identified different types of resources used in LX design, including sequences of steps or activities, computational systems, and learner support. Regarding the use of resources, the results of the study showed that 6.67% (N = 3) of the publications presented a sequence of steps or activities as a resource for LX design. These publications provided a structured approach or framework that guided the development of activities and computational systems. Additionally, 20.00% (N = 9) of the publications focused solely on the use of computational systems in LX design. These systems served as the main resource for delivering and supporting learning experiences. Interestingly, the majority of the publications, 73.33% (N = 33), used a combination of both resources – sequences of steps or activities and computational systems – to support LX design. This integrated approach leveraged the benefits of both resources to create dynamic and engaging learning experiences.

For example, Nail and El-Deghaidy (2021) utilized the steps of Design Thinking – Engage, Explore, Explain, Elaborate, and Evaluate – as a sequence of steps to guide the design of an educational factory laboratory program. The program aimed to implement, test, and iterate with the design principles. In this case, learners were introduced to 3D modeling and computer-aided design concepts using the Tinkercad[8] software. This combination of a structured sequence of steps and the use of a specific computational system facilitated the learning process and supported the attainment of the desired learning outcomes.

To further explore and understand these types of resources, the study defined additional sub-questions within SQ3, namely SQ3.1 (Sequence of steps/activities), SQ3.2 (Computational Systems), and SQ3.3 (Learner Support) to investigate the specific aspects and characteristics of these resources in the use of LX design.

About SQ3.1 (Sequence of steps/activities), The study by Recke *et al.* (2021) employed a non-computational tool called Canvas to support the LX design process. Canvas provides a visual representation that aids in the creation of learning activities. It allows teachers to describe an activity using the following steps: (a) Learning outcome: Teachers define the expected learning outcome or what learners are expected to achieve or experience during the activity; (b) Evidence of learning: Teachers specify the expected evidence of learning, which can be in the form of created artifacts, produced outcomes, or experienced experiences. This step helps assess whether the intended learning outcomes have been achieved; (c) Resources required: Teachers select and include the relevant resources that are needed to support the activity. These resources can be materials, tools, or any other items necessary for learners to engage in the activity effectively; and (d) Narrative sequence: Teachers represent the chronological sequence of events within the activity using Learning Bits. Learning Bits are individual components or steps that make up the activity. They provide a structured framework for organizing and sequencing the learning experience. By using Canvas, teachers can visually design and plan learning activities, ensuring clarity and coherence in the instructional design process. It allows for a systematic approach to creating engaging and meaningful learning experiences while considering the desired learning outcomes, evidence of learning, required resources, and the narrative sequence of events.

Regarding SQ3.2 (Type of Computational System), 28.89% (N = 13) of the publications utilized software (Fig. 7). For instance, Kuhn *et al.* (2009) developed StoryTime, an application designed for children to write and edit stories. The app provided a list of topics, each associated with a short video, which served as inspiration for the child to write a story using short sentences. In sequence, 17.78% (N = 8) of the publications focused on designing digital games. For example, Robertson and Nicholson (2007) conducted GameMaker workshops as a summer break activity, where children were encouraged to unleash their creativity through game creation. The workshops provided a flexible and informal environment for learners to explore their creative processes without specific educational goals. Finally, robotics was employed in 15.56% (N = 7) of the publications. In one study by Martin *et al.* (2017), Arduino was used as a platform to support programming learning. Learners with basic programming skills were given the opportunity to work with Arduino and were challenged to program a dancing robot. This hands-on experience

[8] `https://www.tinkercad.com/`

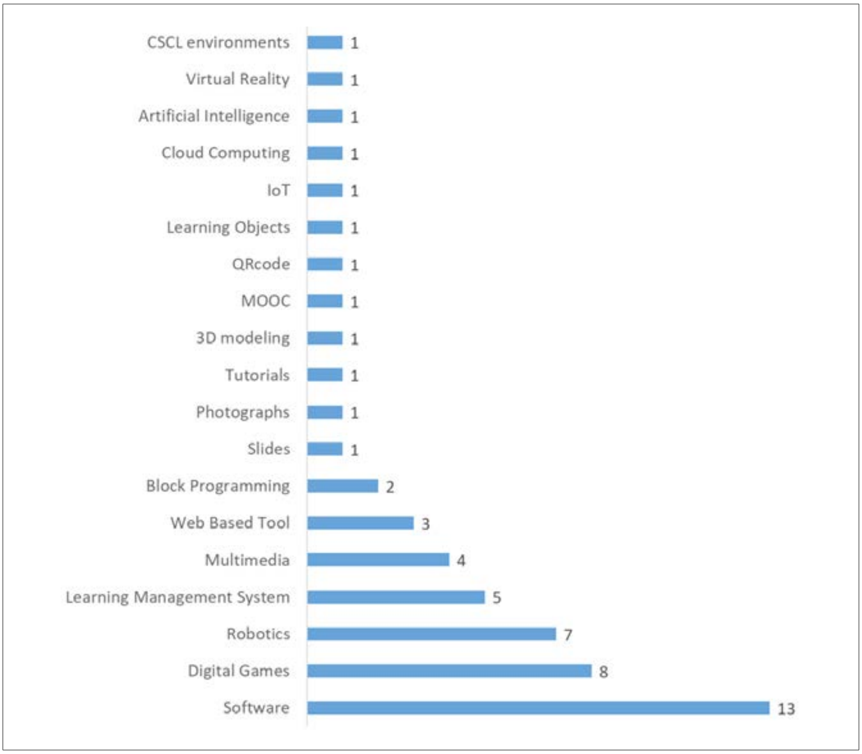

Fig. 7. Computational Systems (SQ3.2).

provided learners with greater independence and served as a practical application of their programming knowledge. These examples demonstrate the diverse range of computational systems used in the LX design process, including software applications, digital games, and robotics platforms. Each of these systems offers unique opportunities for learners to engage in meaningful activities and develop various skills.

Finally, regarding SQ3.3 (Learner Support), in 62.22% (N = 28) of the publications, some form of learner support was offered as part of the LX design process. For instance, Luchini *et al.* (2004) emphasized the importance of providing support to learners for process management, systems development, and collaboration among peers when using resources in the classroom. This support aimed to facilitate learners' active participation and conscious engagement in learning activities. In the case of Duh *et al.* (2010), learner support was provided through an experienced game designer who conducted a brief introduction to the basic concepts of game design, providing learners with more detailed information. This expert-led support aimed to enhance learners' understanding and engagement with the design principles of the game. In some publications, support was provided through computational systems. For example, Cocea and Magoulas (2015) implemented an intelligent support system that assisted learners while they solved tasks. This system offered personalized guidance and feedback, aiming to enhance learners' problem-solving skills and overall learning experience. It is worth noting that in 37.78% (N = 17) of the publications, specific learner support was not identified. This suggests that in some cases, the LX design may have focused on more independent or self-directed learning experiences without explicit support interventions. Overall, learner support in the LX design plays a crucial role in facilitating learners' engagement, understanding, and successful completion of learning activities. The forms of support may vary, including expert-led guidance, intelligent support systems, or other tailored approaches to meet learners' needs and enhance their learning experiences.

4.3.4. *Learning Environment (SQ4)*

The learning environment refers to where the LX design took place. This space needs to be investigated as it can directly influence the learner's experience, impacting their income and performance. The results of this sub-question revealed that in 15.56% (N = 7) of the publications, there was no specific mention or specification of the learning environment where the LX design took place. This indicates that the focus of these studies may have been more on the design of learning experiences and technologies, rather than on the physical or virtual spaces where the learning occurred. In turn, in 62.22% (N = 28) of the publications, the LX design took place in traditional learning environments, such as classrooms. For example, in the study by Quintana *et al.* (1999), learners were engaged in scientific investigation activities within a classroom setting. The scaffolding process involved defining roles, activities, artifacts, information objects, and necessary services. The Symphony system was used for data collection, visualization, and data modeling, allowing learners to investigate air quality problems. It is important to note that the learning environment plays a significant role in shaping the learner's experience and performance. Traditional environments like classrooms provide a structured setting where learners can engage with instructional materials and interact with peers and teachers. These environments offer opportunities for collaboration, guidance, and face-to-face interactions. However, it's worth mentioning that 21.11% (N = 9) of the publications did not fall into the categories mentioned above, indicating that LX designs might have taken place in nontraditional or nonspecified environments. These could include online learning platforms, virtual reality environments, or other innovative spaces that were not explicitly mentioned in the analyzed publications. Understanding the learning environment in which LX designs are implemented is crucial for considering contextual factors and tailoring the design to optimize the learning experience. Different environments offer unique affordances and constraints that can shape the design choices and outcomes of LX initiatives.

In contract, 6.66% (N = 3) of the publications, the LX design was carried out in nontraditional environments. For example, in Papavlasopoulou *et al.* (2019), the research was conducted in collaboration with a local library, which served as the venue for a two-day workshop. Workshop activities focused on motivation, including artistic elements. The invitation to participate was made to high school girls in the region during school holidays. Each day's activities were conducted in an informal setting and lasted approximately five hours, including breaks. The instructors, with previous experience in activities, supported the girls during the activities. During a workshop, the girls had to create storyboards based on solving particular environmental problems and create games using the programming language Scratch[9]. For the activities, the girls could use different materials, such as ribbons, colored cardboard, stickers, and drawing pencils, provided by the library. This example highlights the value of non-traditional learning environments, such as collaborative workshops in community spaces like libraries. These environments offer unique opportunities for engagement, creativity, and interdisciplinary learning. By stepping outside the traditional classroom setting, learners can explore topics in new and innovative ways, fostering motivation and active participation.

Furthermore, in 15.56% (N = 7) of the publications, the LX design encompassed both traditional and non-traditional environments. For instance, in Charlton and Avramides (2016), the focus was on computational thinking, algorithms, and hardware. The study involved a range of learning activities, including a mini-workshop, a brainstorming activity, a 2-day educational hack event, and an accompanying presentation. Following the activities at the school, the groups of learners presented their work to the community and participated in a festival where they delivered a lecture to a large audience. Some of the final ideas and prototypes presented included a glove that controlled household devices, a mobile robot designed to assist blind people with navigation, and a coin reward system that provided credit to learners who collected coins. This example highlights the integration of various learning activities across different environments, combining both traditional classroom settings and external events. By engaging learners in hands-on projects and real-world applications, they have the opportunity to showcase their work, gain public recognition, and contribute to the community. This multifaceted approach enhances the learners' experience and encourages them to explore innovative solutions to practical problems.

4.3.5. *Leaner's role (SQ5)*

The role of the learner refers to the role of the participants involved in the LX design. This type of sub-question is pertinent to identifying who is being considered in the LX design and the social interactions being proposed throughout the activities, which can influence the learner's experience. The results of this sub-question showed that 73.33% (N = 33) of the publications carried out the LX design only with learners, who were the protagonists of learning. For example, in Soloway *et al.* (1996), learners were involved in long-term projects to investigate a river tributary near the school. Moreover, they collected data to determine water quality and, using a modeling system, constructed the flow of the ecosystem. It was also observed that in 13.33% (N = 6) of the publications, the teacher and the learners were included in the LX design. For example, in Capuano *et al.* (2009), an experiment was carried out with learners and teachers of a Mathematics course to validate both the prototype and the teaching methodology. In turn, in 2.22% (N = 1) of the publications, the learners' parents also participated along

[9] `https://scratch.mit.edu/`

with them. As was the case of Martin *et al.* (2017), where they carried out Robotics work in the community where learners could self-organize, comprising a group of six parents and 35 children. Furthermore, in 2.22% (N = 1), industry professionals collaborated with the learners in the LX design. For example, in Quintana *et al.* (2017), professionals acted as facilitators to motivate learners and give practical experiences in UX methods such as personas. In sequence, in 4.44% (N = 2) of the publications, the LX design was focused only on the teacher, who is the LX designer. For example, in Recke *et al.* (2021), teachers designed learning activities to achieve the same learning outcome through different narrative sequences, adapting to space, audience size, and duration constraints. On the other hand, in 4.45% (N = 2), the learner's role in the LX design was not identified.

Within SQ5, other sub-questions were also defined to understand better the context of the LX design, SQ5.1 (Level of Education) and SQ5.2 (Learner Participation). Regarding the Level of Education (SQ5.1), in 35.56% (N = 16) of the publications, the LX design was carried out in Elementary Education. For example, Robertson and Nicholson (2007) conducted an eight-session field study with 30 learners from the 6th grade, aged ten years, for game development through a creative process. The children's games were saved after each session to provide a record of progress. Then, in 22.22% (N = 10) of the publications, the LX design took place in High School. For example, Charlton and Avramides (2016) carried out a pilot study for four months with a group of 15 learners from the 10th grade, aged between 14 and 15 years old. The learners worked with Robotics and the Internet of Things (IoT). The learners had some programming experience in Python. Also, in 22.22% (N = 10) of the publications, the LX design took place during Graduation. For example, Ennouamani *et al.* (2020) used a mobile learning system with 64 second-year Computer Science undergraduate students enrolled in the Object-Oriented Programming course. In turn, in 6.67% (N = 3) of the publications, the LX design took place in the Post-graduation; For example, Girvan and Savage (2019) conducted a constructionist learning experience using SLurtles (three-dimensional robotic turtles of a virtual world) for four weeks with 24 learners of a Postgraduate course in Technology and Learning. Finally, in 2.22% (N = 1) of the publications, the LX design took place in Vocational Education, in which Corbalan *et al.* (2006) carried out a pilot study with 25 Nursing learners from a senior professional education school and used a system with the aim of personalizing the learning process and experience. In 22.22% (N = 10) of the publications, it was not possible to identify the level of education worked.

Regarding the Participation of the Learner (SQ5.2), the learners worked collaboratively in 57.78% (N = 26) of the publications. For example, Duh *et al.* (2010) organized the learners into four groups of four or five participants each for brainstorming sessions, a useful step for developing the games. In 11.11% (N = 5) of the publications, the learners worked individually. For example, Granić and Ćukušić (2007) used an individualized approach, considering the different particularities of learners, such as needs, preferences, and interests. Finally, in 17.78% (N = 8), both forms of participation, individual and collaborative, were foreseen. For example, Anaya and Boticario (2009) conducted a learning experiment that contained two phases. In this way, the learners first did individual work, and later, in teams, they did collaborative work. In 13.33% (N = 6) of the publications, it was not possible to identify the type of participation.

4.3.6. *Elements of the LX Design (SQ6)*

According to the results of this sub-question, the majority of publications, approximately 55.56% (N = 25), focused on designing the Value element as a crucial aspect of the learning experience (Fig. 8). The Value element is directly related to the support and scope of learning. For instance, in Capuano *et al.* (2009), learners were provided with concrete and collaborative experiences through practical activities. The professors created resources that were later exported and uploaded to the college's e-learning system, along with other supplementary materials, to support face-to-face classes. At the conclusion of the experiment, learners were asked to provide feedback on the online learning materials. They expressed that the resources based on models were particularly interesting as they allowed them to experiment and reinforce theoretical concepts learned in the classroom. The availability of interactive experiments provided an engaging and practical approach to learning. Furthermore, teachers expressed enthusiasm for the ability to create interactive learning resources quickly and easily. This example highlights the importance of the Value element in creating meaningful learning experiences. By providing concrete experiences, collaborative activities, and interactive resources, educators can enhance the support and engagement of learners, allowing them to apply theoretical

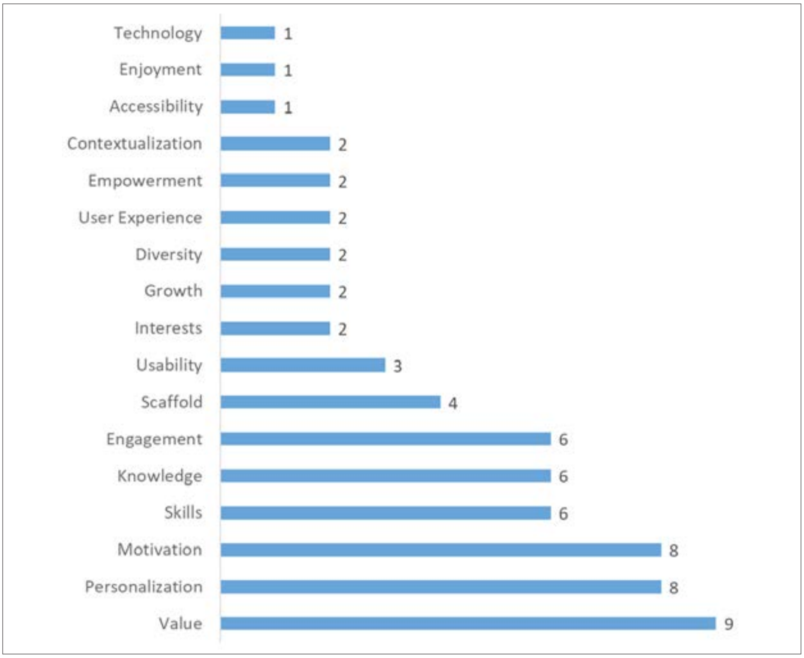

Fig. 8. Elements of the LX Design (SQ6).

knowledge in practical contexts. The integration of technology and hands-on activities can contribute to a more comprehensive and effective learning experience.

Furthermore, 20.00% (N = 9) of the publications addressed the Personalization element related to the adaptation of materials and computational systems based on the learners' particularities. In this sense, Katuk *et al.* (2013) presented three cognitive states: Anxiety, Optimal Flow, and Boredom. These cognitive states were represented by four activity points (A1, A2, A3, and A4) that a learner can have in the context of learning to use a computational system. For example, at Point A1, a learner can be in a virtually optimal flow state, as the given challenge is low, and the learner can deal with that challenge with their current knowledge, holding the learner's attention and focus. However, as the activities progress, two possible cases arise to be considered. One of them is that the challenges presented no longer meet their current level of knowledge (represented in A2), which can cause boredom in the learner. This cognitive state can occur when the learner has mastered the subject, and their abilities are much greater than what the learning system can do for them. In contrast, in A3, the challenge level is greater than the learner's skill level to deal with that challenge. Therefore, in this last point, the learner would experience anxiety that can cause disengagement from the activity, which can cause feelings of loss and difficulties in concentrating on the learning activity. To deal with these cognitive states, the learning system must be able to adjust to a level of difficulty that can be overcome by the learner, increasing their level of knowledge (proceed to A4) or decreasing the challenges given to them (reducing them to A1).

Another element identified less frequently but which deserves to be highlighted is Empowerment, due to the possibility of encouraging and highlighting the protagonism of the learner in the LX design. This element was treated in 4.44% (N = 2) of the publications. For example, Duh *et al.* (2010) presented a method to allow empowering child designers in game development through three main phases, namely Phase I (Narrative Design), Phase II (Game Design), and Phase III (Design Moderation). In this study, the "black box" problem was tackled, whereby children can lose their sense of empowerment about the product they helped to design. With the proposed method, this feeling of empowerment was observed in the children who participated in the workshops. As part of the results, two of the five children believed that the game deviated slightly from the planned design, another two saw some similarities, and the last child perceived the game as very similar. Finally, four child designers felt that they helped "a little" in the design process, and the fifth child shared that he was able to help a lot.

In total, 18 elements were identified to design the LX, in addition to these three elements mentioned above, there are: Motivation (17.78%, 8 publications), which has the objective of keeping learners interested and engaged in the LX design (Soloway *et al.*, 1996) (Quintana *et al.*, 1999) (Wallace *et al.*, 1998) (Barnes *et al.*, 2007) (Quintana *et al.*, 2017) (Blasquez and Leblanc, 2018) (Fardoun *et al.*, 2010) (Lister, 2021); Skills (17.78%, 8 publications), which aims to make the learner the protagonist of their learning (Robertson and Nicholson, 2007) (Dinimaharawati *et al.*, 2018) (Charlton and Avramides, 2016) (Anaya and Boticario, 2009) (Ktoridou, 2014) (Papavlasopoulou *et al.*, 2019) (Katuk *et al.*, 2013) (Zhang *et al.*, 2018); Knowledge (13.33%, 6 publications), which aims to define the set of contents and skills needed in the LX design

(Wallace *et al.*, 1998) (Quintana *et al.*, 2017) (Battou *et al.*, 2017) (Katuk *et al.*, 2013) (Ennouamani *et al.*, 2020) (Zhang *et al.*, 2018); Engagement (13.33%, 6 publications), which aims to make the learner actively participate in the LX design (Kuhn *et al.*, 2009) (Barnes *et al.*, 2007) (Robertson and Nicholson, 2007) (Charlton and Avramides, 2016) (Papavlasopoulou *et al.*, 2019) (Moser, 2013); Scaffold (13.33%, 6 publications), which aims to provide the necessary resources to support the learner during the LX design (Luchini *et al.*, 2004) (Jackson *et al.*, 1998) (Kurti, 2008) (Norita *et al.*, 2020) (Recke *et al.*, 2021) (Herrera and Sanz, 2014); Usability (8.89%, 4 publications), which aims to verify the ease of use and learning of a computational system for the LX design (Barnes *et al.*, 2007) (Brown and Lu, 2001) (Granić and Ćukušić, 2007) (Arachchi *et al.*, 2017).

Moreover, other elements were found that appeared less frequently, namely: Interests (6.67%, 3 publications), which aims to include preferences, desires and needs of the learner in the LX design (Battou *et al.*, 2017) (Nakakoji *et al.*, 2003) (Lammer *et al.*, 2015)); Growth (4.44%, 2 publications), which aims to stimulate the development of learning throughout the LX design through knowledge and skills (Soloway *et al.*, 1996) (Quintana *et al.*, 1999); Diversity (4.44%, 2 publications), which aims to include the particularities of learners, making the computational system used by all (Battou *et al.*, 2017) (Soloway *et al.*, 1996)); User Experience (4.44%, 2 publications), which aims to provide a pleasant and satisfying learning experience (Blasquez and Leblanc, 2018) (Papavlasopoulou *et al.*, 2019); Contextualization (4.44%, 2 publications), which seeks to relate the didactic content and the computational system in the LX design (Kuhn *et al.*, 2009) (Lister, 2021)); Accessibility (4.44%, 2 publications), which aims to support learners who have some type of disability in the LX design (Granić and Ćukušić, 2007) (Arachchi *et al.*, 2017)); Enjoyment (2.22%, 1 publication), which aims to promote fun in learning (Duh *et al.*, 2010)); Technology (2.22%, 1 publication), which seeks to include the computational system in the LX design (Quintana *et al.*, 2017); Aptitudes (2.22%, 1 publication), which aims to include the characteristics of learners that indicate skills needed to carry out the LX design (Battou *et al.*, 2017).

4.3.7. *Empirical Study (SQ7)*

The empirical study refers to how the LX design is evaluated in practice. This sub-question is pertinent to identify evidence about the LX design, which helps to find the strong points and the points where more attention and support to the learners is still needed. The results of this sub-question revealed that in 15.56% (N = 7) of the publications, no type of empirical study was carried out. The publications only described the technology or indicated how to use it. About 88.44% (N = 38) of the publications were empirically evaluated. For example, Lammer *et al.* (2015) came up with a 5-step plan aimed at introducing robotics to children with different backgrounds and varying levels of knowledge. The foreseen steps are related to the creation of a robot: Task, Interaction, Morphology, Behavior, and Parts. Children are encouraged to think like product designers and are offered a simple framework for conceptualizing a robot from scratch.

The results showed empirical studies on the technologies they are proposing. Carrying out empirical studies is a common practice in the areas of HCI and Software Engineering (Lopes *et al.*, 2018) and a concern in the area of Informatics in Education due to the need for research based on evidence (Bittencourt and Isotani, 2018). In short, these areas have been concerned with improving the proposed technologies to promote and expand learners' participation and support teachers and specialists in creating and conducting the LX design. Finally, within SQ7, some sub-questions were also defined: SQ7.1 (Types of studies) and SQ7.2 (Types of analysis).

The results for SQ7.1 revealed that about 55.57% (N = 25) of publications used Case Studies to improve their LX design technologies, as occurred in Lammer *et al.* (2015). About 11.11% (N = 5) carried out an Experimental Study, such as Kuhn *et al.* (2009) and Ennouamani *et al.* (2020). About 4.44% (N = 2) carried out observational studies, such as those described by Wallace *et al.* (1998) and Quintana *et al.* (2017). In sequence, about 4.44% (N = 2) carried out a Pilot Study, such as Georgiou and Ioannou (2021) and Corbalan *et al.* (2006). Moreover, about 4.44% (N = 2) just called it Study, for example, Tsivitanidou *et al.* (2021) and Moser (2013). Only 2.22% (N = 1) of the publications carried out a Phenomenography Study and Survey, such as Lister (2021) and Herrera and Sanz (2014), respectively. The Case Study was the type of study most performed by researchers on the LX design. This may have occurred because the Case Study allows the investigation of a phenomenon within its real context and usually uses an intentional sampling instead of random, selecting more relevant cases for the purpose of the study (Desmet and Hekkert, 2007).

Regarding SQ7.2, 33.33% (N = 15) of the publications presented the analysis of the qualitative study, as presented by Barnes *et al.* (2007) and Quintana *et al.* (2017). About 24.45% (N = 11) of the publications were analyzed quantitatively, such as Duh *et al.* (2010) and Chen and Liu (2008). About 20.00% (N = 9) of the publications, the data were analyzed quantitatively and qualitatively, such as Charlton and Avramides (2016) and Papavlasopoulou *et al.* (2019). In 22.22% (N = 10) of the publications, there was no data analysis. Therefore, it was observed that most of the studies identified in this SMS were analyzed qualitatively. Qualitative analysis allows an understanding of cognitive activities that occurred in the LX design, such as interpretation, association, and correlation. There is an inherent subjectivity in this type of analysis that can help explain quantitative results. Thus, both analyses are relevant to evolve an LX design technology.

4.3.8. *LX Design Technology Context (SQ8)*

The technology context refers to the LX design scenario where educational resources can be used. This sub-question helps to identify the purpose of the technologies identified in this SMS. The results of this sub-question showed that 46.67% (N = 21) of the publications presented specific technologies, that is, directed to a specific context of LX, such as the development of computational systems. Thus, Robertson and Nicholson (2007) presented a creative process to support budding designers through games. The stages of this process are as follows: 1. exploration (the designer discovers and experiments with game design software); 2. idea generation (the designer engages in a cycle of idea generation and evaluation and may return to the exploration phase several times to establish the viability of an idea); 3. game design (the designer expands on selected ideas to create a complete game design, including detailing central personage, game forms, the content of game levels, and narrative progression); 4. game implementation (the designer implements his design as a working game, involving a variety of technical and artistic skills depending on the authoring software); 5. game testing (the designer plays the game itself to identify problems with low-level game elements, which allows finding and fixing bugs); and 6. evaluation (the designer invites a member of the target audience to play the game. They observe the difficulties the player encounters, their emotional reactions to the personages and narratives, and their overall experience with the game). Therefore, the designer can progress through these stages in order and revisit earlier stages as his ideas evolve.

About 53.33% (N = 24) of the publications presented technologies used in a generic context, that is, that can be directed to any level of education and discipline, for example. In this sense, Chen and Liu (2008) investigated how cognitive styles affect learners' learning patterns in a program that provides instructions based on the web. This program provided learners with links within the text and various navigational tools, including a hierarchical map, an alphabetical index, and the main menu. In addition, each topic was divided into four display options: overview, details, examples, and references. In this sense, learners were in control of deciding their own learning paths, choosing their favorite navigation tools and preferred presentation formats. Furthermore, learners had three types of controls available in the program, such as 1. Sequence control, that allows learners to decide the sequence of subjects to be learned; 2. Content control, that allows learners to select the content they want to learn; and 3. Display control to allow learners one of the display options covering the same concept.

The results of this sub-question revealed that most of the LX design technologies are used in a generic context. This can be positive from an LX point of view because its use can be applied or adapted to different contexts. Even so, it is perceived that there is a certain balance between the generic and specific contexts. Thus, it is noted that it is still necessary to create more technologies that can be used in general configurations, not limited to a discipline or level of education.

5. Discussions

The results of this SMS provide valuable insights into the use of technologies in LX design that consider computational systems. (SQ1) The SMS identified various possibilities of LX design technologies, with the approach the most prevalent in the use of computational systems. These technologies can serve as a foundation for other LX proposals, depending on the learner's context and needs; (SQ2) There is a tendency towards learning theories that promote learner agency through hands-on experiences, with the computational system serving as a means or an end. Constructivism was found to be the most frequently mentioned learning theory; (SQ3) The integration of computational systems with sequences of steps/activities emerged as a common practice in

LX design, fostering learner engagement in the learning process. (SQ3.1) The Design Thinking framework, consisting of Empathy, Define, Ideate, Prototype, and Test steps, was mentioned as a consolidated approach.

The results also showed that (SQ4) there is a lack of initiatives that explore non-traditional environments, such as science fairs, workshops, and school competitions, to provide learners with diverse and realistic learning experiences beyond the classroom; (SQ5) There is limited emphasis on enabling learner interactions with other subjects, such as teachers, parents, and industry professionals, which could offer valuable experiences through knowledge exchange; (SQ5.1) There is a growing interest in LX design initiatives in Basic Education, particularly in Elementary Education and High School; (SQ5.2) Collaboration among learners is emerging as a prominent trend, enabling them to meet, interact, and work together to solve problems; (SQ6) The Value element was found to be the primary focus in LX design, as it directly relates to the scope of learning. However, a range of other elements were also observed, which together can enhance the learning experience; (SQ7) Most of the LX designs were empirically evaluated, (SQ7.1) with case studies being the predominant approach; (SQ7.2) Qualitative analysis was commonly used to gather and represent LX responses and perceptions; Finally, (SQ8) the use of LX design was found to be harmonious in both generic and specific contexts, indicating the need for technologies that can be applied in various learning settings.

This SMS had as its main question: "What technologies are utilized in the LX design that considers computational systems". The identified technologies can be seen in Table 6. Based on these findings, it can be concluded that technologies utilized in LX design aim to empower learners, utilize computational systems to support and guide educational activities, foster collaboration, incorporate various LX elements, and address learner needs. These technologies can be applied in both traditional and non-traditional environments, depending on the desired educational objectives.

6. Limitations

In every SMS, there are potential threats to the validity of the results that need to be mitigated to reduce risks. In this SMS, the entire selection and data extraction process underwent peer review, following predefined strategies outlined in a formal protocol. The selection strategy aimed to maintain research integrity, minimize bias, and maximize the number of sources examined. Any discrepancies were resolved through consensus in meetings. During the data extraction phase, it was observed that relevant information was not always explicitly presented in the publications, requiring some inference. The first author made these inferences, which were then carefully reviewed by the research supervisor, ensuring accuracy based on the information provided in the publications. Overall, the data extraction strategy provided consistency and classification of the selected publications.

One potential risk is the exclusion of relevant studies related to LX design. To mitigate this, the selection filter was intentionally broad, considering not only the concept

Table 6
LX Design Technologies Identified in SMS

References	Technology
Soloway *et al.* (1996)	Learner-Centered Design Framework
Quintana *et al.* (1999)	Process to support scientific research
Wallace *et al.* (1998)	Methodology to support systems development
Kuhn *et al.* (2009)	Methodology to support learning by doing with children
Luchini *et al.* (2004)	Guidelines for designing educational tools
Jackson *et al.* (1998)	Approach to design scaffolding in software
Barnes *et al.* (2007)	Design template for game development
Duh *et al.* (2010)	Method to empower children through games
Brown and Lu (2001)	Process to support the creation of usable materials
Chen and Liu (2008)	Approach to working web-based instructions
Nail and El-Deghaidy (2021)	Adapted design thinking process
Quintana *et al.* (2017)	Persona Party method for designing Massive Open Online Courses
Robertson and Nicholson (2007)	Creative process through software
Kurti (2008)	Activity design and development template
Martin *et al.* (2017)	Learning dimensions for designing experiences
Capuano *et al.* (2009)	Pedagogical templates for selecting e-learning resources
Blasquez and Leblanc (2018)	Learner-centered learning approach
Battou *et al.* (2017	Agile approach to designing a virtual environment
Nakakoji *et al.* (2003)	Framework for working with Learning Objects
Dinimaharawati *et al.* (2018)	Instructional design approach to game creation
Norita *et al.* (2020)	Learning design to support tutoring tasks
Fardoun *et al.* (2010)	Design principles to reduce task complexity
Recke *et al.* (2021)	Canvas activity planning tool
Herrera and Sanz (2014)	Mobile learning framework
Charlton and Avramides (2016)	Methodology for working the Computing curriculum
Anaya and Boticario (2009)	Method to encourage collaborative experiences
Ktoridou (2014)	Methodology for exploring m-learning experiences
Parsons *et al.* (2006)	M-learning design framework
Papavlasopoulou *et al.* (2019)	Approach to guide learning interactions
Mutlu (2014)	Method of managing learning experiences
Nordina *et al.* (2010)	M-learning framework for lifelong learning
Cocea and Magoulas (2015)	Iterative design methodology for adaptive systems
Winters and Mor (2007)	Participatory methodology for interdisciplinary design
Girvan and Savage (2019)	Method for working authentic experiences
Katuk *et al.* (2013)	Approach to Examining the Optimal Flow Experience
Georgiou and Ioannou (2021)	Learning Station Rotation Model
Tsivitanidou *et al.* (2021)	Research approach to social construction
Moser (2013)	Child-centered game development approach
Ennouamani *et al.* (2020)	Model that includes knowledge and learning styles
Lister (2021)	Activity design and development template
Corbalan *et al.* (2006)	Custom task selection template
Granić and Ćukušić (2007)	Approach to designing inclusive e-learning systems
Zhang *et al.* (2018)	Game-based experiential learning model
Arachchi *et al.* (2017)	Design guidelines for inclusive e-Learning projects
Lammer *et al.* (2015)	Approach to learning by doing through Robotics

but also its elements and characteristics, aiming to be as inclusive as possible. Another limitation to consider is the possibility of publication bias, as the SMS relied on digital libraries and may have missed studies from other sources such as ERIC and Scopus. Therefore, the results should be considered within this limitation. Future extensions of this SMS can address this by including additional libraries.

By implementing these measures, the SMS aimed to mitigate threats to validity, minimize risks, and ensure a comprehensive analysis of the available literature. However, it is important to acknowledge these potential limitations and take them into account when interpreting the findings of the SMS.

7. Conclusion and Future Work

This article presents the results obtained from an SMS focusing on technologies that design LX using computational systems. Out of a total of 728 publications, 45 publications met the inclusion criteria and were analyzed. The SMS revealed a significant interest in this subject over time, with higher publication rates in 2007, 2014, and 2021. The results identified 12 types of technologies that can be used to design systems or activities for creating a positive learning experience. The SMS followed the guidelines recommended by Kitchenham (2007) and aimed to address specific research sub-questions, providing an overview of LX design in computational systems.

The findings of the SMS highlighted several gaps in the current landscape of LX design technologies. There is a lack of initiatives exploring non-traditional environments, such as technical visits and social projects, to provide learners with experiences in different contexts. Moreover, there is a limited focus on promoting interaction between learners and other stakeholders, such as teachers, parents, and industry professionals, to facilitate knowledge exchange. While there is a range of LX elements available, their combined use to enhance the scope of learning is relatively rare. Additionally, there is a need for the development of LX design technologies that can be applied in general learning settings, allowing for resource reuse and interoperability. Furthermore, most studies primarily rely on qualitative analyses, which are suitable for capturing subjective data, but incorporating mixed evaluation methods (quantitative and qualitative) could provide more robust insights for researchers.

In addition to identifying gaps, the SMS revealed several trends that offer research opportunities in LX design. There is a growing tendency to incorporate learning theories into LX design technologies, with a focus on learner-centered approaches. The use of computational systems in conjunction with sequences of steps/activities to support learners in challenging tasks is becoming more prevalent. The SMS also listed various LX design technologies that facilitate the integration of computational systems in classrooms and enhance the learning experience. Researchers are increasingly interested in developing technologies for elementary and secondary education, aiming to enhance learning experiences and performance for children and young learners. Finally, empirical evaluation, predominantly through case studies, is a common approach to validate and adapt LX design technologies based on the real needs of learners.

The study acknowledges some limitations that may have influenced the research results. The choice of search engines is a potential limitation, as there may be other platforms containing relevant publications that were not included in the analysis. To mitigate this, popular search engines in the field of Computing, such as Informatics in Education and HCI, were selected. Another limitation is the absence of other article retrieval techniques, such as snowballing. Nevertheless, the peer-review process following a formal protocol helped minimize these limitations.

As future work, a more in-depth analysis of LX elements identified in this SMS is planned. This analysis will consider their characteristics and objectives to create guidelines supporting teachers in generic LX design, providing recommendations based on a consolidated set of LX elements that are more meaningful and conducive to learning. This approach aims to simplify the adoption and use of computational systems, particularly for teachers who are not specialized in Informatics and Computing but wish to incorporate these resources into their teaching practices.

Acknowledgments

We would like to thank the financial support granted by CAPES Finance Code 001; CNPq 314174/2020-6; and FAPESP – grant #2020/05191-2.

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